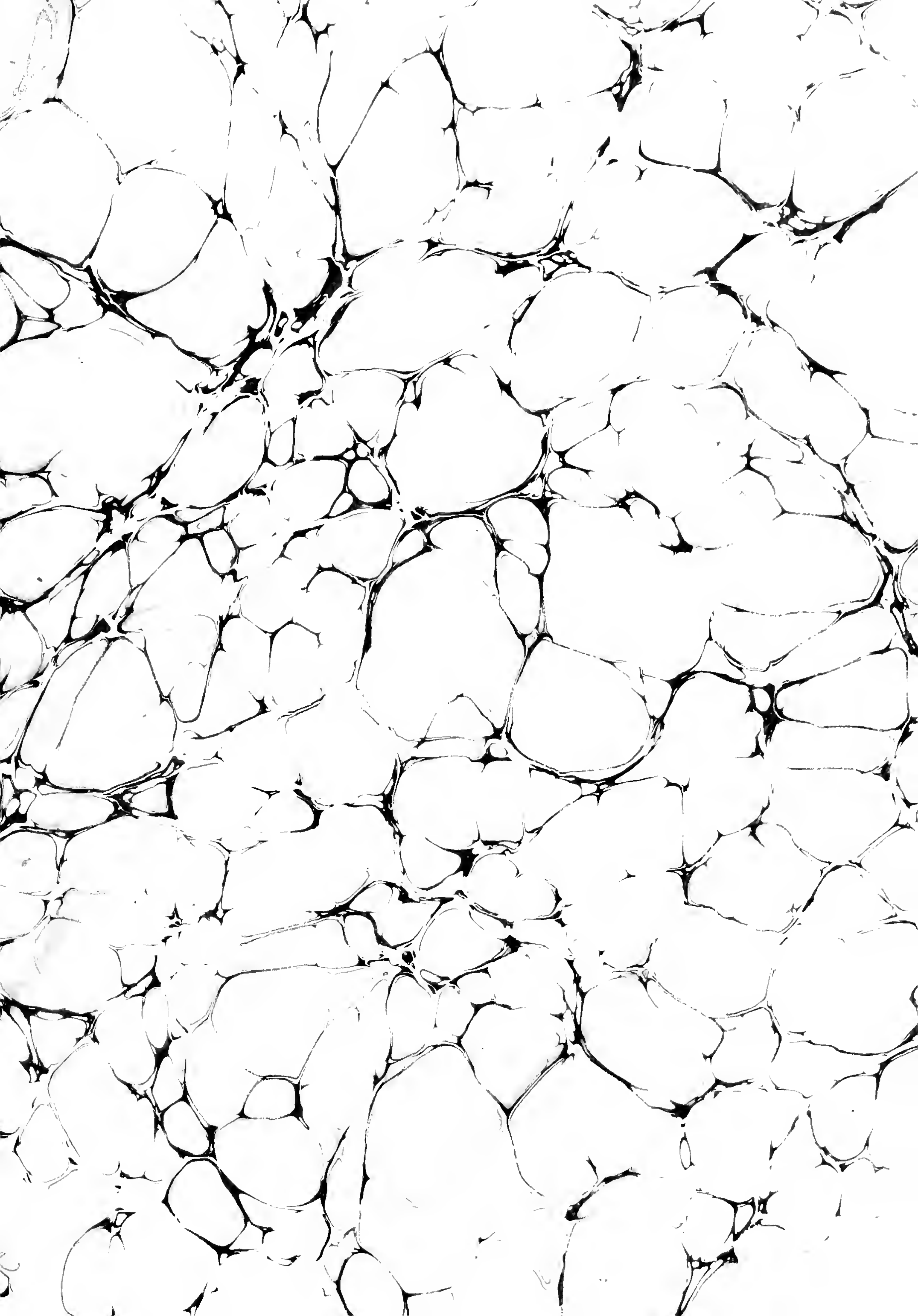

THE

EDINBURGH ENCYCLOPÆDIA,

CONDUCTED BY

DAVID BREWSTER, L. L. D. F. R. S.

With the assistance of

GENTLEMEN EMINENT IN SCIENCE AND LITERATURE.

THE

FIRST AMERICAN EDITION,

Corrected and improved by the addition of numerous articles relative to

THE INSTITUTIONS OF THE AMERICAN CONTINENT,

ITS GEOGRAPHY, BIOGRAPHY, CIVIL AND NATIONAL HISTORY, AND TO VARIOUS DISCOVERIES IN

SCIENCE AND THE ARTS.

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THE AMERICAN EDITION

OF THE NEW

EDINBURGH ENCYCLOPÆDIA.

SCULPTURE.

The principle of imitation is founded deep in the nature of man—in nations—as in the individual early beginning to manifest a decided and happy influence. In the fine arts, this principle supplies at once the source of inspiration, and, to a certain extent, the standard of excellence. Viewed in their general tendency and design, poetry, painting, sculpture, architecture, and even music—all contemplate one end, namely, to awaken associated emotion; while each employs the same means of direct, or of less obvious imitation.

In none of the arts now mentioned, however, is imitation the final object or criterion of the exalted and most refined efforts of the artist. In all, imitation is merely the instrument of accomplishing high and peculiar effects; neither in the varied application of the common means does the individuality or essential character of each reside.

These positions conduct to important conclusions. It is not seldom assumed, that not only is imitation the origin of all art, but that the sole difference between its various branches lies in the manner of imitating. In short, that "painting is silent poetry—poetry, a speaking picture;" or, generally, that the abstract idea or image formed in the mind is identical in all, although particular arts may require diversified or even opposite modes of expression. This theory is partial and erroneous. In each of the arts, a distinction exists not in the manner alone, but still more essentially in the objects and extent of imitation; as also in the facility to be preserved of tracing the sensible architypes or primitive thoughts, on which the associated feeling is engrafted. The creations by which the poet rouses our sympathies, or sways our affections, often but faintly reflect living nature. Architecture, again, fills the mind with awe or delight, from recalling abstract and undefined perceptions of the majesty or grace of the material world. Musical imitation, though sweet and powerful in effect, is still more vague in principle, and more mysteriously associates the corporeal with the intellectual universe. These arts are thus placed widely remote from the direct imitations and definite aims of painting and of sculpture.

A twofold division of the arts of imitation is thus discovered arising from a constitutional distinction in their common and animating principle. To those of one class, embracing poetry, music, and architecture, may be appropriated the name "imitative arts:" while painting and sculpture may not improperly be distinguished as "the arts of design." These terms appear sufficiently expressive of the essential difference between the two divisions—the associated impression in the former depending upon general imitation only, while the latter requires a faithful delineation of perfect, doubtless, yet of living nature. In the following pages, the appellation of "fine arts" is exclusively applied to those of the second class.

Painting and Sculpture, although thus assimilated as constituting one of the grand divisions of art, and consequently exhibiting a certain resemblance in their leading principles, are yet discriminated by marked and peculiar characters. In the latter, form and expression constitute the only legitimate objects of imitation; in the former, the representation includes every attribute of external nature. Extent, in the first, always in one, frequently in every direction, is produced by rules of art, abstractly unreal, though true in effect; in the second, dimension and irregularity of superficies are actually exhibited in absolute or proportional magnitude. Sculpture is more severe, simple, and veracious; Painting more animated and varied, though illusory and conventional in its modes. This imitates, that represents. Though from the addition of colour, as a third element of design, the imitation be more lively, and generally more pleasing than the representation; yet, in respect to intellectual gratification, it may be justly questioned whether the inventions of sculpture do not afford the nobler and more refined enjoyment.

These arts have likewise their points of union as well as of contrast. They happily illustrate the observation of Cicero regarding the mutual blending of the different provinces of human pursuit. In the chart which exhibits the empire of genius, the central portion of each division is strongly marked, but the distant confines melt into each other, nor is it easy to ascertain with precision the exact boundary. Thus in sculpture, relievo approaches the varied composition and illusive effects of painting and perspective, while in simple chiar'oscuro, painting adds nothing, save fiction, to the elements of the sister art. But an important distinction is here to be remarked. While the painter derives power from borrowing the simplicity and learned outline of sculpture, even should his works, like those of the Roman masters and fathers of the art, thus acquire a degree of harshness; yet the sculptor cannot transplant one charm peculiar to painting which does not become a meretricious ornament, detracting equally from the unity and dignity of his composition.

Sculpture, or the actual representation of form by its tangible properties, being the more obvious in application, and the easier in execution, was most probably the earlier cultivated of the arts of design.

Respecting its origin, much has been written, great ingenuity displayed, and authors have claimed for various favourite nations the praise of invention. The same remark applies equally to all the arts. But here theory appears to be not more judiciously applied, than would be speculations on the priority of inventing sight or hearing. Poetry and music—sculpture and painting, each has its spring in a law of human nature, whose necessary operation is to create desires which point to the respective objects of these arts. The imagination only requires to be stimulated by desire, whether natural or artificial, quickly to discover the means of gratification. Accordingly, we shall find it more agreeable to fact, as it certainly is the simpler and more philosophical view, to regard every art as arising insensibly among different nations, and as cultivated independently, though with unequal success, from the earliest period. Nor is similarity of style evidence of continuous imitation. In the infancy of society, men in all countries resemble each other very closely; their wants are the same, their means of supplying these at first but little varied, and the progress from the naked and uninformed savage, to the possessor of some degree of knowledge and of social comfort, is marked by nearly similar gradations. The primitive efforts of invention among every people, as compared with those of other and distant nations, will consequently present little of diversified or peculiar character. The first statues of Egypt and of Greece exhibit almost identical lineaments, and even corresponding attitude,—simply because each had to contend against the same difficulties, with nearly equal facilities of surmounting them. If imperfect instruments, unyielding materials, and inexperience of hand, obliged the Egyptian artist to represent his figures in a constrained posture, with the knees pressed together, arms hanging down and close to the sides, and this not even in the earliest state of the art; the same restraints imposed a similar mode of representation on the Grecian, although from the operation of external causes the advance of genius was very unequal in the two countries. Surely then it is little less unphilosophical to maintain, that the latter must have been a copyist of the former, than it would be to assert that the wigwam, on the shores of the Maragnon or the Illinois, must have been borrowed from the same plan as the aboriginal hut which subsequently rose into the temple and the portico on the banks of the Eurotas or Cephisus. The hut and the wigwam are antitypes of each other, because both are the same primordial rudiment of an art having its scanty origin in necessity, before exalted by taste into a source of beauty and of grandeur. The idols of the Hindoos, the carvings of the South Sea islanders, are not unlike to descriptions of the early images of Greece, sculptured by the predecessors of Phidias and of Praxiteles. Does this resemblance arise from reciprocal imitation, from a common instructor? Consistency would require an affirmative reply. But with equal probability might it be assumed, that the harmonious language and no mean strains of the Malay bard, are derived from Ionia and from Homer.*

All these kindred arts owe their birth to the same law of necessity—necessity of ministering—not to the wants of the body, but to the more ardent aspirations of the heart and of the affections—to piety, to patriotism, to friendship. In this view, though with excusable vanity they assigned to their own country the earliest knowledge of those delightful pursuits, the Greeks evinced a true feeling of their native original, by veiling these claims in beautiful allegory. To love, under which name every noble emotion was included, the ancient poets attributed the gift of the arts.

The historian of Sculpture, therefore, who desires to render his labours useful, will, with judicious humility, limit inquiry to a simple endeavour to trace the progress and improvement of the art among the different nations of antiquity. To amuse with theories of its origin, however ingenious or profound these may appear, is in reality to stop short with a partial view of facts, when a general law is within reach. But in one respect is observed a very marked distinction in the claims of separate states. In the relative degrees of excellence attained there is found a striking diversity; as also in the length of time passed in realizing the same advances. This inequality it will be especially requisite to notice, while an attempt to explain the cause may lead to results of utility in the philosophy of art, exhibiting the union which exists between moral improvement and the lofty exercises of genius, as depending on the political happiness and condition of man.

In arranging the historical details of any art also, or of any intellectual pursuit, the simple order of time will generally be found most congenial with the connection of events, and the most instructive to the

* The Malayese, instead of being the most cruel of cannibals, as long represented, are now known, when treated as human beings, to be exceedingly docile and affectionate in disposition. They delight in the exercises of music and poetry, and speak a language which, from its elegance and harmony, has been styled "the Italian of the East."

The early and lamented death of the late William Jack, Esq. H. E. C. S. the chosen friend and companion of the enlightened and patriotic Sir J. Stamford Raffles, with the subsequent loss of his numerous manuscripts on board the *Fame*, has deprived Europe of rare and valuable information on the inhabitants, productions, and literature of the Eastern Archipelago. To the causes of public and private regret for genius and worth removed in the prime of manhood, this is no small addition; for to this most interesting and novel subject, with many advantages, Mr. Jack is known to have applied, with wonted ardour, the brilliant and varied powers of his accomplished mind. The press, both of Europe and of Asia, has, on this mournful subject, already expressed a sympathising homage; yet it is to be hoped that some memorial more generally accessible may appear—not for the sake of the departed, whose virtues and talents are recorded in the congenial bosoms he most loved, but to be an example and encouragement to the living.

reader. The epochs and eras of art, according to which writers have too frequently divided, rather than classed their materials, where discernible at all, may more commodiously be resolved into gradual changes, while not unfrequently they seem altogether imaginary. The influence of some strong and determining impulse, operating a sudden effect on the style and character of invention or improvement, is to be found occasionally in the progress of individual eminence: but the advance or decline of general acquirement is on the whole equable and consecutive—less dependent on particular occurrences, whether felicitous or adverse, than on the richness or poverty of successive discovery.

In the spirit of these observations, it shall be our object in the following pages to trace the history of Sculpture through the divisions of ancient and modern art. The first part will be occupied with the narrative of its neglect or encouragement, of excellence and decay, in Egypt and the East, among the Greeks, in Etruria, under the Cæsars, till the extinction of letters and refinement in Europe. With the rise of the Italian republics we hail the reappearance of Sculpture, and from the 10th to the 19th century, a series of interesting, but often melancholy events, will form the subject of the second part, and close the history with the labours of contemporaries. Our limits necessarily impose brevity in all instances. In many we shall merely touch upon the leading facts; and in that particular section the state of the art in Greece will include every thing valuable in the ages of antiquity. In part second, the 15th and 16th century, and our own times, adorned by the names of Canova, Flaxman, Thorwaldson, will demand pre-eminent regard.

PART I.

ANCIENT SCULPTURE.

SECTION I.—*Egyptian Sculpture.*

Although the sacred Scriptures, in all cases the earliest and purest fountain of truth, contain the first authentic memorials of Sculpture, we prefer commencing with some account of Egyptian art. In drawing conclusions from monuments actually in existence, many of which we have seen and examined, while no Jewish remain is now to be discovered, regularity will thus better be preserved. An examination also of the style and character observable in the sculptures of Egypt, appears to offer some assistance in collecting the scattered lights which the uncertain touch of scanty or dubious history flings over the mysterious ruins amid which the arts of Babylon and of Persia have been seated.

Egypt, in art, in science, in government, stands alone among the nations of the ancient world. The distinction is, however, a melancholy one, pointing to early promise unproductive of final eminence, and ending in disappointment. In almost evèry mode of intellectual exercise, as in every species of knowledge, she had made the first advances long before those states destined to outstrip her had started in the career. But in all these respects, and especially as regards the progress of art, the singularity of her fate is remarkable in this, that the genius which had received or discovered the first principles, continued in activity and in constant employment on undertakings of magnificence, without progressing—without partaking in the general enlightment derived in many instances from the example of its own success. Egypt, perhaps with justice, has been called the cradle of the arts, understanding by that expression simply priority of cultivation; yet in this their aboriginal seat, during a period of eighteen centuries, from Menes to Alexander, they hardly attained a maturity beyond mere infancy, as regards the higher capabilities of invention. During a far shorter interval in other climes, sculpture in particular had reached the perfection of ideal beauty. While the utmost skill of the Greek artist was rudely capable of fashioning into a square pillar the representations of his country's divinities, the objects of the Egyptian's veneration had assumed no mean resemblance of the human or conventional form. On the other hand, when the sublime works of a refined age had in Greece almost exalted superstition into sentiment, the worshipper in the temples of Memphis and of Thebes still bowed before the hideous deities of his ancestors. "For seven thousand years," says Pausanias, "Egyptian sculpture remained unchanged." The exaggeration proves the truth of the preceding observations, and shows that the absence of improvement had not escaped the notice of those who were more nearly contemporaries, and had examined in their almost perfect state the works from which they deduced the conclusion.

Whence then originated this hostile and chilling influence which arrested knowledge in mid-progress, which blasted refinement in the very bud? The answer to this question involves the fate, and will best explain the history of Egyptian sculpture.

The causes of improvement or of decline in the arts have too seldom been sought where only they are to be found—in the objects and character of national polity. To ascribe their cultivation to climate—to disposition, to opportunity of studying beautiful nature—to patronage—to commerce, is to carry inquiry no further than secondary, and at best but favourable influences; to elevate into causes, effects which regularly proceed from the paramount operation of legislative institutions. Some observations on this subject are the more necessary, that the imperfection of sculpture in the East, and in Egypt especially, has been attributed to deficiency in those minor and less influential considerations, which may become accessory, never preliminary means of success, or sources of invention.

The government of ancient Egypt, though styled, and perhaps esteemed monarchical, was in reality a theocracy—and in its most rigid, most paralysing form. All knowledge, and consequently all substantial power, rested in the hands of the priests, who constituted a separate order, regulated by distinct laws, and holding communication, and preserving intelligence by means unknown to the people, or even to the sovereign. The members of the hierarchy thus became not only the first legislators, but the precepts being written in a sacred and symbolical language, intelligible only to themselves, they of necessity remained possessors of the exposition, true or false, real or occasional of the primitive laws. In such a state of things the whole nation were the subjects, and kings merely instruments under the control of those who were at once the sole depositaries of human authority as also interpreters of the will of heaven. To be perfect, such a system wanted only permanency, and this requisite, except against foreign conquest, was effectually secured. The laws immutable and inexorable, of which the priesthood were the guardians, chained down every form, institution, or practice, once established; determining for ever the condition, and even profession of each family, and of every individual. Religion, business, pleasure, had each allotted hours and prescribed regulations. Free and voluntary action was unknown; legal inquisition penetrated even that sacred circle, and regulated the duties of domestic privacy. National polity to the minutest details was to be unchanged and unchangeable; like the celestial bodies, whose motions formed the grand object of national science, it was to revolve eternally in the same circle. Nothing once connected with the system was to suffer decay, and as has been well observed, the very bodies of the dead were to be rendered imperishable.

In contemplating such a system, although we acknowledge the influence of an awful and stern sublimity, yet the feeling is not of that elevating description which grandeur, whether moral or physical, generally inspires. The mind, on the contrary, experiences a depressing, an overwhelming sense of individual helplessness; while, on its immediate subjects, the operation of such a government must inevitably have been, to produce a gloomy sameness of character, and the most heartless mediocrity of intellect. To improvement of a certain extent in the severer sciences, and in accordance with received opinions, it was not unfriendly; for success in abstract speculation depends not on enthusiasm which is kindled by external appliances, nor on the tenderer inspirations of sensibility. But to those elegant arts which derive their existence and perfection from the susceptibilities of imagination, from the free breathings of genius —the system was death.

Accordingly, in whatever refines, elevates, or soothes the heart, Egyptian art, as appears from the Greek historians, was extremely deficient. In their music and poetry, as in their painting and sculpture, human affections had no place; the modes were severe, unalterable, and consecrated solely to a gloomy and unideal religion. Hence the "bitter Egypt" of the Greeks, not as some explain, indicating the natural saltness of the soil, but because those arts, so cherished them, which are at once the creation and the solace of sensibility in ardent and exalted minds, there languished and were repressed.

To the progress of architecture, indeed, in some essential respects, this stern polity was not unfriendly. In this art, the principles though few, give rise in their varied combination to more than one source of intellectual pleasure. In the Grecian temple are found beauty, grace, proportion, simplicity, harmony, extent. In the mysterious structures of Egypt vastness and simplicity are the only elements discernible of the grand. From these, however, the most powerful, if not the most refined and agreeable emotions are experienced; long withdrawing lines, unbroken surfaces, large masses, simple contours, even should the individual forms be destitute of proportion and grace, will always produce grand and solemn effects, capable of being carried to the majestic and sublime. Thus in viewing the temples scattered over the Thebaid, those very edifices characterised by Strabo as "barbarous monuments of painful labour;"—in contemplating the pyramids whose outline is without variety or contrast, the imagination is exalted to a high pitch of awe and astonishment. But these lofty effects arise from a principle merely accidental, they are not the fruits of intrinsic science or of refined art; they are the inevitable, not the meditated consequents of the system we have described. The eternal durability, to which in all their designs and institutions the hierarchy aspired, necessarily pointed out the selection of a style of architecture, retaining, as the most substantial, only the simplest forms and the largest masses.

These remarks, and our observations generally on the tendency and spirit of Egyptian government as regards the arts, are farther corroborated by the fact, that even to their very measurements, all the sacred edifices of ancient Egypt appear to have been constructed on one and the same unvarying model; without accommodation whatsoever to situation or circumstances.

A system, whose influence thus produced a species of sublimity in architecture, would operate fatally upon sculpture. Attention to durability, regardless of elegance as a primary object, enormous masses and extended lines, so imposing in the former, would, in the latter, produce rigid and motionless figures, devoid of sentiment as without beauty. Such, accordingly, is the character of the genuine monuments of Egyptian statuary. The essential elements of the beautiful are present—simplicity and breadth; but beauty is not elicited; it is the simple uninspired by any feeling of the true, the natural or the graceful; breadth without harmony or proportion of parts, exhibiting lifeless and inert magnitude. A remark bearing on their arts generally may, with peculiar propriety, be applied to the sculptures of the Egyptians, that in these we see only the records of power, of patience, and of labour, not the creations of mind, of taste, or of genius. But sculpture among this people laboured under particular disadvantages. It was considered as exclusively attached to religion, and employed in representations of divinities, priests, and kings—personages to whom only statues were allowed to be erected, for the figures to be found in tombs appear to have been merely symbolical decorations. Now in all these, even in the last, the forms, modes, and expressions were unalterably fixed—and fixed too from types frequently of the most hideous description, at best ill imagined and little adapted to the objects and spirit of the art. This religion also, to the consecration of whose absurdities the noblest of the arts was thus enslaved, was wholly metaphysical and allegorical, not admitting hero-worship, which, by mingling images of human sympathy and virtue, with abstract and exalted conceptions, tended so materially to elevate the style of composition among the Greeks. The Egyptian artist, therefore, even had he been permitted to deviate from his model, had no inducement, and no ennobling source whence to derive beauty. Imagination wanted materials, which neither the subject nor living nature, as he saw it, could supply. Again, sculpture not only suffered from the general disadvantage of hereditary and unchanging professions, a regulation which repressed every thing like the successful predilections of genius; but as a farther security against the possibility of innovation, slaves educated under the eye of the priests were entrusted with the execution of the most sacred, and, consequently, most splendid and important monuments. The art was thus degraded into a servile occupation, and the last hopes of eminence, honour and independent reward, extinguished.

These general remarks will, in some measure, supply an explanation of many leading facts, on which much misconception has prevailed, as regards both the perfection and the epochs of sculpture among the Egyptians. Opportunities will occur hereafter of marking the due application of the lights thus obtained. In the meantime it may be observed, that the fact so often quoted to prove the excellence of art amongst this people, and of their posessing unerring canons of proportion, namely, that statues composed of different pieces, worked by distant artists, were yet so accurately wrought as to fit exactly when united,—if it establish any thing, it is the truth of the preceding observations, and the existence of that o'ermastering despotism we have noticed. For granting the fact, of the truth of which many doubts might be suggested, on any theory of natural imitation, it is impossible; such mechanical correctness could be attained only where the simplest and most rigid attitudes were fixed by unchanging prescription.

As respects the eras of Egyptian art, accurate discrimination has rarely been attempted. From the earliest times, down to the reign of the Cæsars, all statues imitating that peculiar manner, have by some been classed as works by Egyptian sculptors, or at least have been adduced as examples of their style; while by others, minute and often imaginary differences have been erected into permanent distinctions; and epochs and revolutions of taste and execution assumed, which cannot be substantiated from the scanty remains of this interesting but mysterious antiquity.

Two sources evidently remain to us of judging, with sufficient accuracy, the labours of the sculptors of Thebes and of Memphis,—in the ruins scattered throughout upper Egypt—and in the numerous specimens preserved in the galleries of Europe. This latter source derives new importance from the recent additions to the British museum; these not only enable us to contemplate some of the most perfect monuments of Egyptian art, but likewise afford standards for appreciating and classing the specimens of other collections.

The vestiges of the greatness and refinement of ancient Egypt are dispersed over a narrow district, extending on both banks of the Nile from the twenty-third to the thirty-first degree of southern latitude. The island of Phylee, near the cataracts and the ruins of Sais, in the western Delta, may be considered as the boundaries on the south and north of this mysterious vale;—where, amid the wreck of cities, temples, pyramids, and tombs, monuments of forgotten wisdom and departed power, sleep the early generations of the humane race,—where Moses, and Plato, and Euclid studied.

The progress of colonization or of conquest has followed the course of the Nile northwards: the purest, therefore, because the oldest examples of native taste and skill in the arts are to be looked for in the works of the upper Thebaid, in the temples of Phylee, the sculptured excavations of Elephantis, the tombs of the kings, and in the stupendous edifices of Carnac and Luxor. In this view the pyramids, as they adorn the neighbourhood of Memphis, the second seat of empire, situate much farther north, and built long after the splendour of Thebes, the first capital, had passed away, must be regarded as belonging to a more recent age. Into this question, however, it is not our province to enter; nor particularly to describe these remains which, scattered over a length of more than five hundred miles, still strike with wonder and with awe. But among the people of whom we now speak, sculpture appears to have been inseparably associated with architecture; a mode of determining the relative antiquity of works in the former is thus ascertained.

The eras of sculpture in Egypt, as already observed, have been very differently stated. The division of Winklemann is the most simple and perspicuous, and on the whole possesses the greatest share of historical correctness. Still the method is not free from the common objection, that it pays not due regard to the revolutions of native art as distinguished from that excellence subsequently introduced and engrafted upon the national style. This system, therefore, as well as every other, we are forced to abandon for the same reason, and to adopt the following, which, with some degree of novelty, will, it is hoped, be recommended by the more useful advantages of truth and simplicity, and by at once presenting an argument resting upon, while it discriminates intrinsic distinctions.

I. Era of original or native Sculpture.
II. Era of mixed or Greco-Egyptian Sculpture.
III. Era of imitative Sculpture, improperly denominated Egyptian.

I. From the above division of the subject it will appear that we admit only one age of art purely Egyptian; that is, during which sculpture can be considered truly indigenous, without any foreign admixture. The two remaining epochas are added, in order to embrace the consideration of those details which have been hitherto regarded as forming constituent parts of the Egyptian school, though in fact but partially connected therewith, and not unfrequently pertaining to works which, except in rude materials, had never been out of Italy, and never handled, except by Greek or Roman artists. The first or true epoch of sculpture in Egypt ascends from the conquest of Cambyses, till all records are lost in the remoteness of antiquity. During this period only were original institutions in full vigour, and public works conducted by national energy, and stamped with national taste.

In illustration of these views, it first becomes necessary to examine whether the resources of the state and the ingenuity of the people, were adequate to the production of the numerous and stupendous works, which must thus be ascribed to the first age. Not only is the answer to this inquiry in the affirmative, but with no degree probability can any other date of erection be assigned. We learn from Homer, that in the time of the Trojan war, twelve centuries anterior to our era, Thebes was one of the most magnificent cities then in the world; indeed the terms of the description would induce the belief of its paramount grandeur. Again, from himself we know that Herodotus admired these very monuments, the ruins of which excite the wonder of present times. This father of history visited Egypt not quite a century after the reduction of that country by Cambyses. Even then the origin of these structures was lost in the obscurity of distant time; consequently they could not be the erections of an age later than this monarch, who in fact laboured to destroy them. They were on the contrary universally attributed to the reigns of the early native princes; of whom Herodotus attempts a long though imperfect enumeration, prior even to Sesostris. Carrying these pretensions to antiquity no higher than Homer's description, which corresponds with the era of Sesostris, we thus gain two fixed points, which supply an interval of seven hundred years from the war of Troy to the invasion of Cambyses, that is from 1200 to 526, B. C. During the lapse of so many ages, the whole power and riches of Egypt were placed at the disposal of a society of men whose wisdom and learning were proverbial, and whose intelligent and active ambition these very monuments testify. Anciently Egypt was likewise remarkably populous, so as to occasion a saying, "that instead of beauty nature had conferred upon its women the more honourable gift of fertility." Enjoying for a long period the entire commerce of the ancient world, the wealth of this country must always have been great. Even when reduced into a Roman province, and despoiled of much of its original importance, the amount of public revenue under the Antonines was 12500 talents, or two millions and a half sterling—equivalent to a much larger sum. Of the capabilities, both physical and intellectual, of the ancient inhabitants of Egypt to produce the works in question, there can thus exist no reasonable doubts; while by the testimony of history, their erection is restricted to a period not later than now assigned; but if necessary, we might ascend much higher.

We have thus ascertained the limits within which the primitive school of sculpture in Egypt must have flourished; for in most instances its labours are attached to, and consequently have been completed at the same time with the architectural remains, of which they have once constituted the profuse and even lavish ornaments. We are thus enabled to proceed, with no small degree of certainty, to the examination of the genius, character, and principles of this aboriginal style. Here the examples may be classed under three divisions; first, colossal statues; secondly, single figures or groups, about the natural size; and, thirdly, hieroglyphical and historical relievos. In each of these, however, is to be discerned a similar character of invention and finishing, varied only in the degree of excellence or nature of the work. Minuteness of individual description is therefore less necessary.

The works of the first class, many of which still remain both entire and in ruins, from their magnitude fix our earliest attention. Indeed, than a statue of granite sixty feet high, there hardly exists an undertaking more laborious or difficult, or an instance more striking of disregard of time and patience of toil. Of these enormous sculptures, some have been rocks hewn into shape alone, and left adhering by their base to the living bed. Of this class the celebrated sphynx ninety-five feet long and thirty-eight high, is an example. Others, as the figures in the Memnonium among the ruins of Thebes, have been built of square blocks, first built and afterwards carved into form. The greater number have been sculptured from an entire block finished in the quarries of Upper Egypt, and transported to their site by the waters of the Nile. Most of the smaller works of this age are in sandstone and other softer materials, such as the situation naturally afforded; the great statues are universally of granite, seeming to indicate that in their construction time was disregarded that eternity might be secured.

Of these colossal sculptures, the most remarkable, or at least the best known to general readers, are the two statues still remaining in the Memnonium. Exclusive of the lower plinth of the rude throne on which it is seated, the altitude of each is fifty feet high; but between the two, and scattered around to some distance, lie the ruins of a still more gigantic figure of red granite. These, by Denon and others, are conjectured to be the remains of the celebrated sounding statue of Memnon, a supposition which is opposed by the inscriptions on one of the others, but is corroborated by the head now in the British museum—the most splendid specimen of this primitive style in Europe. In both figures the position is exactly the same and may be described as common to all works of this class; the head looking straight forward, arms pressed close to the sides, and hand expanded resting upon either knee, lower limbs perpendicular and apart. This attitude, as will at once be perceived, is little calculated to convey any sentiment of ease or of grace; the whole effect, indeed, is stiffness and constraint. Yet, in these vast though uninformed labours, united as they are with dim and distant recollection, there is something mysteriously grand and solemn. Nor is this produced by association alone. For while it is to be remarked of colossal statues generally, that they exhibit the greatest comparative perfection to which Egyptian sculpture has attained; in them we likewise discover visible approaches to truth and nature, with occasionally, as in the sphynx and the head of Memnon, considerable feeling of the sweet, the tranquil, and the flowing, expression, and contour.

In the second class appear to be comprehended both the earliest and the latest of Egyptian statues. The infant efforts of the art seem to have been exercises on pieces hewn from the living rock, in the process of enlarging or of forming those natural caverns or artificial excavations which were the original scenes of all solemn assemblies and religious festivals, prior to the erection of temples; and during every age, the adorned repositories of the dead. Afterwards statues, thus formed, were loosened from their bed to be transported to distant situations, or were sculptured, in what finally became the general mode, from detached blocks. It is not here intended to imply that these two manners are decidedly to be separated, or that the former, being discontinued, was superseded by the latter, but simply to express the fact of priority, sufficiently obvious from the habits and history of the people. Hence, perhaps, a circumstance may be explained, intimately connected with the subject, and which has given rise to much discussion. In all Egyptian statues of every proportion, and in every attitude, a pilaster is found at the bank as if supporting the figure. Now in all works belonging to the first manner, the ground is never entirely removed, the posterior portion always remaining undetached; while if the statue has been formed by cutting round it to a recess behind, a pilaster is carried upwards to the ceiling, evidently with the original view of increasing strength.

Subsequenly, from that hostility to innovation characterising the system, partly to avoid difficulties of execution, and to obtain a plane surface for the inscription of hieroglyphics, the aboriginal pillar was retained. Of these two manners in figures composing the second class, numerous specimens remain, especially of the first, as in the excavations of Philee, Elephantis, Silsilis, and in the tombs of the kings. These also are not only the most ancient but likewise the most authentic; and there can be no question, that of the second kind, many in the different cabinets of Europe are spurious imitations of Egyptian art. In the genuine statues of both kinds still existing on their native site much diversity of style and character prevails. The varieties, however, cannot be reduced to any determinate epochas, or regular gradations, as has sometimes been attempted. From the contradictions in time and vicinity of situation in the good and the bad, the disparity in point of merit can properly be ascribed only to individual excellence or mediocrity in the artists employed—to the purposes contemplated—to the opulence or taste of the projectors.

The profusion with which Relievos were employed merely as decorative parts, without regard to intrinsic beauty, as also the nature of hieroglyphical representation, where only a general resemblance of outline was studied to the neglect of expression, and the more delicate varieties of form,—necessarily exerted a prejudicial influence not only in this department, but generally on the progress of Egyptian sculpture. In this branch of the art, likewise, as might be expected, where, from the introduction of a number of figures, other principles of design, besides a mere knowledge of form become necessary, the deficiencies of the artist are betrayed more conspicuously. This, however, must be understood with due limitation. In such relievos, sepulchral ones for instance, as contain few figures, seldom more than three, and in which the attitude is simple, without violent or complicated action, are frequently displayed no mean beauties of execution and of outline. But on the contrary, in historical relievos, which frequently cover entire walls of immense edifices, representing processions, battles, sieges, all is confusion, feebleness, and puerility. In the drawing and anatomy the utmost ignorance is manifested; the figures are without joint, and exhibit not the slightest knowledge of balance or spring in motion. Even proportion and magnitude, not to mention perspective, seem to have been utterly disregarded or unknown. The military engines, buildings, soldiers, all appear of the same size, and all equally near the eye. The hero is certainly distinguished from the rest, but in a way which marks the absence of all science, and indeed could be conceived or tolerated only among a people whose taste was in the highest degree barbarous. This personage, who is generally in the bloom of youth, that he may stand forth from the vulgar, is always represented at least double the stature of his followers. The circumstance of confounding moral with physical greatness is alone sufficient evidence of the infancy of invention, and proves the Egyptians never to have passed that limit where, by a slight refinement of imitative tact, if the expression may be permitted, a tolerable resemblance of individual form is accomplished, but where any sustained efforts of abstract imitation is impossible. The hieroglyphics, which form so large a portion of the Egyptian relievos, we have already noticed as destitute of accurate discrimination of form, considered as works of art; but to this latter rank they ought hardly to be elevated; they are more properly to be regarded as conventional representations, dependent on modes and principles equally arbitrary. The praises bestowed on works of this class by Winkleman and others, are to be restricted to the mere excellencies of labour and workmanship. Even in these respects the commendation is often exaggerated, not unfrequently misplaced. The genuine relievos of the primitive age are, without exception, anaglyphics, that is, raised on themselves, but depressed beneath the general surface on which they are engraven. Now we cannot admit the refinement so generally presumed in this fact, which is considered as evidence of elegant invention, both to deepen the effect to a spectator at a distance, and to guard the work against the injuries of time. The latter of these reasons may be true, certainly, not the former; for if the shadow be thus stronger, it obscures in an equal degree the contours of the niched figure; also the practice is universal, as well in works which are to be viewed near, as in those placed remote from the eye. This manner, therefore, is to be regarded as originating in the limited resources of an imperfect art. It is in truth but the first step in improving in the earliest and rudest of all sculpture, often to be met with in the oldest monuments of this very people, namely, a simple outline of the object very deeply cut on a plane surface. An obvious advance was to round the included figure, marking the salient parts, and depressing the hollows. The next step, but more laborious and difficult, especially in hard materials, was to remove the ground, leaving the figures in full and bold relief. This view is so strongly corroborated by the history of the art in Egypt, that any work in relief of the description, properly so called, must be assigned to a later era. From not attending to these circumstances, writers have built very erroneous theories on some specimens of bas relief of the usual kind found in the pyramids. These were internal decorations merely, and show that the interior of these structures had in some instances been adorned long after their erection.

Our observations have hitherto been confined to the primitive ages, and we have dwelt longer on this period for two reasons. This being the true era of Egyptian sculpture, properly so styled, the preceding remarks have nearly exhausted whatever of interest strictly belongs to the subject; again, few important and authentic monuments of any later date now remain. The second epoch will therefore not long detain attention. The expression mixed art, which has been selected to distinguish this epoch, appears sufficiently discriminative, and marks the engrafting of different tastes and styles upon the ancient modes that took place on the conquest of Cambyses, and subsequently under Alexander and his successors. In both cases a change was certainly experienced, still the ancient character predominated: indeed the grounds, already explained, on which it was founded were too deeply laid, easily to be shaken. To have introduced any radical innovation, not only the frame of society must have been dissolved, but the very existence of the nation must have ceased. Under the Persians, as regards sculpture, we conceive, contrary to so many opinions hazarded in opposition, that no actual additions were made. The influence exerted by their dominion on the art, amounted merely to a negative, to the prohibition of its exercise, the destruction of its early and best monuments, and a consequent deterioration in the few and feeble attempts by artists during the latter years of that dynasty. Mythraism, the prevailing religion of the conquerors, prescribed the use of statues, where only they had been previously allowed. Architecture was the only art extensively practised. But the Persian erections were modifications of materials torn from the mighty structures of former ages, not original efforts. Here the impress of the ancient style could not be effaced; while the sculptural embellishments permitted relievos exactly of that description in which the Egyptian artists were the least skilled, and also which was calculated to deteriorate, not to improve.

In little more than a century and a half the empire of the Persians was subverted by the Greeks. But in Alexander the ancient arts of Egypt found not a patron. The majestic range of cities, temples, and palaces, which bordered the sacred stream of the Nile, became so many quarries of tempting access, whence Alexandria was reared; and the mightiest as well as most rational trophy of Grecian superiority borrowed its grandest and most enduring monuments from the stupendous labours of the first age. The successors of the Macedonian prince pursued the same system; and though in seclusion the Ptolemys might have enjoyed the polished representations of her arts, and cultivated the learning of Greece, we do not find that beyond the precincts of the palace any remarkable effects of their refinement are visible, at least in the statuary of this period. The character in all essential respects remained Egpytian. Nor if considered, as the arts always ought to be, in relation to the political system, could this fate be otherwise. The objects, purposes, and forms of Egyptian sculpture had long been fixed, and by that very polity and religion now again partially re-established, in as far as respected the subject under review. We would ascribe then the amelioration of taste and practice, which certainly is to be observed under the Grecian princes, principally to the removal of the restrictions introduced during the Persian conquest, and the renewed splendour of the ancient worship; for as already shown, to sacred purposes only were the magnificent displays of the art devoted. It is not, however, to be denied, that amid the strongly marked features of indigenous character are to be perceived in the sculpture of this era, approaches to a firmer, more natural and bolder style of design, which can be attributed only to an intercourse with Greece. This improvement is most conspicuous in the clothing and action of figures. The drapery, instead of being glued as it were to the body, and in the female deities barely distinguishable, by a few small and rigid plaits, now becomes more full and flowing, with some faint indication of selected arrangement. The attitudes exhibit more of mobility, the arms are farther separated from the sides, and the whole design more easy, vigorous, and decided. The chiseling also displays more of energy, but the forms are still destitute of style in composition, and discover not the slightest traces of any abstract principle of beauty, either natural or ideal.

These brief notices have conducted us rapidly over a course of many centuries, to the third and last era, that of imitative art, under the dominion of the Romans. This epoch may be considered as commencing with the introduction of Isiac mysteries at Rome; but as marking a distinct character in the history of art, the principal works by which it was distinguished are to be referred chiefly to the reign of Hadrian. These works, in strict propriety, have no real connection with Egyptian sculpture. During his abode of two years in that province, and especially by the deification there of his favourite Antinous, this emperor appears to have imbibed a fondness for the arts of Egypt. He accordingly caused imitations of the sacred statuary of the East to be executed; and formed in the Canopus, or Egyptian Gallery of his villa, a very complete and numerous collection. The taste was followed, as might naturally be expected, by the wealthy of his subjects, and imitations were multiplied over the empire. But although these sculptures were modelled after the most ancient of the Egyptian forms, the attributes carefully preserved, and even the material, such as basalt, porphyry, granite, brought from natural quarries, yet the artists were Greeks or Italians, and the Grecian character of design is visible in every remaining specimen whose merits entitle it to criticism. Nothing therefore can be more futile than from these works to deduce conclusions regarding the merits or principles of the art as practised by natives, and in the early ages. It is only in compliance with classing certain details, and from a desire to include under one head whatever has been connected with this particular part of our subject, that this era has not consequently been introduced among the corruptions of Greek art. So far indeed does our scepticism here extend, that we doubt whether a single statue near the natural size of genuine Egyptian workmanship has ever been disinterred in Italy or in Europe. Certainly, we are induced from inspection to pronounce the smaller figures in the different Italian collections as belonging to this last period, while the others, however celebrated, such as the Isis of the capitol, are of such a style, or rather so destitute of all style, that they may belong to any or to no era. A distinction indeed has been attempted to be established, from the circumstance, that these latter compositions are unadorned by hieroglyphics, and have no pilaster behind. But it will surely be admitted that these accessories would not be more difficult to add, than to imitate the whole form and attitude, and that wherever complete imitation was requisite, these attributes likewise would be affixed.

From the preceding account it will appear, that of the various eras under which the history of Egyptian art has been reduced, one only, extending from the earliest records to the year 526 B. C. exhibits the true genius and character of sculpture, and has likewise erected the most numerous and the noblest of its monuments. In establishing this principle, we have not been guided by the often fanciful, always deceitful, analogies discoverable in the varying productions of art, but have been directed by the steady operation of the laws and institutions of society, which govern the spirit and tendency of the arts themselves. The second period, from Cambyses to Cleopatra, is mixed in its principles of government as in its arts. Still the master lines of the primitive age were too widely drawn, and too deeply traced to be obliterated or even much obscured. The Persians carried art from, but brought none into Egypt; and had it not been necessary to account for the retrogression under their usurpation, perhaps the second era had with more propriety been commenced with the foundation of Alexandria. The close intercourse with Greece which certainly existed during the whole of this period has been by some attempted to be carried up so high as the reign of Psammeticus; and hence, following up the weak partiality of the Greek historians, Egypt has been denied all claims to originality in the arts. We have already, with due deference, reprobated the absurdity of theorising on the invention of arts, originating in the universal feelings of human nature. But here the genius of Greek and of eastern art are as opposite as light and darkness: granting then the assumption, which people must have been the creditor?—Egypt, not Greece; for if this king lived at the time stated by those who maintain the opinions now opposed, the art of sculpture in particular was in a state of far higher advancement in the former than in the latter country. With the Macedonian conquest then, not earlier, commences the active influence of Grecian taste; which, without changing the grave severity, the solemn majesty of Egyptian art, softened its sternest and most rigid elements; freed, as far as their consecrated usages would permit, its forms from conventional stiffness; and inspired some sparks of life, of grace and of variety. The third and last era has been added in deference to received opinions, but it is connected with the primitive age merely as an imitation with its original.

In Egyptian sculpture, thus properly understood, we find little to excite that admiration in which travellers and enthusiasts in the cause of antiquity have been prone to indulge. Still we do discover some excellent first principles, and occasionally beauty of detail: but both are without rule, and seem the effects rather of chance than of design, or refined perceptions of symmetry. Their best statues have an elevation of seven heads and a half, and are divided into two equal portions—the torso and limbs, at the os pubis; proportions not unpleasing because founded in nature. They show, however, nothing of that characteristic beauty which, in the varied harmony of parts, indicates moral or physical capability. Their figures consequently have nearly all the same character. The proportions, taken more in detail, follow the same principle; yet are often brought out with considerable propriety and softness, but without anatomical knowledge, especially of the internal details, the heads of the bones, the insertions and terminations of the muscles never being correctly indicated. Hence the forms appear coarse and inelegant, the limbs heavy and inert, without vigorous marking on the joints; the deeper depressions only and the strongest projections are aimed at, not feelingly touched. From this want of anatomical precision, being in these more easily concealed, perhaps arises the circumstance, that the female possess more elegance and beauty than the male statues, and with the exception of the hands and feet, which in both are gross and heavy, the nude in the arms, bosom and limbs of the former is often moulded with considerable delicacy both of contour and of finishing. With these deficiencies of science, the Egyptian statues would appear more like *abozzate* than having received the last finish, did they not present two redeeming qualities, ever highly esteemed by a cultivated taste; simplicity of composition and great breadth of parts. These, indeed, united with sharpness of chiseling, may be regarded as the peculiar excellence of Egyptian, compared with ancient art generally, and which place its productions among those of eastern art, without a rival next to the labours of Greece.

In Egyptian statues, it is further to be observed, that the attitude is constantly rectilinear, denoting that state of art when poverty of resource limits its search of the beautiful by the difficulties of execution. It is in fact the first choice of infant invention, rendered permanent by prescriptive institutions. From the curve being thus unknown in the contour, the action is necessarily angular, whenever the movement is not parallel to the gravitating line of the figure. Hence the arms have but two positions, either hanging close to the sides, or crossed at right angles upon the breast; or sometimes varied by one placed in each posture. Lateral motions are likewise unattempted, the statue standing equally poised on both limbs; with the feet not exactly opposite, one more advanced than the other, and often almost in front. In every posture of standing, sitting, or kneeling, these remarks apply: hence it is easy to conceive that little of grace, ease, or animation is ever to be found in the most perfect works: yet we often observe a grave and staid serenity not unpleasing nor devoid of interest.

In the genuine sculptures of Egypt, little of expression or of character is to be found. As in the selection of attitude the artist has been guided, not by the beautiful, but by his own timidity of hand, and confined resources, so in expression, seldom more than a vague and general resemblance of emotion has been attempted; such indeed as might be produced by casually arranging symmetrically the different features. Although heads are very frequently finished with wonderful labour, the effect is always feeble; this arises from the style of art, and peculiar character of visage which appear to have constituted the beau ideal of those ancient masters. The features are flat, the countenance Ethiopian; the first are just sufficiently distinguished to have the effect of separating them, there being no depth of shadow to give contrast and firmness. The eyes, whether long and narrow, as in the earliest era, or more full and open, as in the Greco-Egyptian period, are flat, and almost equal with the general level of the face,—the nose broad and depressed,—the lips thick, though sometimes touched with great softness and delicacy, but always sharp on the outer edges; the cheeks, chin, and ears, large, ill made out, and without feeling. The whole is uniformly surmounted by harsh and disproportioned masses of drapery, which overpower the little effect that would otherwise be produced, and render the expression still weaker. The superior beauty of some of the colossal heads may perhaps be rightly attributed to their being most probably portraits. Conventional art, even in the most skilful hands, is rarely pleasing; nature, though rudely imitated, possesses always a degree of beauty.

Respecting the technicalities of Egyptian statuary, some scattered details are to be found in various of the Greek writers. These hints have evidently misled modern critics, who have applied to the most ancient state of the art, and generally, those refined practices which Diodorus and others described as known in their time, many centuries after Egypt had in some measure become the pupil of Greece. If a conjecture might be hazarded on this subject, it would appear that the Egyptians, in the infancy of their arts, were guided by an outline traced round a human figure, whether dead or alive, placed upon the block, and extended flat upon the back, with the arms close to the ribs, exactly as their statues are composed. This supposition will account for the correctness of the general proportions, which would be thus ascertained from nature. Also we can detect no theory of proportional parts different from what could thus be obtained, while those details which theory would preserve, but which could not be thus measured, are so defective. Of anatomical knowledge, as is evident from their works, they possessed no more than a view of the living form, in its simplest relations, could give. On this subject it is frequently maintained that the Egyptian artists had carefully studied the structure of the inferior animals, as instanced, it is said, in existing specimens; the hypothesis may be true, but certainly the proof adduced is not to be admitted. Less of restriction undoubtedly has been imposed, and more play of imitation allowed in the one case, but equal breadth and correctness of parts, are to be met with in their representations of the human as of the brute form; witness the head and shoulders of the Sphinx, and of the Memnon, compared with the lions of the capitol, and others at Rome, so justly admired as the finest examples in this department.

In fine, when we contemplate Egypt, if not the parent, at least the earliest nurse of art—when we view her advances in improvement previous to the existence of many other ancient nations—when we examine her early monuments—we are struck with wonder and astonishment. But comparing her with herself—the reign of Sesostris with the dynasty of the Ptolemies, a most melancholy falling off from early promise is remarked,—every nation whom she had taught had now outstripped her. Nor is it difficult to trace the cause—convention and prescription, and intellectual tyranny, had assumed uncontrolled empire over her arts. The first principles were bad, because not founded in nature; the imperfect models thus produced, by superstition consecrated and rendered permanent—fixed barriers to improvement. The genius of her institutions was to rest satisfied at a point of the easiest access, and thus in science and in art she was condemned to a hopeless and eternal mediocrity.

Assuming the era of Egyptian art as the first lucid point in the history of ancient knowledge, we remark the rays of intelligence thus concentrated to diverge in opposite directions, eastward over the regions of Southern Asia, and westward over part of Europe. Here in Greece and in Italy, the day spring was hailed by minds who rejoiced in its beams, and lighted up its splendours. But in the numerous and ill explored monuments of Persia and of Hindostan, the vestiges of this early illumination are too few and too faint to enable us, with any degree of accuracy, to determine its progress or extent. This consideration alone, would not however have prevented an attempt, had such an inquiry promised any illustration of the general subject: for whatever might have been the refinement of these countries, their arts, like wandering streams, gradually lessening as they recede from the parent source, must be regarded merely as derivations from those of Egypt, and bringing no increase to the grand tide of improvement. Of Indian, Persian, Babylonian sculpture, therefore, it appears unnecessary to enter upon any investigation. The ruins of Persepolis, for instance, in one palace of which a recent traveller counted upwards of a thousand sculptures, as well as the excavations of Ellora; the obelisks, statues, and tombs on the Ganges, all exhibit a corresponding though less perfect style, and evidently belong to a later age than the similar works of the Thebaid.

These views, indeed, are opposed by names who deservedly rank among the first in English literature, and who support the priority of the arts of India, considering this as the source of Egyptian and of Grecian knowledge. One consideration emboldens us to differ from authorities so respectable. Sir William Jones and Dr. Robertson have brought, in support of their opinion, all that philological and antiquarian erudition could accumulate; but they have failed in examining the subject as artists, and have not been determined in their decision by those principles of judgment which art supplies. Now in this, its only true aspect, the subject presents a very different view. Both the sculpture and architecture of Egypt bear the impress of uniform simplicity, and the same forms are preserved in the earliest and latest monuments. The grand lines of composition are few and simple in the extreme, accessories are sparingly introduced, and bear the same sober, massive, and unpretending character. In the works of Asiatic art, on the contrary, although resembling those of Egypt in their general design, there appears a style of ornament, replete with complicated detail and pretension. Judging, therefore, according to the acknowledged truths of art, these defects in keeping evidently arise from the superinduction of the offending parts upon the severer and simpler master lines of a more primitive composition. Nor can it be replied that in Egypt a refinement of Asiatic taste has occasioned this difference, because this would imply a corresponding superiority in other respects. Now in mere dexterity of hand, the works of this country are more than equalled by those of India. But the Egyptian artist has never advanced beyond his means; he never attempts what is beyond his knowledge or practice; and we evidently observe that his science extended not beyond what is accomplished.

From the peculiar interest of the subject, we might enlarge on the state of art among the Jews; but this would likewise be to deviate from strict order and utility. Much learned conjecture might be quoted, and opinions brought to pass in review, amusing perhaps, but hardly instructive. The Bible, the best authority, informs us that Moses was the most accomplished of his nation, and adds, by way of eminence, that he was skilled in all the learning of the Egyptians. From the same source the arts of his people were derived; they had been the bondmen of Pharaoh, and knowledge was cheaply purchased by temporary slavery. The scriptures every where confirm these views; the molten calf of the wilderness was evidently a symbol of the Egyptian Apis, and would necessarily resemble its prototype in form and workmanship, and points out beyond dispute the character and origin of Jewish art. The descriptions which occur posterior to this in other parts, both of the historical and prophetical books, show that taste was not refined by the lapse of time. Every passage, in fact, proves the reverse, and that art among the Israelites quickly lost the severe and simple grandeur which their residence in Egypt might have fostered. Witness the relievos on the Arch of Titus, the sole vestiges of Jewish art in existence.

SECTION II.

Etruscan Sculpture.

The origin of the ancient inhabitants of Etruria involves a question of more than usual intricacy, even among those historical inquiries where materials are scanty, or if abundant, perplexing and inconsistent. Here both species of difficulty are to be encountered. A few scattered rays only of certain knowledge break through the gloom of time, and the still deeper obscurity accumulated by conjecture and hypothesis. These dispersed lights we shall endeavour to concentrate and to direct steadily on the subject, free from all adventitious shades of theory or opinion, in order that the reader may be enabled to judge of the real influence exerted by this people on the progress of ancient art.

It is universally conceded, with some exceptions as to the extent of their dominion, that the Etruscans or Thyrreneans possessed at an early period the empire of Italy, and much of the refinement of the ancient world. But of their power and of their skill a few imperfect remains alone exist; while their scanty annals have reached us through the medium of the narratives of the Romans their conquerors, or of the Greeks their rivals. Of these relations the writers are divided between two general opinions: one party affirms that the Thyrreneans, assuming the name from their leader, came originally and immediately from Lydia; in opposition, it is asserted that Etruria was first peopled by the wandering tribes of the Pelasgic race who finally and at different times settled in Italy. On these two opinions, or modifications of them, modern authors have erected various, and in many respects conflicting systems into which we do not enter. At the same time, to adopt exclusively either the Eastern or Grecian colonization of the Etruscan states, will neither accord with contemporary, nor explain subsequent events. Under those circumstances, an endeavour to reconcile the discrepancies of statements which doubtless were drawn from purer and more extensive sources than can now be consulted, appears the only advisable proceeding.

Of the Nomadic nations who first inhabited Greece, the Hellenic and Pelasgic races were the most powerful, distinguished by different character and separate descent. The former, conspicuous for attachment to their native soil, made early improvement in the noble attainments which are fostered by settled habits; the latter, of a wandering disposition and uncultivated manners, never became eminent either in Greece or in Italy. But there is undoubted evidence, not denied by any party, that the Etruscans had attained a degree of skill in the arts, opulence, security, and wisdom in their institutions, while the Greeks were yet in a state of pastoral rudeness. Into Etruria, therefore, the most ignorant of the roving tribes of Greece could not introduce that science and refinement unknown in their native country; nor, as distant colonies, is it reasonable to suppose they could have outstripped the parent state, except by union with a more refined people previously occupying the seats into which they were received. On the other hand, the mythology of Etruria is identical with that of Greece, not merely in the general similarity which indicates a common though remote origin, but exhibiting a system adopted in a state of relative perfection. Again, Etruscan monuments commemorate the earliest achievements in Grecian history prior even to the war of Troy, and of which no trace is to be found in the records of Grecian art. These facts point to one only consistent and rational conclusion; namely, that there were two migrations of colonists into Etruria at distant intervals and from distant settlements. This view reconciles the seeming disagreement of the classic authorities. It would appear, then, that the north-western shores of Italy were peopled as early as any part of Europe, and from the same eastern sources. These colonies, attaching themselves to commerce, naturally kept alive or improved whatever of knowledge they previously possessed in peaceful studies, to which the predatory, pastoral, and wandering life of other tribes, though perhaps established at the same time, proved fatal. These original settlers, who arrived directly from the east, appear to have been joined before the time of the Trojan expedition by numerous bands of the wandering Pelasgi. The two nations seem to have gradually coalesced, the warlike habits of the Greeks enabling the Etruscans to subjugate almost the whole of the peninsula, from the confines of Liguria to the straits of Messina; while the refinement of the latter could not fail to effect a favourable change on the character of the former. It was an error very likely to be committed, to date the commencement of the nation from the rise of the empire, and to confound intellectual with political power. The Etruscans would learn from their allies the new and more lovely modifications of older superstitions; and, to a people who had made some progress in the exercises of imagination, powerful charms would be presented, in the early records of Greece, where, to use the expression of Strabo, all is marvellous and tragic land.

Ancient historians of the greatest fidelity and research have praised the wise legislation and equitable government of the Etruscans. The whole of Etruria was separated into twelve divisions, over each of which presided a chief magistrate or Leucomon. From this supreme council of twelve, the members chose a king, or more properly commander-in-chief, who, in war, conducted to the field the united armies of the republic. The election of these governors was vested in the people, and the nation is said to have cherished an almost personal hostility to hereditary kings. The constitution of the Etruscan state thus combined the dignity and union of aristocracy, with the energy and freedom of popular government. It was the former in the executive, the latter in principle. To this admirable polity, to the security which it assured, to the emulation it excited, is chiefly to be attributed the early progress of the Etruscans in art and elegance. A principle is thus ascertained which fully accounts for the superiority of this people, and which furnishes another proof of the influence, insisted upon in the commencement of this essay, that political institutions exercise over the character and productions of national genius. We do not enter, therefore, into farther discussion on the origin of the inhabitants, by exhibiting the various arguments in support of the view we have embraced, which might be deduced from a comparison of ancient authors—from the analogies of the Greek and aboriginal dialects of Italy—from the evident union of the Cadmean with a more decidedly oriental, and consequently more ancient character in the Etrusco-Pelasgic alphabet—from the style, and in some instances, as at Pæstum, the situation of Etruscan architectural remains. It is sufficient for the reader to bear in mind, that sculpture in Etruria had attained a degree of excellence prior to any extensive cultivation of the art in Greece.

The remains of Etruscan sculpture are not numerous, and of these some are of doubtful authenticity. The works of national art, taken in general, consist of coins or medals—statues of bronze and marble—relievos—sculptures—gems—engraved bronze—and paintings.

The coins or medals of the various Etrurian cities are not only the most numerous, but the most ancient remains of their arts. By means of these, many difficult points in the history and geography of ancient Italy have been, or may be explained. As evidence by which to judge of the refinement and skill of these early ages, many are to be regarded as wonderful examples of beautiful design and delicacy of execution. They are of two kinds, either mythological or merely symbolical in their representations, and appear all to have been cast of a composition, not a pure metal. As mistakes are likely to occur from confounding the colonial Greek or Phœnician coins with the genuine Etruscan, no observations should be regarded founded on specimens without inscriptions. The practice of constantly placing inscriptions on their works, seems never to have been omitted by the artists of Tuscany, and furnishes a very probable presumption respecting the authenticity of their labours.

Etruscan statues are either of bronze or marble, each of which classes may be again subdivided according to the magnitude of the works. Of bronze figures in miniature, resemblance both of men and animals, examples are commonly to be met with in museums. These probably are images of the household deities, and not unfrequently seem to have been ornaments merely; but from specimens so minute, it is not easy to deduce any certain or useful conclusions. Of bronze statues the size of life, there are very few, and of these scarcely one has escaped suspicion as to its antiquity. Of the marble statues, whether large or small, it is exceedingly difficult to pronounce whether they be Etruscan or Greek.

Relievos bearing the general character of Etruscan are found in Rome, Florence, and other parts of Italy. Of these works, the most ancient are doubtless sepulchral monuments, erected prior to the practice of cremation, as a mode of sepulture; but we have also sarcophagi belonging to the latest era, when the artists of Etruria may be considered as almost colonial Greeks. Intermediate between these two are various mythological relievos and altars. Of these Winkleman selects as genuine four, now, if we remember aright, in the museum of the capitol. Apotheosis of Isis; a round altar with three figures; a square altar with the labours of Hercules; and another round altar, or rather mouth of a well. To these recent discoveries have made several additions.

Engraving on gems seems to have been brought to some degree of perfection at an early period both in Italy and Greece. Of this minute art, probably the oldest specimen now in existence represents five of the seven chiefs who fought against Thebes. It is a cornelian $7\frac{1}{2}$ tenths by $5\frac{1}{2}$ tenths of an inch in the diagonals of the oval facet on which the figures are engraved, three seated and two standing, each having his name affixed. The composition is extremely inartificial, but not unpleasing, although by no means indicating a refined knowledge. Other Etruscan gems, however, have been found, which equal the most exquisite performances of ancient art,—such as the cornelian representing Tydeus drawing the arrow from his leg; and Peleus dressing his hair, engraved on an agate. These three, and Etruscan gems in general, are of that form called *Scarabei*, from their resemblance to a beetle, being oval, flat on the engraved side, and convex on the back. Each is pierced through the longer diameter, leaving it doubtful whether worn suspended as an amulet from the neck, or on the finger as a ring.

One of the most curious remains of Etruscan art, which is also the most numerous class, comprises engraved bronzes or pateræ. These, it is well known, were round, flat and shallow dishes, from which was poured wine or water during the sacrifices. The Etruscan pateræ are not quite circular, but have a short tapering handle, round which sometimes is brought the shallow brim, so that it forms part of the cup. This handle is peculiar to Etruscan workmanship. On the bottom inside, which is perfectly flat, and from four to six inches in diameter, is engraved in deep, broad, and bold lines, usually some mythological composition. Of these designs the style is simple—the lines few and straight, but exhibiting firmness and correctness of hand: with more of power than grace of expression or attitude. These make a near approach to our outline engravings, except that the strokes have much more force. Indeed we remember to have examined one at Bologna, representing the birth of Minerva, from which the brim had been removed, and being put through a printing press in the usual way, had given off a very good impression exhibited along with the original.

To examine the Etruscan paintings hardly falls under our present limits. With a few imperfect sepulchral remains at Tarquinia, they are to be found only on vases; if, indeed, these latter are not properly to be considered as belonging to the colonial Greek school. For our own part, we are persuaded that not one of the Necro-Etruscan vases, as they are commonly styled, is of a date anterior to the consular government. Funeral ceremonies among the ancient inhabitants of Italy consisted in simple inhumation, and it was not till after their intercourse with Greece that the burning of the body, and the consequent use of urns were introduced. True, vases of magnificent design and large capacity, appear to have been consecrated in temples, and employed as ornaments in houses; but granting some of these to have reached our time, the nature of the subjects represented, or the style of the design, shows that they cannot be of a higher antiquity than the date assigned. Regarded as works of art, these productions can hardly be admired sufficiently. The pictorial representations are of two kinds, monochromatic shadows, usually black upon a light ground, or monochromatic outlines in similar style; or the order is reversed, the ground being dark, the figures light, but whole pieces are never executed after this method. Of these two manners, the outline figures present the more perfect specimens of design, and when the difficulty of tracing an outline at a single stroke in a pigment which admitted of no repetition, and on a surface from which no line once impressed could be effaced—we compare the correctness, truth, beauty, grace of the forms and expression, we are forced to ascribe no ordinary skill and dexterity to the artist, and no common taste and refinement to the age and nation in which such works could be produced. One general observation, however, may be recorded; taking these remains universally, the delineations are inferior to the perceptions of the abstract beauty of forms, perceivable in the shape of the vases themselves; whence perhaps the conclusion may be ventured, that the Etruscans were greater in sculpture than in painting. These observations do not invalidate the high antiquity of Greek vases.

From the spirit of some of the preceding remarks, it might be inferred that little certainty can be obtained in this inquiry; that much doubt, difficulty, and obscurity is involved in the history of Etruscan sculpture, no one who has studied the subject will deny. But it is equally true, that these doubts and difficulties arise as much from the absurd opinions and interminable wanderings of those who have pretended to elucidate matters, as from any erroneous principles in the real grounds of judgment. Writers have ventured upon this theme, which requires both taste and knowledge of practical art, who were mere antiquarians; what is even worse, each has his favourite theory to make good. Laying aside all prepossessions, therefore, and with some experience in the application of those principles on which works of art are to be discriminated, we shall find, not only that there is a certain and definite style which peculiarly distinguishes Etruscan design, but also that the remaining labours of this school may be regularly classed, from the degree or kind of excellence which they exhibit.

Art contains within itself, and, if rightly interrogated, will always furnish precepts by which its own productions may be discriminated. In searching for these principles, we must carefully compare the monuments of different nations and those of the same people with each other. We shall thus be able to detect certain peculiarities of mode—of expression—of form—certain specialities in the relation between fancy and feeling and nature, which constitute what is termed a national style, or, in other words, characterize the national genius. Thus, if we place in contrast certain sculptures found in Italy with others of any age from Greece, there will be perceived considerable diversity in the relations just mentioned, clearly indicating a mental as well as mechanical diversity. These remains, history informs us, can be ascribed only to the early inhabitants of Etruria, and to this diversity is given the name of the Etruscan style. Again, compared among themselves, these remains exhibit intrinsic distinctions of manner or excellence, which enable the examinator to assign them to their respective ages. We thus discover three epochs of art among the Etruscans.

The first or ancient style commences with the origin of the people. It has been assimilated to the Egyptian, but the resemblance is not more than that general similarity which characterizes the infancy of invention in every nation. Yet there are distinctions to be traced which clearly discriminate the two manners. In the earliest monuments of Tuscany may be perceived an unfettered imagination essaying its powers in modes feeble indeed, but varied;—no systematic, as in eastern art, no conventional representation. In Egyptian sculpture every thing seems to spring from a foreign impulse, whose object is not the advancement of art, or the imitation of nature;—in Italian statuary, all wears the impress of native volition. The characteristics of the first epoch are rigidity—ignorance of the naked—feebleness of relief—perceptions of beauty, especially in the forms of the head, exceedingly imperfect. The contours are composed nearly of straight lines, the limbs are without joints, and the action forced, yet destitute of movement. The face is an imperfect oval, elongated at the base, and ending in a peak. The eyes, long and narrow, are placed oblique; as is likewise the mouth, the external angles in both being drawn downwards. The features are flat; and here the meagreness of relief is chiefly apparent, the eye-balls being nearly on a level with the frontal bone. The general effect thus remains without power, while the individual forms are far from pleasing. Yet there is frequently a robustness of design, a vigour and firmness of handling, which, though destitute of grace, seem to contain the rudiments of those forcible, masculine, even exaggerated conceptions and execution, the peculiar characteristics of Tuscan art in every succeeding age.

The style of the second epoch marks these characteristics in their full display: the former feebleness begins to disappear; and in the few remaining examples, though we cannot trace improvement in all its stages, it may be ascertained that melioration commenced by adding boldness to the relief. The cause of this it is perhaps easy to discover in the practice of engraving on precious stones, to which the artists of Etruria were attached from an early period. These works being executed, as they now are, by means of a wheel, depth of depression could be easily made on the ground, while the figures were thus more fully relieved. Observing the powerful effect obtained, the application of the improvement to works of sculpture generally was obvious. But by such a style of execution, the former defects in design would be rendered only the more apparent. Hence would quickly follow improvement in the forms, in the study of nature, and in truth of expression. It is difficult in art, as in every human pursuit, to preserve the just mean. The Tuscans carried to an extreme the discovery which had conducted to bolder practice. All soon becomes forced, violent, and exaggerated. The action is constrained, the movement unnatural; the whole aim is effect, and to this every feeling of truth or of simplicity is sacrificed. The proportions are robust beyond those of nature; the muscles are constantly in action, and the retiring curves are so deeply impressed, that breadth of parts is every where cut up by alternate ridges and hollows. The bones are learnedly, but so strongly pronounced, as to render the whole effect harsh, dry, and mannered. A want of character is the necessary consequence; for the forced and violent in art always proceed from inability to express the workings of the mind in any other manner than by their most sensible and least intellectual signs. The Etruscan style of sculpture is in fact similar to their architecture. There is strength, and massiveness and power; there is also vigour of conception, and play of execution: but there is wanting delicacy of proportion, nice discrimination of character, and all the pleasing propriety and repose of the sweet and gracious in art.

The genuine style of sculpture among the ancient Etrurians belongs to the second epoch. In examining its characteristics, we can hardly persuade ourselves that these are not derived from the works produced in the same country during the fifteenth and sixteenth centuries. The analogy observable in the national genius at such a distance of time, and after so many vicissitudes, moral, intellectual, and political, is remarkable, and may hereafter demand our notice.

The third epoch embraces that period which marked the gradual disappearance of the Etruscans from among the nations of Italy. Their political empire merged in the rising dominion of the Romans; the discriminative character of their genius was lost in the arts of the colonial Greeks. In the monuments of this era, the ancient style is still to be distinguished; for though the Italians now become imitators of the past, and rivals of the living Greeks, yet the national style was never entirely abandoned. During the early portion of this division many excellent works appear to have been executed, and to these the Latin poets and historians seem to refer. Judging from the most perfect remains, the proportions were rendered more light and graceful, the forms and expression of the heads more beautiful, the execution was softened indeed yet still retained a degree of exaggeration and harshness. The melioration was temporary; and perhaps it is not fancy alone which discerns, in the successions of subsequent feebleness, the gradual approaches of political depression.

In regard to the dates and duration of these divisions in the history of art, they seem nearly to have coincided with as many revolutions in the political annals of the nation. From a small state on the north-west coast, the Etruscan gradually extended its empire from sea to sea, and from one extremity of Italy to the other. This the era of their greatest dominion corresponded with the infancy of their arts, or at least with their first degree of refinement. By the expulsion or conquest of the Siculi, this complete subjugation of the Peninsula appears to have been effected about 80 years before the Trojan war. The Etruscan dominions then consisted of three portions, Etruria Circumpadana, Media, to which properly belong the name, and Campania. The last, containing the whole of the country south of the Tiber, was neither a secure nor a permanent conquest. The Dorians who landed in Italy about 130 years before the taking of Troy, together with the ancient inhabitants, attacked and gradually reduced the Etruscan power on this side. The Etruscan medals, however, which are found in all the remotest parts of the present kingdom of Naples, attest the ancient dominion of that nation. In this southern portion of their empire the Etruscan first mingled their arts with those of Greece. To this union we ascribe the excellence of the sculptors of Magna Grecia, when, at a period long subsequent, the schools of Rhegium and Crotona supplied masters superior to those of the mother country. The Greeks rapidly improved, but discovered slowly. The progress already made by the Etruscan, was therefore early appreciated by the Dorian colonists of southern Italy; a foundation was thus obtained on which the fervent genius of the latter quickly raised a superstructure of beauty and excellence surpassing any example in the parent state. In the first era of their art then, the advantages were imparted, not received by the Etruscans.

On the north the Etruscans had continually to combat against the Ligurians and Gauls. By those persevering enemies that division of their empire called Circumpadana was at length reduced. The coins, however, still found along the shores of the Adriatic, bear witness to the arts and sciences of Etruria. We thus arrive at the second epoch in the political history of this interesting people, when shut up within the boundaries of Etruria Media, their ancient seat, and where their admirable polity was best organized, they enjoyed freedom and security. This era, which corresponds not with their political grandeur, coincides with their greatest and most original acquirements in the arts. This was the reign of their second style, bold, masculine, and energetic, it was calculated to awe and astonish, rather than to sooth or delight the mind. Their architecture partook of the same character as their sculpture. The order, which still bears their name, sufficiently evinces the massive and powerful structures which it was destined to adorn or sustain. The noblest of all architectural inventions, the Grecian Doric, has been derived from this source. Even yet in modern Tuscany, the traces of her ancient inhabitants remain, like those gigantic skeletons of animals described by naturalists, but no longer existing among the orders of life, and which nature created in her primeval strength.

While each of the twelve capitals of Etruria was a school of art—at once the rival and the friend of her compeers—each exciting the industry and directing the advance of the other—each the Athens of ancient Italy; Rome, animated by the brutal spirit of military conquest, broke in upon these intellectual and refined labours. But force was no match for science; the Romans suffered severely from the first effects of their temerity. The opportunity, however, of crushing the growing pest was allowed to pass away; and Etruria, with her free institutions, her elective magistracy, her solemn insignia, fell beneath the rude despotism of Rome.

Thus terminated, 480 years after the foundation of Rome, the second era of Tuscan art. For some time afterwards indeed, we may discover that sculpture was practised to considerable extent. But it soon ceased to be marked by national character. The Roman dominion now embraced the circuit of Italy, and all former distinctions were lost. The Greek colonist, and the Tuscan freeman was alike the vassal of Rome From this period we again trace the union of the arts of the two nations, and Greece now repaid what she formerly borrowed, for soon after the reduction of the Etruscan republics, we conceive the finest specimens of their sculpture now remaining to have been produced. But their common masters did not foster the arts as internal and native ornaments of their empire, although they could place a meretricious value upon them, as the spoils of war, as the prize of the captor.

the evidence of conquest. Under this ungenial patronage the ancient arts of Ausonia soon ceased to flourish, and became as if they had never been.

We might now proceed to class, according to their respective dates, the monuments remaining of these interesting periods. But without engravings of the various subjects, we despair of rendering the descriptions interesting, or even intelligible to the reader. Generally then, we consider the bronze remains as the most ancient, though not more authentic than the marble sculptures, where these display intrinsic evidences of the Tuscan style. All arguments against the antiquity and genuineness of the latter drawn from the nature of the marble, on which so much stress has lately been laid, we regard at least as extremely suspicious. We would attribute the manufacture of the exquisite fictile vases, called Etruscan, chiefly to the period intervening between the expulsion of the Etruscans from southern Italy, and their subjection by the Romans—that is, to the second epoch of their arts and empire. Also these vases we believe to have been fabricated by the Greek colonists only; and it is known that in some places they formed subjects of a lucrative commerce. As a proof of this origin, vases have been found throughout the whole extent of lower Italy and Sicily, but very few have at any time been discovered in upper Italy. Finally, that no exaggerated importance has been attached to the arts of the ancient Etruscans, will be sufficiently apparent from one of many facts; when the Romans captured Volsinum, one of the twelve capitals of Etruria, they carried away two thousand statues from that city alone.

SECTION III.

Grecian Sculpture.

The history of sculpture in Greece naturally divides into two branches of distinct inquiry. We prefer commencing with the chronology, masters, and labours of the successive schools; the second branch will embrace the consideration of the principles and theory of the beautiful as conceived by the Greek artists. This arrangement, although differing from the methods usually followed, seems to promise facility and directness of inference, with a consequent veracity of judgment.

The imagination approaches the subject of Grecian literature, or of Grecian art, with something like to sacred enthusiasm. The mind anticipates the delight of unfolding, amid examples of perfection, the advances of taste and the march of genius. But, alas! the splendour with which the general subject is invested, is often but the reflection of brightness that has passed away—filling the thoughts with light and beauty, yet leaving few memorials of its progress or its authors. Of those whose conceptions peopled the cities and temples of their country with a silent, yet breathing population of matchless forms, a few names alone subsist. From the casual pages dedicated to this narrative, we turn in sorrow, not unmixed with indignation, to the ample relations of war and bloodshed, of crime and misery, which history has so lavishly bequeathed. Is human nature then, really so degraded as to take pleasure in preserving only the mementos of its own depravity; or is good, but an episode in the drama of human existence, to be hurried over as staying the main action? Have the reigns of amity and wisdom been so brief, so far between, that the picture of the past is but as one mighty battle piece—where every figure is agitated with fury or convulsed with agony—where every arm is raised to strike or ward—where every eye flashes with hate, or closes in death? Perhaps it is thus ordered more deeply—more affectingly to impress the truth—that there is no volume, save one alone, whose pages tell of unmingled love and peace and purity and holiness.

In arriving among the arts in Greece, although the records be so imperfect—so inadequate to the interest of the subject,—we do, however, escape from barbarism, and in some measure from uncertainty. It is like revisiting the gracious aspect of heaven from wandering amid the hideous and undefined forms of darkness. We possess the personal narrative of Pausanias, whose "I saw," or "which is still to be seen," coupled with the description of the noblest monuments of human art, excites the vain but excusable regret of the modern reader. The 35th, and 36th chapters of Pliny present an elegant compendium, evidently drawn from the best sources—not unfrequently indeed from the writings of those very artists, by whose hands had been executed the masterpieces described. The poets, orators, and philosophers, afford many remarkable notices, and speak with kindred sympathies of kindred labours.

In arranging these precious bequests, we shall adopt a threefold division of the ages whose relics they embalm. The first period will extend from the rude beginnings of sculpture in Greece to the artists immediately preceding Phidias. The second comprehends an interval of about 150 years, from Pericles to the death of Alexander. The third embraces those evil days from that conqueror till genius expired in the country of Homer.

These divisions mark intrinsic revolutions in the progress of art. The first exhibits the rise and perfection of material art, in which form, not intelligence, constituted beauty. The second—a glorious but brief period, displays art in its highest sublimity, when over surpassing and faultless symmetry, was breathed the expression of intellectual energy and nobleness. The third, like the last age of man, is decline, feebleness, and death.

First period.

The imagination of Greece was poetry from the beginning. Her consecrated groves—her haunted streams—her flowery plains—the depths of her azure mountains, were constituted at once the residence and the representatives of her earliest divinities, heroes, and benefactors. The alliance of natural objects with the human heart, as shadowing forth its affections, or as signs of its regrets, is the origin of all exalted art, as it is the purest species of Polytheism. As such a system indicates only the existence, not the presence, far less the form of a deity or departed worthy, it would be cherished only by a people simple in their habits, and ardent in their feelings. Accordingly we discover permanent traces of this simplest and purest superstition solely among the sunny vales and golden isles of Greece; for this her earliest faith has deeply tinctured much of what is most exquisitely descriptive or sentimental in her poetry.

But a belief so refined and untangible in its forms—so remotely addressed to the senses, would prove insufficient to maintain an empire over the mind. Men therefore would speedily attempt some method of representing the immediate presence of the objects of their veneration or worship. Their desires in this respect, however, would necessarily be limited by their knowledge. In these primitive ages, objects, rude and unfashioned, would suffice to represent the subject of adoration. Nor is this conjecture, or merely plausible hypothesis. Pausanias states that the ancient divinities of Greece were represented by stones and trunks of trees, unformed by art, and that in his time many of these very stones were preserved in temples, and regarded with great reverence. In the time of Adrian, blocks of stone, formerly the objects of ancient worship, as Apollo, Juno, and Bacchus, were to be seen at Thebes, Argos, Delphi; and the Cupid of Praxiteles—the most famous representative of the god of soft desire, was by Phryne, his fairest votary, transmitted to Thespia, in order to replace a stone, adored there from the earliest ages. These and many similar instances have not escaped the notice of some of the Christian fathers.

These were symbols rather than natural representation; but they suggested the first step towards more refined smilitude. As skill improved, the Greeks would attempt to give some regularity of form to these signs. Accordingly the next stage in the progress of improvement was to hew the former blocks into square columnar shapes. Erecting these upon one end, by slow gradations, the artist learned to fashion them into something like a rude outline of the human figure. The extremities, however, seem not to have been attempted, nor were the arms separated from the body, the foldings of the drapery being stiffly marked in deep lines upon the surface. Such, with various degrees, no doubt, of individual merit, appears to have been the state of the art in Greece, when Dædalus, the first sculptor whose name is fully recorded, arrived in that country.

The Greek colonies planted in Ionia, and in the isles of the Egean, quickly surpassed the mother country in wealth and refinement. Of these early establishments, that which first attained to the happiness and consequent power of settled government was the Dorian colony in Crete. We have Plato's authority that the laws promulgated by Minos were not only the most ancient, but the wisest of contemporary systems; this sentiment is fully corroborated by the testimony of tradition, that the gods were born in Crete, and gave laws to the people. Insular situation and maritime power gave security against foreign invasion; a direct intercourse with Egypt introduced the learning and arts of that country; while external advantages were secured and improved by equitable institutions at home.

The opulence, wisdom, and refinement by which the Cretans were thus pre-eminently distinguished, did not escape the notice of the Athenian hero Theseus, when he visited the court of the second Minos, twelve centuries before Christ. Nor were the causes of these effects unappreciated. On his accession to the throne of Attica, Theseus introduced into his own kingdom the improvements he had admired in Crete. While he gave to his subjects a system of regular policy, the arts of elegance which humanize the manners, and then added dignity to religion, the firmest cement of social order, would not be neglected. Accordingly we are to place the hospitable reception of Dædalus in Athens at the time of the voyage of Theseus. Nor can we admit the doubts attempted to be thrown upon the existence of this artist, unless we resolve at once to reject the evidence of classic writers.

The foundation of the first school of sculpture at Athens, destined long after to carry the art to its utmost grandeur, is thus ascertained, about 1234 years before the present era. It is not, however, to be supposed with some, that Dædalus first introduced sculpture into Greece, or even into Attica, but simply that he was the earliest master who instituted something like a school of art, and whose works were long preserved as worthy of notice. We have already remarked, on the futility of arrogating exclusive discovery in arts which owe their birth to the natural desires of the heart; while in the present instance the bare capability of appreciating the improved style of the Cretan, necessarily implies a certain degree of knowledge and of taste previously existing among the Athenians, and corroborating the views above recorded.

The performances of Dædalus were chiefly in wood. Pausanias, who writes in the end of the second century of the Christian era, enumerates not fewer than nine of these labours, the majority of which he had seen and examined. Notwithstanding the injuries of fourteen centuries, and the imperfection of early taste, these works, and particularly a statue of Hercules at Thebes, are described as possessing something of divine expression. Diodorus enters more into detail, whence it appears that Dædalus improved upon ancient art, so as to give vivacity to the attitude by separating the limbs, and raising the arm in varied position from the flanks; as also to infuse more animated expression into the countenance by opening the eyes, which before were narrow and blinking. We mention these particulars for two reasons; they prove the existence of anterior art, and because the passage has commonly been misinterpreted, as if referring to the works of Dædalus, not to those of his predecessors. This sculptor did not confine his talents to one exercise only; he excelled in architecture, and being skilled in mechanics, appears by ingenious contrivances to have given motion to certain of his figures, as in a dance preserved in copy at Gnossus, described by Homer, and reported by tradition to have been a present to Ariadne. This, without having recourse to the absurd notion of Aristotle about quicksilver, may explain the fables which have been united with the story of his adventurous life.

Contemporary with, or more probably anterior to the preceding, was Dibutades. In the humble occupation of a potter at Sicyon, this man became the accidental possessor of an invention the most important to art, both in its immediate and subsequent effects. This was the coroplastic art, or the application of soft materials to modelling the representations of sculpture. It was so named from *Cora*—the daughter of Dibutades, who, inspired by love, traced upon the wall, by means of a lamp, the shadowed profile of a favourite youth, as he slept; that in gazing upon this imperfect resemblance, she might solace the hours of absence. Struck with the likeness exhibited in this sketch, her father carefully filled up the lines with clay, and thus formed a medallion, which, hardened by fire, was long preserved in Corinth as a most interesting relic. To this pleasing incident the poets have attributed the discovery of painting—another proof of the exquisite taste, and of the delightful charm which, to their poetry,—their arts,—their philosophy even, the Greeks have imparted, by the constant union of sentiment with imagination—of the heart with the understanding.

Contemporary, but not pupil of Dædalus, was Smilis of Ægina, famous by his statues of Juno at Argos and at Samos. Working independently, his style differed from that of the Athenian school, while it embraced its improvements. Subsequent to the above, or at least prior to the age of Homer, were Endæus of Athens, celebrated for three several statues of Minerva; Icmulius praised in the Odyssey, as having sculptured the throne of Penelope; Epeus immortalized as the fabricator of the Trojan horse, whose works both Plato and Pausanias mention; Alexanor, son of the "divine Machaon;" with many others, who must have contributed to works enumerated during the heroic ages, several of whose names might be recovered from ancient authors, but whose works had perished or been forgotten.

During these ages, however, it does not appear that sculpture can be said to have progressed farther than that it was not unpractised. And although Athens was thus distinguished in the outset, yet, for several centuries, neither in Attica nor even in continental Greece, was the art nationally cultivated. Almost to the commencement of the sixth century before Christ, the mother country was dependent chiefly on the casual or invited arrivals of artists from Ionia and the islands. From whatever cause assembled, and not unfrequently they were driven from their native soil by political revolutions, ever the enemy of peaceful studies, these sculptors naturally selected as their abode the commercial cities. Here power secured protection, as riches and luxury afforded reward and employment.

From these external circumstances, more than any peculiar predilection or superior refinement in their citizens, we find three schools of art early established in Sicyon, in Corinth, and in Ægina. Sicyon, with its little territory situate upon the south-eastern coast of the Corinthian gulf, though acceding to the equitable jurisdiction of the Achæan confederacy, had long been regarded as an independent and valuable member—a claim which the opulence, intelligence, and commercial enterprise of her citizens amply supported. The situation of Corinth seemed purposed by nature for the seat of arts, empire, and commerce; commanding the navigation of both seas which wash either shore, her position united by land the two grand divisions of Greece. She would have been the greatest, had she not first become the wealthiest of the Grecian states. The little island, or rather rock of Ægina, rising above the waves of the Saronic gulf, nearly opposite Athens, of which it was a formidable rival, affords a striking illustration of the effects of commercial wisdom. By this, a state, insignificant in itself, was enabled to cover the sea with a navy, and to cherish the arts, especially sculpture, in a school if not the earliest, certainly longest distinguished by originality of style and principles. To these primitive schools, or rather seats of art, we might add a fourth, comprehending Chios, Samos, and other islands. These, however, as already observed, were the nurseries from which the preceding were supplied, and merged afterwards into the school of Ionia.

To one or other of these schools belonged those artists, who, in the ages subsequent to the Trojan war, kept alive, without much refining, the knowledge transmitted by Dædalus, Dibutades, and Smilis. From the same schools afterwards arose those masters, who, in the 7th, 6th, and 5th centuries before our era, produced works not without admirers in the most refined ages that followed. Of this latter class, we shall proceed to enumerate in order the principal names, without attempting to reduce them into schools, as from such attempts many contradictions have been introduced into this period.

Rhœcus, the first of this series whose name is recorded, appears, from the testimony of Pliny and concurrent events, to have lived about the first olympiad, or 777 B. C. He was a native of Samos, the inventor of modelling properly so termed, and the first who practised his art in brass. For these reasons, rather than as meritorious artists, have the names of Rhœcus, Telecles, and Theodorus his son and grandson, founders of the Samian school, been preserved. Bas reliefs, their workmanship, in gold, brass, ivory, and wood, were extant in the time of Pausanias, exhibiting the hard and dry manner of Egypt, where probably they had studied. Unless, however, Pliny has mistaken the date, which we here see no reason to suspect, the finishing of the last was very beautiful, since he engraved the emerald, afterwards so celebrated as the ring of Polycrates, and the silver patera dedicated by Crœsus to the Delphian Apollo. Great minuteness and delicacy of finish, the effect of painstaking labour, are by no means incompatible with a state of art, rude in other respects; an observation which seems to have escaped modern authors, and in this particular instance the unobservance has led some unjustly to reject the narrative of the Roman.

In the Chian school we first hear of bronze statues, which, from the durability of the material, were rapidly adopted and multiplied over Greece. These early works, however, are not to be supposed to have been cast; they were executed with the hammer, in the same manner as may still be seen in Etruscan specimens of different cabinets. There were, indeed, two manners; the earlier, and that which continued to be practised in large figures, consisted in joining the parts of them in laminæ or plates, the interior being probably filled with clay; in the second method, used in small statues, the several parts were united in a solid state, most likely brought nearly into shape, and the whole then finished by chiseling, or rather engraving. In both cases the separate portions were at first joined by means of rivets, afterwards by soldering. This latter invention has been assigned to various authors; and after much dispute still remains to be claimed. The matter is intrinsically of slight moment, nor are we disposed to admit the authority of those who talk, of soldering with tin or *iron;* in fact, artists who could form a statue of bronze, would not long remain ignorant of so simple an operation, the utility of which was hourly recurring.

Gitiades, native of Sparta, but a pupil of Sicyon, exercised his profession with success, before the first Messenian war, consequently before the 2d year of the 14th olympiad, or 720 B. C. When Pausanias visited Lacedemon, many of his performances in statues of bronze, were remaining in that city. Statuary, architect, and poet, Gitiades united in his own person all the arts, and in so far may be styled the Michael Angelo of those remote ages.

About the twenty-seventh olympiad, and for nearly forty years afterwards, lived Dionysius of Rhegium, and Glaucus of Chios, carefully to be distinguished from their namesakes of Argos. They were employed chiefly upon the numerous bronze statues placed in the sacred groves of Olympia by Anaxiles, the generous entertainer of the heroic Aristomenes and his people, after the disastrous termination of the second Messenian war. Glaucus is reported to have displayed superior talents, and to have introduced various improvements, especially a better method of uniting the parts of cast figures: but the fame of his contemporary is remembered in preference, as the first who composed a statue of Homer. This identical figure, together with one of Hesiod also by Dionysius, was long afterwards recognised by Pausanias. Hence it is manifest that the world has never possessed a genuine resemblance of the venerable father of verse. Pliny considered the numerous busts extant in his time as ideal portraits, in which, though a certain common air and expression were preserved, the character only, acccording to the conceptions of the sculptor, not the individual features, were delineated. From the general tenor of the passage just referred to in the Greek historian, it would appear that he inclined to believe the bronze, now mentioned, the original whence the primitive idea in all had been taken. This is further apparent from the fact, that he was able to identify the portraiture in its rudest stage. How interesting in this case to compare those sublime heads of the bard executed in the best ages of the art, with the feeble imaginings of the sculptor of Rhegium! To trace not merely the progress of improvement, but to mark the successive acquisitions of genius consecrated to enshrine its own loftiest conceptions of its most gifted possessor.

About this time also must have been sculptured the golden statue of Cypselus, the second of the three in the history of art; and on the dedication of which in the temple of Olympian Jove, the Elians were, by the resentment of the Corinthians, for ever excluded from the Isthmean games. About the twenty-ninth olympiad likewise must have flourished Aristocles of Crete, since before the Messenian exiles had given to Zancle in Sicily its modern appellation, this artist had executed at Elis a group of Hercules combating an amazon on horseback. The attempting and consummation of such a work as this indicates an advanced state, both of invention and of mechanical skill. So early, therefore, as 650 years before Christianity, sculpture must have been understood so as universally to be practised in its most important and useful inventions. In corroboration of this general conclusion additional particulars might be adduced, but sufficient has been done for the continuity of the narrative; in confirmation we may just glance at the contemporaneous condition of the sister art.

Painting, according to Aristotle, was introduced into Greece, for so we conceive the word invented ought to be understood, by Euchirus the relation and ancestor of Dædalus. The first paintings most probably were monochronous, without internal lines of any kind. Hyginon and Dymas were among the last who practised this kind of art; Charamides "first distinguished the male from the female form," according to Pliny; and from the same author we learn that Eumæus, an Athenian, first attempted the representation of every object; which expression, though a little dark, seems from the context to imply, that by this artist human and other figures were first grouped in the same piece. To Philocles, an Egyptian, or to Cleanthes, a Corinthian, is ascribed the introduction of simple outlines circumscribing the object. The discovery was improved by Telephanes the Sicyonian, and Ardices of Corinth; who further extended these simple contours so as to express the natural forms and markings of the parts, movements of the limbs, and foldings of the drapery. Improvement was thus advancing slowly but securely; nothing was yet to be unlearned; the next step, throwing in the lights and shadows, so as to give projection and relief, appeared obvious. Unfortunately, however, Cleophantes directed imitation into a wrong course, by filling up the outlines with different colours laid in flat. This must have greatly retarded the advances of future melioration, as the practice, by suppressing all internal detail, almost threw the art back to monochromatic representation; also it is more tedious to retrace wanderings than to push forward even through obstacles. Hence, though we perceive that in painting, the Greeks had discovered some good principles earlier than in sculpture, we do not find that, in the former, they had actually realized greater improvement in general. At the period indeed of which we now treat, there was a striking similarity in the character and condition of the respective arts. Objects both in painting and in sculpture were represented in a manner infinitely tedious, dry, and minute; while the defects of the composition as a whole were but ill atoned for, by elaborate rendering of the parts, and by the most scrupulous and even wonderful finishing. The encomiums bestowed by Pliny upon the pictures of Elotas and Bularchus, both of whom were anterior to the twenty-fifth olympiad, and consequently contemporaries of some of the sculptors mentioned above, would at first induce the belief, and actually have been brought forward as proofs of the superior excellence of ancient painting. It seems, however, not to have occurred to those who maintain this opinion, that Pliny is thus made to contradict himself; and also that in praising the paintings of Elotas at Lanuvium, which were carried off by Nero, he speaks of their comparative not of their absolute beauty. The battle of Magnete, painted by Bularchus, and which Candaules king of Lydia purchased for its weight in gold, may prove the "fame" in the words of the author just quoted, but certainly not the "perfection" of the art. As the masterpiece of its own age, the picture might be highly and justly prized, while, from the laborious minuteness of its details, the price might not be more than a compensation for the time bestowed.

This passion for extreme finish may be remarked in every remaining work of the age; of which very ancient colossal busts in the British museum are proofs. The taste was introduced and maintained by the limited resources of sculpture itself, by mediocrity in the artist, and by the nature of the ornaments and draperies of the time. Before the fiftieth olympiad, the Greeks always appeared abroad armed; at the public games they assisted naked: but in the retirement of domestic life they were clothed in light stuffs of linen, cotton, or wool. These robes were ample, and naturally fell in numerous parallel rectilinear folds, while they were further arranged symmetrically so as to form a series of triangular plaits one above the other along the margin. Such were the ordinary vestments also of the priests and females which were closely imitated by artists, and thus was cherished as it had been introduced, a style of sculpture, dry, meagre, and laborious.

The school of Sicyon, nearly 600 years before the modern æra, was illustrated by Dipænus and Scyllis, the most famous of her early masters. They were brothers, natives of Crete, and renowned no less by their own works, than for the eminence of their pupils, circumstances which, together with her priority in the pursuit, acquired for the city of their adopted residence the venerable appellation of mother of the arts. The benefits of protection and favourable estimation were thus mutual. On some account, however, the sculptors either retired in resentment or were banished, but speedily recalled, in obedience to the commands of the Pythian oracle. The manner of their return is remarkable, as furnishing an early proof of the operation of a cause, mainly contributing to the final perfection of art in Greece, namely, the respect and importance attached to the profession. The works of the brothers were executed in various materials, metal, wood, ivory, and marble, or of a compound of these, by inlaying, laminating, and joining. Of these different methods, specimens were to be seen in the time of Pausanias, who states also that they sculptured the famous Lydian Minerva, four cubits, or six feet high, out of one entire emerald, and which was extant at Constantinople in the eleventh century. But the fame of Dipænus and Scyllis, as exerting a leading influence on the progress of improvement, rests upon their having been chiefly instrumental in applying marble to the purposes of sculpture; of all substances yet discovered, the fittest for the representations of this art. In Parian marble, statues by these masters, of Juno, Minerva, with others of the lesser deities, were admired in the time of Pliny, excited the cupidity of Nero, and are subsequently described by one of the Christian fathers from the great veneration in which they were held. In proportion, however, as these artists excelled their predecessors in genius, in an equal degree did they refine upon that excess of finish which we have mentioned as giving a meagre and studied effect to the labours of this age. The hair arranged in undulating locks or spiral curls, was laboured as if to be numbered; the drapery disposed in the most rigid and methodical forms, is elaborated with painful minuteness, while the limbs and countenance still retain a tasteless character and expression. Yet they did introduce very considerable melioration; their execution is much more masterly, and the general effect more powerful, as may be seen in the colossal heads of Hercules and Apollo in the British Museum, most certainly works of their school, most probably of their own hands. Of the Sicyonian academy, the most celebrated members were Learchus of Rhegium, to whom is erroneously assigned a statue in metal of Jupiter at Sparta, the separate pieces of which were united by dovetails, being esteemed the most ancient bronze in Greece. Theocles, Dontas, Dorycli des, with his brother Medon, Lacedemonians; Tecteus and Angelion, authors of a statue of Apollo at Delos, the remains of which, with a remarkable inscription, were supposed to be discovered in the 17th century. The latest and most celebrated of this school were Emilius, and more remotely as a scholar Callon of Egina.

Of any single monument executed during those early ages which have yet been particularly noticed, the greatest undoubtedly was the throne or shrine of the Amyclean Apollo in white marble, by Bathycles of Ionian Magnesia. The statue itself was of iron, thirty cubits high, exhibiting every evidence of a style contemporary with, or even earlier than the age of Dædalus. Indeed, as described, with head, hands, and feet only, the trunk being a square pillar, it appears to have been intermediate between a sign and a representation; thus furnishing another proof in support of the remarks introductory to the present section. To support a figure of such dimensions, and also as its base contained the tomb of Hyacinthus, this throne must have been of vast magnitude. It was completely covered with relievos, and adorned with numerous statues, representing incidents of history and fable, either allusive to the story of the youth interred within, or selected as appropriate subjects of agreeable ornament. Among these latter were various scenes from the immortal verses of Homer, an evidence, as has been remarked, that these poems must have been known to the Spartans long before they were first collected at Athens. All the other statues, altars, and ornaments, within the sacred precincts of the temple at Amyclæ, were also the labours of Bathycles, whose greatest work exhibits a singular analogy in the fate of Grecian and of modern art; for by relievos of a kind nearly similar were the reviving powers of sculpture in the fourteenth century exercised.

Bupalus and Anthermus, or Anthemis, brothers, of the isle of Chios, 517 years before Christ, were descendants from a family of celebrated artists, in which, according to Pliny, sculpture had been carried up uninterruptedly from the institution of the Olympiads. Their great-grandfather, Malas, about the 30th olympiad, or 649 before Christ, claims to be the first who applied to his art the beautiful marbles of his native island. Michiades inherited and improved the science of his father, transmitting the accumulated experience of two generations to his own son Anthermus, the parent of those now mentioned. Part of this account may appear discordant with the statement above, that marble was first generally used in the school of Sicyon. Controversy on this subject might easily have been avoided by reconciling the facts. The islands, and Chios in particular, abound in excellent marble; the sculptors of the insular-Ionian school, would naturally have early recourse to this material: while their pupils at Sicyon might rightly enjoy the merit of introducing the discovery into continental Greece.

Be this as it may, and by no other means, can the difficulty be obviated with justice to all parties, Bupalus and Anthermus certainly first brought sculpture in marble to a degree of perfection. The beauty of their works excited the refined but nefarious cupidity of Verres, and was prized by the polished taste of the

Augustan age. Disdaining the narrow theatre of their native isle, the brothers proceeded into different countries of Greece, which they filled with admiration of their labours. At Smyrna, Bupalus erected his celebrated statue of Fortune, the first, according to Pausanias, dedicated to that deity, and of which a resemblance, with an inscription, undoubtedly spurious, was discovered near Bologna, in the 16th century. Two other inscriptions, both ancient, bearing the name of Bupalus, have been dug up in modern times; one of these on a plinth, found near the crouching Venus, has caused that delicious figure to be ascribed to this artist although evidently of a much later and more refined age. At Smyrna were likewise his Graces in marble gilt, showing how early this practice was introduced; and Pliny mentions with great praise a Diana as appearing stern to approaching, but gracious to retiring votaries. It is the besetting sin of Pliny as a critic in the fine arts to attribute complicated expression to sculpture. It seems not to have occurred to him that simplicity in this respect is not only the highest beauty abstractly considered, but is, in this art, from the nature of the imitation, a constituent and necessary quality. Some modern authors, among whom is Falconet, himself a sculptor, have laboured very uselessly endeavouring to prove how this effect might be produced. If it could be attained, the composition would be so much the more defective.

Among other labours, these artists modelled a portrait of the poet Hipponax, who is reported to have been extremely ugly, and who, in revenge, wrote a satire against them, so very severe, that in despair they laid violent hands on themselves. This last circumstance we know from Horace, and from the posterior dates of their works, to be false. The statue of the satirist, however, from the frightful appearance of the visage, is said to have suggested the original idea of the masks worn by comic actors; for before they were accustomed to appear upon the stage having their features ludicrously smeared with vermilion.

At Delos, where they appear to have long remained, the brothers executed many works universally admired; and on which they inscribed the following verse: "The sons of Anthermus will render thee, O Chios, more renowned than even thy vines have yet done:"—A sentiment in the highest degree pleasing, because, while it expresses the candour of true genius, which dares to estimate its own powers, as well as to do justice to the merits of others, it regards personal distinction only as consecrated by union with patriotism and filial veneration. Happy Greece, who could thus discover incentives to generous exertion in the finest impulses of human feeling! Need we seek remoter causes of the moral grandeur, the intellectual vigour, the refined perceptions of thy favoured sons!

Subsequent to the fiftieth olympiad, all the principles of the arts of design were thus known and exhibited throughout Greece. The rules of painting were well understood, as may be gathered from the descriptions of works executed prior to this date, and preserved even to the age of the emperors. Portrait painting was much practised, and could boast of able masters, as witness the portrait of Sappho by Leon, painted about the forty-fifth olympiad, and preserving its freshness to the time of Trajan. From this may be deduced, not only the exercise of the art, but likewise that its professors had skill sufficient to render their works even more durable than can be effected by any method known at present. Much has been conjectured respecting the painting of the ancients. One thing is certain, that wax was employed to impart adhesion in all instances, and latterly consistency to the colours. To us it therefore appears not improbable, that there were two distinct operations practised in different ages of the art. By the early artists prior to, and about the time of which we now speak, the colours appear to have been used in a dry state, similar to crayons; after the piece was thus finished, a transparent preparation of wax was spread over the whole, so as to secure and preserve the tints. This supposition acquires strength from the fact, that such preparations or washes were employed by the statuaries both in wood and marble. These varnishes were of a rose hue, and so hard, that upon the colossal statues of Hercules and Apollo in wood made by Laphaes, a contemporary of Alcæus, this covering remained uninjured in the time of the Antonines. Afterwards *encaustic*, properly so called, in which the wax was incorporated with the colours, was invented. This discovery, however, must have been made at the latest towards the sixtieth olympiad, since it is mentioned by Anacreon. The minuteness of that poet's directions would lead us to suspect that he wished to point out in preference the latter method, which, from its novelty and freshness, would add new beauty to the features of his mistress. About the same time, architecture, as we shall have occasion to show, was understood not only in its indispensable principles of equilibrium, proportion, and durability, but also, contrary to Vitruvius, in those of refined decoration. Sculpture in all its departments, and in all its material principles of imitation, was complete. Engraving on gems had been practised by means of the wheel, from the time of Talus, the relation of Dædalus. Theodorus of Samos had invented the lathe, which was subsequently employed with great dexterity in forming statues of ivory. The superiority of marble was admitted, and the modes of operating with mechanical beauty perfectly known. The art of casting, introduced by the Samian school, had progressively and prodigiously improved; and at this period exhibited some very refined operations in the union of different metals, as witness the works of Alcon, of Aristonides, of Tisagoras, in iron and copper melted together, metals not easily uniting, and difficult of fusion.

Retracing our path over the ages of these discoveries, how are we struck by the slow and painful growth of human inventions! Fixing undistracted attention upon the life of any one artist now mentioned, how crowded with anxieties and active industry must that span have been! To the individual how momentous those cares; yet how feeble their results compared with the final sum of knowledge, which, they were valuable only as they contributed to swell,—a lesson of humility to the greatest; yet, again, how precious as a portion of the general experience,—a subject of gratulation to the weakest. How small the drop of liquid nectar with which each labourer hastens to the hive, yet of such is accumulated the whole treasury of sweets. The collective energies and discoveries of a thousand years were required to rear the arts of Greece, not to their perfection, but to the state whence the first approaches towards excellence begin to be apparent. From the era of Dipænus and Scyllis, in the 4134th of the Julian period, to the 3090th of the same, being the age of those ancient artists whose sculptures certainly exhibited a rude resemblance to the human form long prior to the performances of Dædalus, there occurs an interval of 1044 years. During the course of this time, as remarked by Varro with characteristic simplicity, but with that veracity and good sense which distinguish his unpretending narrative, the arts were invented in Greece.

The first decided improvement fixed on such principles as enabled succeeding efforts to carry it forward, certainly commences, as already stated, with Dipænus and Scyllis in the 50th olympiad. The advancement regarded chiefly a more masterly execution. This was perhaps in part owing to introducing the stronger marking, necessary to effect in metal, into their marble statues. This manner, although productive of harshness, paved the way for a firmness and decision of handling, which subsequently broke in upon the timidity and feebleness of the ancient style. Melioration to a very great extent, not only in the execution, but in the general composition and perceptions of beauty, were to be observed in the works of Bupalus and Anthermus. On this account, we have been more copious in the account of these artists. Between the Cretan and the Chian brothers, however, that is from the 50th to the 60th olympiad, many contemporaries were actively engaged in promoting the art. Nor was the course of improvement limited to the islands or cities of Greece; in Italy and Sicily, excellent artists were to be found, who carried into those distant settlements the science they had acquired in the schools of the mother country. At Rhegium, Clearchus was celebrated both as an artist and an instructor. At Agrigentum, Perillus cast the famous bull of Phalaris, afterwards carried off by the Carthaginians, and restored by Scipio. It must furnish a proof of our not having overrated the science of this age, that the identical work in question is much praised by Cicero.

During the period, also, of which we now write, and prior to the 60th olympiad, Pisistratus had already laid the foundation of the future grandeur of Athens as a school of sculpture. The wisdom, moderation, and intelligence of this wonderful man, evince how unmeaning were the ideas attached by the Greeks to the word tyrant in particular, and furnish a proof in general of the extent to which they were the dupes of names, and of misjudging prejudice. Happy for Athens had she always been governed by such men; by those who, like Pisistratus, would have respected the essentials of free institutions,—that is, who would have consecrated the resources of the country to promote the national grandeur, and saved her from the worst enemy, her own mob, miscalled freemen. Our own days are not without their cant and catch-the-vulgar terms, against which governors like Pisistratus are our only safeguard. Round him he collected in Athens the most esteemed artists of the time, among whom Eucharis, the son of Athenian Eubulides, a sculptor of the last age, and Callon of Elis were conspicuous. By these two was worked the famous statue of Bacchus, in which were preserved the lineaments of their patron, who was at once the most accomplished and the handsomest man of his age. Eucharis rendered himself famous by his statues of athletæ and warriors in armour. Callon's greatest work was in bronze; the statues of thirty-five youths of Messina, who, with their preceptor and flute player, perished in crossing to Rhegium, in order to solemnize a religious ceremony.

Within this period, is to be placed also another artist of deserved celebrity, Callimachus, the inventor of the Corinthian capital. In adopting this chronology, differing so widely from the received opinion which fixes the date of this invention much later, it will be requisite to condescend upon some details. First then, the account of Vitruvius, who has been followed as the authority in this matter, cannot be correct. He states, that Callimachus, the inventor of the Corinthian order, was the same with the sculptor of the statue of Zeno, the Stoic, and consequently who must have lived in the one hundred and twentieth olympiad. But this order was employed by Scopas in a temple erected at the very latest, prior to the one hundred and fourth olympiad, or more than sixty years before the time of Zeno. Such is the negative evidence in support of our position. But, in the second place, there is positive knowledge that an artist of this name did live at the period now treated of. This information is derived from a relievo, not long since examined by us in the museum of the Capitol, on which the name of Callimachus, as the sculptor, is inscribed. This monument, discovered in the ruins of Horta, and representing four figures engaged in the rites of Bacchus, exhibits the style of art which has been described as characterizing the era of the fiftieth olympiad. There is the same dryness and rigidity of execution, the same elaborate minuteness of detail, and the drapery is arranged in the same symmetrical manner in triangles. These, especially the last, we know were not the peculiarities of any succeeding age. This proves, that a sculptor of the name did live between the fiftieth and sixtieth olympiad: but another step is wanting to the desired conclusion. This step is furnished also by a relievo, preserving the advantage of deducing all the proofs from the art itself. In this bas relief, formerly in the villa Albani, but of which we judge only from an engraving, not having been able when at Rome to discover the original, is represented a muse, accompanied by two other figures, who is receiving a cup into which a winged genius pours liquid from a vase. The style of this production is in every respect similar to that in the one just described, evidently proving it to be of the same age, and although not inscribed with his name, most probably also by Callimachus, since the position in one of the figures is almost a rescript from the preceding. What brings this work to bear on the point at issue is, that behind a wall, in front of which the figures are placed, appears a temple in strong and distinct relief, with capitals of the Corinthian order. From the force of this evidence, it is difficult to escape, except by supposing, of which there is no proof or cause to be assigned, that the wall and temple were subsequently added. The subject is certainly involved in doubt, nor do we assert with confidence; yet as the statement of Vitruvius is evidently untenable, it is therefore extremely probable, rating the evidence at the lowest, that our view of the era of this invention is correct. Callimachus is further praised as master of all the arts of design, and as infusing a greater degree of lightness into his composition than had before been attained.

During the period of fifty-eight years, from the sixtieth olympiad at which the narrative has now arrived, to the battle of Marathon and the early contemporaries of Phidias, sculpture was vigorously exercised, and with corresponding improvement. The exercise was owing to those various political or religious causes which rendered the cultivation of this art essential in most of the Grecian states. The melioration, though in a secondary degree depending upon the same causes which cherished the practice of statuary, was chiefly derived from the excellent mode of study, which, with the intuition of genius, the Greeks from the first had discovered and fortunately pursued. Nature is at once the parent, the object, and the perfection of art. Nature, the only source of excellence, furnished to the sculptors of this favoured country their first principles, in opposition to all systems of conventional imitation. The very faults of their early masters, we have seen, sprung from a too great solicitude to render faithfully minute peculiarities, without attending to selection. But about the period which we are now commencing, iconic statues, especially those of the conquerors in their public games, introduced a more generous study of nature, and furnished new rules of art. To the honour of those who had obtained three crowns, statues, in every lineament individual portraits, were erected. This was attended with a twofold advantage. The practice necessarily rendered living artists familiar with the most perfect examples of corporeal beauty; while it bequeathed to succeeding ages a series of the most valuable, because real models. From these transcripts of the most beautiful living forms, were afterwards deduced those laws of proportion and of ordonnance, which contributed so much to the perfection, as they constituted one of the distinguishing merits of Grecian sculpture. The best of these works were certainly not executed till long after the period of which we are now more immediately speaking; but this source of improvement first assumes importance soon after the sixtieth olympiad. The interval, indeed, between this latter date and the battle of Marathon, represents a species of middle age connecting the empyrical skill and casual beauties of earlier times, with the regular knowledge and scientific excellencies of succeeding masters. The art was now in possession of all the means and instruments,—the correct application of which bounds the aspirings and the praise of mediocrity,—but which merely become subservient to the lofty aims of genius. During the above period, these means and instruments were industriously and far from unskilfully employed, yet few names have been preserved. The movement was one of diffuse activity, not an impulse derived from and sustained amongst a few leading minds. To claim remembrance, no prominent events or actors were presented; and the poverty of anecdote seems to have been occasioned not so much by inattention, as from little being worthy of separate notice.

Dameas of Crotona is mentioned with praise as the sculptor of a bronze iconic statue of his celebrated compatriot Milo. Among the wonderful displays of strength attributed to the original, it is recorded that he bore this figure on his shoulders to the site of erection at Elis. From a law then first introduced, permitting a statue of an athleta to be placed in that city, this work must have been executed soon after the sixty-first olympiad. Polycletus, the first of the name, studied under Ageladas of Argos, of which city he himself was a native, and appears to have assisted his master in the statue of Cleosthenes, who gained the Chariot race in the sixty-seventh olympiad, and was therefore represented in a car. This, consequently, was one of the most important works yet ventured upon, on which account it is the more to be regretted that an idle dispute has been raised about the date of the work, originating apparently from Suidas giving Geladas, and one of the scholiasts Eladas, for Ageladas, who has thus been mistaken for the master of Phidias. The works of the first Polycletus exhibited vigorous conception, but by Pausanias are blamed as angular and mannered in design, "being square and all nearly alike." He had for his pupils Canachus and Aristocles, brothers, heads of the school of Sicyon, each of whom executed one of three muses, esteemed the finest performances till then beheld in Greece; the third was by Ageladas, the master of their common instructor. The work of Aristocles is supposed still to be in existence as the celebrated antique of the Barbarini palace which holds the smaller lyre, and is about twice the natural size. Contemporary with the two last was Ascarus, known by his Jupiter crowned with flowers at Elis; rather later were Menecmus and Soidas of Naupactus, who conjointly finished a statue of Diana, long afterwards removed by order of Augustus. Menecmus was also the author of a treatise on his art, according to Pliny, who has, however, placed both too far in advance.

About the era of the battle of Marathon, although the work in question was probably executed subsequently to that glorious achievement, lived Egesias, whose statues of the Dioscorides have in modern times acquired him fictitious renown. The original work was by order of Augustus, placed in front of the temple of Jupiter, and by most writers has been described as recovered in the colossal group which, now placed before the pontifical palace, constitutes one of the most valued monuments of Rome. It is wonderful how far love of a favourite opinion will lead even the best informed writers. Winklemann, for instance, pretends to find in "those parts truly ancient," the harshness of style for which Egesias is blamed by Quinctilian. Others again draw their arguments from the situation where these figures were found, as being the station of the work of that artist. Now in answer to all this, the group of Egesias is distinctly asserted by Pliny, who had seen it, to have been of bronze—the figures at Rome are of marble: instead of the ruins in the forum—these latter were discovered in the quarter of the Jews. This inquiry here is of importance. These antiques are by the best judges considered to be of the era, if not from the hand of Phidias, and therefore furnish most valuable evidence whence to determine the highest principles of art among the Greeks. This subject, also, has something of peculiar interest to us, since from one of these antiques, with what credit to the national taste others may decide, is copied the national monument erected in the capital, to perpetuate the last glorious but tremendous effort of our arms at Waterloo.

The victory of Marathon, gained in the third year of the seventy-fourth olympiad, or A. C. 490, inspired fresh vigour into the genius and institutions of Greece. From this event is to be dated the commencement of an era, perhaps even more important in her moral and intellectual than in her political history. Preparations had long been making; materials on no small scale were collected in almost every field of mental enterprise: and the fervent spirit of the nation required only an external impulse fully to awaken into mighty splendour its slumbering fires. Poetry had already attained excellence in two of its noblest branches—the epic and lyric: and one year after the battle, Æschylus obtained the first wreath placed on the awful brow of tragedy. Composition in prose had long been practised with a degree of accuracy, and the artists recently mentioned, while early contemporaries of Pherycides were in their last years witnesses to the triumph of Herodotus. Philosophy and science had begun to lead men to relish the charms of wisdom, and to appreciate the powers of knowledge. Eloquence, long admired as the natural endowment of energetic minds, had made some progress as an acquisition subject to precept. In the arts of design we have already shown the preparations to have been even more ample. The fruits of these, indeed, remained in the latter at an immeasurable distance; for in poetry, Homer, Pindar, Sappho, Anacreon —had respectively attained perfection in their spheres. The fame of the sculptor, however, or of the painter, rests upon far less independent exertions of the mind than that of the poet. Their success is determined more by the circumstances of the times, and by national prosperity. Hence the defeat of the barbarians and the resulting consciousness of power—the true foundation of greatness, with capture of their wealth, which supplied means, must have proved even more advantageous to sculpture.

From these analogies we might venture to infer the relative excellence attained in the several provinces of taste. The series of works in art is limited and very imperfect, especially of the early ages; but there have been preserved progressive examples of poetical composition. The genius of Æschylus was formed prior to the first invasion of the barbarians, he bore arms in the fields both of Marathon and Platea. The youthful Sophocles, whose tender age was fitted only for such gentle service, performed in the chorus which celebrated the latter victory. Not twenty years had elapsed when the tragic crown was removed from the head of the warrior bard, and placed on the brow of his rival. During the same spirit-stirring period, sculpture was studied with at least equal zeal,—may it not be assumed with similar success? And that the superiority of the Œdipus of Sophocles, over the Promotheus of Æschylus was not greater than were the majesty and beauty of the Jupiter or Minerva of Phidias compared with the Jupiter of Eladas, or the Diana of Soidas. The improvement indeed would not be so conspicuous in the latter as in the former case: for in sculpture, external art, which to the majority is all, had already nearly approached its utmost beauty; there remained to be added only those intellectual refinements, the triumphs of genius, which, though immeasurably beyond the highest efforts of mechanical representation, are yet less generally perceived. This comparison of art with art in opposite provinces, furnishes a means of ascertaining not only the relative progress, but also the ultimate extent of excellence.

Of those artists who were the immediate predecessors or early contemporaries of Phidias, who fill up the interval, perhaps in moral grandeur the brightest in the history of Greece, from the battle of Marathon to the government of Pericles, a few of the principal may now be mentioned. This series we shall conclude with Myron, in whose works the technicalities of formal art were complete, and whose labours close with propriety the first period.

Pythagoras of Rhegium surpassed all his predecessors with whom the previous pages have been occupied. One of the most celebrated works of the kind was by him, the iconic statue of Euthymus, the pugilist, on which Pausanias has bestowed extraordinary commendation. Hardly less celebrated was the statue of Astylus, conqueror in the foot race in the seventy-third and two succeeding olympiads. A performance of a different kind, preserved at Syracuse, representing a Philoctetes, is mentioned by Pliny in terms of the highest admiration. The sufferings endured, and the cause of these,—a festering wound in the leg, were expressed with terrible fidelity, so that the spectators, while they gazed, believed themselves to be seized with the same pains. The figure, to use the words of old Ennius, preserved by Cicero,

> Ejulatu, questu, gemitu, fremitibus
> Resonando multum, flebiles voces refert

But not from the merit of individual pieces only, is Pythagoras entitled to notice. His name is intimately associated with the general advancement of art, as ranking among the inventors of the beautiful theory of abstract proportion which taught to unite elegance with truth; and by the harmonious relation of parts to express physical intelligence or power. A proof of the use and advantages already pointed out, of iconic statues. He also introduced a bolder and more decided mechanical practice, especially in the manner of rendering the hair, which he expressed at once firmly, yet softly, and arranged with unstudied grace. Hence some writers have proposed his as the era by which to establish the antiquity of certain works, but unfortunately for their own views, through a love of partial system, they have placed this period too far in advance.

While Pythagoras, Onatas of Egina, author of an admirable statue of Gelon of Syracuse; Glaucias of Egina, who modelled the famous Theagines of Thasos four hundred times victorious in the public games; Critias, whose works replaced the original statues in bronze of Harmodias and Aristogiton, carried off by Xerxes, and restored by Alexander,—while these and many others were celebrated for their representations of the human figure, Calamis became still more renowned by his statues of horses. These were likewise iconic statues, a proof how early nature was admitted as the only guide in every branch of sculpture. *Calamis jactet exactis equis.* There is, indeed, some question, whether there were not two artists, bearing the name of Pythagoras, equal in age as in reputation, but of different countries. This seems, however, to have been a mistake arising from Pliny inadvertently writing one city for the other,—Leontiam for Rhegium. Pythagoras was originally a goldsmith: hence we may infer, although it is no where directly asserted, that he wrought exclusively in metal. Vases of his workmanship, of exquisite design and execution, were, in the time of Nero, coveted by the great as articles of the highest luxury. By Quinctilian he is extolled above all his predecessors, and for delicacy of style, placed inferior only to Myron.

The true era of no Greek sculptor is more difficult to ascertain than that of Myron. The difficulty is occasioned both by contradictions among the ancient authorities, and by the imperfect manner in which the subject has been investigated. The principles on which Pliny has fixed his epochs of art, are seldom easy to be discerned. Certainly, they do not rarely appear to be merely arbitrary; nor is the supposition of Heyne unfounded, that the Roman, collecting his materials from general history, and finding the principal artists mentioned on the conclusion of the different wars in Greece, the cessation of hostilities affording a resting place whence the historian could look back on minor occurrences, was led to conceive an imaginary connexion between the enjoyment of peace and advancement in the fine arts. According to this theory, he has divided his subject, and, as in the present case, has frequently sacrificed truth to opinion. But his errors here being set aside, the other ancient authorities are consistent. As to the moderns, there is on this particular point such trifling about names, —such gratuitous assumption,—such slavish adherence to pre-conceived notions, as subvert every precept of manly criticism, or independent judgment.

It is admitted that Myron studied under Ageladas of Argos, in whose school he was the fellow student of Polycletus and Pythagoras already mentioned. Consequently, the question here, as involving much of the preceding arrangement, demands particular attention. It may be proper to explain, that we have fixed the era of a sculptor from the time when he is first mentioned as engaged in a work of public estimation. This method has been constantly followed where practicable; otherwise, the date of his most celebrated performance has been assumed as the era of the author. The only deviation from this plan that has been made, and which will be adhered to, is, where several artists have appeared in the same age, the most eminent has been last mentioned. It must be obvious, that a similar arrangement is the only one calculated to afford just views of a progressive art. Let us observe how these principles apply in the present case. Polycletus has been placed in the 65th olympiad, because then associated in a public work with his master: Pythagoras, a superior contemporary next; and lastly, Myron have been noticed. These, Pliny has also made coeval, but has placed them in the 87th olympiad, and posterior to Phidias. This order has either implicitly, and to appearance, without examination, been followed by modern writers; or seemingly struck with the inconsistency of the narrative, they have pursued a middle course, in adhering to the chronology, while, in the course of improvement, they have described the labours of Myron as paving the way for the excellencies of Phidias. But on examining the subject more in detail, we find that Myron, in the earlier part of his career, must have been contemporary with Anacreon, since there is still extant an epigram by the poet on the far-famed heifer of the sculptor. Now, the life of Anacreon cannot be extended beyond the 76th olympiad, since he was born in the 55th and died at the age of 85. There thus remains an interval of more than forty years between Anacreon and the time in which Myron has hitherto been placed. Therefore, it is barely possibility that the youth of the latter fell in with the last days of the former; but it is altogether incredible, that a youth should have produced a work perfect in its kind, admired in every era of the art, and in praise of which not fewer than thirty-six poetical compositions have reached our times. Erynna, likewise, a poetess, much earlier than the death of Anacreon, has mentioned this sculptor; while Pausanias, Quinctilian, and Cicero, compare him with those artists only who lived prior to the 87th olympiad. Lucian alone, who speaks merely of public estimation, makes any reference to a later period. Myron also inscribed his name, and, in the ancient character, upon his statues, both of which circumstances prove their antiquity, as does also the fact, that many of these were executed in wood. This evidence must be held conclusive against the chronology of Pliny; other opposing arguments, therefore, need not be insisted upon, which might be drawn from his own criticisms, as containing remarks utterly irreconcilable with the condition of sculpture, immediately posterior to the age of Phidias.

Myron, a native of Eleutheræ, exercised his profession chiefly at Athens, of which he was a citizen, finishing his principal works in bronze, and his largest in wood. We have consequently no original work of his hand; but there can be no doubt that the famous Discobolos is preserved to us in more than one excellent copy or repetition in marble. From these, we may deduce a fair estimate of the merits of the inventor. The style of Myron appears to have been distinguished for strength, energy, truth, and science. The last, indeed, like Michael Angelo, he has been blamed as having carried too far, to the sacrifice of simplicity, in studied and difficult attitude. There is every reason to believe, however, that the statue in question, representing a young man about to launch from his hand the ponderous disc, used in the public games, faithfully exhibits the position adopted by the ancients in this exercise. Also no false play of muscle, nor any impropriety against the laws of mechanical action, is to be detected; every limb has that movement, calculated to impress and to second a forward and elevated impetus. The objection then has probably originated in the misconception of a passage in Quinctilian, where, speaking of this figure, he employs the words, "Distortum et elaboratum," yet with the obvious intention of commending the novelty and propriety of the composition, in boldly deviating according to the nature of the subject, into untried modes of art.

Iconic statues were by this artist carried to the highest degree of perfection; in which department his portrait of Ladus the foot racer was esteemed a masterpiece unsurpassed in every succeeding age. Poised on one foot, the most difficult of all positions, the figure was in the act of springing forward, and in the language of an ancient writer, "breath seemed to agitate his lungs; and the form was gazed upon as if flying from its pedestal to snatch the crown of victory." Besides this, the Athenians much admired the Bacchus and Eretheus sculptured by their order; as also an Apollo, carried off by Antony, and in consequence of a dream, returned by Augustus. Representations of animals by Myron were equally admirable, and appear to have been even more highly valued; his famous heifer has already been noticed. Originally placed at Athens, it was transported to Rome and remained in the Forum till the days of Procopius in the sixth century. Four oxen behind the temple of Apollo Palatinus, are mentioned by Propertius as little, if at all inferior, and a dog licking his wound, preserved in the temple of Juno, was, like one by Lysippus, esteemed so precious that the lives of the keepers were made responsible for the security of the work. Myron carried mere imitative art to its utmost extent; but in the management of the hair, as also in some slighter respects, he is represented as having retained much of the dry manner of former masters. Sculpture, as the representation of external form he perfected, but as an instrument of touching the heart—of elevating the imagination, he was unable to call forth its powers. He represented nature forcibly and with fidelity, but without grandeur or intellectual expression. Approaches to just conception of abstract beauty may be perceived in the principle which he is said first to have taught, that propriety of parts was beauty, or in other words, that a work of art was beautiful as a whole according as the parts in form and proportion were in accordance with their office and destinations. This, in fact, is the essence of corporeal beauty—the highest refinement of material art, and assigns to external form, independent of mind, the noblest character and expression of which it is susceptible. This is the utmost range attained during the first period, and formed an admirable ground-work for the sublimity, which was added in the following era.

Second Period.

The invasion of the Persians, fatal as it had proved to her ancient monuments, became a chief cause of improvement to the living arts of Greece. Her temples being every where thrown down, the statues of her noblest citizens and most distinguished characters carried off or destroyed—every sentiment of religion, of patriotism, and of private zeal was interested in replacing monuments so sacred. From the state of knowledge also, this restoration could be accomplished in a manner the most perfect, from a single statue to the most spacious temple. By the combined efforts of sculpture and architecture, the ruined cities, and Athens in particular, rose, phœnix-like, more resplendent from their ashes. An universal activity in the cause of the arts was thus spread over Greece, which continued with little distinction of school, from the battle of Platea, to the death of Themistocles. This period embraces the latest and best part of the professional life of Pythagoras and Myron already mentioned, with numerous others of inferior note; among these was Eladas, who formed the statue of Jupiter, erected in honour of that victory, and in whose school Phidias had already become distinguished. Of the style of the intervening age, which thus, coinciding with the pupillage and early labours of this great master, connects the first and second periods of our history, the lions, placed by Themistocles upon the Piræus, and now adorning the arsenal of Venice, afford a fine example. In these, the art has acquired all its external force; and in contemplating the vivacity of attitude, the fidelity and grandeur of detail, the observer may be at a loss to conceive how far room was left for future improvement. To us, indeed, it has occurred, on repeatedly examining these sculptures, that they respire an air of ideality and imaginative composition, not to be found in human figures of the same date. This seems to arise from the mixed forms and expression of the heads, which, though not to be found in nature, yet produce a noble and elevated effect by assimilating, in a manner more easily felt than defined, to those of man. This character is to be traced in all antique representations of the same species; and as regards animals, generally, the ancients appear early to have entertained this as a principle of the ideal. These works were among the few ornaments added by Themistocles; his prudence, satisfied with providing for the security and power of the capital, resigned, with ample means, the care of decoration to his successors.

Every favourable circumstance thus conspired to render the age of Pericles distinguished in the history of Sculpture. His own lofty conceptions were in unison with the animated and exalted tone of general feeling in his native city. Athens, despoiled of her ancient monuments, passionately attached to the cultivation of the fine arts, with flourishing resources, and with such a government, almost of necessity became the abode of its splendour, as she had been the earliest nurse of elegance. Above all—then appeared Phidias in maturity of talent; and it has been a question whether the patron or the artist was the more fortunate in their mutual connection. Neither would have acquired equal renown apart from the other. The commanding mind of the statesman perceived and rendered available the political advantages and wealth of his country, while, with rare magnanimity, he consecrated both to the promotion of her truest glory. The sculptor seized the inspiration of art in its most elevated range; he possessed that rarest and highest of all genius which is at once creative and regular—learned and original; having mastered the entire compass of preceding experience and attainment—such a spirit adding its own heaven-derived stores, gives to art its loftiest sublimity.

Hitherto we have collected our intelligence from every corner of Greece; henceforth the attention is fixed chiefly upon Athens and her sculptors. The subject, in thus becoming more concentrated, is rendered also less uncertain; still doubts and difficulties do occur. There is even considerable diversity of opinion regarding the time of the illustrious founder of the new school. Phidias, by Pliny, has been placed in the eighty-third olympiad; an arrangement which, with more than due animadversion has been censured by Heyne and his followers. On his disgrace, the common misfortune of the friends of Pericles overtook the artist also, who became an exile from that ungrateful city, whose proudest monuments, "the wonder of Greece and of the world," he had reared. He died in banishment before the decease of his patron, which happened in the last year of the eighty-seventh olympiad. For the space of fifteen years Phidias had been director of the works at Athens. Prior to this he had executed the statue of Jupiter, which was finished according to the ancient authorities, in the eighty-third olympiad, the era adopted by the Roman historian. But to the composition of this celebrated work ten years were devoted, while the circumstance of being chosen for an undertaking of such value and magnitude, necessarily implies that he had already attained eminence in his art. Indeed there is evidence that he finished, about the seventy-seventh olympiad, the famous Nemesis from the block of Parian marble left by the Persians on the plain of Marathon, and which they had vainly thought to have reared into a trophy over Greece enslaved.

From these facts, it is apparent that the date fixed upon is neither happily selected as respects the individual, nor calculated to display the continuous improvement of taste. At the same time, the principles of judgment are here so obvious, that the correction needs not to be held up as an extraordinary instance of critical acumen; nor can we justly make any other supposition than that Pliny, injudiciously no doubt in this instance, has chosen the conclusion of a celebrated work as the chronological era of the author. On the other hand, the early labours of Phidias, thus properly extended, justify our previous arrangement of the subject, as they are shown to have corresponded in date with the mature productions of Myron and Pythagoras. This circumstance explains the near approaches to the highest style made by these artists, while they were surpassed by their later contemporary. In fact, to the perfect imitation and exquisite finishing of these, Phidias, while he retained all natural beauties, added grandeur of expression, breadth of effect, and nobleness of form.

The works of this "Homer of sculpture" may be divided into three classes,—Toreutic, that is statues of ivory and other materials,—Statues in bronze—Sculptures in marble. Of these, the first class, with what justice will subsequently be inquired, has attracted the largest share of attention. The colossal statue of the olympian Jupiter adored at Elis, has been described by every ancient writer whose subject led him to speak of the arts. Placed in a temple two hundred and thirty feet long by ninety-five in breadth, the figure seemed too gigantic even for these dimensions. From an anecdote preserved by Strabo, we learn that Phidias being interrogated whence he had derived the divine conception of his composition, replied that the original of his Jupiter was to be found in the following verses of Homer.

> Η και κυανεησιν ἐπ' οφρυσι νεῦσε κρονιων·
> Αμβροσιαι δ' αρα χαιται, ἐπερρωσαντο ανακτος,
> Κρατος απ' αθανατοιο· μέγαν δ' ελέλιξεν Ολυμπον.

This is a description of an effect not of an agent; and the alleged saying of the sculptor, so often repeated, if it mean any thing, can merely imply that he conceived in his mind the idea of a being capable of producing the consequences mentioned. Seated on a splendid throne, the god was represented in an attitude of repose, one hand supporting a figure of victory, the other resting upon a burnished sceptre of precious metals. The body naked to the cincture, was composed of ivory, the hair being of gold with an enamelled crown surrounding the awful head; the lower limbs were clothed in a flowing vestment gemmed with golden flowers and other ornaments. Notwithstanding the colossal proportions of a form sixty feet high, every part was finished with the most scrupulous nicety. The throne also which rose above the head of the figure, was most exquisitely sculptured with sacred and historical subjects; while others were painted in their natural colours by Panænus, the brother of Phidias; and the whole further adorned with precious stones, of which, from an expression of Plato, the eyes also appear to have been composed.

Of dimensions scarcely inferior, and of the same, or if possible, even superior workmanship and materials, was the Minerva of the Parthenon, the glory of Athens, as the Jupiter was of Greece. The figure of the goddess stood upright, armed, one hand grasping a spear, the other holding an image of victory; at her feet lay a shield covered with the most beautiful sculpture, representing on the convex the Amazonian war, the Athenian leader being a portrait of Pericles, a cause of the artist's banishment; on the concave were seen the giants warring against heaven. On the golden sandals, with exquisite delicacy, was portrayed the battle of the Centaurs. In the figure itself, the nude was of ivory, the robes and ornaments of gold, exceeding in value L. 9000 Sterling.

Such was the admiration attached to these works, that those were esteemed unfortunate who, once in their lives, had not been able to behold and admire. Yet, examined according to the precepts of pure sculpture, and in obedience to the rules of refined taste, as cultivated by the Greeks themselves, we question much the legitimacy of the effects produced by these statues.

It is not enough that a work of art does produce on the beholders powerful impressions; it is indispensable to the superiority of such a work that these impressions arise from the appropriate means permitted to the artist. The neglect or denial of this first virtue of imitative art, has, more than any other cause, been fruitful in extravagance, and destructive of genuine beauty. Now, in these stupendous compositions of Phidias, exposed as they were to the gloom of the ancient temple, their vast proportions from very magnitude dimly seen, while the varied lustre of the parts added the force of powerful contrast in light shade and colouring, glowing but unearthly, the effect must have been tremendously imposing. For exciting awful and undefined ideas of superhuman existences—for increasing the mysterious terrors of a superstitious devotion, such effects also were adapted; and in so far doubtless as accomplishing the end in view, the works were perfect. But the feeling was meretricious;—it was an influence derived from other sources than the graceful and unmingled sublimity of fine forms and noble expression; it was altogether diverse from the solemn and simple majesty which constitutes the essence of sculptural representation.

Of the future fortunes of the Minerva little else is known beyond the existence of the statue in the reigns of Constantine and Julian; but respecting the Jupiter various subsequent details have been preserved. The materials composing these statues required the external covering to be formed merely of veneers; this, from the small extension and tenuity of the parts, rendered frequent repairs necessary. Accordingly, so early as the commencement of the Peloponnesian war, soon after the death of Phidias, the Jupiter was repaired and cleaned by Damophon, a Messenian artist of considerable reputation, with whose exertions the Eleans were so well satisfied, that they conferred upon him an honourable mark of their esteem. Afterwards a sculptor appears to have been attached to the temple, to whose care the work of repair was entrusted. In the reign of Julius Cæsar, as we are informed by Eusebius, the figure was partially damaged by lightning. In the reign of Caligula, Memmius received orders to transport this most splendid of heathen divinities to Rome, that the head might be replaced by the portrait of this most abandoned of emperors and of men. The design of a removal was declared impracticable by artists; and the superstitious fears of the Roman governor were wrought upon by the contrivances of the priests, who caused a voice, apparently issuing from the statue, to denounce the destruction of the ship on which so sacred a freight should be placed. From Libanius again we learn, that in the time of Julian the apostate, the Greek artists were engaged in imitating, with the utmost scrupulosity, the Jupiter of Phidias in the minute works on gems, which were then the taste. This noble monument was finally transported to Constantinople about the conclusion of the fourth century by Theodosius the Great, who perhaps reconciled his Christian prejudices by reasoning such as the following verse contains,

——— ——— liceat statuas consistere puras
Artificum magnorum opera. Hæ pulcherrimæ nostræ
Ornamenta cluant patriæ, nec decolor usus
In vitium versæ monumenta coinquinet artis.

The works of Phidias, in bronze, were numerous; so that a question has unnecessarily been agitated whether he ever exercised the art, except in ivory and metal. The general testimony of history, corroborating the personal evidence of both Greek and Roman writers, proves the affirmative. In these materials, however, his labours were of more gigantic magnitude; and, in bronze especially, his Minerva Polias even surpassed, in this respect, the figures already described. This statue, erect, armed, and grasping a spear, was of such majestic proportions, that the crest of the helmet, towering above the battlements of the Acropolis, might be discerned by the mariner as he rounded the promontory of Sunium. This graphic expression, for a distance of twenty-five miles, evinces both the surprising grandeur of the object, and the fine taste of the Attic writers, by whom every thing noble in sentiment or action is constantly associated with local and homefelt impressions. The ornaments, most probably the whole of this statue, were painted by Parrhasius,—a proof that not in the decline, as has been asserted, but in the meridian of refinement, painting was united with sculpture. Indeed we have ourselves remarked, in the most ancient ruins of Magna Grecia, that even the severity of Doric architecture, to heighten the effect of particular members, did not disdain to borrow aids also from colour.

Examining the merits of Phidias in marble sculptures, we enjoy an advantage denied to every other ancient artist. Respecting the most esteemed masterpieces of antiquity, there still exist doubts not altogether groundless, how far our judgments are formed upon the real originals. But in the ornaments of the Parthenon are beheld the conceptions of the mind, and even in some measure the labours of the hand of the great Athenian sculptor. In this our own age and country, we may still admire the identical works, which for seven hundred years formed the unrivalled studies of her artists and writers while yet Greece could boast of art or letters. From an examination of the *Elgin marbles*, then, we shall obtain no imperfect idea of that style and of those very models which the Greeks themselves have pronounced to be the proudest achievement of their genius in sculpture.

In these precious remains are presented, for our inspection, both statues and relievos. The former ornamented the two tympana of the Parthenon, which was amphiprostylous, in compliance with the religious institutions of Athens; while it thus corresponded also to the other edifices and natural entrance of the Acropolis. On the eastern pediment was represented the birth of Minerva; on the western her contest with Neptune. Of these two compositions we possess in all, besides fragments, fourteen pieces, consisting of seventeen figures, more or less mutilated, five belonging to the western, nine to the eastern front. From the centre group of the former, which has fortunately been preserved, it appears that the whole was of heroic size, or at the least double the proportions of nature. Each figure stood completely detached from the wall, being finished with equal care on all sides. In 1676 these breathing productions, over whose fragments taste now mourns with unavailing regret, were entire. Their destruction commenced in 1687, when, by the blowing up of a Turkish magazine during the siege of Athens by the Venetians, the Parthenon, till then almost uninjured, was reduced to a ruin. Thus one of the noblest bequests of the ancient to the modern world—a sacred legacy which more than twenty centuries had respected, and just in the moment when the gift would have been appreciated, was rudely intercepted by the petty mischief of contemptible and semibarbarous warfare.

Of the relievos there are two classes, originally occupying distinct positions on the edifice, and varied also in their respective modes of execution; yet each bearing the undoubted impress of the same master mind. The temple of the Parthenon was constituted of an exterior peristyle, and of an inner cella. The former composed a double portico on the east and west fronts; but single on the flanks; the latter formed a simple parallelogram, with an entrance in the centre of each end. Two fine situations were thus afforded for sculpture in relief,—the intercolumniations of the outer entablature, and the unbroken frize of the cella. In the Doric order, to which the temple belonged, the metopes of the portico might have been either plain or variously ornamented. In the present instance, the embellishments represented the combats of Theseus against the Centaurs; a subject most interesting to the Athenians, of frequent occurrence in the monuments of Attica, and therefore, excluding the beauty of form in which art had clothed the conception, singularly appropriate in the national temple. These designs, of which fifteen have been preserved, display a very bold relief, approaching to full roundness. The invention, action, and grouping, are truly admirable, pertaining to the very highest style of sculpture: but occasionally the execution is unequal, betraying a timidity and meagreness not easily reconcilable with the lofty character of the composition.

The frize of the cella, a surface of more than eighteen hundred square feet, covered with the most exquisite relief, exhibited probably the grandest creation of art in any age. The same subject was continued throughout the whole; the national procession at the opening of the Panathenean festival. Over the principal entrance on the east the solemn representation commenced; here were delineated the principal actors; and to this point an innumerable multitude appeared advancing in two parallel columns along the flanks of the cella, while, on the western front, as the rear of all, various parties were seen,—some hastening to join the right, others the left of the procession. The most varied and animated design pervaded the whole, delineating the living population of Athens on horseback, in chariots, on foot, young and aged, male and female, mingled with functionaries, victims, and sacred insignia. Over all is diffused a character of elevation and enthusiasm befitting the majesty of a religious rite, and sweetly raising the fidelity of nature to the grandeur of the ideal.

Of the entire composition there still remain about two hundred feet containing specimens from each of the sides and fronts. The relief is flat, evincing, in this respect, the nice discrimination of the artist; since, as the work could be viewed from a short distance, and only by the secondary light transmitted through the intercolumniations of the peristyle, strong shadows and high projections would have rendered the effect harsh, and obscured the figures.

In addition to the materials of judgment furnished by these more directly and certainly the works of Phidias, we have also in the British Museum, from the private munificence of his majesty, the Phigalian marbles. These, amounting to about ninety feet in length, formed part of the frize of the temple of Apollo, present a similar character of design, and in all probability are from the school at least of Phidias; as Ictinus, the architect of the Parthenon, built also the temple at Phigalia.

The remains now described are the memorials of Sculpture in its utmost perfection, and discover, fully developed, every exalted principle whether of theory or of practice. Grandeur is the prevailing character but it is the grandeur of true simplicity and nature, devoid of all parade or ostentation of art. The means are forgotten from their very excellence, and in the full accomplishment of the end. The sublimity resembles that produced by eloquence, where, on some elevating subject, the orator, earnestly and with unaffected sincerity, labours to impress his own convictions upon the hearts and affections of his auditors. The Sculpture of Phidias, indeed, might well be assimilated to the Oratory of Demosthenes, in the truth and reality of its images, and in its power of bearing the whole soul along in one engrossing feeling. But in the artist all is sweet and gracious: we are willing captives to the witchery of art. In the orator a sternness and a severity often induce us to struggle against the potency of his spirit.

In this excellence of uniting the graceful and the pleasing with the energetic and sublime, consists the surpassing merit of Phidias. Exquisitely delicate in the minute, he is bold, vigorous, and flowing in the great. His grandeur combines individual delicacy and scrupulousness of detail, with breadth and greatness of general effect. In these remains, indeed, as in all architectural sculpture especially, effect has been studied as a principal aim. Yet nothing appears done for effect. No effort—no exaggeration; every thing is consistent with itself, with the whole, and with nature. So exquisite is that accordance of design, manner, form, and execution, that not one of these could be changed without injury to truth. This is the very essence of grandeur in art, giving to its productions an ease, a grace, a vitality, resembling more the spontaneous overflowings of inspiration, than the laborious offspring of invention and science.

In these respects the ancient critics seem justly to have appreciated the character of Phidias. Pausanias, in describing the Parthenon, bestows the highest encomiums on the sculptures by the artist of the colossal Minerva, without mentioning the name, which he conceived to be thus sufficiently designated. Demetrius Phalereus, contemporary of Praxiteles, and who had consequently the advantage of comparing most directly the two best ages of the art in Greece, says, that only in the sculptures of Phidias was the magnificent united with the delicate style. Plutarch characterizes his works as inimitable for grace and beauty of form. "Nothing," says Cicero, "is more perfect than the statues of Phidias; they enchant the spectator at the first view." Many other testimonies might be added, assigning to his style, and to it alone, majesty, truth, and grace. By modern writers, however, previous to the removal of the remains now described, the merits of Phidias were estimated with scanty justice. The grandeur of his genius had always been admitted, but not unfrequently his works were characterized as retaining a portion of the rudeness and constraint of former ages—as sacrificing beauty to strength and greatness of effect. In giving origin to this censure, Winklemann seems to have consulted neither ancient writers, the works of the artist, nor the abstract principles of just criticism. A glance to either of the two former will afford sufficient proof that no other man has united in his works more of the highest excellences of art. It is in fact this union which truly constitutes beauty, especially in Sculpture, whose sources of pleasing and of moving being few, and derived from the essential elements of form and expression, admit of separation with peculiar disadvantage. But in each of the fine arts, nay even in nature, although beauty may exist in an object incapable, from circumstances, of greatness,—yet the truly grand can never be disjoined from the beautiful, and that in the highest sense of the term. In the case to be considered, more seductive expression, greater delicacy of air, may have been given to the female statues of the succeeding school under Praxiteles; but for that perfect beauty which arises from including the essentials of excellence in the most liberal proportion, dignity, grace, richness, truth, we search successfully in the labours of Phidias alone.

The attentive study of the works of this artist, supplies the criterion by which to judge of the sublime and beautiful in Sculpture. The ideal of Phidias is perfect universal nature—nature freed from individuality and accident. This, the real object of art, he views through no medium of fancy, he imitates according to no conventional principles. He only looks abroad on all existence, refining partial conceptions and partial modes, by the unerring harmony of the whole. The true ideal—the ideal of Phidias—is but the embodied union of whatever of beauty or perfection still lingers among the forms of nature, viewed in her fairest models. Much, indeed, has been conjectured on the import of certain passages in the classic writers, speaking of the divine archetypes of this sculptor; as if he had drawn his materials from an abstract idea existing in his own mind independent of reality. The sublimity and truth of such remarks have been praised. We hesitate not to condemn the sentiment as inconsistent with both, and subversive of the genuine excellence of art. In this also we are borne out by the works now considered. In the Elgin marbles, every conception breathes of humane life and action. So intimately does the representation partake of reality, that in the opinion of the venerable President West, "When we view the young equestrian Athenians, the conviction is forced upon us, that they and their horses actually existed such as we see them." From this opinion, no one who has carefully examined these remains will be inclined to dissent. This happy effect of truth, however, does not arise from an imitation of common nature, for every figure respires of an heroic and elevated character. The science with which the forms are composed, the freedom of their movements, the ease of their attitudes, express the same capability of moving in momentary action as possessed by the living models. This is wholly opposed to any thing strained or remote from every day perceptions, and throws over the whole an air of simple reality. But with these essential qualities of merely imitative art, are united perfect symmetry, the most harmonious contours, the grandest composition, the most refined grace and delicacy. Truth is thus the primary constituent in the ideal of Grecian sculpture. Beauty is the perfect expression of this truth agreeably to the most unblemished forms which general nature presents. In this union of collective excellence and individual verisimilitude, the mind feels and at once acknowledges the presence of the sublime in art. The works of Phidias enable us to unfold these principles in their purest elements, and to trace the modes in which this union is accomplished. It has been the constant aim of this master to ground ideal upon imitative art; to address the imagination by grandeur of composition and perfection of form, while he appealed to the judgment by fidelity of detail and correctness of science. The relations under which truth and imagination produce results at once grand and interesting, have been closely sudied and successfully exhibited. To attain this, after composing his work in the loftiest intelligence of the ideal, this consummate artist has carefully impressed from individual nature, simply and without exaggeration, those fugitive traits of the surface,—as its fleshy texture, the foldings of the skin, the swelling of the muscles, the lubricity of the joints,—which infuse softness and animation, and which all can estimate.

In all that merely meets the eye, the Elgin marbles display the finest keeping with the general nobleness of their character. The execution is perfect, simply because the whole composition is so. The finishing is delicate and even minute, because the extreme beauty of the design required to be rendered with a corresponding care and dexterity. The chiseling is facile, vigorous, and flowing, harmonizing with attitudes and expressions full of grace, dignity, and truth. The touch is broad, the shadows deep and firm, corresponding with, while they increase the grandeur of effect. The style of design is in the strictest acceptation learned; the muscles and marking of the bones are pronounced with a decision and truth we had almost said, unparalleled in any other ancient specimen. In fact the anatomical science of those fragments surpasses in correctness the most perfect of the statues hitherto discovered. As an expression of action, they are in this respect superior to the Apollo; nor can it be doubted, though from mutilation we cannot exactly ascertain, that, as expressive of character, they were at least equal. Yet these, the highest excellences of manual and material art, appear as if they had been altogether unsought; the marble might be supposed spontaneously to have moulded itself after the most exquisite fashion in the very act of obeying the creative impulse of the artist's mind. So total is the absence of all pretension, that this mastery of touch, this matchless exhibition of skill, is at first unseen and unfelt amid the intelligence it conveys, and at last is noticed only as an harmonious element of a perfect whole. When pretension appears in the means it is doubly offensive; here, at the same time, the utmost beauty constantly marks the productions of lofty genius. Homer and Shakspeare in the mere fabric of their poetry are unrivalled. What more harmonious than their verse; what more felicitous than their language! Yet these never obtrude; study, effort, apparent solicitude, is unknown, unsuspected. The numbers flow, the expressions live as the thoughts arose or the feelings kindled in the breast of the bard. The exquisite mechanism operates unobserved. As surrounding imagery is reflected in truest loveliness by the purest and stillest waters, while the medium itself is lost amid the groves and skies which it shadows forth: So art, the mimic of nature, charms the most where this very mimicry is most concealed. In this happy and unobtrusive union of nature and imagination, in remounting without ostentation or convention to the eternal sources of natural beauty and true science, Phidias displays the perfectly sublime of art, and stands unrivalled among the masters of the ancient world.

We have thus reached an era beyond whose general excellence the genius of Greece never attained in Sculpture. But this eminence, though principally reached in the age and by the labours of one man, did not fall with its author. The spirit of Phidias continued to animate the disciples whom he had instructed. Indeed the artists whose names adorn the succeeding portion of this period, may be classed into two schools, receiving their distinctive character according as they closely imitated or more distantly followed their illustrious predecessor. In both, the principles were the same; these could not vary: but their application was made to subjects requiring a modified exhibition of certain distinguishing qualities. The grand has been explained as the characteristic of the style of Phidias. Succeeding masters, despairing to rival in this department, turned to subjects of a softer nature, gradually creating a school whose leading object was the beautiful.

Agoracritus of Paros, and Alcamenes the Athenian, especially the former, were the favourite pupils of Phidias, and approached nearest to the excellence of their master. It is not, however, easy to determine the real merits of these disciples, since their works were directed, if not retouched, by their instructor, and their performances after his death are said to have been inferior. The grand reliefs of the temple of Olympus by Agoracritus, partook of the heroic character of the Phidian school; but the most celebrated statues of Alcamenes, the Venus of the gardens, and the Cupid of Thespis, prove the commencing partiality for less heroic subjects. In a contest for supremacy, each of these artists submitted a statue of Venus to the judgment of the Athenians, who it is said, partially awarded the prize to their fellow citizen. The rejected labour of Agoracritus, subsequently changed into an image of Nemesis, drew more admirers at Ramnus, than its successful rival at Athens. The statue in part is reported to have been by Phidias himself, and its conversion into a representation so opposite, furnishes an illustration of the sentiments of the Greeks regarding the ideal in expression.

At the same period lived Polycletus, the second and most famous of the three who bore that name. Respecting these artists, Pliny and those who follow him, have fallen into great error, admitting only the earliest, and ascribing to him the merits and labours of the three. In this they have completely confounded the chronology, and contradicted the principles of art. The talents of the second Polycletus appear to have been of a high order, and his influence on the future state of sculpture considerable. His greatest work was a colossal statue of Juno, composed of ivory and gold. The figure, in a sitting posture, was erected in the temple of the goddess at Mycenæ, and is described by Strabo. But the genius of Polycletus carried him rather to the imitation of the beautiful than of the grand qualities of his art. Excelling all other artists in the ease and delicacy of his finish, he was deficient in force; and, to use the words of Quinctilian, as he added more than human grace to the figure of man, so he proved unequal to the majesty of the divine form. Dionysius of Halicarnassus, indeed, differs entirely from this criticism, placing this sculptor next in dignity to Phidias. Polycletus himself, however, has decided the controversy by the selection of his subjects from among the young and the fair. His most celebrated works were the statues of two youths, antique copies of which on gems and relievos are still extant. They were both nude, one binding his head with a fillet, hence called Diadumenos; the other holding a spear, hence termed Doryphorus, also said to have been an Iconic statue representing one of the guards of the king of Persia. There is a question whether this or another statue composed the celebrated "canon" from which, as from an unerring rule or measure, all succeeding artists, even Lysippus himself, took their proportions. Pliny makes a distinction, Cicero says the figures were the same. The former writes expressly, the latter incidentally; neither is it likely that an Iconic statue would be selected for the formation of a standard of abstract proportion. A more interesting inquiry is, what really were those "canons" of art among the Greek sculptors, respecting which so much has been conjectured?

Struck with the unerring truth and harmony of the proportions in the works of the Greek sculptors, some have maintained that they possessed a secret knowledge of geometrical rules by which their compositions were in all cases regulated. Certain it is that the ancient masters had compiled treatises on proportion, and that we meet with the expression "mathematical canons of art" on more than one occasion. But when we remark the variety and animation of attitude in the antique statues, it is difficult to reconcile this playful rivalry of life and nature with the undeviating exactitude of geometrical modes. This has led others into the opposite extreme of asserting the whole of antique art to be the empyricism of talent residing untaught in the hand and eye of genius.

Απὸ τῆς κατα την ἑξασιν φαντασιας.

The characteristic of true genius, however, is to be indefatigable in labour, while its privilege is to conceal the effort. The perfection which we admire in the production of Greek statuary sprung from the accumulated experience of centuries; rules of proportion in particular were the recorded and methodised results of actual measurements taken from the purest living forms of every age. The Iconic statues of the victorious athletæ, we have already hinted, introduced this practice; and the extreme vigilance of the hellanodists, or judges, appointed to decide on the fidelity of these works in every member, as compared with the living original, served both to improve her arts, and to direct the physical education of the youth of Greece. But in any state of ingenuity, more especially with the limited resources of early art, such exactness, without measuring the model, was impossible. Founding on the principle that the corporeal beauty of man consists in the suitableness of the different parts for their destination, artists, by these measurements, were guided in the composition of ideal works: nor can there be a doubt, from the expressions of Diodorus, Lucian, and particularly of Hippocrates, not to insist on the representations on more than one antique gem, that the proportions thus obtained were collected, not only in treatises, but ranged in tables and scales for practical use. Polycletus carried this theory to perfection. Not satisfied with writing upon this interesting subject, he wished practically to illustrate its precepts, and composed the statue which has led to this discussion. The nature of this work has been much misapprehended. To us it appears that in this figure Polycletus intended to represent a perfect form, whose physical character should display an equal aptitude for every exercise, where strength and agility—power and grace, should be harmoniously united. Nor does the creation of such a standard seem at all chimerical, from comparing and combining tables of living measurements with constant reference to nature. The difficulty truly would consist not so much in the construction as in the effective application of the abstract rule.

Among the contemporaries of Phidias, a most distinguished place was occupied by Ctesilaus, since he divided with that master and Polycletus the public prize of merit for a statue to be dedicated in the temple of the Ephesian Diana. To modern times his name possesses peculiar interest as the reputed author of the third finest male antique in existence—the dying gladiator—popularly—but erroneously so called.

He leans upon his hand—his manly brow
Consents to death, but conquers agony,
And his droop'd head sinks gradually low—
And through his side the last drops ebbing flow
From the deep gash, fall heavy one by one,

Like the first of a thunder-shower; and now
The arena swims before him—he is gone!

The beauty of position is peculiarly striking as illustrative of profound anatomical knowledge. The figure is neither resting nor falling, but simply seeking to breathe exactly in the only posture in which, from a wound in the thorax, this function can be performed. Into the interminable question of the subject represented we enter not; but from the grand, learned, and feeling style of this astonishing composition, we hesitate not to place it in the best era of sculpture, being in all respects worthy of that artist, *qui nobiles viros nobiliores fecit*, and who succeeded in competition with Phidias. The assignment of the work to this particular artist, indeed, rests upon an erroneous application of a passage in Pliny, where he says that "Ctesilaus made the statue of a man wounded and dying *in quo possit intelligi quantum restet animæ.*" This description was inconsiderately applied to the statue in question. It was easy for subsequent inquirers to observe that the critic spoke of a bronze, not a marble figure. Hence the originality of the latter was denied. Whether the premises or the inference be here the more illogical, or how the merits of a work of art can be implicated in the non-application of a passage in an ancient author with which it has no connection, it is impossible to determine. The truth is, we know not the artist, but we must acknowledge the presence of the highest art. Surely those who speak of a copy have not gone morning after morning to the capitol, and have found in this dying hero proofs constantly renewed of the immortal energies of the human mind.

During thirty years from the death of Phidias, the Peloponnesian war raged without intermission, involving as principals or allies every state in Greece. In the midst of these hostile commotions, the arts flourished with almost unimpaired vigour. There was united with the sentiment of hostility a spirit of rivalry, which rendered the contention a striving for mastery in every excellence. Sculpture, indeed, appears to have participated largely in the fortunes of Athens, and consequently, towards the close of the contest, suffered some depression. Perhaps the same might be true of painting also. The cause of this seems to be found in the circumstance, that during this tempestuous interval no new style was attempted, while the principles of the grand and the beautiful in sculpture had emanated from the Athenian school, and thither the artists of all Greece resorted for instruction. Also the imitative arts, in their essential qualities rarely derive any permanent impress from passing events; on the contrary, literature, which more easily borrows its hues from the complexion of the times, received, during the same period, quite a distinctive character; and Attic eloquence especially, then assumed that conciseness and vigour for which its remains are still so eminently distinguished.

More than fifty names of eminent sculptors, including his contemporaries, have been preserved, who flourished from the time of Phidias to the hundredth olympiad. Of these Naucydes was the author of the youth holding a discus, and considering with himself the distance to which his preceding competitor has just attained: *Spatium jam immane parabat.* Of this figure three antique repetitions still remain, which are admired for their fine pose, the sweetness and variety of contour, and unaffected expression. Patrocles executed in bronze, thirty-one statues of the Spartan generals and allies at the battle of Ægospotamos. Others we need not mention.

The style of Scopas constitutes in some measure an intermediate gradation between the Phidian and the school of Praxiteles. He was of Paros, and though much uncertainty prevails in the dates assumed by different writers, yet since he was one of four artists engaged to adorn the tomb of Mausolus, this fixes the era to the 102d olympiad, or 370 years B. C. Grace, softness, and truth, distinguished the performances of this artist, of which qualities his Venus and Bacchante were the most celebrated examples, dividing with the subsequent works of Praxiteles the admiration of Greece. Of Scopas two famous works are said to be still extant, the Venus in the Townley collection, and the Niobe at Florence. The former is a standing figure, draped from the cincture by a robe which enfolds the lower limbs only; and whether we regard the beauties of the composition, or its fine preservation, is undoubtedly among the most valuable remains of art in the world. Pliny is divided between Scopas and Praxiteles, as to who was the author of the group of Niobe, while the writer in the Anthologia assigns it to the latter.

While mourning o'er my hapless offspring's fate,
Stone I became through the celestial hate;
The doom revers'd Praxiteles has shown
By whom I live again and grieve in stone!

In this group, which originally consisted of sixteen figures, and of whose transportation from Greece we know nothing, the style assimilates closely to that of Phidias; there is the same grandeur of effect, dignity of expression, and delicacy, yet breadth of detail. The forms also like his are robust, without being inelegant, awing rather by the majesty of virtue, than subduing by the mere allurements of loveliness. The expression of fear, grief, and consternation in the countenance of the mother, is exquisitely true to nature, without injury to beauty, and worthy of Scopas, who is termed δημιουργος αληθειας, *artist of truth.*

Scopas had for assistants, or rivals in the erection of the Mausoleum, Leochares Bryaxis and Timotheus. These, with other less celebrated names, fill up the interval to the age of Lysippus and Praxiteles, falling in with a very unsettled period in the political history of Greece. The rise of the Spartan power upon the ruins of that of Athens; the hateful dominion of the thirty; the virtuous struggles of Thrasybulus and Conon, ending in the restoration of liberty with some degree of power; had kept the latter state in continual agitation. Finally, the ambition of Thebes, which, with the solitary exception of Pindar, had added not one gem to the intellectual crown of Greece, rekindled the rage of general hostility. This terminated in the impious battle of Mantinea, where, to gratify the ambition, or hide the disappointment of one man, were assembled for mutual slaughter two of the greatest and most gallant armies Greece had ever seen—men who could have liberated and enlightened the world. Still the arts shed a pure and softening light over the dreariness of the scene; their brightness, like the dewy arch spanning a troubled sky, might be partially broken and obscured; but elsewhere in every calmer spot—in Sicily, in Rhodes, in the Greek cities of Italy, the splendour continued unimpaired, or even derived fresh accessions from the distractions of the native schools.

Lysippus of Sicyon, as is well known, was the contemporary and the favourite artist of Alexander. Coeval with that prince was also Praxiteles; both sculptors belonged to the same age, and the discussions which have been agitated on this subject, seem to have been quite gratuitous. Lysippus wrought exclusively in bronze, but of the six hundred and ten works which he is said to have produced, not one can be proven to remain; the bust at Portici requires to be authenticated; the horses brought from Chios to Constantinople by Theodosius the younger, and since the year 1204, placed in St. Marks at Venice, have, we think, with justice been pronounced unequal to the fame of their alleged author. We learn from ancient writers, that the style of Lysippus was more grave and severe than the genius of contemporary art; and that he seemed desirous of recalling the more solemn grandeur of preceding masters. This predilection would naturally be cherished by his materials and subjects. Colossal and equestrian statues in bronze demanded forceful, vigorous, and dignified composition. His greatest works were the Tarentine Jupiter sixty feet high, of cast metal, and twenty-one equestrian statues of Alexander's body guards who fell at the Granicus defending their prince. To Chares also his favourite pupil, is ascribed by Cicero the famous colossus of Rhodes. But Lysippus proved himself equal to works the most beautiful and delicate; his finishing was exquisite, his imitation of nature most faithful, and he excelled in his knowledge and expression of symmetry. Of all the artists of this age, his education appears to have been the most complete. He commenced his study where art itself had begun—with nature, and finished them by confirming and applying the precepts thus obtained according to the practice of the greatest masters, if, indeed, a greater than himself can be found. The esteem of Alexander is confirmed by the unanimous testimony of all writers, and, by the admiration in which his works were held, long after the approbation of a prince would have been as nothing. A statue by this artist representing a naked youth preparing for exercise, had been carried to Rome in the time of Augustus, being placed in the baths of Agrippa, it formed the delight of all ranks. In the reign of Tiberius it was removed by his order to the imperial palace, but the Romans rose as one man, and, by their remonstrances, caused the work to be restored. *Princepsque*, says Pliny, *quanquam adamatum reposuerit*.

The influence exercised by Praxiteles upon the progress and character of sculpture, seems to have been misunderstood. In almost every age he has received praise from each successive writer, as an original inventor, as the discoverer of a new style. Yet notwithstanding the supreme beauty of his labours, and the superiority of his genius, we deem this estimate irreconcilable with the history or the philosophy of art. With equal propriety might Sappho or Anacreon be styled inventors in lyric poetry, because their sweetness is not the majesty of Pindar. It has been shown that all the sublimities of which imitative or ideal art is capable, were attained in the works of Phidias. From the era of that master, a gradual declension has been traced from the loftier and severer style to one of gentler subject and softer manner. Without decay of talent, various causes might combine to operate this change—fewer opportunities of great undertakings, a gradual revolution in the opinions and usages of society, works of art becoming more the objects of private patronage than of public munificence, and consequently of private taste. Likewise, it must be admitted, that in all the various departments in which the human mind can be exercised, there is not to be found in the annals of any nation a lengthened display of the very highest genius. As respects the intellectual empire even of the species, a few elevated spirits only are placed in the solitary majesty of general eminence. Succeeding aspirants are contented to select some particular province which they may cultivate and render their own. Thus Praxiteles, falling in with the current of general predilection, and following, it may be, the bias of his own mind, resolved to woo exclusively the milder graces of his art. In this pursuit, he proved conspicuously successful. He has caught the happy medium between the stern sublimity which awes, and the beauty which merely seduces—between the external allurements of form and the loftier but colder charms of intellectuality. In his, of all the works of antiquity, we especially admire softness united with force and elasticity—where refinement has not degenerated into affectation, nor the elegant into the artificial. Over his compositions he has diffused a perfect grace—an harmonious movement if the word may be allowed—a voluptuous majesty—an expression spiritual at once and sensual, confessed by the coldest heart, satisfying the most fastidious taste, admired by the most trembling modesty.

The truth of this encomium will be borne out by the fine antique repetitions of the statues of this master. Or if of these the Faun so renowned among the ancients under the name περιβόητος be really the Barbarini Faun, and the Thespian Cupid, the same marble now in the capitol, the originals will not detract from the justness of the criticism; they place their author first among sculptors of the school of beauty. The Faun is an example of manly grace and of the finest science, and shows that Praxiteles had not selected the graceful because he could not have attained the sublime and forceful. The Cupid is instinct with playful and elegant fancy; and by a well-known artifice of Phryne we possess the artist's own opinion of the superlativeness of this and the former, over every other of his works. The Apollo Sauroc-thonos, as the figure about to kill a lizard has been termed, exhibits whatever of simplicity and elegance can be supposed to exist in boyhood. In the nascent forms the artist has expressed with astonishing truth the promise of future nobleness, in this encountering one of the most perilous experiments in his profession, nor in the whole range of ancient art, is it clear that there could be pointed out an example of greater difficulty more exquisitely overcome. To this work Martial alludes in the following epigram.

> Spare foolish youth! the creeping insect there,
> Death from thy hand it courts—than life more fair.

Praxiteles was the first, perhaps the only sculptor who attained to the true ideal—the perfect union of intellectual charm with feminine grace in the representations of the "Queen of soft desire." His draped and nude, or Coan and Gnidian Venus, fixed each a standard from which succeeding invention dared scarcely to depart. In the Medicean, we almost possess the Venus of Gnidos, the admiration of antiquity, and which in this representative "still enchants the world."

> There, too, the goddess loves in stone, and fills
> The air around with beauty; we enhale
> The ambrosial aspect, which beheld instils
> Part of its immortality; the veil
> Of heaven is half withdrawn; within the pale
> We stand, and in that form and face behold
> What mind can make when nature's self would fail.

Third Period.

The circumstances of birth enabling him to profit by the distractions of the times, had elevated the son of Philip to a situation and to an interference in the affairs of the world which not his talents, far less his virtues entitled him to hold. Circumstances again, yet more than his own intrinsic weight in the scale, conspired to render the death of Alexander a memorable epoch in the history of human transactions. Rather through the fears and jealousies of others than elevated by his own conduct, he had become the sole point of union in an artificial and unnatural system, whose gigantic extent necessarily produced on its dissolution a fearful reaction. Greece particularly, in consequence of this shock, was exposed to the rapacity and misrule of successive masters. Despots assumed sway over this fair domain of freedom and of elegance, not one, but multiplied in almost every city.

Literature and the arts, as adding to the splendour of his empire, had been patronised, and merit liberally encouraged by this conqueror. The distant warfare also in which he was engaged, while it drew off her turbulent spirits, poured into her bosom the riches of the east, thus procuring for Greece an interval of prosperity and repose. Never had she before displayed a more imposing assemblage of intellectual worthies. Philosophy and science, sculpture and painting, every department of mind had its representative scarcely inferior to the greatest of her former names. Surely then the death of a despot could not alone have overcast with settled gloom a prospect so glorious? No. Had the free institutions of Greece been then restored; had the moral vigour, the unshaken patriotism of her better days reappeared, even amid wars and revolutions—contests it may be for existence, not empire—her genius and her taste, her arts and letters, would have survived with repaired, perhaps augmented, lustre. Amid such struggles they had been nourished. But the sources of corruption lay deep and incurable in the decay of that moral and political constitution, amid whose sterner and nobler fruits the arts had sprung up an ornamental blossom; and long did they flourish amid the wrecks of liberty—a wreath upon a tomb—a solitary and stunted tree, hiding for a while the unseemly nakedness of the ruin on which it grows.

Sculpture, our more immediate subject, had reached too high a state of excellence—was too generally diffused in its exercise and examples, to suffer immediate or conspicuous deterioration. The numerous disciples of Lysippus and Praxiteles, supported for a length of time the unimpaired science derived from their instructors. Indeed, it has been questioned, and with seeming plausibility, whether a single work now exists more ancient than the age subsequent to the death of Alexander. Pliny and his followers have therefore fallen into great error, in representing this as the date of a most rapid declension, if not extinction, of taste. *Cessavit deinde ars.* In assuming the demise of the Macedonian prince, and the dismemberment of his empire, as the era of decline in the history of Grecian sculpture, we, on the contrary, wish to be understood as pointing to the period in which the causes of that decline were called more directly into active effect. These causes, indeed, had for a length of time been previously preparing; but the conquests—the riches—the patronage—the excitement and spirit of enterprise then operating, retarded their consequences for a season.

The arts of Greece were innate in the constitution of her free states. They depended on—they fell with the vigilance of her magistrates, the incorruptibility of her judges, the bravery of her warriors, and the virtue of her citizens. It is not from this intended to maintain an amiable, although erroneous theory, which history contradicts, namely, that the fine arts have never flourished under despotic governors. The reverse is certainly the case; and in this more than in any other walk of imagination, is the countenance and active assistance of the existing government especially requisite. But we do maintain, that never can these arts flourish where patriotism and popular feelings are not the paramount, or at least the obviously paramount principles of the times. The arts themselves must be essentially free, and they must likewise derive their quickening inspiration from a common sentiment of interest, and free applause of the country. Whatever might be the knowledge or refined taste, however great the power or liberal the patronage of any prince, without awakening a community of feeling in the people, and the honourable zeal inspired by the public service and public estimation, his own solitary influence never could rouse into exertion original or continuous display of national talent. In sculpture and in painting, he might indeed, like Louis XIV. create schools of imitators and of flatterers; but vigorous, true, original genius lives not to be called forth by the smile of a monarch. As well might be expected in the artificial atmosphere of the hot-house, the beauty and the freshness which bloom amid glades and groves, freely visited by the pure breath and blessed light of heaven.

These truths are opposed both to the opinions of those who embrace, and of those who reject the theory. Are they consistent with the history of art? Pisastratus and Pericles, during whose respective administrations sculpture and the arts, in the principal school of Greece, first acquired importance, and attained their highest splendour, were absolute rulers of Athens. But the arts were free. They were applied exclusively to the public service and aggrandizement, while the voice of their fellow-citizens alone decided upon the merit of artists. So powerful was this last influence, that no work could be placed in its destined situation till after a public discussion and full admission of its excellence. Even Phidias prepared for this award with such trembling anxiety, that during the progress of his works, he was accustomed to listen unseen to the animadversions which might be offered. In the Elgin marbles also, parts are finished with a care which, not in the slightest degree contributing to effect in their future position, could have respect only to a close inspection while thus previously exhibited. In the age even of Alexander, the public voice continued to be the sole passport to fame, as it was the sole judge of merit; nor could all the influence of that prince obtain its award for a favourite whom he patronised, and whose failure grieved him more than the loss of a kingdom. Only when the purity of this source of honour was contaminated—only when a writer, fearing an iniquitous decision, could say to his friends, "Why should I go to the scorching valley of Pisa to read before the assembled Greeks; does not your approbation suffice?" Only then did art fall never to rise again? Political causes therefore, as contributing to the advance of sculpture, were essentially popular among the Greeks. And if we consider the epochs among the moderns, in Rome and Florence, it will be found that Julius II. and Leo X. rendered homage to the majesty of genius, and to the power of public sentiment. These pontiffs reared a school of matchless greatness, because they directed the energies of the arts to an undertaking which commanded the deepest sympathies of the whole Catholic world. In Florence, the best age of sculpture did not survive the republic, or at least republican forms; the last favour conferred upon his country by Michael Angelo, was to fortify her capital against the armies of her dukes. Many years afterwards the sculptor was brought back—a corpse to be returned to his native earth. There is in the sympathies which stimulate the exercise of talent, as in those which awaken the social affections—a sweet and gracious influence spreading from breast to breast, and uniting man to his fellow. The moral virtues flourish only in society, and genius lives but in the generous admiration of freemen.

These remarks sufficiently point out the causes of decline in sculpture after the age of Alexander. Into the few remaining details, or the names of artists whose works are now unknown, it seems unnecessary to enter. We may just observe, that not till every institution belonging to the republican times of Greece, and every sanction of a generous nature had been trampled upon, was art extinguished in that country. Not till the Olympic games ceased—till the physical education and martial exercises of the youth were neglected; till the arts, separated from national utility and glory, became the amusement of individuals; till there was no longer public spirit or patriotic feeling—not till all that creates and endears the name of country, had sunk under the military despotism of Rome, did Greece cease to produce artists.

The period of decline has been differently divided into various portions. Each favourable turn of circumstances which enabled the arts to recover a little from their depression, has been exalted into an epoch. But regardless of these transient intervals, we may separate this melancholy subject into two periods of unequal duration, and strongly discriminated in their events. Through both, however, as regards the fortunes of sculpture, we trace a similar declension. Happier views do now and then open upon the art, but the prospect is soon overcast, and the hopes entertained are soon perceived to arise from a brief revival of the practice of art—not a revival of science. A peace, the temporary triumph of some particular state, the influence of princes, might give a short-lived encouragement, and multiply works, imitations of greater names, but could not recal the principles and influences which to the labours of former ages imparted all their grandeur and excellence.

The first of these periods embraces a space of about two hundred years, from the death of Alexander to the final reduction of Greece into a Roman province. The second contains the history of the Roman school of sculpture, which, with various obscurations and revivals, existed to the age of the Antonines, or even of Gallienus. The latter division we have considered as properly belonging to the narrative of the decay of Grecian sculpture, because the Roman school of art was formed solely of plundered specimens, and of transplanted artists from Greece.

Alexander died in the last year of the 114th olympiad, or 324 B. C. At this time, Lysippus was alive, and Praxiteles survived to the 123d olympiad. For nearly forty years then subsequent to the death of the Macedonian prince, there could thus be no decline of genius, but there certainly was a want of encouragement, and a lamentable falling off in national enthusiasm for art. These causes would soon perceptibly operate against the production of great and original undertakings; still the excellence of individual performances would display little, if any, inferiority. If, again, the scholars instructed by these two great men be considered, the period may be greatly extended, during which Greece could have produced sculptors not unworthy of her best days. During this interval must have flourished Cephissodotus, son of Praxiteles, Tauriscus, sculptor of the Toro Farnese, Eubolus, Pamphilus Polyceutus, Agasias, and others. The chronology of Pliny, who assumes the art to have lain dormant in Greece from the 120th to the 150th olympiad, it is impossible to reconcile with these facts. To one of their Macedonian governors, Demetrius Phalereus, under Cassander grandson of Antipater, the Athenians, in the space of one year, erected three hundred and sixty statues of bronze, a proof at once of their means and their skill. Yet so rapidly did their reverse of fortune approach, that a few years afterwards, having engaged in a contest with Thebes against Sparta, they were unable, even by a personal tax upon every description of property, to discharge their quota of the expense. The Achæan league, and the expiring efforts of Greece under the last of her heroes, Aratus and Philopæmon, seem to have infused some degree of vigour into the art. Of these warriors, statues remained to the days of Pausanias; the latter, indeed, is said to have been particularly versed in painting, of which a flourishing school existed in Sicyon, his native country. The unhappy Etolian war proved most destructive to these prospects, and may be considered as giving a fatal blow to the interest of art, since it first taught the Greeks to disregard the sacred rights of the honoured dead, and the privileges of national genius. In this war, temples were first thrown down, statues destroyed, paintings defaced in Greece, and by the hands of Greeks.

The successors of Alexander in Egypt and Asia certainly endeavoured not merely to maintain, but to improve the feeble lights of European civilization spread through these regions by the conquests and policy of their leader. The courts of the Ptolomies and of the Seleucidæ furnished sustenance and protection to the banished sculptors of Greece; but both in Egypt and Syria, letters were cultivated in preference to art. In these foreign seats also, especially at the court of Alexandria, the principles of the great masters appear to have been departed from; and artists, while they multiplied works in a taste between Grecian and barbarous, only hastened the corruption of art. At the court of Pergamos in Asia Minor, a similar preference for science was cherished; but down to the time of Attalus, and the seizure of his kingdom by the Romans, the Pergamenean princes continued the most generous and the most judicious of foreign patrons. Sicily, long one of the favourite abodes of art, even during the early contests of the Romans and Carthaginians, offered an asylum and encouragement to sculptors. Soon, however, from her shores, as also from the Greek cities of Italy, the wide spreading despotism of the republic banished the pursuits of elegance. The capture of Syracuse by Marcellus terminated the glory of Sicily. In these countries, even the Greek language became disused; and as the last badge of servitude, permission was solicited to employ the Latin in their public transactions.

In Greece, the Etolian war was doubly unfortunate, destroying the idea of a common country, and giving cause to the first introduction of the Romans. For once, however, these soldiers were moderate, or they venerated, even in their fallen condition, the mother of arts and arms. Uniting with the victorious Achæans, they defeated the Macedonians, and proclaimed the Grecian cities free. This event occurred in the 145th olympiad, or 194 B. C. and forms the last bright interval in the history of Grecian art,—the setting beam of a long cloudless sun sinking into dreary, everlasting night. For more than thirty years, Greece enjoyed liberty and repose. Sculpture, during this interval, acquired new vigour, and was exercised by many artists of considerable merit, though far inferior to the masters of former times. Of this age, many names have been preserved, the chief of whom were Antheus Callistratus, Polycles, Apollodorus, and Pasiteles. But the liberty of Greece endured only through sufferance. The Romans permitted its enjoyment only because they could take away the blessing at pleasure; or their attention was engaged by more powerful opposition. The same year in which Carthage fell, the Achæan league was dissolved, and Corinth, the capital of the association, levelled with the ground to the sound of Roman trumpets. This ominous peal sounded the death-knell of the liberty and arts of Greece.

Before bidding adieu to this part of the subject, one particular inquiry demands attention; to what age are to be assigned the principal remains of classic sculpture now in existence? This investigation is deserving of far more space than can now be afforded; but a few remarks may not be irrelevant. The different opinions which, in this instance, have been hazarded or maintained, may be referred to one or other of the following:—that these remains are copies executed during the imperial government at Rome from Augustus to Titus inclusive, and some even so low as Hadrian; or secondly, that in the finest pieces we possess the actual originals—productions of the best ages of Greece. The former position is endeavoured to be proved from the fact, that the artists whose names are inscribed upon some of the most celebrated of these master pieces, occur in no writer prior to the era of Pliny; while the works themselves cannot be traced to any ancient description, or where a connection can be ascertained, it is between a bronze original of some older master, and the marble now remaining. To these historical doubts, arguments in favour of the second position are opposed, drawn from the philosophy of art, the style of composition exhibiting too great perfection almost to admit of higher excellence, certainly not showing any of the usual characteristics of works merely copied from others.

Without entering into the merits of this interesting controversy, it may suffice briefly to state our own impressions, derived from a careful examination of the marbles themselves, and comparing the experiences thence obtained, with the analogies supplied by history.

It is difficult, if not impossible to fix beyond even reasonable doubt, the particular era or master of any one of the most esteemed antiques. Two facts, however, may be elicited with a degree of certainty. First, that very few indeed of the ancient statues now existing are originals of celebrated Grecian masters; but secondly, none of the most esteemed of these remains can be ascribed to a period much later than the death of Alexander. From the premises whence these conclusions are derived, all considerations founded on mere omissions in the limited accounts of Pausanias or Pliny are excluded. The positive evidence of these writers, especially of the former, is very valuable; but as he describes such works only as existed in Greece at the period of his travels; and since Pliny's narrative is an abstract, meagre at best, and confessedly inaccurate, arguments drawn from omissions, in such cases can have no weight. It remains then simply to show how copies would be preserved while the originals perished; and that the age we have fixed upon was capable of producing copies so exquisite. The very care with which precious originals were preserved, and the veneration attached to them, became active means, in many respects, the sole means, of their destruction. In fires, in war, during political revolutions, by the fall of edifices, the statues which, being most valuable were placed in the interior, would suffer most. Under the later emperors, when all that was most admired in Grecian statuary was to be found in Rome or Italy, and in Constantinople, religious zeal proved more destructive than either time or warfare. The Iconoclasts would select as objects of peculiar hostility exactly those works over which "the fond idolaters of old" had bent in greatest admiration, and which would now be most highly prized by the cultivated mind. It is easy to perceive how this reasoning applies to the preservation of transcripts from these perished masterpieces. On the death of Alexander, we have seen that the schools of Greece, especially the Athenian, were formed of the disciples of Lysippus and Praxiteles, and that the latter survived that catastrophe many years. For nearly half a century, therefore, there could not be wanting sculptors in Greece equal to the most perfect works now known. But political convulsions rendered this period unfriendly to the advance of art in the production of original performances. Nor is it too much to say, that original genius from this date became more and more rare. At the same time, imitations from the earlier masters were multiplied in every era, as may be proved from the close resemblance existing between innumerable single figures and individual remains which have been copied from the Elgin marbles. The pupils of the two last great sculptors of Greece were employed, then, during this interval, in which the arts, supported solely by individual patronage had first ceased to be the care of the state, in copying, or rather repeating the most admired conceptions of their masters. And to this period we assign the greater part of antique statuary now in the different collections of Europe. Our limits do not admit a more extended detail of proof; but as a general inference, selecting the most beautiful of these works, it may with confidence be affirmed, that whether originals or transcripts, subsequently to the date assumed, they could not have been executed. Considered as a whole, each is so perfect; between the intellectual and material excellence the harmony is so delightful, so complete, as could be obtained. while yet the art languished only in practice from defect of encouragement, but while talent and skill continued unimpaired. It will be found, also, that in works avowedly executed later, although parts separately considered, and portraits especially of the earlier Cæsars, may display the highest beauty; yet this perfection of the whole, this pervading impress of a rich, vigorous, and accurate science—this *imponere totum*, the triumph of art is wanting.

But it may be said, if there be original works of the great masters, how are they to be distinguished, what are the grounds of decision, and why should other productions, hitherto perhaps enjoying equal estimation, be degraded from their rank? These are questions not to be determined without reference to taste merely—a principle always more or less subject to individual modes of thinking and of feeling, or to rules of criticism not fully established, or not universally applicable. Judgment consequently becomes simply an expression of opinion, entitled to deference according to circumstances; beyond this a conclusion ought neither to be urged nor received. The least objectionable criterion of originality seems to be to select a standard, the merits or authenticity of which cannot reasonably be called into dispute. For such a purpose the Elgin marbles appear on the whole most proper. From these, notwithstanding their mutilation, to one versed in similar inquiries, it does not seem impossible to elicit a system of infallible criticism applicable alike to characteristic and to executive art.

Tried by such a standard, while it is compared with itself, and with the history and principles of classic sculpture, a very limited portion indeed of the antique statuary now extant will be found to belong to the age of Phidias, or to be from the hand of an original master. Of the former period, we believe there is but one specimen in Italy, namely, the *Torso* of the *Belvidere*; which compared, for instance, with the Theseus of the Elgin marbles, displays the same bold, learned, and breathing style of composition, and is certainly of the same school, perhaps by the same hand. After this, the Venus de Medici, the Niobe, and the Venus of the capitol, approach nearest to the perfection of the grand and simple style of execution, while the sentiment belongs to the truly beautiful. These are certainly originals of the earlier schools, most probably of Phidias, of Scopas, or of Praxiteles, but not later. With these we rank the Townley Venus or Dione, now in the British Museum. The Apollo we are inclined to consider as a transcript from a bronze original—probably of Lysippus. This opinion is founded not so much on the inaccuracies of detail, as upon the general bearing of the figure, which scarcely seems not adapted to representation in marble so well as in metal, without external support, in addition to the balance obtained from the disposition of the attitude. This is a principle never neglected by the ancient masters. We not unfrequently discover the most exquisite skill employed to unite grace with strength in this respect. On the contrary, copies from bronzes may be often detected by some unbecoming fragment of marble left adhering between the body and an extended member. In some few instances this defect has been obviated by the introduction, or novel distribution of drapery. In the present case, the Chlamys, wrapped round and descending from the right arm, has been added in the Apollo, an arrangement which, though not ungraceful, is inconsistent with the action of the figure. The numerous class of antique sculptures, which may be termed athletic, appear to have been all copied from bronzes, seemingly from the age of Myron down to that of Lysippus. Of these, one of the most celebrated, is with equal impropriety, styled the fighting gladiator or Chabrias. This beautiful form represents a warrior defending himself against an antagonist who stands on vantage ground. Of the Laocoon there is difficulty in speaking with assurance; or rather the praise which has been lavished, both by ancient and modern authors, on this remarkable production, creates a timidity in expressing a dissent from the almost universal applause. Whatever may be the individual excellence of parts, considered as a whole, the work is in more than one respect faulty. The figure of Laocoon himself is truly noble; but those of his sons are in every view unequal accompaniments. They are, in fact, mere mannikins, deficient in expression, in form, and in anatomical science. The position of the principal figure is dignified, natural, and even awfully imposing; their attitude is ill selected and ineffective. While the one is not unworthy of the best ages of Grecian art, the others are by no means superior to works executed under the Antonines in almost its latest decline. The expression, indeed, in the former is more powerful in character, than altogether consistent with that majestic serenity which formed the intellectual ideal of ancient masters. This expression, however, is only a general indication of suffering, and the soul seems struggling to overcome or repress its agony. In the execution there is a meagreness, a dryness, not to be discovered in the age to which the high style of design can properly be referred. We are thus lost in the contradictions which the work presents; and in what era lived Agesander, with his sons Apollodorus and Athenadorus, to whom the work has been assigned, is by no means apparent. Whether, with the Italian and German critics, we place this period between Phidias and Lysippus, or, with the French writers, fix it so low as the first century, during the reign of Titus, the difficulties remain. The figure of Laocoon would do honour even to the former of these ages, but it is impossible for a moment to believe that the children could have been executed in an era of the most perfect art; again, these latter may well belong to an epoch of Roman sculpture, but in the reign of Titus no performance can once be compared with the sublime conception of their aged sire.

We shall not pursue further this examination; the application of the standard proposed, to every remaining specimen of antiquity, may be easily made on the same principles. The conclusions are here ventured as modest expressions of opinion; let it however be remembered that they are formed on no imaginative theory, but on a comparison of art with itself—the only criterion by which the works of art can be classed or estimated. One argument, not yet noticed, may be deduced in opposition, from the names inscribed even upon some of the examples we have selected. This furnishes an opportunity of observing, once for all, that when such inscriptions contradict the chronology implied in the style of the work, the names are certainly not to be considered as those of the original fabricators of the statue. Indeed, in a very few cases only do these names agree with the ordinary tests even of antiquarian criticism. The form of the letters in most, and in some, as the Venus de Medici, grammatical inaccuracy indicate a lower age than could possibly have produced such works. These inscriptions, therefore, are either actual forgeries, a species of literary larceny, or have been affixed on occasion of repairs or restorations by the Greek artists of the empire. Such repairs we know to have been effected, in more than one instance, by command of the reigning emperor.

From the fall of Corinth, Greece is known in the history of the arts only as the unhappy source whence the plundered ornaments of Rome and of the patrician palaces of Italy were torn. Or more unfortunate still, she furnished the talent which, in busts and statues, was to immortalize the lineaments of her enslavers. Or yet greater degradation, she, the nurse of free born genius, was doomed to impart to their manumitted slaves those noble arts which her haughty conquerors disdained to exercise. Cicero has condemned to perpetual infamy the rapacious cruelty of Verres, but in every state of Greece the rapacity, if not the cruelty, was exercised unpunished; even the orator himself did not scruple to beg, as gifts, statues which he could not purchase, and which he knew his more fortunate friends had acquired only by violence. Three thousand statues are reported by ancient writers to have been removed from the isle of Rhodes alone. Corinth was deprived of all; each city yielded up whatever appeared most precious; and this desecration of her temples, this despoiling of her high places, this general sacking of public territories, and revolution of private rights, was not finally completed by the republicans. Greece possessed something of value in sculpture till the close of the first century, during the course of which every portable masterpiece disappeared.

During the latter period of the commonwealth, the practice of the art, but by Greek sculptors, was introduced at Rome. Scylla, Pompey, Cæsar, introduced or first patronised, to an extent equivalent to an introduction, the custom of erecting statues to public men. By thus furnishing employment to the actual arts of Greece, they compensated in some measure the removal of her ancient treasures; but finished by transferring from her soil the remembrance of the dead, and the merits of the living. Of all the nations which have held supremacy on the earth, the Romans show the least claims to originality, or have least impressed the future fate of the human mind by any bold peculiarities, or successful darings of their own genius. The character of their intellectual partakes of the tenor of their warlike achievements. In both this character staid and regular, but neither novel nor much varied; forming part of one system by which care, perseverance, and discipline supply the place, or indeed deny the exercise of the generous but more desultory efforts of native talent or untutored bravery. In warfare they borrowed their principles from enemies by whom they were first beaten, but who in turn were subdued by the addition of Roman vigilance to their own science. They left nothing to chance—no room was given for surprise, and little for stratagem. Each march was marked out—each night the camp fortified—prudence was opposed with success to valour, and they subdued the world by the discipline of the legions, rather than by the heroism of the soldiers. Hence in the history of Roman conquest, we meet with little of that chivalrous enterprise—of bold adventure—and high heroic soldiership which give their spirit-stirring interest to the annals of Grecian or even barbarian warfare. In the regions of imagination and of taste, the progress of their genius resembles the march of their arms on the globe. They have left only modifications of the exquisite materials produced by their predecessors. Yet from the Greeks they have borrowed little which by care and study has not been improved. The improvement, however, extends only to the fabric—not the material, which remains with little alteration and no addition. In fact, had the Romans ceased to exist before the rude ignorance of our forefathers had borrowed from their legislative or rather civil code, not one element of thought—not one discovery which dignifies his nature—not one invention which extends his power, would have been lost to man.

If such be nearly the case in literature, in philosophy, and in every branch depending upon fancy—in the fine arts the originality of Roman genius is still more circumscribed. The character of the national talent seemed indeed well adapted to succeed in sculpture. But three things opposed this: they regarded the art as the peculiar eminence of a conquered people, and its productions as fruits of victory not as triumphs of mind, hence they cherished no genuine enthusiasm, no real respect for its excellencies, they never practised its labours; secondly, their national manners, and the desire they early affected for being represented in armour, were opposed to the advancement of sculpture; and thirdly, the amazing richness and beauty of the Greek specimens so profusely lavished throughout Italy, rendered their masters indifferent to original works, which could not even equal these, and desirous only of portraits. But even the statuary, whether busts or ideal statues, were executed by Greeks, nor does it appear that a single Roman attained eminence in the art. The history of sculpture indeed among this people is distinguished by two singular yet very similar epochs.

In the dawn of her rising fortunes, we have seen that Rome was first adorned by the ravished spoils of

Etruscan art: that sculpture there transplanted, soon decayed or was forgotten, among a warlike and unimaginative people. It would answer little purpose, therefore, to enlarge on the consular and early republican ages: the past borrowed—the living arts are characterized by Tibullus

"Stabat in exigua ligneus æde Deus."

And Cato opposed the introduction of the statuary of Greece, on the plea, that its divine forms would expose to ridicule the rude fashioning of their own deities. As the first era of the art was thus formed by an ineffectual attempt to affiliate the genius of conquered Etruria; so the second exhibits a similar trial, and similar success with subjugated Greece. The history of sculpture in Rome then is but the melancholy continuation of its fate, closing the last faint glories of Grecian art in a strange land.

The reign of Augustus, like that of Alexander, was favourable to the arts only as respected their political influence. The crafty successor of Julius, to conceal the loss of civil liberty, affected to turn the genius of his subjects to intellectual empire. From being the mistress of the world by arms, he aspired to render his capital the seat of elegance and of knowledge. This was but gilding after forging with exquisite nicety the fetters of the once haughty and jealous republicans. The objects here were not those which an innate, a real love of acquirement seeks, yet the external effects in reviving the practice and awarding the professors of the art at least were the same. Rome now became the sole field where the sculptors of Greece, in the exercise of remaining skill, found recompense if not honour. Hence every man of talent began with the first appearance of settled government, to repair thither, and the collecting there all the master pieces of former and better days, added a new inducement. Rome then, as now, came to be regarded by every artist, as

"His country—city of the soul."

Among the sculptors who thus adorned the Augustan age, several names have reached us. Pasiteles, Archesilaus, Zopirus, Evander, Athenians, or Greeks, were the most eminent. The first excelled in metal and as a modeller. His silver statue of Roscius, an infant in the cradle on the point of being strangled by a serpent, an incident in the childhood of the actor, was much admired. The vases of Pasiteles, as also those of Zopirus and Evander, were highly esteemed. The two latter were likewise eminent for relievos in metal.

——— Mensave Catillum
Evandri manibus tritum dejicit.

Archesilaus greatly excelled in works of marble: he is praised by Pliny for his improvements in modelling, and for the care with which he studied his compositions in clay or wax, before attempting to realize his conceptions in more durable materials. Varro describes, with lively simplicity, a group from his hand of one block, the property of Lucullus, representing a lioness with cupids sporting around and forcing her to drink. The Venus Genetrix, ordered by Julius Cæsar of the same artist, so delighted the accomplished patron, that through impatience to dedicate so beautiful a work, he removed it before the last finish had been given;—a defect, however, not to be discovered.

But the movements created by the patronage of Augustus of one who could wield for his purposes the energies of the enlightened world, were too general and too extensive to admit of particular description. Every branch of human pursuit felt more or less the influence. Museums of nature and art crowded the temples; galleries of painting and of statuary assembled whatever was rare, beautiful, or precious in either; libraries were formed, displaying the whole intellectual riches of human science.

"—— Veteres revocavit artes."

As regards our present subject, however, the creative spirit could not be recalled. The remains which undoubtedly belong to this era of sculpture offer the strongest proof how little can be effected by even the most unlimited patronage without the aid of moral causes, in the production of genuine and original talent. To those who extol this reign as capable of such works as the Apollo, we recommend a comparison of that divine figure with any statue of Augustus. Surely an inferior artist would not have been employed upon the likeness of the emperor, while others so much abler could have been procured. Compared with any work having pretensions to Grecian antiquity, these statues are poor in the extreme. Not so the busts of the Roman school, which, without suffering by the contrast, may be confronted with similar works of the best ages of Greece. In this department only do we discover undoubted vestiges of ancient genius; and we believe it will be found, that, forming from these remains their estimate of the state of Roman art generally, writers on the subject have been led into those exaggerated opinions of its excellence already noticed. These busts indeed, from Julius to Gallienus, through a series of three centuries, present some of the most perfect examples of the art in portrait. They do not indeed equal in heroic character one or two remains of Greece, but we are struck with the most powerful representation of individual mental resemblance. Omitting all dry or minute detail in the scrupulous rendering of each separate feature, the artist has addressed himself to the portraiture of the mind. Into the whole movement of the countenance is infused a speaking, a characteristic expression, as if the marble were but the translucent prison of the soul, setting before us the very actor in those deeds which have formed the studies of our youthful years. But this high perfection applies only to the last period of the commonwealth, when each chief of a division among the conscript fathers could have embroiled and would have ruled the world; or extends not beyond the early reign of Augustus, while yet the free and fiery spirits of former times had not learned to quail before a master. As we advance, the impress of grandeur and energy of thought becomes more obscured. The withering influence of despotism, or the debasing contagion of profligacy, spreads a dull and brutal calm over the expression like the mantling of the lake above corruption. The series of the Cæsars, indeed, as furnishing examples of art, continues to be fine, but the expression is too often such as the imagination cares not—or dreads to explore. The fall of material art keeps pace with the decay of internal grandeur. The rapid decline of the only branch of sculpture in which the Roman school attained eminence, is certainly in a great measure to be attributed to the discouragement imposed by the jealous fear of succeeding emperors, who forbade the erection of busts save in their own honour: but there is too much truth in the lament of Pliny, that when there were no longer images of mind, the lineaments of form also degenerated. *Quoniam animorum imagines non sunt, negliguntur etiam corporum.*

From this series of busts, the style of art during the Augustan age, and the different vicissitudes which Roman art has undergone, may be known with great precision. The character of design and of execution is evidently the same as that by which the last era of art in Greece is distinguished. In the finest specimens there is no evidence of new energies added by the union of two separate modifications of talent; nor in the most inferior is there any exhibition of the more original, though perhaps ruder, efforts of an aspiring and distinct national taste. Either or both of these effects must have been perceivable, on the supposition that there were native, previous to the migration of Greek artists. Nothing is more easily discriminated than is the vigorous inaccuracy of rising art from the languid correctness of its decline: and every thing in Roman sculpture discovers a progressive step from a condition of high excellence; every touch shows what has been, not the eminence for which we are to draw upon futurity. When we compare the latest works executed in Greece with the earliest productions of the republican and Augustan ages, there appears in each a continuation of the same principles, with such difference as the political and other causes already noticed, can easily reconcile. The style of design during the period of which we now speak, is accordingly marked by a squareness and decision in the arrangement—a boldness and firmness in the pronouncing of the parts evidently derived from the successors of Lysippus and of Praxiteles. The mastery of touch, indeed, is frequently so bold, as to be redeemed from the imputation of careless and unfinished only by the truth and vigorous meaning of every stroke. Dexterity of mechanical detail is among the last beauties which linger in declining art; it begins first to disappear in those passing lines of thought and form where little meets the outward sight, but in which the science and feeling of the skilful artist are most surely displayed. Striving to recover these, but more by practice of hand than by exercise of mind, the succeeding age still further degrades art by rendering their productions tame, hard, and laboured. The Augustan age of sculpture hovers between these extremes; the masses are large and fine in distant effect, but the details are not clearly made out. The expression of the eyes is studied, and, evidently with the intention of producing an imposing air, the eye-ball is made larger than in nature. The hair is particularly heavy, and, though bold in the general arrangement, is harsh, from a want of a proper and just degree of finish. As compared with the sculpture of the preceding ages, there is, indeed, in the works of this school a general character of harshness. An absence of those sweet and flowing lines, which bring the whole contour fully but graciously upon the sense, yet without palpable obtrusion on the eye; which invest the pure specimens of Greek art with a moving and evanescent shape eluding research, yet circumscribing beauty with the breathing variety of softness and of life.

Such continue to be the leading characteristics of Roman art, under the immediate successors of Augustus. The defects, however, continue to increase, and a considerable degradation is to be perceived even during this reign. A laborious and mannered style, in imitation of the sophists, spread from literature to the arts, and introduced the beginning of the lapse toward the second stage of deterioration, where remaining mechanical skill is wasted on tedious and ineffectual finish—patience of labour supplies the place of vigorous design—and from Augustus to Constantine, the art gradually subsides into worse than pristine feebleness.

The reign of Nero has been considered as peculiarly favourable to sculpture, and has been assumed by Pliny as forming an era in the history of art, which he considers to have been dormant for nearly forty years. That Nero lavished immense sums upon building, painting, and statuary, is true,—he collected from Greece whatever of precious or rare former invaders had spared; but that he improved the actual state, or even retarded the decline of art, may be questioned. His taste like his morals was vitiated, and to him the arts were objects of luxury and vanity, not sources of intellectual pleasure, of which he was incapable. Nor does it argue much for the state of art in Rome, that Zenodorus, a provincial artist of Auvergne, was called from Gaul to cast the famous colossal statue erected in the vestibule of the golden house. The age, however, must have been very far from deficiency of resource or of refinement, in which could be produced a bronze figure one hundred feet high, or the heads of Nero, especially the exquisite likeness as a child, now in the Florentine gallery.

The school which flourished in Rome from the termination of the republic to the reign of Nero, adhered strictly to the principles of the Greek masters, allowing for the defects of general inferiority. The founders or principal artists of this school were Diogenes of Athens, who finished the statues with which Agrippa adorned the Pantheon. Batrachas and Scauros, sculptors and architects, who built and adorned the porticos of Octavia, and whose ingenious hieroglyphic cypher is still to be traced in the frog and the lizard, in the eyes of the volutes, in some ruins of the Forum. This was contrived in order to associate their memory with a building upon which they were prohibited from inscribing their names—the literal meaning of these names being the animals thus artfully introduced. Pliny enumerates and praises many others. Philiscus, Pythodorus, Hermolaus, Artimon, Lysias, &c. whose exact age or labours are not ascertained, but whose names and pupils bring down the art from the republic, through the first eighty years of the Christian era.

The reigns of Vespasian, Titus, and Trajan, were on the whole favourable to Sculpture. The great works of this period, however, being architectural—temples, palaces, and triumphal arches, the sculpture chiefly encouraged was that adapted to the decoration of such erections. This was not calculated to retrieve the lapse of the art, but rather to nourish the deterioration arising from bold and facile execution being preferred to simple and accurate design and natural expression. The bas relief still existing upon the frize of the temple of Minerva, in the Forum of Domitian, instances the truth of this remark. As Winklemann has observed, this figure, for their remains only one, has the appearance of having been merely blocked out, so bold and unfinished is the workmanship,—to the justness of which criticism we can bear witness from having frequently drawn and studied this interesting ruin. The few remaining sculptures on the ruined arch of Titus exhibit the same character, but the monument itself is of fine proportion and design. Architecture, indeed, longer preserved its purity among the Romans than sculpture; such at least appears from the more enduring edifices whose gigantic remains have reached our days. But there is abundant proof from more fragile sources, that even early in the reign of Augustus corruption had commenced in this noble art. The great error in the views introduced by the Roman architects, was a constant aim to lessen the diameter, while they added to the height of their columns. The principle indeed may be generally applied to all supporting members. The solemn grandeur and majestic serenity of the Grecian proportions were thus lost without any increase of lighter grace. The cultivation of such a taste among the Romans becomes the more singular, when considered in connection with the facts, that they were a less imaginative people, less gay in their dispositions than the Greeks, while on the whole, in their grander erections they employed materials of superior mass. In architecture, however, in which no standard of immediate imitation is fixed from natural prototypes, deviation from abstract symmetry once admitted, license has no acknowledged bounds. There exists a tendency in false taste to substitute in this art ingenious contrivance for elegant skill; hence the principle of deterioration above noticed. The enormous pillars of the Egyptians were by the Greeks refined into proportion uniting security with grace. The Romans, aiming at greater lightness, then at surprising, first reduced this proportion, and finally deviated into almost every barbarity of column, paving the way for the fantastic tricks of the Gothic architect, who seems to have placed perfection in setting at apparent defiance the ordinary laws of gravitation.

In the empire, as respects architecture, there also existed a peculiar source of corruption not known to Greece. In the latter, one patron, namely the state, the representative of the public, left the artist untrammelled by the influence of private judgment or individual taste, and free to pursue the general principles of art. In the former, the emperors were not only the sole dispensers of reward, the approvers of merit in works undertaken by their especial order; but the example of their sovereign being followed by wealthy subjects and public functionaries, who, erecting at their own expense, porticos, temples, theatres, aqueducts for the public benefit, claimed and exercised similar rights of private patronage. The art was thus no longer the free servant of the public, but subject to individual taste, against whose exclusive approbation or censure there was found no protection in the common sentiment.

That some of these causes of decline in architecture had begun to operate so early as the reign of Augustus, is obvious from remains, and from pictures recovered from Herculaneum and Pompeii, as also from history. At the period now mentioned, Plutarch informs us, that under Domitian columns of Pentelic marble had been rough hewn at Athens for the temple of Jupiter at Rome, but when finished in their site according to the Roman taste, they had lost their noble proportions, and to an eye practised in the arts of antiquity, seemed about to be crushed by the building which they supported. This taste appears more incongruous still when viewed in comparison with the contemporary style of sculpture as observable in the fragments of the colossal statue of the same Domitian now in the capitol. These immense masses, bold and harsh, but vigorous in their execution, would indicate a state of art the very reverse of what has now been described, and evince the absence of all uniform or consistent principle.

But although corruption was thus at work, the external condition of art was flourishing. Vespasian and Titus erected noble edifices, containing not only the most precious productions of the chisel and the pencil, from the hands of ancient masters, but also adorned with the works of living artists. Of these, such names as Cornelius Pinus, Accius Priscus, would seem to furnish evidence that, in painting at least, natives now began to rival their Grecian instructors. Artists, indeed, educated in Italy were usually freed men: hence our term liberal arts, and in these or other instances, might, therefore, have adopted the names of their former masters—an usage not uncommon. Certain it is, that the whole fabric of Roman art, in its principles and practice, still continued Grecian; while in the succeeding reign of Trajan, an era peculiarly favourable to the arts of the empire, his favourite architect Apollodorus, as well as the sculptors whose names are known, were Greeks.

The arts under this emperor partook of the elements of his personal character. Their applications were grand, substantial, and useful—beautiful in execution; but this beauty subservient to utility. Of the grandeur and enduring character of the erections with which he adorned almost every province of the empire, the triumphal arch at Ancona is an instance composed of the largest masses of any classic work in Europe. But even here, in the proportions of the columns and ornaments, we detect the faulty principle already noticed. Of utility in these works, the harbour of Ancona—of greatness united with beauty, the historical column remains an example. Considered as a monument of labour or of skill, this storied pillar is one of the most wonderful vestiges of the ancient world. Rising amid the spires and domes of the modern city, it is conspicuous by a certain venerable simplicity; and though, with a diameter of eleven feet, attaining an elevation of nearly one hundred and twenty, the whole is composed of only twenty-two blocks of white marble. From the base to the abacus, the exterior surface is covered with sculpture in relief, representing the leading events of the Dacian war; internally is a winding stair hewn from the solid blocks, each of which forms a complete frustum of the pillar. It is this latter adornment which requires our present notice, for in architecture the work constitutes an innovation. These sculptures are contained within a kind of fillet about four feet broad, making in the height of the shaft twenty-three spiral convolutions. The number of figures, including elephants, horses, and warlike engines, amounts to some thousands, all wonderfully varied, and forming subjects of study not less interesting to the artist than to the antiquary. The design and execution are correct and vigorous; the relief well adapted to effect, yet without injury to the general outline. The character and style are decidedly Grecian, though the details are defective or usually wanting; yet there appears a strength and decision in the forms, a breadth in the parts, a facility of hand, and firmness of drawing, which point to their source in the Athenian school. This noble monument, erected by the senate and people, shadowy names! in the commencement of the second century, exhibits the greatest, as it was among the last efforts, of the true Greek school in Italy.

With the reign of Hadrian in the seventeenth year of the second century is introduced a new style of sculpture. From this date commences Roman art, properly so called, the distinguishing characteristic of which is extreme minuteness of finish, in this respect differing widely from the genius of the preceding century. Writers on the subject seem to have overlooked, or not to have been acquainted with this fact, and have described the distinctive peculiarity of Hadrian's age as belonging to the arts of the empire generally. There are, as already hinted, two eras in the history of sculpture in ancient Italy. Boldness of general effect, without the Grecian delicacy and exquisite skill in the detail, characterize the art under the early Cæsars. The second stage of decline we have now reached; when, seeking to recover the varied harmony of parts, the correct, yet grand details of ancient masters, but ignorant of their scheme and method of study, the Roman artists fell into the dry, the languid, and minute. In a falling art, while the greatest master-pieces had long been produced, and consequently, where imitation only could be the highest praise of the best, this path necessarily conducted to feebleness, imbecility, and final extinction.

Under Hadrian, however, this extreme is yet distant, the downward inclination only is more decisively given. The admiration of this emperor, otherwise possessed of taste, and some knowledge of art, for imitations of Egyptian sculpture proved directly adverse to the recovery of a free and generous manner. In the sculpture of this period every thing indicates the labour rather of the hand than of the mind. The design is borrowed, the execution is painfully original—the chisel—the file—the drill have been plied with ceaseless care, and with great mechanical dexterity. The hair in particular is often finished with a most wonderful address, as are likewise the eye-brows, which are more elevated than in works of a better age. The pupil of the eye is marked by a deeply drilled orifice, a peculiarity by which a work of this period may certainly be distinguished from all earlier performances. Over the whole genius and spirit of the art is now diffused an air of research, of studied, and even affected refinement, which smooths away every characteristic and natural expression. Hence in the contours of the head, and features of the countenance, though the separate parts be diligently rendered, and even more deeply marked than in more happy times; yet the principle of life, the exhibition of mind and soul, is wanting. For the sublime is substituted the difficult; for the elegant the florid; in short, sculpture abundantly proclaims the taste which preferred Antimachus to Homer, Dionysius and Favorinus to Demosthenes and Cicero.

The state of art under Hadrian, indeed, illustrates in a forcible manner our former remarks on the influence of individual patronage. His was a mind, active, not great, desirous of knowledge, without the grasp required for extensive acquisition; a taste capricious rather than refined, an imagination imitative, scarcely original, since the limit of his conception was to bring home more directly to the feelings, habits and national taste of his Roman subjects, those arts which they had been content hitherto to cultivate as exotics. Thus, the character of the prince, is exactly that of the genius of his age. Nor could it be otherwise in the arts, for however liberal to writers, to artists he proved an imperious dictator or envious detractor; painter, sculptor, architect, he could "bear no rival near the throne," who was not the creature of his will. Apollodorus, the favourite of his predecessor, paid with life the opposition which he ventured to make to some plan of a temple proposed by this "imperial mimic of old Egypt's piles." Yet has it been maintained that despotism is the clime genial to the arts! Let us not, however, be unjust; the remains of this age exhibit in some instances no mean beauties, and are among the latest relics of ancient elegance.

The reign and disposition of the Antonines were very favourable to the exercise, if not invigorating to the style of sculpture. Vigour, indeed, could not be restored, and the splendour was but a temporary dispersion of the darkness fast closing around the horizon of ancient greatness. Beyond this period, indeed, we need hardly carry our inquiries. How rapidly the arts had degenerated is evident on comparing the historical column of Trajan with that of Antoninus Pius, or more properly of Aurelius. Both are constructed in the same manner, the latter being composed of twenty-eight stones, and though of greater diameter, nearly of equal height, but in every respect indicative of talent the sculpture is greatly inferior. The equestrian statue of Marcus Aurelius is indeed one of the noblest monuments of antiquity, and shows deficiency neither of talent nor resource, but not possessing the means of comparison with any similar work, we cannot ascertain the comparative state of art. The busts of this period, especially the portraits of Marcus Aurelius, and Lucius Verus, are examples of the minute finish now constituting the highest excellence which the genius of the age was capable of producing or of appreciating. Throughout the course of the succeeding reigns this character varies only in its accessions of cold and unmeaning laboriousness. Under Severus a singular fancy arose of marking the countenance, especially the forehead, with deep furrows, adding still greater rigidity, with a yet more decided retrogression of redeeming excellence. Indeed it is hardly possible to conceive more rapid decay in all the remaining qualities of higher art, than must have taken place between the execution of the bronze equestrian statue of Aurelius, now in the capitol, and that of the sculptures on the arch of Severus, half buried amid the ruins of the Forum. The difference is yet greater, because the interval is longer and the inferiority more lamentable, in the bas reliefs on the arch of Constantine, that is, those of the same date, and not carried off from more ancient buildings, as compared with those on the arch of Severus. Beyond Constantine it would be vain to trace the progress of sculpture. Even the building of the eastern capital imparted no revived energies: for although the shell was the work of the age, as also the grosser ornaments, the plundered cities of Europe and of Asia supplied the only precious evidence of refined embellishment. Succeeding emperors pursued the same path, yet some degree of intelligence in art still continued, even to the fall of the empire; but to explore its results, would prove at once a melancholy and profitless exercise.

PART II.

MODERN SCULPTURE.

In the preceding columns we have traced the history of ancient art till genius appeared no longer to animate its efforts. It is not intended to assert that art itself became extinct; it is impossible to conceive the existence of a people, rich and luxurious, among whom the fine arts to a certain degree had ceased to be cultivated. But when in Italy an imperial master of the world is found pilfering from the virtuous record of a predecessor a few ornaments to adorn the tribute of their applause or of their flattery, which the living talents of his subjects could not supply—when her own matchless speech ceased to be understood in Greece—the ancient annals of human improvement might, as appeared, be closed. Long, dreary, and void is the darkness which must elapse before the books can be again unsealed in light. Still the human spirit was at work; the stroke of sculpture, rudely directed indeed, might be heard feebly sounding through the gloom; the pencil yet traced its barbarous mimicry on the chapel and the palace: the legend of the monk, the learning of the cell, filled the seats where philosophy and the muses once presided. In the west a series of monuments in Italy and Sicily enable us to trace the vitality, if not the progress of art, from Sylla to Nicholas of Pisa. In the east, the collections of the Byzantine historians, and even the remains now existing in Constantinople, prove a similar fact. The literature of the middle ages evinces, in both empires, the activity of imagination if not of judgment. The preservation of the classic monuments exhibits also a degree of taste, incompatible with the supposition of those ages possessing no arts of their own. In the commencement of the twelfth century, or even later, many of the master pieces of Greek sculpture, transported to the eastern capital by Constantine and his successors, were to be seen uninjured; they just caught to reflect for a moment the first ray of returning intelligence, then sunk for ever. To restrict our remarks to the subject under review, in the provinces of the west, the kindred studies of sculpture and architecture preserved throughout the lapse of those ages emphatically termed dark, some degree of reputation. The gloomy magnificence of the feudal baron, as formerly the polished elegance of the Roman patrician depended on their aid. Accordingly, in the monuments of those Italian cities, as Naples, Pisa, Siena, Venice, whose antiquities unite, as it were, ancient with modern history, we trace an almost continuous cultivation of those arts. An attempt, however, to record and to arrange the scattered evidences, unknown names, or probable conjectures, with which this space might be filled up, would neither be wise nor entertaining. We pass at once then from the age of Constantine to the revival of arts and letters in the Italian republics. In rapidly sketching the history of modern sculpture, our chief attention is commanded by the genius of Italy, on which the greatest artists of other nations must be content to appear as attendant stars. Our subject will readily admit of the following division. I. Revival of the art, including the sculptors from the 12th to the termination of the 15th century. II. Perfection—Michael Angelo and his school. III. Decline—Bernini and his followers. IV. Restoration—Canova and his contemporaries.

SECTION I.

From the preliminary remarks, it will appear that the extinction of the arts in the west has been assumed improperly as total. Their revival has in like manner been too exclusively ascribed to resources derived from the east. From various causes of partial judgment, the two grand events which in succession changed both the political and intellectual aspect of western Europe, the invasion of the empire by the Goths, and the fall of Constantinople, have been represented as exercising immediate and decisive influence on art. The occupation of Italy by the barbarous warriors who overthrew the Roman power, was followed, it is said, by the total destruction both of the monuments and the knowledge of learning and refinement. On the other hand, the reappearance of the arts in the twelfth, and their splendour in the fifteenth century, have been attributed, the former to an occasional influx of Greek artists, the latter to the misfortunes of the eastern capital, whose natives, seeking protection in Italy, enlightened the country of their exile.

It may be shown, however, in opposition to the former of these opinions, that in Italy neither the monuments of ancient taste were destroyed, nor the remains of living science exterminated by her conquerors; and that, in the various principalities into which this country was separated, the arts were never entirely forgotten, but, on the contrary, were cultivated, and by natives. The conquerors of this fairest portion of the empire were less ignorant and brutal than those by whom the distant provinces were finally occupied. They had been reared in the armies of Rome—they spoke her language—they venerated her grandeur. When the fury of contest had passed, therefore, when conquest was secure, they were more disposed to encourage than to suppress the useful arts, or elegant studies of their more cultivated, but unwarlike subjects. These acquirements in fact added to their splendour; and the earliest erections of the Gothic chiefs are evident though rude imitations of works of the Cæsars. Of these princes also we have still remaining several mandates prohibiting the destruction of ancient buildings, and offering encouragement to those who could repair or imitate them. Of these efforts in architecture and in sculpture, for these arts were inseparable, a series we have stated might easily be selected, uniting the reign of the last of the emperors with the establishment of the first of the modern republics. That these essays, such as they are, were the productions of native Italians, the names of the architects or sculptors, Bonani, Diotisalvi, Antelami, Beduini, Gramonti, Viligelmi, and many others, all living previous to the twelfth century, furnish evidence.

In regard to the latter assertion that Italy borrowed her reviving arts from the rival capital, it appears that so far from advancing the progress of western art, Constantinople could send forth no artists superior to those who flourished in the same age in Italy. During the thirteenth and fourteenth century, Dante, Petrarch, Boccacio, in energy of intellect far transcend any name which adorns the eastern empire: the country which could produce and relish these had surely nothing to fear from a rivalry in talent. Still more to our present purpose a more numerous and ingenious population, greater and more useful industry animated the Italian republics of this era, than were contained within the pale of the byzantine empire. The fall of its capital so far from advancing the progress of western art, took place after many of the happiest efforts of modern genius had already been accomplished. Sculpture had created works which have since been declared worthy of paradise; architecture had reared on the banks of the Arno the first dome of modern times—the exemplar of that edifice the most majestic ever reared by human skill.

Is there then no source whence we may derive modern sculpture at once consistent with the veracity of history, with the philosophy of art itself, and with the condition of mankind? Revolutions or improvements which deeply and permanently affect the habits or character of a people can be promoted by great internal changes only. For such then we must search in the present instance, and shall be able to discover another proof of the constant intimacy existing between the social happiness, the moral dignity of man, and his progress in refinement.

The subjugation of the western empire might have proved an event in the highest degree fortunate for Europe. In every part of the Roman dominion the powers of genius, moral worth, social virtue, all that dignifies man's nature, had long rapidly declined. The engrafting then of the rude but honest virtues and energetic character of their conquerors upon the refinement that yet remained to the Italians, would have wrought a material improvement. A new impulse would have been given, and civilization would have recommenced as from a new era. Unhappily for this reciprocal melioration, throughout the wide extent of these conquests, the feudal government was uniformly established; than which no system could be more directly opposed to individual happiness or general improvement among the people. The affections and the energies of the human heart were alike benumbed where the human race acknowledged the sole relation of tyrant and slave, or its sympathies were roused only in deeds of violence and of lawless power. A deathlike depression overspread the empire of intelligence. Some vital change could alone break the dismal solitude of the mind, and restore its nobler faculties to activity. Accordingly, when about the commencement of the eleventh century, the cities of Italy threw off the the yoke of feodality, and proclaimed themselves independent, the sound of liberty broke the unhallowed calm—the waters were moved—the healing influence was shed abroad—cleansing from mental degradation and political debasement. In the train of freedom sculpture and the arts appeared among the earliest attendants. The moral history of these republican cities presents indeed an agreeable and brilliant contrast to their political annals. The latter exhibit a fearful record of the turbulence, vacillation, and injustice of popular authority and licentious liberty. In the former are strongly illustrated by their effects, those generous and dignified principles of legislation, which originate not in artificial systems, but in the heart and constitution of man—which interest the noblest feelings in defence of the dearest rights.

The arts, as moral causes of powerful efficacy, and as pursuits of general concern, were from the first cultivated with ardour. Their labours, especially those of sculpture, were, from the earliest, dedicated to the service of religion; next exercised on public works, uniting utility with magnificence; and finally, consecrated to embalm the memory of patriotic deeds and virtuous characters. While his acquirements were thus prized, the intelligent artist was honoured as the ornament of his country. Reciprocal sympathies thus gave and received inspiration.

Among the republics of Italy, Venice earliest succeeded in fully establishing liberty; Pisa, however, took the lead in founding a school of native art. Early in the eleventh century, (1016), her cathedral was begun, the ornaments of which were composed chiefly of fragments of Greek sculpture, relievos, capitals, and even whole columns, which the eastern commerce of the Pisans enabled them to procure, and which proved most valuable in the renovation of taste, as both exciting emulation and supplying models. This great building was conducted by Boschetto, the first architect and sculptor of eminence in Italy; but the incorrect reading, from a fracture in the tablet, of an inscription at Pisa has deprived her of the honour of having given birth to this founder of modern art, who has thence unjustly been recorded as a native of Dulichium.

Of the numerous schools thus established at Pisa, the most distinguished members afterwards became celebrated by their works in various of the surrounding cities. But the reputation of these has been forgotten in the superior merits of Nicolo Pisano, the glory of the twelfth century, and under whom sculpture first assumes dignity and importance. He early attached himself to the study of antiquity, having remarked the striking difference between the labours of Boschetto and fragments which had been brought from Greece. It was from the latter he formed his style; and in his works we often trace a very marked resemblance to the character and manner of some remains still preserved in the cathedral or in the *Campo Santo*. His principal works are the pulpits of Siena and Pisa, the beautiful bas relief on the façade of the cathedrals of Orvietto and Lucca, &c. But it is a species of injustice to particularize: the influence of the genius of Nicolo is to be traced in every building in Italy of this era; as also the authors of minor works of art, as chapels, altars, tombs, fountains, relievos, must be ranked as pupils either immediately or remotely of this school. Of the former class the most eminent were Giovanni, the son of Nicolo, and two strangers, brothers, of Siena, Augustine and Angelo.

With these the science of their master did not languish, as may still be seen in the cathedral of Siena, one of the finest in Italy, of which the three were the joint architects. In this erection we first read of sculpture being admitted as a separate profession; and there are still preserved the original rules and regulations of a confraternity of sixty-four sculptors, then first incorporated. The style of Giovanni however, was considerably diversified from that of his father, his outline being more flowing, his drapery broader and less determined in the folds, and his whole composition more soft and delicate. This artist exerted a degree of influence over the arts not only of his native country, but of the whole of Europe where art was known. Even in England in the sculptures prior to Henry VII., as in the monuments of Queen Eleanor, it has been thought that the style, if not the very designs, of Giovanni have been discovered.

Before the end of the thirteenth century the cities of Etruria, the ancient seats of the arts, had already made progress in the study of sculpture. Florence, destined afterwards to become so conspicuous, had not yet from domestic feuds been able to distinguish herself in the arts of peace. When the attention of her citizens was at length directed to the study of elegance, painting at first obtained the preference. Cimabue, born in 1211, received the rudiments of a barbarous art from some Greek painters who were employed at Florence; he quickly surpassed his instructors, and was himself excelled by his own pupil Giotto, whom he had taken up a shepherd boy in the vale of Arno. Andrea da Pisa, the grandson of Nicole, was, about the commencement of the fourteenth century, invited to Florence, and thus became the father of Tuscan sculpture. The works of this artist, the relievos of the Campanile, and the bronze folding doors of the Baptistry, still proclaim his merits; while his sons, Tomasso and Nino, sustained the reputation of their instructor, and by their pupils widely disseminated the art over Lombardy, Venice, and the south of Italy. The primitive school of Pisa is thus the true source of modern art, for Venice was at first occasionally assisted by artists from the east, and subsequently from Tuscany. The grand political and moral causes which operated so powerfully in other states, were there comparatively feeble in their effects. Her proud and exclusive aristocracy rather converted the arts to the purposes of private magnificence than employed them in the service of national greatness. It was this union of the arts with national feeling, while the freshness of newly acquired liberty gave to that sentiment energy and vigour, which so eminently conduced to their progress in Italy. Her free cities had thus advanced in the acquisition of elegant taste, for in 1350 was established the first academy of design in Florence, at least two centuries before the rest of Europe had started in the career.

The fourteenth century closes the infancy of sculpture; of this period the principal works are relievos; statues are few in number, and generally inferior in workmanship. The former are to be regarded among those performances and discoveries of one age, which immediately conduct to the improvement and superiority of the succeeding. Thus the relievos on the altars and tombs in the different cities of Tuscany, and of the Tarlati and Scaligers at Verona; the pulpits of Pisa and Siena; the bas reliefs on the cathedral of Orvietto; the decorations of St. Mark's at Venice and the Ducal palace; the sculpture of the Belfry at Florence, above all the bronze folding doors of the Baptistry,—constitute the intermediate gradations while genius was emerging from the barbarism of the dark ages, presenting the steps by which it ascended to the eminence of the two following centuries.

As respects the style of art during these early ages, we find that from the time of Nicholas of Pisa, whose views are frequently drawn from antiquity, a general character of simplicity, of fidelity, and of just expression, begins to appear in sculpture. The mind is never astonished by boldness of execution, or grandeur of composition; but the art being chiefly dedicated to the service of religion, or to the memory of the dead, there is often in its best labours an air of devotional sincerity, a touching representation of the gentler affections, which soften the heart and awaken the sensibility. The effect is never daringly ventured; it is sought by force of labour—by persevering discovery, rather than produced by any acknowledged principles of taste or rules of design. But if the creative faculties have seldom been conspicuously exerted, we are sometimes agreeably surprised by unexpected beauties of the sweetest power arising from a diligent imitation of nature, which give back the image of the original in all its simple and unpretending reality.

The fifteenth century forms a splendid era in the progress of intelligence. Advances in moral, intellectual, and political knowledge were then accomplished, which form the groundwork of no small portion of modern science. In the arts of elegance, especially in sculpture, the labours of this age will always hold distinguished rank. During this interval, love of liberty and of information animated the Italian republics. As if there had also been a commonwealth of talent, no single master so far excelled his contemporaries as to impress upon the art the stamp and bearing of an individual style. The very opening of the century presents the friendly contest of six great masters, competitors for the same public work, who had been selected from a still greater number of candidates. Brunelleschi and Ghiberti, Florentines, Jacomo della Quercia of Siena, Nicolo Lamberti of Arezzo, Francisco di Valdambrino a Tuscan, Simone dei Colli, were the artists thus chosen to compete for the honour of executing the bronze folding doors of the baptistry. After a year's trial, in which each produced a pannel of the proposed work, representing the sacrifice of Abraham, the specimen of Ghiberti was preferred. The undertaking thus honourably assigned to his superior merit, occupied forty years of his life, still remaining one of the noblest monuments of modern art, and declared by Michael Angelo worthy to be the gate of Paradise. The subjects of the one are taken from the Old, and of the other from the New Testament.

Of the other candidates, Brunelleschi afterwards applied chiefly to architecture; the remaining four, by their works and the merits of their schools, widely extended and improved the art. Among the crowd of illustrious contemporaries, Donatello, born in 1403, stands forth pre-eminently conspicuous by the magnitude and excellence of his labours. These are in almost every material capable of receiving the impress of his chisel, and dispersed throughout the principal cities of Italy. The best are in Florence; among these the statues of St. George, Magdalen penitent, and St. John, are fine examples of grandeur, simplicity, and truth, in composition and expression; while the equestrian statue of Erasmus duke of Narni, in that city, claims notice as the first attempt in the revival of art. But the great superiority of this sculptor is chiefly remarkable in relievos, a department of the art which in the course of this century acquired a degree of perfection that yet remains unsurpassed: nor does it appear easily possible to excel the beauty of those in the church of San Lorenzo, in which this master has represented the most memorable events in the life of the Saviour. The subject seems to have imparted to the genius of the sculptor a portion of its own sacred dignity—of calm and holy feeling. Indeed, to the influence of religious impressions we attribute in no small degree that improvement so conspicuous in this age, the principal exertions of which were directed to the representation of Scripture history.

The scholars of Donatello were very numerous, for he may be said to have founded schools in the leading cities of Italy; they may be divided into two classes. The first comprehends those who, without producing much of what was original, have attained reputation as co-labourers in the most considerable undertakings of their master; such as Simon his brother, Giovanni da Pisa the second of the name, Bartoldo, and William of Padua, who travelled into England. The second division of the school of Donatello consists of his true disciples, who, not servilely following in his train, preserved, or even improved the science of their instructor. These include many of the leading masters of the time—as at Florence, Michelozzi, famous in bronzes—Settignano, whose sculptures are graceful and lovely—the two Russilini, the elder of whom was the first architect of St. Peter's. In Bologna, Modena, Lombardy, Naples, were scions of the same school; in the last were especially distinguished the two Massicii, Monaco, Cicione and Fiore. Of the Venetian school, the ornaments were Riccio, who wrought exclusively in bronze, Cavino and Leopardi, scholars also of Donatello. This great artist died in 1466, having survived his rival Ghiberti about eleven years. For nearly three quarters of the century, these two masters presided over sculpture, nor has the lapse of successive centuries diminished their just claims to estimation: both excelled in relievos; and Donatello in high, Ghiberti in low relief, have produced models yet unsurpassed—seldom equalled. The influence of the former on the art universally was the more direct and extensive: but the talents of neither claim such pre-eminence as to obscure the merits of contemporaries, or of immediate successors. Improvement was more the effect of general talent than of individual superiority. After their demise, the art was far from languishing in the hands of Luca Della Robbia, Briosco, Lotto the first repairer of the antique—of the Majani, eminent in sculpture and Mosaic—of the Pallajoli, painters and sulptors, instrumental in the introduction of anatomical science—or of Andrea Verrochio, undoubtedly the greatest master at the close of this century—while towards its close in the academy of the Medici are to be found Pietro Perugino—Leonardo da Vinci—and more illustrious still, Michael Angelo.

From the Alps to the shores of Calabria sculpture was thus cultivated with eminent success, while in the other states of Europe the arts still slumbered, or merit not particular examination. Florence was the central point of refinement, where is to be observed most full development of principle with greatest freedom of execution. Assuming the best works as exhibiting the real extent to which science had attained during this period, we find the style and character of art to be in a high degree elevated as well as pleasing. The simplicity is refined, remote alike from affectation and poverty, the skill is great, but never exercised to astonish or surprise: nature is imitated with fidelity and by the simplest means; the manner never allures from the subject, so that the work is long admired before it occurs to inquire whence the fascination arises. The great proportion of sculpture of the fifteenth century is in bronze, a circumstance which may account for the style of execution minute and delicate, but frequently unenergetic and restrained. As respects intellectual merits, the style of design is always chaste, often extremely elegant; the composition judicious and unaffected, seldom strongly marked; the expression sweet and calmly dignified, for rarely is strongly marked passion attempted. We observe no decided aims at representation of abstract beauty; the powers of fancy are never presumed upon, and seldom roused; but the mind of the artist, now no longer wholly occupied in mechanical detail, selects and combines; if the forms and manners are not invested with ideal elevation, the most perfect models of real existence are not unsuccessfully imitated. Were the extent or object of art confined to the simple representation of nature, sculpture would now verge on perfection. But, by the genius of the sixteenth century, there yet remained to be added greater ease and grace of execution, more forceful and elevated expression, more refined selection of form, and more of those charms which imagination lends to reality

SECTION II.

The sixteenth century, in its commencement, discloses a state of things highly favourable to the advancement of Sculpture. In Italy—yet the only seat of art, refinement had been widely diffused; learning was esteemed, freedom and opulence reigned in the republican cities: princes and nobles generally showed attachment to elegant splendour, and were emulous in patronising merit, whether in arts or letters; while, above all, energy and activity were the characteristics of the age pervading every rank. The advanced condition of their attachments enabled sculptors to derive every advantage from these external causes. A new field likewise was then opened for their exertions. To maintain that universal sway to which the papal sovereigns had constantly aspired—spiritual weapons and temporal power had in succession been employed; the progress of knowledge had dispelled the terrors by detecting the unhallowed nature of the former, and the temper of the times was no longer disposed to bend before the latter. Means of empire, more congenial to the minds of living men were to be essayed; it was resolved to constitute to Rome the metropolis of religion and of art; to consecrate her monuments by devotion and by taste.

To carry into effect the mighty undertakings, the greatest in modern ages, to which this design gave birth, Michael Angelo arose. As the splendid resolves of Pericles to render Athens the abode of ancient refinement would have proved vain without the talents of Phidias, so the energy of Julius, or the elegance of Leo, would not have availed, unaided by the mind of Buonaroti. The times, the men, the objects and the consequences, bear a striking resemblance in both cases. As the Greek commanded our chief attention in classic art, so, from the labours and genius of the Tuscan, we derive the truest estimate of the best age in modern sculpture. The former, however, asserted the assigned pre-eminence by the intrinsic merits and beauty of his productions: the latter arrests our regard, not so much from the perfection of his works, as from having left the impress of an irregular though mighty spirit upon his own and the succeeding ages. When the attainments of Michael Angelo are collectively considered, when in the same individual is discovered the architect of the Cupola—the painter of the Last Judgment—the sculptor of the Moses, discriminating qualities are lost in general admiration; and to him who thus bears away the palm of universal talent, we are inclined to concede the foremost rank in each separate pursuit. For nearly three-fourths of a century he was acknowledged also as the head alternately of the schools of Florence, Rome, and Venice. When this pre-eminence was first assumed, painting was in infancy; the feeble attempts of his master, Ghirlandajo, were viewed with wonder, and only in the frescoes of the unhappy Massaccio, had any indications of an elevated style previously appeared. The cartoons of the battle of Pisa, and other works of Michael Angelo, appearing under these circumstances, suddenly raised the art to strength, boldness, and scientific correctness; to that sublimity which formed Raphael and his compeers. In architecture, though at a later date, St. Peter's stood, and still stands, alone, unequalled—

> Yes thou, of temples old or altars new,
> Standest alone. With nothing like to thee—
> Worthiest of God, the holy and the true.
> Since Zion's desolation, when that He
> Forsook his former city, what could be.
> Of earthly structures, in his honour piled
> Of a sublimer aspect? Majesty,
> Power, glory, strength, and beauty there are aisled.

In sculpture, such superiority could not be attained; here great excellence had already been achieved, in some respects little remained to be added, nor are the additions always improvements. But the style of the fifteenth century, exquisite in unaffected simplicity, was not adapted to please in the succeeding age, and under a system of refinement, when the forcible and the imaginative were admired in preference to the simple and the true. The works of Buonaroti at first created and subsequently fostered this taste. His sculptures were erected into a standard, according to which earlier masters were to be estimated, and by which future artists were to direct their aspirings. The past thus appeared tame and lifeless, while contemporaries and successors constrained to become imitators, successively remained inferiors, where laws were thus received from the prestiges of an individual mind. The character of that mind, indeed, elevated sculpture; but round a false, though gorgeous and imposing art, genius swept a magic circle, within whose perilous bound none else durst walk—and where the mighty spirit still reposes in self-created superiority—in awful and unshared solitude.

Hence as a sculptor, the fame and excellence of this artist have been exaggerated. His works are far from numerous, and even of these few are finished. His undertakings were gigantic—his activity indomitable—his daring boundless, but impatience of slowly progressive labour, or fastidiousness of fancy, formed striking distinctions in his intellectual temperament. In these works, scattered throughout Italy, and found even in France, two styles have been supposed to be discovered; or at least in his earlier years their author is presumed to have followed a distinct set of principles from those which guided his maturer judgment. A gradual departure, it is said, may be traced from the simple and the natural towards the exaggerated; and two classes of his sculptures have been made accordingly—a position thus illustrated by a learned and elegant writer on the arts. *Una donna che accostomarsi giovinetta a lisciarsi le guacie di minio non passano molt' anni che senza avvedersene le pare d'essere sparuta se non mostrarsi colorita come una maschera scenica.* That diversity of style is to be detected, we admit; but after a careful examination of every original, except two unfinished statues, said to be in France, we are inclined to discredit the existence of any regular progression. The Pietà, or Virgin and dead Saviour, is at once the last, the most finished, and the least exaggerated group of the author; and so far from being insensible of the peculiar characteristics of his style, he lamented them, and predicted at the close of life the fall which he had thus prepared for the art.

The works of Michael Angelo are now divided between Florence and Rome. In sculpture, each contains a master-piece; the tombs of the Medici in the former, and the unfinished sepulchre of Julius in the latter city. To this belongs the Moses—a record of genius isolated and rendered unavailing in art by the peculiar nature of its own especial sublimity. But without entering minutely into description, we shall state generally the impress left on the mind, and the influence exerted upon the arts by the genius of this extraordinary man.

The sculpture of Michael Angelo discovers much that is derived from a liberal and enlightened study of sublime and graceful nature; but still more of those qualities which arise from the peculiarities of an individual, though rich and powerful imagination. His studies rarely exhibit the simplicity and repose essential to the character of an art—grave, dignified, or even austere, and possessing means comparatively limited and uniform. But forced and constrained attitude, exaggerated proportions, unnatural expression, are redeemed by a force, an energy, an enthusiasm elsewhere unfelt, which give to every composition a vitality and power resembling rather the effect of inspiration than of reiterated and laborious effort. Neither with nature nor with the antique can his works be rightly compared. They stand isolated by a peculiar sublimity of conception, the matchless monuments of a daring spirit forcing present admiration in despite of calmer judgment. The first impressions are thus irresistibly powerful, but they are those of surprise, of astonishment, not of delight or of sympathy. The fascination is thus quickly dispelled, the mind reluctantly yielding to an influence, originating solely in the imagination, and in which the sensibility has no portion.

The ideal of Michael Angelo indeed, is constituted entirely of the imaginative. His sublimity is sought too exclusively in the vehement and the marvellous. His design, expression, forms, and attitudes, have little communion with nature, at least with nature in her solemn majesty—her dignified repose—her unpretending simplicity, or in those her milder beauties, which sentiment and feeling appreciate. The perfection of art, as displayed in the works before us, appears to have been placed in embodying the wildest, the most gloomy, the severest, and most awful imaginings of the mind, under shapes the most masculine and energetic; and in positions the most difficult or uncommon. Both in conception and in execution Buonaroti has created a style adapted to display his own powers, but which could be supported by these alone. With him the arts were not imitative, but creative. Compared with themselves his productions are astonishing evidences of human power: tried by nature's rules, they are ever remote from reality, not seldom irregular and fantastical. Every thought exhibits the impress of a mind delighting in the grand and the wonderful—eager in the pursuit of untried modes of existence, and conscious of powers to execute the most daring conceptions. This gives to his ideal more of the vague, but soul stirring enthusiasm which belongs to poetry, than of that sober inspiration and steady imagery which direct the judgment and guide the practice of the sculptor. His execution participates largely in this unquiet and aspiring character of composition. It is rapid and fervent, but inaccurate in minor details, and too prominent in general effect. Intelligence in the naked, breadth of touch, boldness of manner, give the very effect of life and movement; but to a display of science, simplicity, and even truth, have been sacrificed. Difficulties seem to have been courted in order to be surmounted with address; the attitudes are consequently the most remote from such as would voluntarily be assumed, or graceful design select; they are in a high degree constrained, and from an undue exhibition of knowledge—the pedantry of art in rendering them, the forms have more the appearance of anatomical studies than the warm full figures of life. The general character of this style then is every thing but natural; art stands forth boldly prominent, challenging admiration, not as a means perfect as it eludes regard, but as a final end, claiming in itself a distinct and paramount excellence, independent of nature or of imitation, and exhibiting its creations as evidence of separate origin,

"Like life, but not like mortal life to view."

The death of Michael Angelo, in 1564, created a blank in the history of art, which never has and never can be filled; but in the principles of the art itself, in those principles which he himself had introduced, the event caused no change, save that their ministration passed into feebler hands. During his lifetime, the sculptors of this era, however various in talent, may be classed as his disciples; for though many approach, and one or two even excel in some quality, yet they rest generally inferior, while the character and manner of their productions but reflect the style he had invented. Still, among his contemporaries, we are to distinguish between imitators merely, and pupils, properly so termed.

Baccio Bandinelli, born at Florence in 1487, was the enemy rather than the rival or imitator of Buonaroti; there is yet a strong resemblance in their manner, allowing for general inferiority in the first, with a similar display of exaggerated science; although in some instances, Bandinelli exceeds in softness and delicacy. But this is not the general character of his works, which exhibit strength without regularity or refinement. Baccio di Monte Lupo was also an original artist of considerable eminence, as is still attested by his best performance, the crucifix in the church of San Lorenzo. Andrew Contucci, founder of the school of Loretto, whence many excellent works then issued, is an imitator of Michael Angelo, with no mean additions of his own. Francisco Rustici, eminent as a founder, pupil of Leonardo da Vinci, carried the manner of this school into France, and died in Paris in 1550. During the early part of this century, Giacomo Tatti or more popularly Sansovino, presided over the Venetian school with much reputation. The magnificent range of the Piazza di San Marco, is of his erection. His style of sculpture is distinguished for richness of composition, but is deficient in purity; and though decidedly founded on that of the Tuscan, whose principles Sansovino had studied at Rome, whence he fled on the sack of that capital by Bourbon in 1527, it displays greater softness, with less of vigour and originality. He survived his master, and was the head of a numerous school, of which Danese Cattaneo and Alexandro Vittoria were the chief ornaments, the one in arts and letters, the other in having perfected the useful practice of working in stucco. In Lombardy and in Naples, similar principles were followed, and with scarcely unequal success; or, in these schools, the less valuable peculiarities of rapid execution and exuberant fancy were cultivated in preference to learned design or accuracy of taste, from the splendour of the respective courts demanding the employment of the arts on objects of temporary interest. In Milan, however, Agostino Busti, and especially Guglielmo della Porta, whose statues of justice and prudence on the tomb of Paul III. in St. Peter's have been admitted among the best examples of modern sculpture, were highly esteemed; as also in Naples, were Marliano Nola and Girolamo St. Croce.

Among the real disciples of the great Tuscan master, the following may be mentioned as the principal:—Raphael di Monte Lupo, a favourite pupil, by whom are the two statues of the Virtues on each side of the Moses in the tomb of Julius II.: Nicolo di Tribulo, an excellent founder, author of the fine bronze-gates of the cathedral at Bologna: Giovanni dell Opera, whose name attests his prolific genius, and who had the honour of placing the statue of architecture on the tomb of his instructor; where in Florence

In Santa Croce's holy precincts lie
Ashes which make it holier—dust which is
Even in itself an immortality.
——————— here repose,
Angelo's Alfieri's bones, and his
The starry Galileo with his woes.

——— "Beata che in un tempio accolte
Serbi le Italie glorie—ultime forse.

Vicinzo Danti closely and not unequally imitates the style and manner of his master, as attested by the group of victory chaining a captive in the old Ducal palace, being ascribed to him, though the most intelligent judges assign it to the latter, as one even of his most vigorous thoughts. Michael Angelo certainly did retouch this still unfinished piece; and tradition rightly attributes to his crayon the lines in red chalk visible on the back and shoulders of the figure, where reduction seemed to be required. Bartolomeo Ammanati first studied sculpture with some success, but subsequently transferred his attention to architecture, in which he became eminent. Benvenuti Cellini, a man of the most versatile powers; his works of sculpture are in metal, of which the Perseus and the Mercury, poised on one foot, are the principal. But the greatest of this school still remains to be mentioned, Giovanni di Bologna, a Frenchman by birth, an Italian as a sculptor, who, from the magnitude and number of his productions, from the beauty of his style, and the excellence of his genius, approaches nearest to his master. To the end of the sixteenth century, this artist occupies the prominent place in the history of sculpture; he terminated the series of illustrious names of that era, and his last great work, the group of Hercules and the Centaur, erected in 1600, closed the Tuscan school for ever. In examining his performances, we ascertain those advances which were accomplished during the last thirty years of this century, while the mantle of their great teacher still rested upon the favoured of the disciples; while yet the impetus derived from the mighty movement awakened by one mind had not spent its force. During this space we find the technical part considerably improved, operative art better understood, and its processes facilitated. Hence, though no preceding sculptor can show works more numerous or important, those of Giovanni di Bologna discover no marks of haste, no deficiency of a high, and even in some instances exquisite finish; it is even apparent, that many of the inaccuracies, into which a fervid and impatient spirit hurried his master, have been avoided.. Still in the works of the pupil, in their general style and manner, we observe the growing evils which the example of the instructor introduced, but which supreme genius consecrated or concealed—bold, rapid, and masterly execution—grand and imposing composition preferred to, and even excluding, delicacy of expression—attentive study of truth, and of those sweet and gracious sensibilities through which art becomes the "obvious, not apparent, but retiring" representative of nature—which elevate without startling the imagination.

Before leaving the subject of Italian sculpture during the sixteenth century, one name, closely connected with the general improvements of art during this interval, claims some notice, more especially as the merits of Leonardo da Vinci, one of the most venerable names of the age, seem to have been hardly estimated by the elegant historian of Leo X. On perusing the observations of Mr. Roscoe, the impressions, we think, which are left upon the mind regarding Leonardo, are, that he was a dabbler in various knowledge, but proficient in no one branch; a laborious trifler, who wasted in useless multiplicity—in chemistry, mechanics, and experimental philosophy, talents which ought to have rendered him great in art. We confess, however, that the manuscripts of Leonardo which we have seen in the Ambrosian library at Milan, give no mean opinion of his attainments, even in science, the times considered. If in art his productions be few, they are very precious; let it also be remembered that his cartoon of the battle of Pisa, drawn in conjunction with one by Michael Angelo, was not inferior, if it did not excel, and that these first exhibited true greatness of style in modern design. In relation then, to the remarks of the English historian, we join with count Cicognara, who concludes rather a severe criticism in the following words, *ci sembra troppo azardato e non mai dittato da quella matura circospezione che tanto distingue lo storico da noi indicato.* The common opinion respecting the "Last Supper" repeated by Mr. Roscoe, namely, that the artist was unable to represent the principal figure with a dignity superior to the others, and therefore, left the piece unfinished, is certainly erroneous. The mistake seems to have originated with Fra Bartolomeo of Siena, who, in a book entitled *de Vita et Moribus beati Stephani*, first relates the circumstance: but, before the appearance of this work, cardinal Frederico Borromeo in 1625, had published a little treatise expressly on this picture, in which he not only says nothing of the head of Christ being left unfinished, but actually praises the expression, *venerabile Salvatoris os altum animi mœrorem indicit, qui tamen gravissima moderatione occultatus atque suppressus intelligitur.* This little tract, from its rarity and the fine taste which it displays, is, by the Italians, termed, *Aureo Libretto.* To the other claims of Leonardo as one of the fathers of modern art, it may be added, that names, eminent both as painters and sculptors, received from him their knowledge of these branches. "Art," indeed, "is jealous," but at her shrine the devotion of da Vinci was neither without fervour nor unfruitful, although he courted, not unsuccessfully, the favours of science, then new to the mind. We trust an endeavour to reconcile these claims with the observations of a living historian whom we hold in high admiration, will be deemed neither improper in us nor irrelevant to the subject.

Beyond the confines of Italy, the art had yet made few advances worthy of notice; and what little had been effected was on the principles of the Tuscan school. In England, Spain, and Germany, during the sixteenth century, painting was patronised in preference to sculpture. Torregiano, the envious rival of Michael Angelo, had erected in Westminster Abbey the tomb of Henry VII., for which he received £1000, a very considerable sum at that time; but this turbulent spirit was inclined rather to brawl with, than to instruct the English in his art; and in the succeeding reigns we find Holbein and Zucchero in high favour; but hear little or nothing of sculptors, with the exception of John of Padua, who acted as master of works about the close of this century. In fact, in the early history of English art, anomalies of a singular nature are encountered. From the seventh to the fifteenth century, four distinct species of architecture may be traced in the sacred and feudal edifices of Britain. During the two succeeding centuries the art declines, nor till the reign of Charles I. is it revived with any degree of magnificence. Sculpture, in these early times, was exercised only as an ornamental branch of architecture, or in tombs; and in each, it is singlar that, taken generally, the sculpture of the thirteenth is superior to the art of the fourteenth or fifteenth century; that of the sixteenth exhibits evidences of Italian origin.

Bermudez, the Spanish historian of native artists, has given a splendid account of Sculptors from the sixteenth century upwards. The beautiful ecclesiastical edifices of Spain afforded an extensive field for sculptural ornament, and it is easy to perceive that those employed with a remarkable success in such embellishments have been exalted by national partiality to the rank of sculptors and artists. This opinion derives confirmation from the fact, that not till 1558 was sculpture, in consequence of a royal edict, allowed the privileges of a liberal profession. About this period Berruguete, after studying under Vasari and Buonaroti, returned to his native country, and at once exalted the arts of Spain to grace, beauty, and correctness. Previously, indeed, she had been indebted to Italy, and Torregiano in his wandering life, after residing and working for some time, had starved himself in the prisons of the inquisition to escape a horrible death, to which priestcraft and aristocratic insolence had unjustly condemned him. Berruguete, however, appears to have been the first native artist of Spain who acquired and deserved a high reputation; he founded a numerous school, of which Paul de Cespides was the ornament, perhaps the greatest of Spanish sculptors.

Before the seventeenth century, Germany makes no appearance in the history of sculpture. Both in letters and in art she has entered the field at the eleventh hour: in the former, her sons have already effected noble progress; and in the history or philosophy of the latter, what have we finer than the writings of Winklemann and Lessing? In practical art, however, the Germans are still deficient: nor, perhaps, is that metaphysical enthusiasm—that ideal aspiration by which their national genius is distinguished, well adapted to succeed in the energetic but laborious realities of sculpture. Or if they do obtain reputation, it will be in that department which forms the most precious portion of their poetry and painting—unadorned representations of sweet and simple nature. The past history of their arts supports this idea in some measure, although it is probable had their enlightenment been such as to enable them to meet the advances of the sixteenth century, the grand and the wonderful in the style of Michael Angelo, would, to the Germans, have possessed irresistible attractions.

In France, the expeditions of Charles VIII. but more especially the close connection between the two countries in the reign of Francis, together with the personal predilections of that monarch, tended to diffuse some knowledge of the arts of Italy. French writers have strained hard to elevate their native arts from an early date; and Jacques d'Angouleme is reported to have surpassed Michael Angelo himself in a trial of skill at Rome. Certain it is, that during the sixteenth century no artists out of Italy could have competed successfully with Jean Gougon, author of the celebrated fountain of the Innocents, finished in 1550. He was also an architect and engraver. Of his life little is known, except its termination in the massacre of St. Bartholomew's. Of all his countrymen and contemporaries, Jean Cousin possesses most grace and delicacy, but to the acquisition of these he has sacrificed strength and correctness. His works are still to be seen in several of the churches of Paris. German Pilon displays great energy and fire, with much beauty of mechanical detail; but his works are affected and destitute of natural expression. Indeed, from its origin we may trace an affected manner in French sculptors, which gives to the style even of these early masters a peculiar air of nationality, although it is evident that the principles in all other respects are derived from Italy. These artists in fact were all pupils, either mediately or directly, of the Tuscan school; and Giovanni de Bologna and Francavilla, both French by birth, filled the whole of France with the style and manner of Buonaroti.

During the sixteenth century, the most brilliant period in the history of modern sculpture, the genius of Michael Angelo thus dominated throughout Europe to the utmost capacity of her living arts. The character of that genius we have feebly endeavoured to estimate; and we fear, to indiscriminate admirers our estimate may not be deemed so favourable as the general voice proclaims. An explanation then of the principles on which we have formed our judgment, seems not uncalled for, nor of the standard with which his works have been compared. Irregularities in the productions of genius have not seldom been caused, and are extenuated by an idea too generally entertained, that to its genuine efforts no established modes of judging are applicable; in like manner, as rules are inefficient to create its presence. A power certainly resides in superior minds of being a law unto themselves, *petimus damusque vicissim*. This privilege of invention, however, or of departure from the more obvious relations of existence is limited according to the nature of the exercise; in poetry most excursive, in the imitative arts more restrained, and of these, sculpture admits the least deviation from reality; here truth is more especially the criterion of beauty, because its imitations are constituted of no illusive effects. The objects of this truth are in all the arts two—resemblance and consistency. The former respects the connection subsisting between the representation and the original: the latter regards the agreement of the composition with itself and with the peculiar mode of imitation. In the first case, art is compared with nature, in the second with itself, and in both sculpture is particularly circumscribed in its elements; in resemblance being restricted to form and expression, while, to be consistent, it must be grave, simple, and uniform. The practice of antiquity also, here exerts so paramount an influence, since the art so exclusively belongs to classic times, that it may be justly questioned how far any modern artist can improve by deviating from forms, which rest upon the intrinsic excellence of the examples, and on the prescriptive influence of opinions established long and felt universally. An authority thus neither local nor temporary, operates as a precept of immutable taste, as a sentiment of unchangeable feeling, and consequently assumes the certainty and importance of truth.

But from all of these principles, both of nature and of the antique, Buonaroti has departed. Nor can it with justice be urged, as is done in his favour, that his powers are too original—too mighty for subjection to these laws; that by no standard can we estimate, by no rules can we judge the most sublime, yet the most daring of modern artists, who hovers on the confines of possible existence, and in whose labours like contending light and darkness, grandeur, and extravagance are often blended. This would imply that he was above, because he was ignorant of the principles by which he has been tried. But than Michael Angelo few great names have more extensive obligation to preceding knowledge; he was acquainted with some of the finest specimens of antiquity, while his predecessors had left instances of beauty yet unexcelled. On what grounds then can we concede to this artist those privileges which Homer, Shakspeare, and others who like them have lived in ignorance of more perfect models, and in the infancy of their respective arts, can alone justly claim?

From the antique, Michael Angelo has deviated in one most important respect. Of the two elements of sculptural design—form and expression, the Greek artists selected form as the object of their imitation. The modern has preferred expression, to which we may say he has almost sacrificed form. To this, not only the force of associations springing from the most perfect of human productions was opposed, but the internal proprieties of the art favour the choice of the ancients. In sculpture all is staid, enduring, actual, movement alone is the only passing object of imitation. Expression, therefore, at least strong expression as the primary characteristic, both as destructive of symmetry, and as implying an effort ungraceful when connected with the unyielding materials, seems not a legitimate element of higher art. A sweetly-pleasing, a gentle agitating sentiment, or a nobly repressed feeling, is the genuine expression of sculpture.

From nature Michael Angelo has departed further, we will venture to say, than any great name on record, whether in literature or in art. Irregularities and imperfections in almost every other instance of lofty genius are forgotten amid the deep thrilling pathos or soothing loveliness of natural representation; but amid the awe-inspiring, the commanding, the overpowering creations of Buonaroti, the soul languishes for nature and simplicity. His forms are of superhuman energy—fit habitations of the fierce and resistless spirits that seem to dwell within; they are not of this world, nor does the heart respond to that interest which with mysterious mastery they exert over the mind; yet their power is confessed—the power of art and imagination. This great sculptor had marked the perplexities and the constraint under which, amid their fidelity and affecting expression, his predecessors had visibly laboured in their endeavours to unite the images of living nature with the grand conceptions of ideal beauty. Overlooking the productions of classic times, in which this union is so happily accomplished, because to his vigorous rather than refined perceptions its simplicity appeared poverty, he struck fearlessly into a line of art—where art alone was to be admired—where all was to be new—vehement—wonderful.

Even the manual processes necessary to realize these conceptions were to participate in the ardent temperament of the mind, by which they could have been inspired. This, indeed, forms one of the most powerful spells in the sculpture of this great artist, that between the animated forms, the breathing spirit of his composition, and the rapid, the impatient execution, there exists the most perfect harmony. The hand seems indignant at the very hardness of the marble that gives to its creations their immortality. Yet even in this respect we discover many technical peculiarities and imperfections. From having merely sketched, or at most modelled the subject in small; nay, in some instances, with no other suggestion or guide save the accidental shape of the block, he struck into the marble. While the mind, the eye, the hand, were thus in instant exertion; while propriety of expression and beauty of outline, mechanical detail and general effect were at once to be studied, error could hardly be avoided. Hence the want of proportion so conspicuous in his works,—hence so few finished, and those commonly presenting one sole point of view. As regards more individual details, in the salient lines of the contours, the circles have rarely their proper value, and the surfaces want their just fulness. Partly to compensate this deficiency in the advancing curves, partly as a characteristic distinction, which consists in strongly pronouncing the muscles, the retiring lines or muscular depressions are marked with exaggerated depth. Trusting to mechanical dexterity also, and to profound anatomical science, Buonaroti was often seduced to work from memory without reference to the living model. This frequently produces a rigidity, a want of feeling even in his best performances, paving the way for the introduction of those conventional modes which finally superseded the diligent study of nature, leading to the abandonment of every genuine principle of soft, gracious, or correct design.

No artist has ever exerted a more extensive influence, or more deeply impressed his own peculiar spirit upon art. But this influence has not been favourable to its progressive improvement, or even stationary excellence. The imitation of a natural and simple style, either in literature or the arts, will never prove injurious. But even the excellencies which this recognised, urged as the character required to the extremity of daring, necessarily became sources of error to imitators. A style of art which thus carried imagination to the very verge of possibility, which not only aspired to an excellence altogether distinct from imitation of reality, but introduced a necessity of constantly pursuing novelty; which created a standard of beauty highly artificial, and in many respects independent of nature, operated with baneful influence on the future advancement and purity of art. The works of Michael Angelo, exhibiting the principles and full development of this style, were regarded as the only models of imitation. Originality thus began quickly to disappear. The deviations even of his immediate successors from the simple and the beautiful were great, because in adopting a standard thus exclusively ideal, they receded more and more from nature.

The irregularities and defects also growing out of this system his genius alone had been able to consecrate or conceal. Deterioration thus becomes rapidly apparent in the works of inferior imitators who failed to acquire those nobler qualities by which the errors or extravagancies of mightier spirits are redeemed. From these causes, various in their effects, yet all originating in the system and style of art now explained, a decline had visibly taken place, and exaggeration, and mannerism, had evidently commenced at the close of the sixteenth century, when the principles of Michael Angelo were established in all the schools of Europe.

SECTION III.

The decline which is perceived to take place in the productions of sculpture, even from the commencement of the seventeenth century, is to be ascribed in part to causes political and moral, though more especially to those which originated in the state of art itself. Indeed, without the operation of such external influences, when a high degree of excellence has been attained in any intellectual pursuit, internal corruption never can occasion a sudden or rapid retrogression; at the same time a lapse under such circumstances always indicates an inferiority in knowledge or practice. The different states of Italy, in which the arts had been cultivated from political motives chiefly, were no longer alive to the same interests. Rome at no period had possessed a native school, cherishing the arts only as sources of political importance. Florence no longer enjoyed her free constitution; and the other states had, with the dignity, lost the sentiments of independent communities. In Bologna, indeed, a new era in painting commenced; but its principles were not calculated to bring back simplicity and correctness. In fact, the subsequent ascendency acquired by the school of the Carracci, may be numbered among the means contributing to the decline of sculpture. Moral causes also operated strongly in directing attention to other studies, and in forming intellectual habits opposed to those of the artist. A spirit of philosophical inquiry had gone abroad in the age, turning the genius of the time to mathematics and to science. Michael Angelo died at Rome on the day which gave birth to Galileo at Florence. Nature, as if unwilling to bless the same epoch with transcendant powers in opposite provinces, seemed to rob the arts in order to enrich philosophy. Poetry and the Fine Arts depend upon the same intellectual temperament, and the same state of society seems congenial to both. Hence they have generally flourished or fallen together. But between the spirit of analytical inquiry—of minute discovery which belongs to scientific investigations, and the creative fancy which leads to successful exercise of the poet's and the sculptor's art, the dissimilarity is so great that the human mind has never attained eminence in both at one period and among the same people.

The commencement of the seventeenth century thus promised by no means auspiciously for the future progress of sculpture. A crowd of undistinguished names followed the dissolution of the great Tuscan school; and when an artist of high talent at length appeared, the circumstance proved only the more hurtful from throwing splendour around a capricious and injudicious style. Bernini, born at Naples in 1598, was endowed by nature with all the qualities requisite for becoming one of the greatest of modern sculptors. No artist ever displayed happier dispositions for excelling, nor at an earlier age. Unfortunately, however, he aspired to invention instead of imitation, and chose rather to be a founder of a sect than to take his place among the fathers and chiefs of regular art.

To Bernini the beautiful simplicity of ancient taste appeared meagre in outline, poor in composition, and in effect feeble. The style of Michael Angelo he preferred as being more forcible in its impressions, but possessing a character too severe and forbidding. He aimed at eliciting a third style with distinctive qualities of its own, which should display greater strength and energy than the former, while it surpassed the latter in suavity and grace. In pursuit of these imaginary and incompatible excellencies, he deviated still further from the simple, the true, and the natural. To produce effect was now the only object of study; every means of startling attitude, voluminous drapery, forced expression, was employed to strike, to dazzle, to surprise. Statues were composed and draped after the fashion of painting; and the full-flowing robes of the Bolognese school, the most improper for the sculptor, were selected as the model which he was to follow. Thus, amid greater errors engrafted upon those of the antecedent age, Bernini, by the introduction of a style rendering less necessary the science hitherto constituting a redeeming quality in the school of Michael Angelo, and which had tended to maintain an intercourse with this primal source, prepared a more fatal separation from nature. The powers of a fine and facile execution, possessed by him in so eminent a degree, recommended or concealed the impurities of his composition, tending only to render his example the more pernicious. This style was adopted quickly and almost universally, both as it was the reigning mode, and as its author, till his death in 1680, enjoyed such dominating influence and exclusive patronage as rendered him the tyrant of art, to whom all who expected to rise in their profession or in fame, were expected to do homage. The works of Bernini in sculpture are very numerous, but all composed in the same pretending and affected style. The group of Apollo and Daphne, executed in his eighteenth year, is his most chaste performance. As an architect, the circular colonnade of St. Peter's does him more honour than his sculptures.

The most celebrated contemporaries were Algardi and Fiammingo, who, among the crowd of imitators, retained the dignity of independent, and the praise in some degree of original, minds. By the former is the largest relievo extant, representing the invading army of Attila, met in its march to Rome by St. Leo. Francis du Quesnoy, born at Brussels, thence better known by his partial surname Fiammingo, is justly celebrated as the sculptor of children. The concert of cherubs at Naples, and the two infants in a monument at Rome, are his most admired works: of which latter, Rubens, no mean judge, writes thus: "Nature rather than art appears to have sculptured them, and the marble is softened into life." But the comparative purity in the style of these two masters availed little in opposition to the influence of the reigning taste. To Bernini, but immeasurably beneath him, Rusconi succeeded as the great man of the age, the former part of the eighteenth century. The greatest work of this artist, executed with the assistance of Monnot, le Gros, Maraldi, Moratti, Ottoni, and Rossi, pupils of the last school, and deeply embued with its erroneous principles, was the colossal statuary on St. John Lateran. With this school terminated in utter helplessness the further progress of sculpture during this era. To the conclusion of the last century, indeed, a crowd of artisans continued to haunt the scenes of former glory, but their names or performances would furnish neither illustration nor pleasure.

The history of transalpine sculpture during the preceding two centuries, now demands our attention. In France the immediate pupils of Giovanni di Bologna, among whom as chief may be mentioned Adrian, Anzirevelle, Della Bella, and Tacca, fill up the interval of forty years to the commencement of the reign of Louis XIV. a period highly favourable to French sculpture, in the practice of the art at least. This patronage indeed formed a part of that national and personal aggrandisement which constituted the political rule of this reign. For the formation of a school of French art, he established academies, endowed professorships, proclaimed rewards, instituted honours, and accomplished the object. But even during this the golden age of her intellectual labours, France derived her arts from Italy; and unfortunately they were not the models of a purer age, the monuments of more manly taste that engaged imitation. The works of Bernini and of his followers, the principles of their design and composition, formed the guides of the French school. In both countries also, similarity of circumstances concurred to introduce the same vitiated style of practice and of criticism.

Of the school of sculpture in France during the reign of Louis XIV. two artists claim to be head. Gerardon, born at Troyes in 1630, and Puget at Marseilles in 1622. The style of the former, though cold and somewhat heavy in design, is noble; more correct, firm, and manly, than that of his contemporaries. He excelled in modelling, which greatly contributed to the perfection of his works, the most remarkable of which are the tomb of Richelieu, and the equestrian statue of Louis, both in Paris. His most celebrated pupils were Fremin, Charpentier, Granier, Nourisson. Were the works of Gerardon possessed of more character, and did they less frequently remind us of the productions of former masters, not many names in the history of modern art could be preferred. Strongly opposed to the disposition of his compatriot appears the character of the fiery and energetic Puget, the favourite of native writers, who are fond of representing him as the Michael Angelo of France. In execution, his style is bold, rapid, and full of movement, but in composition he is studied, in science inaccurate, and in the intellectual beauties of art, in elevation, nobleness, and grace, as also in the choice of forms, defective. The most esteemed work of this artist is the statue of Milo at Versailles, which indeed exhibits both the beauties and defects of his genius.

To the schools of these two may be referred, at least in principle, the succeeding artists of France; the manner of Puget, however, was the more popular, and becomes in some measure characteristic of the national art. Contemporaries of the above were Sarrazin and Guillain; both of considerable merit, and of fine taste, especially the former, as may be seen from the Caryatides of the Louvre. As we advance to the conclusion of the seventeenth, and especially in the early portion of the last century, French sculptors become very numerous. Among the artists who flourished during this interval may be mentioned, Le Pautre, Desjardins, Coysevaux, Vaucleve, and the two Coustou's, of whom Gregoire is highly distinguished by the horses in the champs Elysées; Falconet, celebrated for his writings and the equestrian statue of Peter of Russia at St. Petersburgh. During this period, as the opportunities of exercising it were on a grander scale, the art appeared to be in more flourishing condition than in Italy; taste in both countries, however, was alike fallen. With Louis terminated the grandeur of French sculpture; under his imbecile successor it suffered a rapid decline: yet Bouchardon, the sculptor of greatest merit under this latter reign, possessed no mean talents, as may be seen from the bronze equestrian statue of Louis XIV. of which the horse is a master-piece. Louis XVI. early evinced a disposition to patronise the fine arts, and, previous to the revolutionary excesses, had given directions for a series of statues of the great men of France. To this series may be considered as belonging the statue of Voltaire by Pigal, now in the library of the Institute. This figure, without drapery, and, as the living original was remarkable for meagreness of person, copied from a model the most emaciated and squalid to be found, gave occasion to the following epigram:

> Pigal au naturel represente Voltaire,
> Le squelette à la fois offre L'homme et L'auteur,
> L'œil qui le voit, sans parure etrangere
> Est effrayé de sa maigreur.

Pigal's finest work is a statue of Mercury, which we believe is at Lyons, of which he was a native; he founded a numerous school, of which are Mouchy, Lebrune, Moette, Bocquet, Chaudet, and others, who bring down art to our own times.

In Spain, during the preceding period, many sculptors might be mentioned; but their influence extended not beyond their own country, their works being little known without the walls of Madrid, Grenada, Cordova, Seville, where they form chiefly the internal decorations of churches. The principles of the Spanish school are derived from Italy. In Germany, the reputation of Rauchmuller of Vienna, of Leigebe in Silesia, of Schluter at Berlin, Millich, Barthel, and others maintained reputation during the period now spoken of. Ohnmacht, Sonnenschein, Nahl bring the art to contemporaries of the present century.

On reviewing what has been said, it will appear that in the fifteenth century, the fine arts became important as national causes: till this date they had flourished in connection with those of utility, rather than from abstract feeling of the pleasures awakened, or the moral impressions enforced by the great and the elegant. While sculpture in particular was thus cultivated with the ardour inspired by a fresh object, it was improved by the vigorous efforts of unworn and unshackled intellect. Hence it has been the singular fate of the sculptors of this period, to have created models in those that followed, while they have continued models themselves; to have remained originals, in succeeding ages of originality. During the sixteenth century, political causes, more remotely connected with real patriotism, an ostentatious desire of splendour, not an unaffected love of refinement, operated in the promotion of the arts; and the artificial excitement seems to have imparted a portion of its spirit to its effects. Sculpture, indeed, was practised with the magnificence and success, which power, riches, and talents, will assuredly command; but purity and simplicity of design disappeared in proportion as peculiar ideas of grandeur and novelty were pursued. Genius hovered on the very confines of credibility; its creations derived their elements exclusively from an imagination awful and imposing; but the sympathies of human feeling were overwhelmed, not awakened, by those visionary forms of gloomy sublimity and power. Art was raised to regions where nature was unknown, and where the very highest exertions of intellect and fancy could hardly maintain empire or preserve interest. It fell therefore with him who had placed it on this dangerous height. While every preceding deviation from nature and simplicity was exaggerated in the sculpture of the two following centuries, the grandeur and originality which had redeemed minor imperfections were lost in the feeble hands of imitators. Nature was everywhere abandoned, conceit and affectation usurped the names of taste and of grace; and the solitary quality which finally remained—dexterity of hand, was calculated only to increase absurdity and mannerism, by affording facility of execution to every capricious novelty.

From the age of Michael Angelo inclusive, we find that the desire of novelty, a continued endeavour to extend the boundaries of the art by the introduction of imaginary perfections inconsistent with its real character and excellence, were the rocks on which was made fatal shipwreck of truth, of simplicity, and beauty. These imagined improvements were directed to the acquisition of two grand objects. A style of composition was aimed at more purely ideal, less connected with nature than is to be found in the remains of the ancient, or in the works of the early modern masters, or than is consistent with the principles of art. As characteristics of this imaginative style, the proportions are enlarged, the expressions forced, and power and energy are given destructive of grace and of reality. This was more especially the style of the Tuscan school. In the second place, sculpture was sought to be assimilated to painting, and merit was estimated by the extent to which imitation in this respect was carried—in difficulty and variety of effect, and in complicated detail, and in volume of drapery, and latterly even in facility of production. This taste necessarily cherished the mechanical powers of execution, in preference to the unobtrusive beauties of purity and correctness of design. This style began decidedly to display itself in the school of Bernini; and subsequently sculptors excelled, or rather were less inferior, according to the manner of the painter whom they followed as a model; till finally imitating Pietro da Cortona, and even Carlo Marratti, they rendered statues confused masses of cumbrous drapery, from which heads and extremities protruded often with little apparent connection. Still the chisel was wielded in a bold and even skilful manner; but moral beauty, sentiment, and truth,—chaste design and graceful composition had long ceased to animate the proofs of its mastery.

SECTION IV.

To correct, or perhaps to avoid the corruptions of taste and false principle, is in all cases more arduous than to elevate to higher excellence a rising art. In addition to this general difficulty, two peculiar obstacles opposed the renovation of Sculpture. The aberrations first to be repressed were exactly those which appeared to indicate genius and spirit. Exterior qualities, by which alone the many judge, were in no respect deficient; indeed, an exuberance of executive dexterity and management existed, first to be reduced, consequently the preliminary steps to reformation would seem to imply diminished freedom and energy. In the second place, the fine arts generally, and our subject in particular, had suffered from a system of criticism, originated in France under Louis XIV. which had long vitiated the public mind, and misled the judgment of the artist by false refinement and conventional principle. Towards the end of last century, however, more perfect discoveries of classic remains, aided by the writings of a few enlightened authors, had begun to excite a movement towards a happier order of things. To sculpture, the influence had not extended; this art was in the hands of those who, educated in former abuses, wanted the patience and the discrimination either to perceive the evil, or to apply the favourable occurrences of the time. Reformation in art has never been accomplished by mere imitation of examples, however excellent; nor by only adopting rules in opposition to methods less pure. Some mind of uncommon firmness and good sense is required, who, beginning the art with nature, brings to the work of reformation all the original powers, with more of severe judgment than have distinguished the greater proportion of even the fathers of invention. Such a mind had not yet assumed its enlightening career. At Rome, then the only school, if school it might be named, hardly any work save a copy was attempted; or if by chance an artist aspired to an original composition, a performance was exhibited, made up of plagiarisms from ancients and moderns, combined in an union of extravagance and conceit. Such were the labours of Penna, of Pacilli, of Lebrun, of Pacetti, of Rhigi, of Angellini; and without promise of rising merit, the art seemed fast verging to extinction.

Such was the condition of Sculpture, when, in 1787, was exposed to view at Rome a work declared at once by the intelligent, "of all the monuments of modern times to approach nearest to the beauty of ancient taste." This was the tomb of Clement XIV. the celebrated Ganganelli, a work ranking among those memorable productions which mark the commencement, while they announce the continuance of a new and better era. Standing itself nobly conspicuous, it is but one step from barbarism, yet directs the eye to a lengthened prospect of renovated grandeur and beauty; the first fruits of one of those rare minds just described, more rare than even original genius, whose fire, tempered with steady judgment and patient correctness, shows them born to redeem and to elevate a fallen age. The Sculptor was Antonio Canova.

The education of this artist, self-conducted and amid difficulty of every kind, completed with successful perseverance, alone supplies ample proof of transcendant talent, and of those qualities we have pointed out as necessary in one who aspires to reform a degraded art. Fallen upon evil days, descended of obscure parentage, remote from all means of advice or instruction, he raised himself to the highest honours, and greatest of all, became the true restorer of prostrate taste. Canova was born, in 1757, at Possagno, a distant and till then unknown hamlet of the territory of Treviso. Here he was intended by his friends for the humble situation, hereditary for two generations in his family, of stone-cutter to the village. A happier destiny however awaited him. Having early discovered marks of docility and talent, he was permitted, through the benevolent recommendation of the proprietor, to attend upon a Venetian artist, then employed on some stone ornaments at a neighbouring villa. In his fifteenth year, repairing to Venice, partly aided by the same patron, and having procured a workshop in the cloisters of a convent, he struggled forward; prudence and industry preserved independence, and merit at length procured friends whom virtue ever afterwards retained. At Rome, whither he had ventured to proceed, his only certain means of support being a small pension granted for three years by the Venetian senate, he greatly recommended himself to the discerning few, by the classic elegance and purity of his first production—the group of Theseus and the Minotaur. On this account he was selected to execute the monument already noticed.

The works of Canova are too numerous to admit here of particular description, or of minute examination. The impression is yet fresh upon the memory, when representations of them arranged in his funeral hall might well have been deemed the labours of successive periods, and of a race of sculptors, not the productions of one short life—the creations of a single mind. Neither have we forgotten, while now writing on the subject, that the undertaking has been gone into, only because we have seen and examined on the spot each of these exquisite masterpieces, and that to enjoy this advantage a very considerable portion of Europe must be traversed. These works, thus in number so imposing, and so widely extending the influence of their individual excellence, may be classed as follows:

I. Heroic compositions, or subjects of masculine strength and character.

II. Compositions in which softness and grace predominate as distinctive attributes.

III. Monumental erections and sculptures.

IV. Relievos chiefly in model.

In the first of these departments only has the superiority of Canova been questioned; or rather, while his claims have been universally recognised in productions of softer grace and loveliness, his powers seem less generally appreciated in the sublimities of severe and masculine composition. He has been admitted a master of the beautiful—hardly of the grand; the Praxiteles—not the Phidias of modern art. This opinion, causes merely extrinsic and unconnected with the genius or labours of the artist concurred to originate and to maintain. Notwithstanding an early predilection for this especial branch of his profession, as appears from his own letters, and from the choice of subject, where that choice was left free, more than forty years, and those the best of life, had passed away, before a proper opportunity occurred of gratifying this inclination or of proving his capabilities. Thus his fame was first established as the sculptor of the softer affections and more tender forms of nature. The world is parsimonious of praise, nor is it easy to pass those limits which public opinion has set to its own suffrage. Subjects of gentler character seem also to be more generally pleasing in Sculpture; hence while his works in this class have been spread widely by numerous repetitions, his labours in the more elevated style have remained in the originals. But it may be justly doubted how far Canova is not even superior to himself in the grander attributes and higher walks of art. By not one, but many, groups and single statues, he has attained, in nobility of form, correctness of science, strength of character, harmonious design, and, where demanded, forceful expression some of the best effects and loftiest aims of Sculpture. Nor is this merely a general character; individual works may be instanced, in each of which, while the intrinsic requisites of excellence are conspicuous, some especial constituent of greatness is remarkable. In manly and vigorous beauty of form, where grace and elegance are justly distinguished from the effeminate, we have the Perseus; not unworthy of its immediate prototype, the Apollo. In strength, in forceful expression, and perfection of science, there is the group of the Pugilists, in its peculiar range the most classic work of modern times. In harmonious and noble composition, united with grandeur of action, the Theseus combating the Centaur, offers an admirable example; nor does the whole extent of three preceding centuries afford a happier combination of poetic feeling and natural effect. For the terrible in expression and suffering, the Hercules and Lycas carries sculpture to its utmost limits in the representation of passion, yet without extravagance. These, with the Palamedes, the Hector and the Ajax, the Paris, and others that might be added, all belong to the grand style of art, furnishing a series of works in only one of several departments unparalleled in the history of any single man; while in the beauties of sustained effect—of learned design—of boldness and exquisite delicacy of execution, they may challenge comparison with the style of any former age. On leaving the regions of poetry and fable, to whose heroic imaginings he has thus given high embodiment, we find that in the faithful portraiture of the great or the venerable realities of human life, Canova has proved himself an equal master. The statue of Napoleon is a most majestic figure, combining the ideal in composition with individual and striking resemblance. Of dignity inspiring veneration, the kneeling figure of Pius VI. which received the very last touches of the artist;—of sedate energy and classical arrangement, that of Washington, furnish fine examples. In modern art, what more worthy of the highest praise than the characteristic firmness of good intention which respires in the statue of Ganganelli? or than the solemn and affecting feebleness of Rezzonico, which speak their sole support to be in religion?

In the second division of his works, Canova remains not only unequalled but unrivalled in our days. His compositions have enriched modern art with the most glowing conceptions of elegance and grace—raised and yet more refined by the expression of some elevating or endearing sentiment.

> —— Spargi intorno sì onesta dolcezza
> Che inanzi a te non ha chi pensi vile.

In all the elements of the beautiful—in form, attitude and expression, Canova is generally—often preeminently, happy. His forms, if not always possessing the highest ideal elevation, are never mean nor common; they are ever graceful selections from nature rendered with every beautiful aid of art. Contours simple and continuous, yet varied and flowing, are sustained by profound anatomical science, still without harshness or severity. His female figures are thus equally removed from the flimsy affectations of his immediate predecessors, as from the too robust and austere proportions of the Tuscan school. It is in those compositions which admit of a direct comparison with the antique, where we sometimes remark most decidedly a deviation into the meagre and the cold, when dignity is to be united with sweetness in the female form: a defect arising from a want of harmony between the just height and fulness of the figures. Of this the Venus exhibits a remarkable instance, where we look in vain for that sustained maturity of beauty which charms in her Grecian rival, for those inexpressibly soft, yet firm and full outlines, meeting but eluding the eye, rounded into life, and lost in the animated marble. In regard to expression in the department of the graceful, the idea of Canova appears to have been to unite the two elements of sculptural design, keeping each in due subordination to the other; hence his female statues have more of expression than the antique, and less than those of the modern schools. But in this expression, though he is always true, he is not often simple, except where nothing beyond mere placidity is attempted:—effort is not unfrequently too discernible, the expression is too elaborately pleasing to please, and though we acknowledge the presence of much suavity, there is little of feeling. The attainment of that ineffable charm, grace, in all its various constituents of attitude—composition—character—arrangement—appears to have been the leading object of Canova's study, and of which he has proved himself a perfect master. In every part of each of his numerous works, even to the smallest ornament, all is the emanation of the same refined taste and cultivated mind. Indeed he has been charged with running into the extreme of affecting studied elegance—of a laboured and fastidious refinement. And without doubt, his graces would be too ornate, were not the whole effect productive of the most inimitable ease;—ease proceeding from the very perfection of labour. The attitudes have all the freedom and truth of nature—yet they are not in reality the positions which nature would readily suggest or assume, but which graceful art would select as the most uncommon or the most attractive. The choice has finally, but not obviously been determined, after much thought and many trials. Even to the minutest fold of drapery the same principle extends; all is the perfection of art, not the simple imitation of nature, but it is art by which art itself is best concealed, and which to its creations lends the enchantment of nature's own sweetest graces.

In the third division of his works Canova displays all the peculiar excellencies of his genius, with more of originality and simplicity than is perhaps to be found in his other labours. This class may be divided into two; architectural elevations supporting colossal statues—and simple tablets in relievo with sculptures the size of life. Of the former, the tombs of the popes at Rome, of Alfieri at Florence, and of the archduchess Maria Christina at Vienna, are magnificent examples, and may be compared in magnitude, as in excellence, with any similar works of modern art. The monument of Ganganelli has already been noticed as announcing the dawn of reviving purity; that of Rezzonico Clement XIII. followed and confirmed the glories of the coming day. From these the monument of the archduchess is of a character totally different, and indeed stands alone in the annals of sculpture. A simple pyramid represents the sepulchre; towards the dark and open entrance, a procession of eight figures with funereal emblems, and bearing to its last earthly resting place the urn of the deceased, appears to move with silent and stealthy pace. Here reign a simplicity and pathos which speak directly to the heart; and if we may judge from the impression made upon our own feelings, no record of mortality ever better accomplished its purpose,—whether to awaken regret for departed virtue—or to tell by its own perfection—that there exists an intelligence in man which shall live beyond the grave.

The monumental relievos constitute a numerous and very beautiful class of works, and though composed of nearly the same slender elements of design, a female form mourning over a bust or an urn, yet they exhibit much diversity of character and arrangement, with great excellence of execution. With one exception they are all bassi relievi, extremely classical in design, and may be said to have been invented by Canova, since we trace resemblance only on one remain of Grecian sculpture. In many cases, however, greater force might have been given, if the contours, instead of melting gradually into the plane of the tablet, had been terminated by a perpendicular outline, as in several of the most admired specimens of antiquity. A firmer and more vigorous effect would thus have relieved the whole piece, which often resembles a highly finished picture, where the light is too equally diffused without just equivalent of shadow. To this the grand relievo on the monument of the Countessa de O'Hara offers a most splendid exception.

Not, however, till 1790, as a relaxation from severer labours, did Canova turn his studies to relievos properly so called, nor, except in one or two instances, did he execute any example in marble. But in this beautiful department of the art, he modelled numerous subjects from history, poetry, and mythology, all displaying the same pure taste and severely regular judgment as appear in more finished works. But, devoting his powers to more arduous pursuits, he left open this career for the exertions of others.

There still remains to be explained one distinctive characteristic of the works before us; namely, the uniform and exquisite beauty of the execution. They unite the dexterity and vigour of handling, which formed the praise of Michael Angelo and Bernini, with a delicacy, elegance, and truth, altogether and exclusively their own. Canova appears to have been the first to remark, certainly the earliest to imitate, this excellence in the models of antiquity, an excellence of the very highest import, not so of itself, but because it can be rendered pleasing only when united with intrinsic beauty of composition and veracity of science. A statue deficient in the higher qualities of art, would by nice finish be rendered only the more ungraceful. In sculpture, works of the greatest merit alone admit with advantage the external embellishment of the surface. The most perfect statues of antiquity are also the most highly wrought. But modern artists either studied general effect to the disregard of beautiful finish; or in the endeavour to attain minute excellence, fell into the dry and the laboured. For Canova it seemed to be reserved to combine grandeur and breadth of effect with the most delicate touch and the most careful detail. To him modern practice is indebted for this most valuable precept, elicited from a comparison of the antique with nature; namely, that from whatever resources the figure may be composed and brought nearly to a termination, the last touches, the final surface, must be faithfully copied from individual nature. This principle has in every instance guided his hand in the mechanical details. Another may be distinguished which has uniformly traced the gracious and sweetly flowing outlines of his statues; namely, the ternary combination of members in a whole—or that law of arrangement, which in the living as in the inanimate world, seems to create beauty by the relation of a primary and two secondary forms. To the former of these laws is to be ascribed the yielding and elastic, the almost living surfaces of Canova's statues; to the latter, their delightful propriety and just ordonnance of parts, yet devoid of all obvious symmetrical or artificial balancing of masses or attitudes. The exquisite purity of surface and lubricity of contour thus produced, gave rise to the supposition, that less legitimate operations of secret washes or preparations were employed. But though he certainly did make experiments on this subject with a view of discovering the processes with which there is reason to believe the Greek artists were acquainted; yet over his own works was merely poured a solution of pumice stone, or emery in water, in order to equalize the effects of light, and to take off the glare of recent finish. In the construction of the clay and stucco models, the *crete* and the *gessi* of the Italian sculptors, Canova likewise introduced the most important improvements; being the first who employed models fully and carefully completed, and the exact size of the intended marble, even in cases of colossal proportions. By this means the labour of the sculptor has been incredibly abridged, and his valuable time saved; for thus the formation of the statue to a very high degree of forwardness may be safely committed to the mere labourer. In short, not one branch of his profession was left by Canova unexercised nor unimproved.

The preceding series of his works, which, including busts and portraits, amounts to upwards of two hundred, fully establishes this, as these works exhibit the same merit in every department of the art, and in each separately, attaining a degree of eminence alone sufficient to insure immortality to any single artist. In this view there can be no hesitation in pronouncing Canova the most indefatigable; nor, when we consider the influence of these labours, and of the principles which they illustrate and enforce, the greatest of modern sculptors. Yet in estimating truly the rank and constituents of his genius, there arises no small difficulty. The very fecundity of that mind diffusing its richness over every province of the art, and in each varied character constantly displaying by the same admirable judgment and fine taste, increases this difficulty by blending into one harmonious whole the marked qualities and outbreakings of peculiar energies usually indicative of lofty powers. Hence we might be inclined to pronounce his genius distinguished more by correctness than by fire. Yet though such really seems externally to be the character impressed upon their exercises, of his powers generally, the estimate would be erroneous. His genius wanted neither fire nor enthusiasm—his imagination was uncommonly active, and stored with materials; but over the treasures thus lavishly poured forth, judgment and taste presided in severe scrutiny. Hence, though in composition rapid and energetic, in correcting and finally determining, he was slow or even fastidious; often changing, but always improving. With Dante he could truly have said

L' ingegno affreno
Perche non corra che virtù nol guidi.—
Piu non mi lascia gire il fren' dell'arte.

Such an intellectual organization is by no means favourable to that grandeur, usually associated with our ideas of the highest genius, which hurries alike the artist and the spectator beyond the bounds of reality; which, deriving its very mastery from daring disregard of rule, grasps with dangerous hardihood those aspiring graces, pardoned only when successful, and even then, however they may elevate the individual, not enriching art with useful examples or solid acquisitions. But such a mind was eminently fitted for exalting fallen taste, especially for succeeding in the serene majesty and regular magnificence which constitute the true greatness of sculpture. Hence in the labours of Canova there is to be found this superiority, that his march is uniformly dignified and consistent; correct without coldness, if he rarely attain the height of sublimity, he never falls beneath himself or into the extravagant in the pursuit. Compared with the ancients, he remains inferior, in as far as he has, like every modern, been indebted to the precepts and the examples of Greece. But his was no servile imitation, to have studied constantly their works, to have discovered and applied their principles, forms his greatest praise, and constitutes one of the most essential services ever rendered to sculpture. Among the moderns, Canova claims pre-eminence as being the first to establish the grounds of progressive improvement on genuine and universal principles of art. The greatest names whose labours illustrate former ages, either wrought without principles—their skill was merely personal, and the same tomb thus closed over the knowledge and the possessor; or they were at best but founders of partial theories, and of exclusive schools. By the sculptors living prior to the sixteenth century, accuracy of imitation was the only essential generally known and practised. The masters of that splendid era combined, with forceful execution, the magnificence of elevated—but of peculiar theory. Before Canova, no one had exhibited in his own works a just harmony between the several requisites of excellence, nor had given in practice rules conducting to general and undeviating results. From a degraded and lost condition he not only elevated art to a state of perfection, such as may be compared with its brightest periods, but founded this improvement on principles that lead progressively to greater excellence, or at least cannot bear to error since they conduct to nature. It is this remounting to the eternal sources of truth and beauty, this influence of universal principle, this exhibition of unchangeable and uniform art, which will render the works of Canova a standard in all ages to come—inseparably associating his merits with the future history of sculpture.

We approach with respectful diffidence our more immediate contemporaries. A few notices of those names who already belong to posterity may, however, prove not unacceptable.

Among the Italian sculptors,—consequently among the masters of Europe, Thorwaldsen has obtained the first place since the death of his illustrious contemporary above mentioned. The life of this artist displays a striking instance of the powerful volitions and deep-toned sensibilities of genius. Thorwaldsen was born at Copenhagen in 1771-2. His father, a builder in that city, possessing some knowledge of the arts, began early to cultivate the turn displayed by young Albert for sculpture. The years of childhood were passed in modelling and in carving architectural ornaments at home; on early entering a student in the academy of fine arts, in which professors, enjoying pensions from the government, are bound to give instruction without fees, he soon became distinguished; on every occasion carrying off the prizes proposed as the rewards of industry and merit. In his seventeenth year an extraordinary gold medal happened to be offered for the best relievo on the subject of sacking the temple at Delphi. The competitors were placed in separate apartments, and thus shut up from external communication, were to finish their respective pieces, or to relinquish the contest. The latter resolution, it is said, had almost been adopted by our youthful aspirant, whose feelings were so tremblingly alive to the peculiarity of his situation, that after hours of fruitless solicitude, he had not been able even to make an attempt. At length the flow of inspiration came; Thorwaldsen produced a model, not only unanimously declared the best on the occasion, but of such pre-eminent excellence as to entitle him to the award of the great gold medal assigned to the most accomplished pupil of the Danish academy. To this honour a pension was also joined for assisting the holder in foreign travel. It was thought advisable, however, that on account of inexperience, some time should be permitted to elapse before this latter advantage should be embraced. Accordingly, for some years Thorwaldsen remained at Copenhagen, where he executed several works of great promise. When at length he set out for Italy, having landed at Naples, the most longing desire of returning to his native land seized his mind; and not without difficulty was he prevailed upon, in the first place at least, to visit Rome. The sight of this venerable capital, and the friendly offices of some of his countrymen whom he there met, seem to have in part reconciled him to absence. But a new anxiety arose, and threatened to put a stop to all future hopes. He saw and ardently appreciated the rich treasures of art contained in that city; but the perfections of past exertions, far from stimulating, overwhelmed his spirit. He despaired of ever accomplishing an effort which should deserve mention in the place where these were to be found, and deep melancholy preyed upon his mind. For more than a twelvemonth he remained in a state of depressing irresolution, during which studies were thrown entirely aside, or resumed only to increase his mental sufferings, and almost to confirm into permanent disability the temporary diffidence of high-wrought feeling. The encouragement and advice of friends, his own ardent aspirations after honest fame, conquered at length this painful sentiment. Once more he addressed himself to his art, and produced the statue of Jason, a work which warranted the most honourable expectations, although the artist was yet personally so little known, that he himself was asked by one at a large party if he knew the young Dane who had just produced the admired model of Jason. Other labours followed, and the fame of Thorwaldsen was established by the two statues of Mars and Adonis, each of very opposite but of great beauty. Among the foremost to acknowledge and to praise the merits of these performances, was Canova, the sole individual who had reason to feel alarm from the success of such a rival. Canova, in 1809, received an order from the Danish monarch for four Bassi relievi, to be placed in the cathedral of Copenhagen; this order he declined, representing the justice of employing equal ability in a subject. Nor was the conduct of Thorwaldsen less noble.

> But let not sculpture-painting-poesy,
> Nor they, the mighty masters of these spells,
> Detain us,—our first homage is to virtue.

Among the masterpieces of Thorwaldsen, executed since the full establishment of his reputation, may be enumerated, the Graces—the exquisite allegories of Night and Aurora in relievo—the statue of Mercury as a shepherd—the triumph of Alexander, a relievo, ordered by Napoleon for the vice-royal palace at Milan—and, lastly, the colossal statues of Christ and the Apostles, commissioned for his native city. From these works, a just estimate of the Danish sculptor's powers may be formed. The character of these powers is certainly of a very elevated rank, but we apprehend is not to be placed so high as has often been done. The genius of Thorwaldsen is forcible, yet its energy is derived more from the peculiarity than from the real excellence of his manner. His ideal reminds us less of antiquity or of nature than of his own mind—it is the offspring of an imagination seeking forcible impression in singular combinations, rather than in general principles, and therefore hardly fitted to exert a lasting or beneficial influence on the progress of art. His aims appear hitherto to have been chiefly directed to the attainment of simplicity and of imposing effect. That the former quality, so essential to genuine sculpture, is in many instances very successfully preserved, will not be denied; but the simple differs widely from the meagre and the rude; and in the works of the Dane, the distinction is not always observed. This especially appears in those compositions wherein grace should be the predominant feeling; these are too austere, and without due refinement of character. The forcible, too, often approaches the exaggerated, as is particularly apparent in the air and contours of the heads, which, though grand and vigorous, are rarely found to harmonize in the principles of these effects, with the majesty and regularity of general nature. In strong contrast with the powerful conception thus displayed in the heads, is the feebleness frequently conspicuous in the attitudes and forms. The first have a littleness of manner, a cramped and studied action; while the second want firmness, sustained effect, and fulness of contour. Of the beauties and defects of Thorwaldsen's style, the Mercury may be pointed out as an admirable example, and as best known, from several models in this country. The figure is seated in the act of unsheathing a sword, with which to slay Argus, whom he had just lulled to sleep by the sweet melody of a pipe still held in his hand. The general idea of the figure is beautiful, we would say poetical in no ordinary degree. The head is of exquisite beauty, the prescriptive forms of antiquity being here too obviously associated to permit wide deviation. But when we scrutinize the more particular conduct of the piece, it is far from corresponding in manly character and science with these external excellencies. The attitude is too studiously contrasted—too artificially balanced; while, with a prettiness of action utterly unequal to the effort, he is attempting to draw a ponderous falchion, by slightly pressing the scabbard between his heel and the trunk against which he leans. The forms likewise are poor and feeble, without vigorous rendering, and destitute of their full roundness of outline. This last is the leading defect in the modelling of Thorwaldsen, which probably has arisen from his greater practice in relief. It is in this latter department that his genius is most unexceptionably to be admired. The frize representing the triumphal entrance into Babylon, notwithstanding an occasional poverty of invention, is one of the grandest compositions in the world; while nothing can exceed the delicacy of execution, and poetic feeling, in the composition of the Night, or the Aurora. But in statues, Thorwaldsen excels in those only whose lineaments and expression admit of uncontrolled imagination, and which may not be tried by regular principles or natural effect. Hence, in this department, the Apostles are by far the most excellent of his works, because the subject admitted novel or even uncommon modifications of the imagination. In short, Thorwaldsen possesses great, but singular, and in some respects erratic genius. His powers of fancy excel those of execution; his conceptions seem to loose their value and their freshness in the act of realizement. As an individual artist, he will command, and he deserves a high rank among the names that shall go down to posterity. As a sculptor, however, who will influence, or has extended the principles of his art, his pretensions are not great; or should that influence and these pretensions not be thus limited, the standard of genuine and universal excellence will be so far depreciated.

The present school of Italy has hitherto proved hardly worthy of these two great leaders. In the pursuit of certain mistaken notions of refinement, vigour and simplicity of character have been lost. The numerous imitators of Canova have omitted the study of his learned principles, and too often have followed with exaggerated effect the only failing towards which he inclines—elaborate grace. In French sculpture, as in painting, the modern school exhibits more of science than of feeling. Like Poussin, the artists of the present day seem to have so long devoted their attention to the forms of the antique, that they have forgotten living nature; but unlike their illustrious countryman, they have failed to realize the sentiment of antiquity. They have imitated faithfully the cold and correct lineaments—the canons of art: but the essence which unites art to nature—which breathes into Grecian statuary the breath of life—has escaped. In Germany, the studios of Vienna and Berlin appeared to us deserted from want of encouragement: in the younger Shadoff, who died in the prime of manhood, that country lost an artist of high promise. His *Filatrice*, or girl spinning, ranks among the most exquisite imitations of simple nature which modern times have produced.

If hitherto little has been said of British sculptors, two circumstances will explain the cause of this silence. Till the present age could boast of native artists, sculpture amongst us was an exotic—cultivated by foreigners, constituting no portion of national glory, and regarded with few or no national sympathies. Again, whatever efforts have been accomplished, these, except, in one or two instances, have produced no influence on the general progress of taste. In architecture, indeed, during the reign of Charles I. this country undoubtedly excelled every other in point of classical purity, if not in magnitude of undertaking. But the refinement was short-lived; the stern enthusiasm of the true—the coarse hypocrisy of the pretended republicans, and the turbulent spirits of all, rendered England an ungenial clime for the arts of elegance. Subsequently, Cibber, Roubilliac, Scheemacher,—all our celebrated sculptors,—were foreigners. Bacon, Banks, Jusson of the last age, were natives, and of merited celebrity; still their isolated labours tended slightly towards the formation of a school of British sculpture. By the distinguished masters of the present day this has been effected; and if we do not equal our neighbours on the Continent in the number, or probably in the separate excellence of works, yet speaking of the principles which guide the practice of our sculptors, and of the progress already made, we hesitate not to affirm, that this school has produced names equal to any in modern art; and that at this moment, in rectitude and sobriety of precept —in the walk which has hitherto been followed, where nothing is yet to be unlearned, and which must infallibly conduct to the very perfection of sculpture, the British school is the first in Europe. To particularize individual names might seem invidious, and would certainly prove an ungrateful task; but Flaxman we have unhappily lost; he too surely belongs to posterity; and Chantrey confessedly stands at the head in the province he has selected. In the sculpture of portraits, we have already spoken of the artists of Augustus' reign, and we know not if, since that period, any has ever so nearly approached the last lingering excellence of Greece as Chantrey. Indeed, the general effect of his busts and portraits, as regards their admirable representation of character, "La scultura del cuore," as it has been expressed, the works of the English artist are not unlike, and not inferior to those mentioned of that period.

Flaxman has more widely extended the influence of his genius—more intimately connected his labours with general improvement, than any other English sculptor. Towards the propitious revolution which has been described as taking place about the conclusion of last century he contributed; and had he then continued to remain in Italy, would have divided honours not unequally with the great reformer of taste. As it is, the artists and intelligent critics of that country admit his claims, regretting only their want of due acquaintance with his works. One of the most judicious of Italian writers thus speaks of Flaxman: "Gli debbe moltissimo, poi che quanto di lui cognosce servi grandamente a svegliare da una certa letargia monotona, e far risurgere il gusto dello stile aureo, e severo dell' antichità ch' egli seppe applicare alle sue invenzione." Even in early youth, Flaxman was distinguished from the crowd, by devotion to the study of the antique, and by fearless but judicious disregard of those feeble and conventional modes by which art was then disgraced. He was among the first, if not the earliest, to awaken the long dormant energies of sculpture—to unite art anew with nature, and with its own best examples. The simple, the grand, and the severe of the ancient remains he made his own; nor is there one name among all those now enumerated, who in these attributes has excelled the best works of our countryman. Since the ages of Grecian genius, we no where find greater meaning—more deep feeling of truth, with less pomp of art, than in the sculpture of Flaxman. Excelling both Canova and Thorwaldsen in the inventive powers of the mind—in all that constitutes the epic of art—he is inferior in the grace and facility of execution. Had his mechanical capabilities in modelling and in finishing equalled the loftiness of his conceptions and the purity of his taste, no sculptor of modern times would have enjoyed higher fame than Flaxman.

We omit with regret, yet not unadmired, not a few names of living English sculptors. In favour of these, however, we again repeat, that, looking prospectively—founding our remarks as much on what may be—as on what has been, no school in Europe can at this moment boast of happier auspices, of more vigorous practice, or of sounder principle. The noble and manly character of sculpture agrees with our national genius, harmonizes with our free institutions, and finds in our history sources of brightest inspiration. But to realize these advantages, let our style, especially here, be truly British; we have hitherto taken too much of our principles and of our criticism in the fine arts from others. Let us in future depend on ourselves. Let the British sculptor take nature, and antiquity, of which he possesses now the most perfect examples in existence—let him take these as his sole guides—and he must excel.

J. S. M.

SCURVY. See MEDICINE.

SCUTARI, or ISKENDERIE, a large fortified town of European Turkey in Albania, is situated on the river Bojane, at the south east extremity of the lake of Scutari, which is about 16 miles long and 7 broad. The town is divided into four quarters, and has several mosques and Greek churches. It is the see of a bishop, and the capital of a pachalic. The plain on which it stands is one of the richest in Albania, abounding in vines and olives, and adorned with numerous hamlets and country houses. Population 12,000, composed of Turks, Greeks, and Albanians. Distance from Constantinople 448 west.

SCUTARI, the Chrysopolis of the ancients, a large town of Asiatic Turkey, in the province of Natolia, beautifully situated opposite to Constantinople on the Bosphorus, on the slope of several hills, and richly intermingled with trees. The strait here resembles a large lake surrounded with large cities. This town being the rendezvous of the caravans from the interior of Asia, carries on a considerable trade. The summits of the hills above the town command the finest views of Constantinople and the adjacent country. It is a fashion among the Turks at Constantinople to be interred at Scutari. Population 30,000.

SCYLLA, now CAPE SCIGLIO, a rocky promontory at the entrance of the strait of Messina, which separates Sicily from the territory of Naples. Projecting into the sea, and stemming the waters as they flow through the narrowest part of the strait, a formidable current is produced, which, with an opposite wind, has a tendency to drive vessels on the opposite rocks of Charybdis. The smaller rocks near the base of the promontory increase the danger; and the tremendous noise of the waters dashing against the caverns, strikes terror into the inexperienced mariner. The height of the rock is about 200 feet. See MESSINA.

SCYLAX, an ancient geographer, was born at Caryanda in Coria; and according to Suidas, was the author of a Periplus of the coasts beyond the Pillars of Hercules, of a book respecting the Heraclides, a description of the Circuit of the Earth, and an Answer to Polybius's History. This Periplus, which is still extant, is a short survey of the coasts of the Mediterranean, the Euxine, and part of the west coast of Africa, as surveyed by Hanno. According to Herodotus, Scylax, along with others, was employed by Darius, son of Hystaspes, to discover the embouchure of the river Indus. "Proceeding," says Herodotus, "from the city of Caspatyrus, and the Pactyian territory, they sailed down the river in an easterly direction to the sea, and then continuing their voyage on the sea westward, they arrived on the 30th March, at the place where the king of Egypt despatched the Phœnicians to circumnavigate Lybia. After their voyage, Darius subdued the Indians, and opened the navigation of the sea." Some authors are of opinion, that the extant Periplus was not the production of the Scylax mentioned by Herodotus. It was edited by Vossius in 1639, by Gronovius 1697, and by Hudson in 1698. See the *Athenæum*, vol. iv. p. 32.

SCYTHIA is the name given in ancient times to an extensive country, extending from the 25th to the 116th degree of east longitude, and from the Circassian mountains to the Arctic circle. It was divided into Scythia in Europe and Scythia in Asia, these divisions being separated by the two Sarmatias in Circassian Turkey. See *Ancient Univers. Hist.* vol. iv.

SDILLES, or SDILI. See DELOS.

SEA. See PHYSICAL GEOGRAPHY.

SEA, DEAD. See ASPHALTITES.

SEA, PHOSPHORESCENCE OF THE. See PHOSPHORESCENCE.

SEA WEED. See AGRICULTURE.

SEAL. See MAZOLOGY.

SEAMANSHIP. See HYDRODYNAMICS; NAVIGATION INLAND; PNEUMATICS; and TACTICS NAVAL.

SEBASTIAN, ST. a frontier town of Spain, in the province of Biscay. It is situated at the mouth of the little river Urumea, and between two arms of the sea, about ten miles from the mouth of the Bidassoa, which separates France from Spain. The town contains 20 streets, several of which are wide, strait, and paved with large smooth stones. There are here three churches, five convents, an hospital, and a naval academy. The town is flanked with bastions and half moons, and the citadel occupies a conical and bare eminence, ascended by a spacious path. The harbour, enclosed by two moles, holds only about 30 merchant vessels. There were here five manufactories of hides and leather, some tan-yards, and a manufactory of anchors and cables for the royal navy, when this city was taken by the British on the 31st of August, 1813, (see FRANCE and SPAIN.) It was almost entirely laid in ashes, but has since been rebuilt. Population 12,000. East longitude 1° 58′ 30″; north latitude 43° 10′ 30″.

SEBASTIAN, ST. See BRAZIL.

SECEDERS, the name given to a numerous and highly respectable body of Presbyterians who have seceded or withdrawn themselves from the Established Church of Scotland. This secession took place in August, 1733, in consequence of a decision of the General Assembly, carried by the casting vote of the moderator, by which Mr. E. Erskine of Stirling, Mr. W. Wilson of Perth, Mr. A. Moncrieff of Abernethy, and Mr. J. Fisher, minister of Kinclaven, were expelled from the Church of Scotland for the boldness with which they attempted to alter the law of patronage. The Assembly, which met in May, 1734, empowered the Synod of Perth and Stirling to receive the ejected ministers into communion with the church, and to restore them to their respective charges. This resolution, however, was accompanied with the express direction, that the synod should not take upon them to judge of the legality or formality of the former procedure of the church's judicatories in relation to the affair, or either approve or censure the same. Although this resolution was a complete triumph to the seceding clergy, yet they refused to return to the church courts on this ground; and they published their reasons for this refusal, and the conditions on which they were willing to return into the bosom of the church. Having created themselves into an ecclesiastical court, under the name of the *Associated Presbytery*, they published what they called an *Act, Declaration, and Testimony*, to the doctrine, worship, government, and discipline of the Church of Scotland. They were now joined by other four of the brethren, and the Associated Presbytery consisted of *eight* clergymen. As the congregation of these individuals had become very numerous, the General Assembly of 1738 ordered the eight ministers to be served with a libel, and to appear before the Assembly of 1739. They accordingly appeared as a constituted Presbytery, and having declined the Assembly's jurisdiction, they instantly withdrew. The Assembly of 1740 deposed them from the office of the ministry, but they erected regular meeting houses, where they exercised their clerical functions till their death.

In 1745 the Seceders had become so numerous that they formed one Synod, consisting of three different Presbyteries. In 1747, however, a controversy arose among them respecting the legality of the burgess oath, in which burgesses professed "the true religion presently professed within the realm, and authorised by the laws thereof." The presbytery, who asserted the lawfulness of the oath, were called *Burghers*, and those who condemned it *Antiburgher Seceders;* and under these names they formally separated into two distinct communions. This separation continued till within these few years, when an union took place, and the two classes of Seceders were reunited under the name of the *United Associate Synod of the Secession Church*, consisting, in 1827, of 19 presbyteries and 333 churches. About 50 congregations of the *Burgher Synod* refused to enter into the union, and now form the *Original Burgher Associate Synod;* and 16 congregations of the Antiburghers likewise refused, and form the *Constitutional Presbytery*, or *Original Antiburghers.* These different bodies have each Professors of Theology, by whom their students are instructed in theological literature.

The Relief Seceders, who separated from the Church of Scotland solely on the ground of church-patronage, now consist of 84 congregations. They have now a Professor of Divinity of their own, their students having been till lately instructed by the Professors of Theology in the Established Church. All the clergy of these different sects of Seceders are well-educated and highly respectable individuals, and are in no respects inferior to the Established clergy, either in theological or in secular learning. See our article SCOTLAND.

SECOND-SIGHT, or TAISCH in Gælic, is the name given to one of the superstitions of our countrymen in the Highlands of Scotland.

The person who possesses this extraordinary faculty is supposed to see, in his mind's eye, events which are taking place at a distance, and even those which are to take place at some remote period.

The visions which are thus presented to the eye, or to the imagination, relate to subjects of all degrees of importance, from the most trifling to the most interesting; and sometimes they are so truly ludicrous that a person who is disposed even to be credulous, cannot fail to regard them as the inventions either of weak or of wicked minds.

Disposed as we are to consider the second sight as a gross superstition, we should not have deemed it necessary to occupy our pages with any account of it, had it not had its peculiar locality in our own country. In a Scottish work, however, foreigners may expect to find some notice of a Scottish superstition, and, on this ground, we have ventured to give our readers some idea of its nature and pretensions. It appears to us that many of the facts which have been brought forward in support of the existence of a *second-sight* may be simply admitted without adopting the conclusion to which they are supposed to lead. There are few men of warm imaginations and contemplative natures, who are not in the habit of seeing in their mind's eye vivid dramatic representations, in which their relations and friends generally perform the most conspicuous parts. Without being able to trace the association, how often do we see a friend or a relation sinking beneath the wave, falling in battle, suffering under the hands of the executioner, or stretched a lifeless corpse on a bed of sickness. These pictures are often presented to us in all the freshness of reality, but frequently in the most mutilated and imperfect state. We cannot tell how the drowning man fell into the sea, in what battle the victim bleeds; for what crime our friend has suffered, or of what disease he has died. We merely see him in one or other of these distressing situations, and so singular is the ambiguity which accompanies these visions, that the person thus seen may be one of two friends; he may bear the name of one and yet have the appearance of another; he may stand to us in the relation of a parent or a child, and yet some circumstance may attend the vision which proves that he is neither. The mind, in short, of an idle, dreaming, and fanciful man, who is not engrossed by the cares and active business of life, is continually at exercise, roaming wherever it listeth, and covering its track with creations and visions of all kinds. When a friend suffers or dies, he can scarcely fail to have anticipated his agonies; when an unexpected event occurs, he must have encountered something convertible into it among his day dreams. When an enemy lands on his coasts, he is likely to have seen him in the offing during his nocturnal cruises. If our Highland seers had put on record all their visions, and given us an account of those which were not realized, as well as of those which appeared to them true, we should doubtless have been able to explain their second-sight by the ordinary doctrine of probabilities.

Although we do not think that any other explanation of second-sight is necessary than the above, yet we doubt not our readers may be gratified with the following observations on the subject by Dr. Beattie and Dr. Johnson, on the opposite sides of the question.

"The Highlands of Scotland," says Dr. Beattie, "are a picturesque but a melancholy country, having long tracts of mountainous desert covered with dark heath, and often obscured by misty weather; narrow valleys thinly inhabited, and bounded by precipices resounding with the fall of torrents; a soil so rugged, and a climate so dreary, as in many parts to admit neither the amusements of pasturage nor the labours of agriculture; the mournful dashing of waves along the friths and the lakes that intersect the country; the portentous noises which every change of the wind, and every increased diminution of the waters, is apt to raise in a lonely region full of echoes, and rocks, and caverns; the grotesque and ghastly appearance of such a landscape by the light of the moon; objects like these diffuse a gloom over the fancy, which may be compatible enough with occasional and social merriment, but cannot fail to tincture the thoughts of a native in the hour of silence and solitude. If these people, notwithstanding their reformation in religion, and more frequent intercourse with strangers, do still retain many of their old superstitions, we need not doubt but in former times they must have been much more enslaved to the horrors of imagination when beset by the bugbears of popery and paganism. Most of their superstitions are of a melancholy cast. That of second-sight, by which some are still supposed to be haunted, is considered by themselves as a misfortune, on account of the many dreadful images it is said to obtrude upon the fancy. It is said that some of the Alpine regions do likewise lay claim to a sort of second-sight. Nor is it wonderful if a lively imagination, immured in deep solitude, and surrounded with the stupendous scenery of clouds, precipices, and torrents, should dream (even when they think themselves awake) of those few striking ideas with which their lonely lives are diversified; of corpses, funeral processions, and other subjects of terror; or of marriages, and the arrival of strangers, and such like matters of more agreeable curiosity. Let it be observed also, that the ancient Highlanders of Scotland had hardly any other way of supporting themselves than by hunting, fishing, or war—professions that are continually exposed to fatal accidents. And hence, no doubt, additional horrors would often haunt their solitude, and a deeper gloom overshadow the imagination even of the hardiest native. That any of these visionaries are apt to be swayed in their declarations by sinister views we will not say; but this may be said with confidence, that none but ignorant people pretend to be gifted in this way. And in them it may be nothing more, perhaps, than short fits of sudden sleep or drowsiness, attended with lively dreams, and arising from some bodily disorder, the effect of idleness, low spirits, or a gloomy imagination. For it is admitted even by the most credulous Highlanders, that as knowledge and industry are propagated in their country, the second sight disappears in proportion; and nobody ever laid claim to the faculty who was much employed in the intercourse of social life. Nor is it at all extraordinary that one should have the appearance of being awake, and should even think one's self so, during those fits of dosing, that they should come on suddenly, and while one is engaged in some business. The same thing happens to persons much fatigued, or long kept awake, who frequently fall asleep for a moment, or for a long space, while they are standing, or walking, or riding on horseback. Add but a lively dream to this slumber, and (which is the frequent effect of disease,) take away the consciousness of having been asleep, and a superstitious man may easily mistake his dream for a waking vision; which, however, is soon forgotten when no subsequent occurrence recals it to his memory; but which, if it shall be thought to resemble any future event, exalts the poor dreamer into a Highland prophet. This conceit makes him more recluse and more melancholy than ever, and so feeds his disease, and multiplies his visions, which, if they are not dissipated by business or society, may continue to haunt him as long as he lives, and which, in their progress through the neighbourhood, receive some new tinctures of the marvellous from every mouth that promotes their circulation. As to the prophetical nature of this second-sight, it cannot be admitted at all. That the Deity should work a miracle, in order to give intimation of the frivolous things that these tales are made up of, the arrival of a stranger, the nailing of a coffin, or the colour of a suit of clothes; and that these intimations should be given for no end, and to those persons only who are idle and solitary, who speak Gaelic, or who live among mountains and deserts, is like nothing in nature or providence that we are acquainted with, and must therefore, unless it were confirmed by satisfactory proof (which is not the case), be rejected as absurd and incredible. These visions, such as they are, may reasonably enough be ascribed to a distempered fancy, and that in them, as well as in our ordinary dreams, certain appearances should, on some rare occasions, resemble certain events, is to be expected from the laws of chance; and seems to have in it nothing more marvellous or supernatural, than the parrot, who deals out his scurrilities at random, should sometimes happen to salute the passenger by his right appellation."

To these objections Dr. Johnson replies, that by presuming to determine what is fit, and what is beneficial, they presuppose more knowledge of the universal system than man has attained: and therefore depend upon principles too complicated and extensive for our comprehension; and that there can be no security on the consequence when the premises are not understood; that the second-sight is only wonderful because it is rare, for, considered in itself, it involves no more difficulty than dreams, or perhaps than the regular exercise of the cogitative faculty; that a general opinion of communicative impulses, or visionary representations, has prevailed in all ages and all nations; that particular instances have been given with such evidence, as neither Bacon nor Boyle has been able to resist; that sudden impressions, which the event has verified, have been felt by more than own or publish them; that the second sight of the Hebrides, implies only the local frequency of a power, which is nowhere totally unknown; and that when we are unable to decide by antecedent reason, we must be content to yield to the force of testimony. By pretension to second sight no profit was ever sought or gained. It is an involuntary affection, in which neither hope nor fear are known to have any part. Those who profess to feel it do not boast of it as a privilege; nor are they considered by others as advantageously distinguished. They have no temptation to feign, and their hearers have no motive to encourage the imposture."

SECTIONS, Conic. See Conic Sections.

SECTOR, called by the French the *Compass of Proportion*, is the name of a mathematical instrument in common use for determining the proportion between similar quantities.

It consists of two flat legs, or rules, made of wood, brass, or ivory, which, being moveable round a common axis or joint, represent the radii of a circle. Hence the double lines which belong to the sector can be made to fit all radiuses and all scales, whereas common single lines are suited only to one radius or scale.

The sector depends on the fourth Proposition of the VIth Book of Euclid, or the XVIIIth Proposition of Section IV. of our article Geometry, where it is demonstrated that equiangular triangles have their homologous sides proportionals. Let, for example, the lines BD, BC. (Geometry, Plate CCLXXII. Fig. 123.) represent the legs of the sector which open and shut round B as a centre, and let BA, BE be equal sections or distances from the centre of motion B: then, if the points C, D; E, A, be joined, the lines EA, CD, will be parallel, and consequently, the triangles BAE, BDC, similar; hence, BA : AE = BD : DC; and therefore, if BA be the half, third, or fourth, &c. of BD, AE, will be the half, third, or fourth, &c. of DC. Consequently, if BA be the chord, sine, or tangent, of any number of degrees to the radius BD, AE will be the same number of degrees to the radius DC.

The scales commonly engraven upon the best sectors are divided into *single* and *double*. The single scales are the same, and used in the same manner as those put upon *Gunter's* Scale, which we have fully described in our article Navigation. They have no connection with the property of the sector, but are merely put on to fill up usefully the vacant spaces which are not occupied by the *double scales*. The *double scales* consist of two similar single scales, each of which is engraved twice on the same face of the instrument, viz. one on each leg, each scale occupying a symmetrical position upon the legs.

The following table shows the nature of the scales generally put on.

Double Scales.

1.	A Line of Lines, or equal parts	marked	Lin.
2.	Chords		Cho.
3.	Sines		Sin.
4.	Tangents to 45°		Tan.
5.	Secants		Sec.
6.	Tangents to above 45°		Tan.
7.	Polygons		Pol.

Single Scales.

1.	Inches, each divided into 8ths or 10ths		
2.	Decimals containing 100 parts		
3.	Chords	marked	Cho.
4.	Sines		Sin.
5.	Tangents		Tan.
6.	Rhumbs		Rhum.
7.	Latitudes } For dialling		Lat.
8.	Hours } For dialling		Hou.
	Longitude		Lon.
	Incln. Merid.		In. Mer.
	Logarithms of Numbers		Num.
	Logarithms of Sines		Sin.
	Logarithms of Versed Sines		V. Sin.
	Logarithms of Tangents		Tan.

The single scales above-mentioned may be all used whether the sector is open or shut, but the double scales cannot be used without opening the sector.

The method of laying down the double scales by means of tables calculated on purpose, will be found in James Ferguson's *Select Exercises*, or in Dr. Brewster's edition of *Ferguson's Works*, vol. v. pp. 287—304.

1. *On the Line of Lines, and the method of using it.*

Each scale of the line of lines is divided into *ten* equal parts, which may be called *Divisions of the first order*. Each of these great divisions is subdivided into ten other equal parts, which may be denominated *Divisions of the second order*; and each of these is again divided by shorter lines into *two* parts, which may be called *Divisions of the third order*.

When the whole line of lines represents 10 parts, then the primary divisions represent units, and the secondary divisions represent 100th parts, and the divisions of the third order 200th parts.

When the whole line represents a 100, then the secondary divisions represent units or 100th parts of the whole, and the divisions of the third order 200th parts of the whole.

If the whole line represents 200th parts, then the smallest divisions are units, or 200th parts of the whole.

1. In order to divide a given line into any number of equal parts, for example 5, take the given line in your compasses, place one point on the 5 of one scale of the line of lines, and open or shut the sector till the point of the other foot falls on 5 on the opposite scale of the line of lines, then the distance between 1 and 1 of the same scale will be the fifth part of the given line, or the $\frac{4}{5}$th part of the given line will be the difference between the given line, and the distance of the points 4 and 4.

If the given line is too long to be applied to the sector, divide only $\frac{1}{2}$ or $\frac{1}{4}$ of it by 5, and the double or quadruple of the result will be the fifth part of the whole.

2. To form a scale of a given length to contain a given number of equal parts. If the scale to a plan

is 8 inches long, and contains 120 poles, let it be required to obtain such a scale from the sector. Having opened it, make the distance between 6 and 6 of the line of lines $= \frac{12}{2}$, equal to 4 inches ($= \frac{8}{2}$,) and the line of lines will now give the required scale.

3. To divide a line, for example, one 7 inches long into two parts of any assigned proportion, as 3 to 5, take 7 inches, the length of the line, and set it from 8 to 8 = 3 + 5, and the distances of the divisions 3.3 and 5.5 will be the parts required.

4. To find a third proportional to two given lines, for example 2 and 8, take in the compasses the lateral distances of the second term 8 from the centre or axis of motion of the sector, and setting one foot on the division expressing the first term, viz. 2, open the sector till the other foot falls on 2 on the other leg. The sector remaining in this position, take the transverse distance of 8 and 8, and this distance measured laterally from the centre will be 32, the number required for 2 : 8 = 8 : 32.

5. To find a fourth proportional to three lines, as 3, 6, and 8. Open the sector till the transverse distance of 3 is equal to the lateral distance of 6 from the centre, or some part of it; then the transverse distance will give 16, the fourth proportional required for 3 : 6 = 8 : 16.

6. To open the sector so that the two scales of lines shall form a right angle. As every triangle whose sides have the ratio of 3, 4, and 5, is a right angled one, take between the points of the compasses the lateral distance from the centre to the division marked 5, and set one foot on the division marked 4 on one of the scales of lines. Open the sector till the other foot falls on the division marked 3 on the other scale of lines, and the sector will stand at right angles to each other.

7. To find a mean proportional between two lines, for example, between 20 and 80. Place the two scales at right angles, and taking in the compasses 50, half the sum of the two lines, apply one foot to 30, the half difference, the other foot will reach to 40, the mean proportional wanted, for 20 : 40 = 40 : 80.

8. To diminish a line of 13 inches in the proportion of 6 to 5. Open the sector till the transverse distance of 6 and 6 is equal to the lateral distance of 5 and 5. Mark the point where 3 inches taken from the centre as a lateral distance reaches, and the transverse distance at that point will be the line required.

The operations of subtraction, multiplication, and division, may be performed by the line of lines; but as this process is of no utility, we shall not occupy our pages with any account of it.

2. *On the Scale of Chords, and its use.*

This is the most generally useful of all the double scales in the sector.

1. To open the sector till the two scales of chords make an angle of any number of degrees, for example, 35°. Take in the compasses the distance from the centre or joint to 35°, the proposed number of degrees, and having opened the sector till the transverse distance from 60° to 60° on each leg is equal to the distance in the compasses, the scales will make an angle of 35°.

2. To find the inclination of the two scales of chords when the sector is opened. With the compasses lay the distance from the two brass points at 60° and 60 from the centre along one of the scales of chords, and the degrees indicated will be the angle required

3. To determine the angles made by the external or internal edges of the sector, lay a straight edged ruler from 60° to 60°, of the line of chords, and having taken in the compasses the distance between the points where the edge of the ruler cuts the inner edges of the sector, lay this distance along the line of chords from its centre, and the degrees indicated will be the angle of the internal edges of the sector, which will also be that of the external edges, as these edges are respectively parallel.

Hence the sector may be used as an instrument for taking angles, by putting sights on its outer edges. It may also be used in many cases as a gaoniometer for measuring the angles of crystals.

4. To lay off an angle of any number of degrees, such as 42° less than 60°. At any opening of the sector, but the wider the better, take the transverse distance of 60° and 60° on the line of chords, and with this as a radius describe the arch of a circle. Take the transverse distance of 42° and 42°, and put this distance on the arch described. From its extremities draw two straight lines to the centre of the circle, and these lines will contain an angle of 42°. When the degrees are above 60, as 129, taking one half or one third of them, so that they may be below 60, viz. in this case $\frac{129}{3} = 43°$, and having described an arch as before, take the transverse distance of 43° and 43° from the scale of chords, and having set it thrice on the arch, and drawn lines from the extremities of the triple arch, they will form an angle of 129°.

5. To find the inclination of two given lines, describe an arch round the vertex or point of intersection, and open the sector till the distance from 60° to 60° is equal to the radius of the above arch, then taking the chord of the arch, or the distance between its extremities in the compasses, set it on each scale of the line of chords till each point of the compass falls on the said division, the degree thus indicated will be the inclination required.

6. To lay down an arch of any magnitude on the circumference of a circle. Having found the radius of the circle, open the sector till the distance of 60° and 60° be equal to that radius, then take in the compasses the chord of the given number of degrees on each leg of the sector, and lay it off on the circumference of the given circle.

By this operation a polygon of any number of sides may be inscribed in a circle. If, for example, the polygon is required to have 20 sides, then the chord of one of its sides will be $\frac{360}{20} = 18°$, which, taken as above described, and set round the circumference, will divide it into twenty parts. By joining the different points thus found, the polygon will be formed.

3. *On the Scales of Sines, Tangents and Secants, and their use.*

1. As all the scales of chords, sines, tangents, and secants are laid down to the same radius, we can o-

tain for any radius within the compass of the sector, the chord, sine, tangent and secant of any number of degrees by one adjustment of the sector. If, for example, we require them for 20°, we have only to take the given radius, and set it from 60° to 60° on the line of chords, from 90° to 90° on the line of sines; from 45° to 45° on the line of tangents, brass points being inserted at all these places, and then take from the proper scale the transverse distance of 20° to a given radius.

2. To find the chord of 80°, which is a greater number than 60°, the highest in the sector, take the transverse distance of 40° or half the arc, and lay it down twice on the circumference of a circle of the given radius, the distance between the extreme points of this double arch taken in the compasses will be the chord of 80°.

3. To find to a given radius the tangent of 70° greater than 45°, the highest on the sector take the given radius, and set it transversely from 45° to 45° on the upper scales of tangents marked 45, 50, 60, 70, 75, then take the transverse distance of 70° from the same scale for the tangent required.

4. To find the secant of an arch, for example, of 20°, open the sector till the given radius taken in the compasses is the transverse distance between 0° and 0°, or the inner termination of the scales, then the transverse distance between 20° and 20° will be the secant required. The secant of any number of degrees may be found from the line of sines thus; but this can only be done when the radius of the circle can be made a transverse distance to the cosine of the given number of degrees. Let the given radius be two inches, and let the secant of 76° be wanted. Make the radius two inches a transverse distance to the sine of 14°, the complement of 76°, then the transverse distance of 90° to 90° will be the secant of 76°.

4. *On the Line of Polygons, and its use.*

The line of polygons is placed at the two internal edges of the sector, and is numbered from 4 to 12. These lines are drawn to meet the inner lines of the line of chords, and the line of lines, and the reckoning is to be made from these lines.

1. To inscribe in a circle a regular polygon, viz. a decagon or figure of ten sides, open the sector till the transverse distance of 6 and 6 is equal to the diameter of the circle, then the transverse distance of 10 and 10 will be the side of a decagon, which may be inscribed in the circle. In the same way, any other polygon may be inscribed provided its sides do not exceed 12.

2. To describe upon a given line a regular polygon, such as an octagon, open the sector till the given line is a transverse distance to 8 and 8; then take the transverse distance of 6 and 6, and with this radius describe round the extremities of the line as centres small arcs of a circle intersecting each other. Round the point of intersection as a centre, and with the same radius, describe a circle which will of course pass through the extremities of the given line, and in this circle the octagon may be described by repeating the given line round its circumference.

The sector is an instrument of great use in dialling, in projecting solar and lunar eclipses, in the orthographic and stereographic projections of the sphere. The reader is referred for more minute information respecting its structure and use to Bion on the *Construction of Mathematical Instruments*, Robertson's *Treatise of Mathematical Instruments;* but particularly to a separate treatise on the *Compass of Proportion* by M. Ozanam.

SECTOR, DIP, the name of an instrument contrived by Dr. Wollaston* for measuring the angle of dip, or the depression of the visible horizon below the horizontal plane passing through the eye of the observer. The following very distinct description of the instrument itself, and of the method of using it, is given by Captain Basil Hall in his voyage to Loochoo.

"A perspective view of the dip sector, is shown in Plate CCCCLXXXVII. Fig. 1, and a plan of it with the telescope removed in Fig. 2. In Fig. 2, A and B represent the two reflecting glasses at right angles to the plane of the instrument, and also nearly at right angles to each other. It is clear that when the plane of the instrument is held vertically, an eye situated at E, and looking through the unsilvered part of the glass A, at a distant point C, will at the same time see by joint reflection from both glasses, another distant point D at 180° from C; and D will appear to correspond with C, if a suitable motion be given to the index glass B by the tangent screw F.

The instrument may now be supposed to measure the arc CZD. If the points C and D be each three minutes farther from the zenith than 90° the entire angle will then exceed 180° by double that quantity. The relative position of the glasses then corresponds to 180° 6′, and the six minutes of excess would be shown on the arc at F if there were no index error. But by reason of the index error, the real quantity will not be known till a similar observation has been made with the instrument in an opposite direction. If the instrument be now inverted, so that the unsilvered glass is uppermost, the arc intended to be measured is CND, or the sum of the distances of the points C and D from the nadir instead of the zenith, which of course falls short of 180° by as much as the former arc exceeded that quantity.

The difference of the two arcs is consequently twelve minutes, and if the index be now moved till the objects C and D appear to correspond, the amount of this double difference will be shown by the change of position of the vernier.

Hence it is evidently unnecessary that the index error should be previously known, and even preferable that its amount should be such as to avoid the needless introduction of negative quantities by positions on different sides of zero.

In the preceding description, it is supposed that the eye is looking directly through the unsilvered glass at the horizon, and that it also perceives the opposite horizon after two reflections; but an inspection of the figure will show that the observer's head would necessarily intercept the rays from the horizon behind him. To obviate this, both the direct and the reflected rays are received in coming from the unsilvered glass (and after passing through the field glass of the telescope) on a mirror placed at an angle of 45°, which

* See *Phil. Transactions*, 1800, 1803.

reflects them to the eye. By this ingenious contrivance, the obstruction is removed, and the opposite points of the horizon may be both seen at one moment.

In practice it is most convenient to direct the telescope to the same part of the horizon in both cases. Thus, if the east and west parts of the horizon be observed, and that the index glass be uppermost, and telescope pointing to the west, the observer is on the south side, and his face must be turned to the north. When the instrument is inverted, if the observer turn himself round at the same time, so as to face the south, then the telescope will be pointed as before to the west; but since the index glass is now undermost, the inferior arc will now be measured precisely as if his face were to the north, but with the advantage of the same lights seen in the erect position of the instrument.

In using this instrument at sea for the first time considerable difficulty arises from the constant change in the plane of the instrument from the perpendicular position, in which it is absolutely necessary that it should be held, in order to obtain a correct observation. What at first appears to be a defect, however, is a real advantage, namely, that whenever it is held in the least degree out of the vertical plane, the two horizons (that seen direct, and the reflected one) cross each other, and it is only when the plane is vertical that the horizons can appear parallel.

The object is to get the two horizons to coincide exactly, and for this purpose it will often be necessary to have them of different shades. This is managed, as in the sextant, by means of the screw, which raises or lowers the telescope. When the telescope is brought nearer to the plane of the instrument, the reflected horizon becomes dark and distinct, but when screwed off it becomes fainter, and is not so well defined. Practice alone can teach the degree of intensity which is most favourable. In general, it is best to have one horizon dark, and the other light; then bring them very nearly to coincide, and wait till the ship is steady, at which moment a slight touch of the tangent screw brings them exactly to cover one another. It will happen, of course, that when the coincidence is perfect, there is only one horizon to be seen, and a doubt remains whether all is right, but a slight motion of the instrument, by making the horizons cross each other, defines them at once.

It is advisable to take several observations, and the safest way is to take one first with the index glass uppermost, and then with the instrument inverted, after which to return to the first, and so on for two or three times each way."

SECTOR, Astronomical, the name of an instrument contrived by Mr. George Graham, for taking differences of right ascension and declination, which are too large to be observed with a micrometer in a fixed telescope. A full description of it, with a drawing, will be found in Smith's *Optics*, vol. ii. p. 350.

SECTOR, Zenith, the name of an instrument for measuring small angles near the zenith. A very fine instrument of this kind, constructed by Ramsden and Berge, has been described by Major Mudge in the Phil. Transactions for 1803, p. 383. The following abstract of this description has been given by Dr. Young.

"The external frame of the instrument is of mahogany, constituting a truncated pyramid, on a base of six feet square, tapering to a vertex of three. The internal frame, which immediately supports the sector, revolves on a vertical axis, terminating below in a cone, which rests in a conoidal cavity, convex to the axis, and above in a cylinder, passing through an octagonal aperture in the upper frame. As it turns, its motion is indicated by an azimuth circle attached to the lower part of the external frame, and it may be brought into the direction of the meridian by a telescope fixed in the plane of the arch. The telescope of the sector is eight feet long, and its aperture four inches; the axis is like that of a transit instrument, the plumb-line passes through two perforations in it, and is adjusted by means of a screw with a jointed handle, and a long bent microscope with specula, so as to bisect a point marked on a plate of mother of pearl, precisely in the axis of the instrument; this plate is properly illuminated by the same lamp that serves for the micrometer wires of the telescope, its light being reflected downwards upon the wires from an oblique surface covered with plaster of Paris.

The pivots of the sector's axis are of bell metal, they rest in Y's, firmly attached to the frame: their sliding horizontally is prevented by a fixed friction wheel on one side, and a spring supporting a friction-wheel on the other; four cylindrical braces are employed to fix the telescope firmly to the axis; and the bending of the axis is still farther obviated by levers with counterpoises, acting by means of friction-wheels, close to the tube of the telescope, so as to leave so much of the weight only to be supported by the pivots as is necessary to keep the instrument steady. The telescope is moved by strings and pullies, and is retained in any given situation by weights. A long spirit level is employed for bringing the axis into a position truly horizontal.

The arch is divided into portions of five minutes each, marked by points, on golden pins, let in at each division. A fine line was struck when the telescope was properly supported on the pivots; the instrument being then removed, the diameter of the circle, of which this arc was a part, was ascertained, and one sixteenth of this, being taken as extremely near to the chord of 7° 10′, was laid off on each side zero; and this arc was verified by comparison with another, obtained, by means of continual bisections, from an arc of 60°. The micrometer screw carries a head divided into 59 parts, nearly corresponding to seconds; the half of the arc on one side zero was found to contain only a single second more than the other portion.

The greatest error that could be observed from a difference of temperature in different parts of the observatory, was found to be little more than half a second for an arc of five degrees. The observations of the zenith distances of the various stars employed, were completed in October 1802; and the instrument was brought back to London without having sustained the least perceptible injury."

SEDLITZ Waters. See Mineral Waters.

SEGESTAN, or Seistan, an independent province in the east of Persia, bounded on the north by Candahar and Khorasan, and on the south by Mekran and Balouchistan, is 300 miles long and 160 broad. It was once one of the finest provinces of the empire, but the sand winds from Mekran and Balouchistan, which blew for 120 days during the hot months, have reduced it to the most desolate condition. The banks of the Heermund, which rising in Cabul, flows through the province into the lake of Durrah, consist of a valley from one to two miles broad, which is cultivated and covered with verdure and brushwood. On each side of it rise perpendicular cliffs, which bound the arid desert, intersected with one or two ranges of mountains, which form the rest of the province. Along the valley are great numbers of ruined towns, villages, and forts; and at one of these was Kulcauput, a noble palace in a state of good preservation. The Heermund is 400 yards wide and very deep, and its water is remarkably fine. Captain Christie describes the remains of a city called Poolkee as immense. The principal place of Seistan is Doorhak, the residence of the prince, in east long. 63° 10′, and north lat. 31°. It is situated 10 miles from the river, and is small and compact, though the ruins of it cover a great surface. It has a good bazaar, and is populous. The country round produces wheat, barley, and good pasturage. The revenues of the prince are 80,000 rupees, and his military force 3000 men. The ruins of a very large city called Peshawaroon stand 25 miles north of Dooshak; and a few miles beyond it are the ruins of Joaen. Ferrah, a large walled town 65 miles from Dooshak, stands in a fertile valley, on a river which runs into the lake Zerreh. The city of Kubbees, about ten days journey from Dooshak, stands in the midst of the arid plain above mentioned, fifteen days journey from Kerman, and sixteen from Yezd. See Kinneir's *Memoir of the Persian Empire*, p. 189—194.

SEGNA, a free sea-port town of Morlachia, under the protection of Austria. It stands on the Adriatic, at the mouth of a narrow valley, surrounded with marble hills. It is ill built, ill paved, and ill fortified, and is exposed to such violent winds from the mountains, that the sea in the channel of Segna, opposite the valley, is seldom calm. The soil scarcely supplies provisions for two months of the year, and water is brought from a spring twelve miles distant. Such a city, therefore, cannot prosper, and yet it is said to contain 6000 souls. East long. 16° 3′, north lat. 45° 4′.

SEGO. See Africa, and Bambara.

SEGOVIA, a town of Spain, in Old Castile, and capital of a province of the same name, is situated on a rocky eminence between two steep valleys, one of which is watered by a brook called Clamares, and the other by the river Erosma, which is crossed by five handsome bridges. It is supposed to resemble a ship with its stern to the east. It is between three and four miles in circuit, and is surrounded with a turreted Moorish wall. The streets are narrow, crooked, and irregular, and in some places steep, but the suburbs are built on more level ground.

Segovia, which is an episcopal see, contains a number of churches and convents, and other public buildings. The Mint is a handsome edifice, the operations of which are carried on by hydraulic machinery. The town-house is handsome, having two compartments in front, with double rows of doric pillars. The cathedral is a mixture of Gothic and Greek architecture. It was built in the 16th century, and has its principal altar of marble. The convent of the Carmelites, and that of the Capuchins, with a subterraneous chapel, are good buildings. The alcazar, the residence of the Castilians, and celebrated as the place where Alphonso composed his astronomical tables, is a venerable ancient pile, containing apartments fretted with Mosaic work still fresh.

The greatest curiosity of Segovia is its aqueduct, which, though supposed by some to be Egyptian, is more probably the work of Licinius or Trajan. It begins with a large stone basin, fifty yards from the town, the water of which it conveys to an open canal to the streets. It is built of rough square freestones, with cement, and consists of a long range of 75 arches, the first of which is fourteen feet six inches long, and the last, at the convent of St. Francisco, thirty-three feet six inches. At this place there begins a double row of arches, one above another, extending east and west, and crossing the valley and the plain of Azoquejo. The greatest height of this is eighty feet ten inches. The whole aqueduct contains 159 arches, sustained by pilasters, most of which are six feet eleven inches in front, and nine feet four inches on the inner side. After distributing its water to different parts of the town, the aqueduct terminates at the Alcazar. The magnificent appearance of that fine building is disfigured by houses built against its pilasters. This city, situated in the midst of the finest sheep pasturage, has been long distinguished for its cloth and woollen manufactures. It is said that 34,000 persons were once employed in them, but they have greatly declined. The quantity of cloth at present manufactured is stated to be about 4000 pieces, coarse and fine. Dyeing is also extensively carried on, and delft ware, paper, and lead, are among its other manufactures. It has an extensive trade in wool, which is brought from Villacastin, and sent to different ports, particularly Bilboa. The number of families is estimated at 5000, and the population at only 10,000. There is an artillery school, and several hospitals in the town. West long. 4° 1′ North lat. 41° 3′.

SEINE, the name of a department in the north of France. It embraces little more than Paris, the capital. It includes three arrondissements, viz. Paris, St. Denis, and Sceaux, forming a square of about sixteen miles. The population is 70,000, exclusive of Paris, which contains, according to the census of 1827, 890,431 inhabitants.

SEINE, Lower, the name of a department in the north of France, containing the north east part of Normandy. It is bounded on the N.W. by the English channel, on the east by the departments of the Somme and the Oise, and on the south by that of the Eure and the Calvados, from both of which the river Seine divides it. It occupies about 2500 square miles. Its surface is generally level or undulating. The coast consists of sandy downs, and the soil, though generally suited to corn and pasture, does not favour the culture of the vine. Hemp, flax, and coleseed are cultivated. Black cattle, horses, cheese and butter, are exported. The principal fruits are pears and apples. The Seine, the Argens, and the Bresle, are the principal rivers. The chief towns are Rouen, the capital, Dieppe, Havre de Grace, Yvetot, and Neufchatel. The contributions in the year 1803 were 9,104,417 francs, and its expenses 570,526. The population in 1827 was 688,295, being an increase of 32,491 since 1822.

SEINE and MARNE, one of the departments in the north of France, bounded on the north by the departments of the Oise and the Aisne, on the east by that of the Marne and the Aube, on the south east by those of the Yonne, on the south by that of the Loiret, and on the west by those of the Loiret and the Seine and Oise. It occupies about 2300 square miles. Its surface consists of gently undulating plains, which produce wheat, barley, oats, flax, hemp, and wines in small quantities. It is watered by the Seine, the Marne, the Yonne, the Great and Little Morin, and several smaller streams; the canal of Briare, which joins the Seine and the Loire crosses the southern part of it. (See NAVIGATION INLAND.) Its chief towns are Melun, the chief place, Fountainbleau, Meaux, Provins, and Coulomiers. The contributions in 1803 were 5,126,616 francs, and the expenses 307,818. Its population in 1827 was 318,209, being an increase of 15,059 since 1822.

SEINE and OISE, a department in the north of France, bounded on the north by the department of the Oise, on the east by that of the Seine and Marne, on the south by that of the Loiret, and on the west by those of the Eure and the Eure of Loire. It occupies an area of 2200 square miles, which are level or gently undulating. It produces wheat, barley, oats, hemp, and flax, but vines are raised in small quantity. The chief rivers are the Seine and the Oise. The principal manufactures are those of porcelain at Sevres, of calicoes at Joui, and of arms and clocks at Versailles. The most important towns are Versailles, the chief place, Etampes, Mantes, Pontoise, Corbeil, and Rambouillet. The contributions in 1803, were 7,373,685 francs, and the expenses, 448,928. Population in 1827, 440,871, being an increase of 16,381 since 1822.

SEISTAN. See SEGESTAN.

SELBY, anciently SALEBIA, a market town of England in the west riding of Yorkshire, is situated on the south or right bank of the river Ouse, which is crossed by a very handsome wooden bridge, which opens for the admission of vessels into the river, which is here navigable for ships of burden. It consists of three streets in the shape of the letter Y reversed. The principal one, beginning at the foot of the bridge, is the road to Leeds, and the other leads to Snaith and Thorne. The ancient and ill-built houses of the town are now replacing by those of more modern aspect. The church, which formed part of the abbey founded by William the Conqueror, is of various styles of architecture. The body and the nave are Norman. The church has the form of a cross, the shaft of which is 267 feet long, and its transept 100 feet. The principal manufactures in this place are those of ships, leather, sail-cloth, and iron goods. A very considerable trade in vessels of good burthen, has been created with London, Hull, and Lynn, by means of a canal from the Ouse to the Aire. Number of houses in the town and parish 840. Population in 1821, 4099. See the *Beauties of England and Wales.*

SELDEN, JOHN, honoured by Grotius with the appellation of the "Glory of England," was an eminent scholar and politician. He was born at Salvington in Sussex in 1584. He was educated at Chichester, and after studying four years at Oxford, he entered the inner temple, where he acquired great reputation by his learning.

His first work was entitled *Analekton Anglo Britannicon*, a chronological summary of English history down to the conquest. This was followed by *England's Epinomis* and *Jani Anglorum Facies Altera*, a Latin and English treatise on the origin and progress of English law. His largest English work, a treatise on *Titles of Heroism*, which appeared in 1609, obtained him great fame; and in 1617 he entered upon a new field, and made himself known throughout Europe by his work *De Diis Syris*, a work of great learning and research.

The next work of our author's was a *History of Tythes* published in 1618, in which he opposed the claim of divine right to tythes made by the clergy of those days, and therefore exposed himself to the hostility of that body. He was accused before King James, and being called before the Archbishop of Canterbury, he was induced to sign a declaration of his regret for what he had done. This event seems to have prepared him for that resistance to civil tyranny, which formed a striking feature in the rest of his life.

In the contest between the king and the parliament which he assembled in 1621, Selden was a leading agent in drawing up the splendid remonstrances of that body. He accordingly fell under the royal resentment and was committed to prison. Being discharged on his own petition, he resumed his peaceful pursuits, and published in 1623, the historical work of Eadmer of Canterbury.

In 1629, he was elected one of the members of parliament for Lancaster, and he also enjoyed a seat in that house in the two first parliaments of Charles I. In the second of these parliaments he was appointed to support articles of impeachment against the Duke of Buckingham. He afterwards took up the cause of Sir Edward Hampden; and in 1628, he was employed by the House of Commons to justify by facts its resolution respecting the right of the subject to his liberty and property. Amid these engrossing pursuits, he found time to compose his *Marmora Arundeliana*, which appeared in 1627.

On the dissolution of parliament, Selden was one of the eight members of the House of Commons, who were thrown into the Tower, on a charge of sedition. Having refused to purchase his freedom by the slightest submission, he was removed to the Marshalsea prison, and then to the Gatehouse, and, along with his companions, was allowed to go at large on bail till 1630, when they were fully liberated.*

During this confinement, Selden composed his work, *De Successionibus in bona Defuncti ad Leges Ebræorum*, which appeared in 1631, and was reprinted in 1636, with a new treatise *De Successione in Pontificatum Ebræorum.*

A dispute having arisen with the Dutch respecting the herring fishery on the British coast, Selden was induced by Archbishop Laud to draw up his treatise, entitled, *Mare Clausum Seu Dominio Maris*, and another to the work of Grotius, entitled *Mare Liberum*. King James read and approved of this work, which appeared in 1635, and the object of which was to prove, "that the British have an hereditary uninterrupted right to the sovereignty of their seas, conveyed to them from their earliest ancestors in trust for their latest posterity."

Having for some years devoted most of his time to

* About fifteen years afterwards the Parliament allowed Selden £5000 for the losses he sustained from this treatment.

Hebrew literature, he published in 1640 his work *De Jure Naturali et Gentium juxta Disciplinam Ebreorum*, which contains a copious digest of the laws and institutions of the Jews.

In 1640, Selden was chosen one of the representatives of the university of Oxford to the long parliament. He took an active part in reforming the abuses of the day, but he was well affected to the constitution both in church and state, and he opposed the violent attempts of both the contending factions. In 1643, he was appointed by the House of Commons keeper of the records in the Tower, and likewise one of the lay members of the Westminster Assembly of divines.

From this period till the time of his death, our author published the following works.

Eutychii Ægyptii Origines Ecclesiæ suæ, a translation from the Arabic.

De Anno Civili Veteris Ecclesiæ uxor Ebraica.

An edition of *Fleta.*

De Synedriis Veterum Ebræorum.

Vindiciæ de Scriptiore maris clause, which was the last production of his pen.

Selden died in 1654, in the seventy-first year of his age, and was interred in the temple church, where a monument is erected to his memory.

His works have been collected and published in 1726, in three vols. folio, with a life of the author in Latin, by Dr. David Wilkins.

SELENOGRAPHY, from σεληνη *the moon*, and γραφη, *a description*, is that branch of astronomy which treats of the lunar surfaces. See our article ASTRONOMY, Vol. II. p. 623, 636, for very full details respecting this curious subject, and also Ferguson's *Astronomy*, edited by Dr. Brewster, App. vol. ii. Since these details were published, Professor Lohrman of the military academy of Dresden, has published an atlas of lunar maps, which represent the whole visible surfaces of the lunar globe, with an accuracy and precision beyond any thing that has yet been attempted. See Dr. Brewster's *Journal of Science*, January, 1825, vol. ii. p. 172.

SELEUCIA, an ancient city of Asia, built by Seleucas, one of Alexander's generals, about forty-five miles north of ancient Babylon, and on the west bank of the Tigris.

Suadea, the port of Antioch, and about four miles distant, is considered by Browne the African traveller, as identical with Seleucia, while Mr. Jackson, author of the "Journey from India," regards Bagdad as the site of the ancient Seleucia; several coins of Seleucas having been found in that city. A description of Suadea will be found in Brown's *Travels in Africa*, p. 391.

SELKIRK, ALEXANDER, the name of a celebrated Scottish traveller, whose adventures form the subject of Robinson Crusoe, was born at Largo in the county of Fife, about 1676, and was brought up to the profession of a sailor. As sailing master of the Cinque Ports galley, he left England in 1703, and in September of the same year, he set sail from Cork in company with the St. George of twenty six guns, Captain Dampier, with a view of cruising against the Spaniards in the South Seas. Pickering, the captain of Selkirk's ship, died on the coast of Brazil, and was succeeded by Lieutenant Stradling. From Juan Fernandez, to which they proceeded after doubling Cape Horn, they were compelled to fly by the sight of two French ships of thirty-six guns each, and left on the island five of Stradling's men, who were taken by the French.

Dampier and Stradling having separated on the coast of America, in consequence of a quarrel in May 1704, Stradling returned to Juan Fernandez in September. Here Selkirk and he had a quarrel, in consequence of which the former resolved to remain on the island.

When the galley was about to leave the island, Selkirk's resolution began to fail, but though he requested Stradling to receive him on board, this inhuman officer denied his request, and left him behind, with his clothes, some bedding, a gun, with a little powder and ball, and a few books, and mathematical instruments.

In this solitary situation, "the monarch of all he surveyed," he was seized with melancholy, and often resolved to put an end to his life. After enduring this species of wretchedness for 18 months, his mind began to reconcile itself to the sadness of its condition, and he chased away the weary hours by building huts and hunting the wild goats of the island. He amused himself with training young kids and other animals as his companions, and when his drapery had lost its folds, he replaced it by the skins of the goats whose flesh had served him for food. In this desolate condition Selkirk spent *four years* and four months. During that time he had caught 1000 goats, half of whom he had set free after slitting them in the ear.* While pursuing a goat with great eagerness, he caught it at the edge of a precipice, over which he fell through a great height. After lying, as he computed, three days senseless, he recovered, and found himself so much bruised, that he was scarcely able to crawl to his habitation. The only other adventure which happened to him was the arrival of a Spanish ship, the crew of which saw him at a distance. Dreading, however, to fall into their hands, he exerted himself to escape, and, by climbing a tree with much foliage, he succeeded with great difficulty, after having been shot at by the Spaniards. On the 2d February 1709, Selkirk was delighted with the sight of two ships approaching the island. Having recognised them to be English, he lighted a signal fire, and he had even the happiness of finding that they were English privateers, the *Duke* and the *Duchess* from Bristol, commanded by Captains Rogers and Courtney. Selkirk was kindly received by his countrymen; and, after continuing a fortnight at the island, they all embarked, and sailed by the way of the East Indies for England, where they arrived on the 1st October 1711; after plundering a town on the coast of Persia, and taking a Manilla ship off California. During this cruise, Selkirk was appointed by Captain Rogers master's mate of the *Duke*. Although Selkirk had performed his devotions with great regularity yet his language had become scarcely intelligible when he was first taken from the island. The curiosity of the public having been greatly excited by the narration of his extraordinary adventures, Selkirk put an ac-

* Thirty years afterwards, Commodore Anson said that the first goat which was shot, had a slit in its ear, and was, therefore one of Selkirk's.

count of them into the hands of that celebrated writer Daniel Defoe, who, in place of publishing them as a true narrative, made them the ground work of the interesting story of Robinson Crusoe. The future history of Selkirk is not known, but so late as 1798, the chest and musket which Selkirk had with him on the island of Juan Fernandez, were in the possession of his grand-nephew, John Selkirk, a weaver at the village of Largo.

SELKIRK, a royal burgh of Scotland, and capital of the county of the same name, is finely situated on a commanding eminence below the confluence of the rivers Yarrow and Ettrick, and about 1½ mile above the junction of their united streams with the Tweed. This town has of late been greatly improved, and contains several good houses. The principal buildings are a new town-house, with a handsome spire and clock, and containing apartments for the Sheriff court and the business of the burgh. A new prison has been erected at the back of the town. It is encircled with a lofty wall, which incloses an area accessible to the prisoners. The other buildings are the parish church and the Secession meeting-house. The principal manufactories here are an inkle one, which has been long established, and a tan-work; and the making of stockings and the spinning of woollen yarn are carried on to a considerable extent.

This burgh has been celebrated by the devoted bravery of its citizens at the battle of Flodden. Of 100 who followed James IV. to the field, only a few survived. A standard taken from the English on the occasion, by a member of the corporation of weavers, is still in their possession; and the sword of William Brydone, the town clerk, who led the citizens to the battle, and who was knighted for his valour, is still in the possession of his descendant, an inhabitant of Selkirk. The English were so exasperated at the bravery of that band of citizens, that they laid Selkirk in ashes. James V. however, in reward of their eminent services, granted them a thousand acres of Selkirk Forest, which are now worth about L.1500 per annum, and are divided into a great number of small properties. In their annual survey of this tract, the English standard is carried before the corporation of weavers.

A battle was fought on Philiphaugh, opposite to the town, on the 15th September, 1645, in which General Lesly completely defeated the Marquis of Montrose.

Selkirk unites with Peebles, Lanark, and Linlithgow, in sending a member to Parliament. The town is governed by two bailies, a dean of guild, a treasurer, and 29 councillors, in all 33. The revenue derived from three large commons, mills, feus, and other sources, is about L.1000 annually.

The vicinity of Selkirk, towards the united streams of the Yarrow and Ettrick, is beautiful; and a fine view of it is obtained from the town. The chief object of interest here is the ruin of Newark Castle, situated on a peninsula formed by the Yarrow, which has cut its course through rugged rocks enveloped in wood. Haining, the seat of John Pringle, Esq. of Clifton, is situated close to Selkirk; and Yair, the seat of Alexr. Pringle, Esq. of Whitebank, situated on the banks of the Tweed, is celebrated for its picturesque beauties. Sunderland Hall is beautifully situated at the junction of the Tweed and the Ettrick, about two miles below Selkirk.

SELKIRKSHIRE, or Ettrick Forest, lies nearly in the middle of the southern division of Scotland. It is bounded on the north by Peeblesshire and Mid-Lothian; on the east by Roxburghshire, on the south by the latter and Dumfriesshire, and on the west by Peeblesshire. The boundary line on the west and south is very irregular, Selkirkshire being dovetailed into the neighbouring counties in these directions in the most unaccountable manner. From this cause, although it is one of the least counties in the kingdom, its greatest length and breadth are considerable. From Phawhope Pen, a high mountain at the source of the Ettrick, to the heights of Caddon water, on the north-east boundary, is nearly 30 miles; and from Borthwickbrae to the foot of Glensax, where it reaches within a short distance of Peebles, may be nearly 20. Yet it contains only about 260 square miles, or about 166,000 acres.

This shire is divided, according to its natural features, into three dales or valleys, by two ridges of mountains running N.E. by E. but diverging as they retire towards the west, and an undulated flat muir falling from the southern heights of the Ettrick towards the water of Borthwick; the upper part of which is green hill pasture, and is mostly included in the county. The water of Ale, with some tributary streams, rises in this muir from many small lakes. On all this side of the Ettrick there are no hills of any great height, and the ground is much covered with heath. The higher elevations on the middle ridge between the Ettrick and Yarrow reach from 1700 to nearly 2000 feet above sea level. The northern ridge between Yarrow and Tweed is more lofty, and has of course a wider base, and the diverging and minor valleys are of greater extent. Besides these, Selkirkshire is properly surrounded from the north-east to the south by a range of mountains that form part of the great central chain that sinks into the sea between East Lothian and Berwickshire. Many of these rise to a height considerably above 2000 feet. Through these mountains, the Tweed issues from Peeblesshire, or Tweeddale, leaving on its right Blackhouse heights, and passing on its left under Windlestrae Law; the one 2370, and the other nearly 2300 feet above the sea. These mountains extend towards the south, and cover the sources of the Yarrow and Ettrick. As the two minor ridges, before mentioned, branch off, their character is changed, and they form around the winding lakes of St. Mary a mingled group of lofty hills, smooth and round, and clothed with herbage, the fine green of which refreshes and delights the eye. All this, connected with the embosomed lakes, gives to them in a summer evening a singular character of softness and quietude and pastoral beauty almost peculiar to the district. In winter, when covered with undrifted snow, the scene rises towards grandeur and sublimity. As there are no rocks, the pure white of the splendid envelope is unbroken, there is nought save the majestic forms of the mountains, and their azure shadows to arrest the eye, and from different eminences to the northward, the view can never fail to be deeply impressive on a mind capable of enjoying the silent sublimity of nature. It is likely Burns had this scene in his mind when he wrote

While maniac winter rages o'er
The hills, whence classic Yarrow flows,
Rousing the turbid torrents roar,
Or sweeping wild a waste of snows.

The main river is the Tweed, (see PEEBLESSHIRE.) which flows through the northernmost of the three valleys for ten or twelve miles. This, although not the richest, is, to a traveller, the finest part of the country. The river itself, with its "crystal streams," often fringed with trees, is beautiful, and its lively and murmuring current has a cheerful effect. The hills rise more abruptly than elsewhere, and are ornamented with almost enough of natural wood, extending with little interruption along the skirts of the southern hills, while old hollys, hawthorns, and ashes, the hardy remains of a former race, are scattered among the rocks and shingle, along the steep declivities of those on the north. Besides, the picturesque ruins of the old baronial castle of Elibank, and four or five gentlemen's seats, each of different styles of beauty, greatly tend to soften the wildness of this mountainous valley. As one ascends the Tweed, below its junction with the Ettrick, by a sudden turn of some miles to the south, it seems to fall into, and be subsidiary to the valley of the lesser river; the Ettrick by its direction towards the southwest appearing to be a continuation of the strath of the Tweed.

The length of the Ettrick to its highest source is about 30 miles. For the first ten or twelve, the banks of the water are partially covered with natural wood, mixed with plantations, and now and then even scattered remains extend to the sides of the hills. This alternation of wood and pasture, and arable fields, with the town of Selkirk overhanging the river on the south, Bowhill, a fine seat of the Duke of Buccleugh's, on the slope of a mountain that divides it from the Yarrow on the north, one or two old towers, and the excellent cultivation of the haughs and lower grounds, give this part of the valley a character of varied beauty and richness. The valleys of most of the tributary rivers in Scotland, at their junction, are bounded by mountains that are dry, healthy, and comparatively barren; and such are those separating the Ettrick and the Yarrow, and between the latter and the Tweed. The middle and upper part of the valley of Ettrick is perhaps the most beautiful pastoral district in the kingdom. The hills are almost without exception of the finest deep-green mountain pasture, on which are spread thousands of sheep, and for many miles the valley opens into wide haughs of great fertility, where are seen many herds of fine cattle.

The head of the Yarrow is properly formed by several glens, and slopes, and cleughs, that open upon St. Mary's Loch and the Loch of the Lowes, and send their streams to supply its waters. The principal of these is called Meggat. It is a dark valley, having all the characters of a wild deep highland glen rising by numberless sources among the highest summits of the great range already mentioned. It flows into St. Mary's Loch through a tract of fine meadow land, the hills on each side of which are skirted with bushes and old natural wood: but it is altogether in Peeblesshire, the shore of the lake forming the boundary line for a little way. After leaving those beautiful pieces of water, Yarrow flows among hills and cultivated haughs, where there is little of the picturesque for eight or nine miles, yet it is similar to the Ettrick in its general character. It has more heath on the hills, and fewer haughs in the valley: but its hills are likewise green, and its haughs are fertile, and for several miles, it will yield to few waters* in Scotland in varied and romantic beauty, until it joins the Ettrick below the castle of Newark, and Bowhill already mentioned, which is situated in view of both waters. Through most of this part of its course it dashes through a rocky channel, while its banks and the sides of the surrounding hills are covered with fine natural wood, and a magnificent extent of old pines and forest trees.

The water of Ale belongs to Roxburghshire, but it draws its sources from a number of small lochs in the extensive muirs between the Ettrick and Borthwick. These lakes are mostly full of shell marl, and of great value, had they lain near the cultivated country. It may be mentioned as not a little curious, that they have all the Westmoreland appellation of *mere* or *muir*, as it is here pronounced, attached to their names: as Kingsmuir loch, Alemuir loch, Akermuir loch, Hellmuir loch, &c.

Borthwick, in its upper course, belongs to both Selkirkshire and Teviotdale. It rises like the rest among green grassy hills, on the borders of Dumfriesshire. Rankleburn rises contiguous to the Ale and the Borthwick, and has a claim to notice only because there is situated the farm that gives a title to the duke of Buccleugh, the proprietor of two-thirds of the county.

Gala runs for twenty miles through Mid-Lothian, and only bounds Selkirkshire for a few miles before it joins the Tweed. This part of its course is well wooded and beautiful, and as it runs through and drives the machinery of the village of Galashiels, it probably conduces more to the wealth and industry of the district than all the rest.

The lowest part of the county at the side of the Tweed, is nearly 300 feet above the sea. The county town, and Thirlestane castle, and St. Mary's loch, are all 560. The highest farm house on the Ettrick is more than 700, so, as may be expected, the climate of Selkirkshire is wet, boisterous, and stormy; and although protected on the west by a high range of mountains, yet the west and south-west winds rage with much violence, generally bringing rain to the greater part of the district. As most of the lesser rivers run towards the east and north-east, the cold winds from these points blow up the valleys with little obstruction.

The following is the average of seven years, abstracted from a very accurate register of the weather kept at the farm house of Bowerhope, on the north side of St. Mary's loch. The height above the sea is, according to Ainslie, 560 feet. It is to be regretted that a register of the thermometer is not included. Along with the register is kept a memorandum of the first appearance and flowering of several of the deepest rooted plants, and the first appearance of frog spawn.

* Only a few rivers in Scotland get the name of *river*; they are universally called waters, except the Tweed, the Forth, the Spey, the Clyde, &c.

	W.	S. W.	N. W.	E.	S.E.	N. E.	N.	S.	Days fair.	Rain.	Snow.	Annual average of the barometer.			
Average No. of days yearly, for seven years, the wind blows.	75	105	37	26	19	21.4	14	26	167.6	154	43.4	1821	29.38	1825	29.51
												1822	29.3	1826	29.88
												1823	29.4	1827	29.42
												1824	29.31	Mean	29.43

On the 26th of February 1810, the barometer stood at 30.8, and on the 20th December 1821, it stood at 27.8.

The following is from a register kept at Tinnis, about eight miles down the Yarrow, and 60 feet lower. Therm. at 8 A. M. and 10 P. M.

For the year 1827.

Fair days.	Rain and snow.	Mean heat.	Mean of barometer.
171	194	44.23	29.12*

At Thirlestane castle, on the banks of the Ettrick, and about 650 feet above the level of the sea, a very accurate register of the thermometer has been kept by Lord Napier since 1821, of which the following are the results. Thirlestane castle is situated in W. Long. 3° 9′, and in N. Lat. 55° 26′.

	Mean Temp.	Mean temperature of Winter.	Spring.	Summer.	Autumn.
1821	44° 9	36°	42° 3	54° 3	47° 3
1822	45° 4	36° 3	43° 9	56° 9	44° 9
1823	43° 7	35° 3	41°	52°	46° 5
1824	42° 2	35° 7	39°	52°	42° 3
Mean	44° 05	35° 8	41° 55	53° 8	45° 25

Frosty mornings are prevalent even until the first of June, and it is only in rare seasons that the early varieties of apples and pears ripen properly. But in the valley of the Tweed, and the vicinity of Galashiels, which is lower and better sheltered, the temperature is greater; here there is less rain than its elevation and mountainous neighbourhood might seem to warrant, and of late years, when the summers have been warmer, plumbs, peaches, and even nectarines, have come to good flavour. However, there are reasons for thinking† this may be attributed to the superior care and cultivation of modern times.

Around Selkirk and Galashiels, even the hills are subjected to the plough. Here wheat is raised even as a considerable part of the rotation; and such has been the improvement in the cultivation of the "golden grain," and so well is every process of its management now understood, that it has often been raised 60 lbs. per Winchester bushel, 700 feet above sea level. Mildew is of rare occurrence, and smut is considered a proof of carelessness, and is still more seldom to be seen.‡

In the upper valleys of Ettrick and Yarrow, tillage is confined to the haughs and low ground contiguous. Although the attention is chiefly devoted to sheep and cattle, yet as most of the farmers must keep a pair of horses to drive fuel, and secure their crops of hay, they find it profitable and more convenient to have between 20 and 30 acres in a rotation of turnips, barley, hay, and oats, which otherwise might perhaps be more economically kept in pasture, for which the moisture and lateness of the climate renders it better adapted. Yet in favourable seasons, more luxuriant crops are nowhere to be met with; and, indeed, throughout the county generally, agriculture is as well understood and practised as in any district of the kingdom.

A small stout breed of horses was common to Selkirkshire and Teviotdale in former times, some of which were capable of great action, and which, it may be regretted, have been superseded, during the last fifty years, by crossing with horses from Lanarkshire, and in consequence, those now used for the plough much resemble that breed, but not so weighty and powerful.

There is an excellent breed of cattle, but more fit "for feeding than for milk," it having been the custom for many years past to purchase the bulls from Northumberland, of a breed perhaps too fine for the wet climate, and exposed pastures. Dairy farming is not practised.

Between fifty and sixty years ago, the blackfaced sheep, with coarse wool, were general, excepting on a few of the lowest farms near the meeting of the rivers, and they were for some time totally changed for the Cheviot breed. In 1798, when Dr. Douglas wrote his excellent survey, the whole number of sheep in the county were about 118,000, of which 36,000 were then blackfaced. Ten years ago there were none. Of late, a few farmers have again had recourse to them, as the low price has rendered the wool (the original cause of their banishment) of less consequence; and on the most upland farms, they are now confessed to be a surer and more profitable stock. There are at present about 2500 of the original breed, and they are likely to be increased. In the meantime, great attention and skill is directed to the improvement of both kinds; and this has been stimulated and kept up principally through the benevolent and patriotic exertions of Lord Napier, who, at the end of the war, returning from sea, rebuilt the "mountain home" of his ancestors, and betook himself to sheep-farming, as a rational amusement. By his lordship's influence, a pastoral society was formed, which is very numerous, including many from the adjoining districts. It has a great annual meeting, and distributes premiums for the best cattle and horses, as well as sheep. It may now safely be averred, that in no district of Scotland is so much skill and care directed to sheep farming. Perhaps, in some respects, this has been carried too far. A great proportion, particularly of the western part of the county, consists of a deep soft

* The barometer used here was one with a wheel. † An old tune.

‡ The consumption of this grain has so greatly increased, that whereas forty years ago, only two loaves came weekly into the parish of Ettrick, one to the manse, and the other to the principal farm house, now three carts with wheaten bread arrive weekly.

clay along the slopes of the hills, and forming the bottom of the narrow valleys. For almost one half the year, this kind of soil was formerly surcharged with water, and it was never in a dry state. A kind of rush called *sprett*, and a *scirpus* called *pry*, (*juncus articulatus* and *scirpi*, var. sp.) occupied the ground almost exclusively. These sloping bogs were carefully drained, and another kind of herbage took possession. But the *pry* is an evergreen, and the *sprett* begins to spring in the end of April; and so they were found when most wanted. Again, it was discovered that the moles with which the rich dry green pasture was overrun, and annually *topdressed*, became partial to the newly drained bogs, and tapped the dams, and let out the water. Mole-catchers were introduced from Lancashire; and in twenty years, a mole became as rare as a hedgehog. Some of the old people go the length of saying, that since the bogs were drained, and the moles destroyed, their farms have neither kept so many sheep, nor fed such fat lambs as formerly. Moreover, a vexatious disease has, within the same period, been gradually increasing,* ascribed by many to the above causes. But we have not room to be more minute, although the subject is both curious and interesting in many respects.†

The transition series of rocks, and that of remarkable uniformity, prevails throughout the whole of Selkirkshire. It is entirely schistose, consisting of gray wacke and slate, with one interesting exception to be afterwards mentioned.‡ The stratification is regular, on a great scale, running ftom S. W. to N. E. with various dips. At Newhouse Lynns, about seven miles above Selkirk, where the Ettrick has cut its way through the barrier of an ancient lake to the depth of a hundred feet, the thin strata of gray wacke and soft slate is bent to a curve of more than 220°. The same phenomenon is to be observed on the Yarrow below Newark, in the direction of the strata, and about four miles distant. Near the junction of both rivers, the gray wacke contains so much iron that it is of a brownish yellow for a thickness of 800 yards or more. The town of Selkirk is partly founded on another variety, containing many veins of heavy spar. Mountainous masses of feldspar and feldspar-porphyry rest upon the schistose rocks near the junction of the formation. These masses reach nearly in one direction from St. Abb's Head to near Selkirk; but do not enter the county. Dirrington Laws and Colding Knolls in Berwickshire, and Eilden Hills and Whitelaw Kips, consist of this rock.§

A curious anomaly occurs in the N. W. of the county. Along the lofty range already mentioned that separates it from Peeblesshire, there run thick strata of beautiful porphyry of various shades of colour, from nearly blood-red to brownish yellow. It is observed first overlying the clay slate that has been long wrought for sale at Grieston, a mile west from Traquair. The direction is through the centre of Windlestrælaw. The schistus and it continue overlying one another for a distance of nearly three miles across; the most southerly porphyry being near Hollylee. But what renders this more interesting, there is found alternating, with this porphyry‖ thin strata of flinty slate, clear gray porphyry, gneis, and granite. Now stratified granite is mentioned by Professor Playfair, as having been discovered by Sir James Hall and himself in Fasnet Water in Lammermoor, and he mentions it as having been found likewise at Loch Ken in Galloway. There is therefore great probability that the granite and gneis of these three places are a continuation of the same strata, for the intermediate point is nearly in a line with the other two, and not far from the line of direction of the under and overlying slate and gray wacke. The flinty slate has been observed in glens connected with the head of the Yarrow in the requisite direction. Both the latter and the gray porphyry are of great hardness; the porphyry ringing like metal when struck on a large block, and taking a high polish, and the slate giving fire with steel. Sometimes the gray wacke runs into amygdaloid, and veins of black carbonaceous slate, intermixed with pyrites, occur in divers places. Pieces of insulated galena have been found in the course of the porphyretic strata near Traquair, and trials to find lead have been made repeatedly without success. A considerable quantity of ore of antimony was found in digging a well at Traquair manse. No limestone has yet been discovered, but in two or three places there are springs supersaturated with carbonate of lime, and generally in lines, indicating, that in their way to the surface they pass over considerable masses of calcareous rock.

Probably owing to the uniformity of the rocky structure, the botany of the district is likewise very uniform. Notwithstanding that the mountains rise to a considerable elevation, few alpine plants are found. The *Rubus Chamæmorus* is plentiful in several places in the massy hollows between the higher summits, *Sedum telhephium*, *Saxifraga stellaris* and *Oppositifolia*, are met with near the limits of the country with Dumfriesshire. The more rare plants in the district are *Circea alpina*, in the shingle on S. E. verge of St. Mary's Loch, *C. lutetiana*, near Gleddes-weel on Tweedside; *Trollius Europeus*, and *Cnicus heterophyllus*, in a bushy cleugh falling into Douglas burn; *Drosera rotoundifolia*, in Deucher hope; *Thalictrum alpinum*, at Newhouse lynns; *Sedum villosum*, Douglas burn; *Hydrocotyle vulgaris*, below Oakwood; *Melampyrum sylvaticum*, in Newhouse-bank and on Glen heights.

The remains of the ancient natural woods, of which, including the bosky cleughs in the uplands,

* First known in Ayrshire, where it is called *vinkish*, and on the Cheviot, where it is called *pining*, from the slow and sure wasting of the animal.

† In the meantime, quarter has been granted to the moles. Several who had made agreements with the mole catchers continue to pay them, but refuse to let them work; and one or two farmers have begun partially to reinundate their boggy land.

‡ The red free stone of Roxburgh and Berwickshire reaches no farther up the Tweed than to near Old Melrose.

§ A quarry was lately cut into the steep declivity on the S. W. point of these hills, when the rock was found to be crystallized pentagonal prisms, perpendicular to the horizon, and about fifteen inches diameter. The pillars are extremely beautiful and elegant, the angles being sharper than any basaltic pillars we have seen, and of a pale flesh colour. The height laid bare as yet is only about twenty feet, but as the declivity is great it would require but little expense to uncover more than double the present length of the columns which probably may reach the sparry schist upon which the mountain reposes.

‖ These are strata of granite gneis, and are observed in Priesthope, a deep glen on the south side of the Windlestrælaw.

there is not more than 600 or 700 acres in all, are made up of oak, ash, elm, (*montanus*,) birch, alder, hagberry, (*P. padus*) holly, sloethorn, hawthorn, hazle, mountain ash, aspin (rare) ivy, honeysuckle, and four or five species of roses, and a number of willows. Sometimes a solitary mountain ash has outlived its cotemporaries, and is found overshadowing a rocky cleugh, 1500, and in one solitary instance, even near 2000 feet above sea level. Travellers who attend to such matters have often been struck with the numbers of large and ancient hollies which remain along the steep and shingly faces of the hills on the north side of the Tweed, from Yair to Hollylee, with here and there a hawthorn, seemingly of equal duration, where a modern hedge of either could hardly be raised in a lifetime even with great trouble and expense.

Since the draining of the bogs along the sides of the higher valleys, which were covered formerly with *Juncus articulatus* and *carices*, these plants have given place to *Aira cespitosa* and some *Agrostidæ* on the clay, and groves of tall *Carduus Palustris* on the mossy ground. The latter is a valuable acquisition to the sheep in late springs, when they scoop out the roots even an inch or two below the surface; but the former although an evergreen, they seem to refuse on such soils as this altogether, probably because it has got up with too rank luxuriance. As a remedy, some farmers have tried burning it in spring, some mowing in early summer for hay, and some have stopt the drains that they may rather have the *Juncus* and *carices* the former inhabitants.*

Little can now be said of the wild animals of Ettrick Forest. It is likely that in ancient times the Urus had been common, for skulls of that animal have frequently been found in the marl mosses along with those of the stag,† and another extinct species of deer with palmated antlers, of a size which seem to indicate the bearers to have been as large as a blood horse.‡ The wolf and the wild boar had been common, for several places bear their names to this day. Foxes in the memory of old people were very destructive, but now few of them even attack lambs. The wild cat is nearly if not altogether extinct.

Two species of mice have occasionally been met with, which as yet have been overlooked by scientific naturalists. One inhabits the tops of the highest mountains, is a little larger than the *Mus sylvaticus*. The fur has a silky softness and lustre, and as the animal is turned round it falls open by its weight in a shed along the body, being apparently attached to the skin by a filament of extraordinary fineness and elasticity. The other is of a size between this and the *Mus aquaticus*, has, like them, a short tail and ears; the tail tipped with white. It has very large strong grooved semicircular teeth, and inhabits the low grounds, but is extremely rare. Only three have been observed, one of which, when running, stopped at times and stood upright with its fore paws over its eyes like a weasel or squirrel. It was known and distinguished by a mole catcher, who had sometimes, although rarely, caught it in his traps. Rabbits seem to have gradually ascended the rivers, and in the lower part of the county have increased so much as to have become a nuisance.

Birds, migratory and resident, are similar to those of the adjoining districts. The black grouse was not uncommon seventy or eighty years ago, but from some unknown cause left this part of the country, but were again introduced as well as pheasants by the late Duke of Buccleugh, both of which have become uncommonly numerous. Partridges and hares are plentiful, and red grouse or *muirfowl* remarkably so on the heathy grounds. The green and grey plover are likewise common, but not so the woodcock. The dotterel sometimes breeds on the higher mountains adjoining Peeblesshire. There is hardly such a variety of small birds as in the neighbouring counties.

Salmon, grils, whitling, many subspecies of trout, lampreys, eels, pike, minows, barbels, sticklebacks, are found in the rivers, but far from so numerous as formerly: and pike, perch, eels, and some excellent varieties of trout inhabit the lochs.

In ancient times, the sheriffdom of Selkirk was known by the general name of The Forest, or sometimes Ettrick Forest, although in the oldest deeds relating to it, it appears to have been divided into Selkirk Forest, Ettrick Forest, and the Forest of Traquaire or Strathquaire, and is so designated by Robert I. when he made a grant of the lands to the famous Sir James Douglas. Upon the attainture of the family of Douglas in 1455, these forests were again annexed to the crown, in the immediate possession of which and of its tenants they remained until alienated by royal charter after the restoration. We find that upon the 24th May 1503, James IV. granted the forest of Ettrick and the town of Newark as dower to his queen Margaret of England. In 1529, we find from Leslie that James V. had 10,000 sheep "going in the Ettrick Forest, in keeping by Andrew Bell, who made the king so good count of them as they had gone in the bounds of Fife."

In consequence of the whole county being anciently the property of the king, or of the Abbey of Melrose, the proprietors hold their lands by charter from the crown. Two-thirds belong to the Duke of Buccleugh, the rest is divided among twenty-seven other freeholders. The valued rent is £80,307, 15s. 6d. Scottish money; and in 1812, the real rent was £41,160, 10s. sterling. The land rent was then divided among forty-four estates, nine of which were above £2000 Scots, twenty between £2000 and £500, and fifteen below £500. About two-fifths of the county is under entail.

The office of sheriff was hereditary in the ancient

* The following are the principal plants that contribute to support the sheep after the failure of their winter pasture. They are stated in succession. *Festura ovina*, which continues to spring through winter in open weather. *Nardus stricta*, the roots of *C. palustris*, *Dactylis glomerata*, *Eriophorum vaginatum*, a variety of *J. agrestis*, *J. articulatus*, *Anthoxanthum odoratum* and *Poa trivialis*, below the drains on the mossy bogs, and in some high grounds large tracts entirely filled with *Scirpus cespitosa*, which are set on fire annually. This is done when the sun shines and the withered plants are dry and brittle, and the flame streams along the ground in a rapid and beautiful manner. The points of the young sprouts rise through the black surface like the braird of corn, and during or after a shower, are cropt with great avidity by the spreading flocks.

† In early times Ettrick Forest was celebrated for its red deer, and were accounted the largest and finest in the kingdom.

‡ Probably the same as the deer of Saomme of Cuvier.

family of Murray of Philliphaugh. Sir Walter Scott was deputed to that office in 1801.

The principal towns in Selkirkshire are Selkirk, already described, and Galashiels, one half of which nearly is in Roxburghshire. Galashiels is situated on the south bank of the river Gala, with the exception of a part of it called Buckholm side, which stands on the north bank, and is in Roxburghshire. It is a neat thriving town, and contains many good and substantial houses, most of which are covered with slate. A new street, containing many handsome houses, has been just finished (1828,) facing the Gala. The Gala is here crossed by two bridges, one of stone, and the other a private suspension one of iron wire, which was the first that was erected in Britain. The merit of the construction is due to Mr. Richard Lees, an extensive woollen manufacturer, whose works are situated on both sides of the Gala, and who conceived the idea of constructing a foot bridge to form a communication between them. It was accordingly erected in November 1816. The length is 111 feet, and it cost £40. Galashiels has been long celebrated for its woollen manufactures, which being at first very coarse, and of a grey colour, were known throughout Scotland by the name of "Galashiels Grey." Broad cloths, however, of every degree of fineness have been for some years manufactured in the town. A considerable quantity of the wool produced in the country is manufactured at Galashiels. Water power is employed. The parish church of Galashiels is a neat modern building. There is also a Relief meeting house in the town.

There are very few objects of antiquity in this county. In the eastern part of it there are the remains of seven British stations, erected upon heights, and having a slightly elliptical form; and in the midst of several of these there is a Roman camp in the parish of Roberton. One of the most remarkable remains of the Britons is the battle fence or "Catrail," which consists of a large fence with a rampart on both sides. It is about 28 miles long, and its construction can only be referred to the Romanised Britons, who, after the departure of the Romans, were obliged to defend the country from the invasion of the Saxons on the east during the fifth century. Some of the ruined castles and moss grown towers, erected some of them in the 12th century, are not of sufficient interest to merit description.

The population seems to have increased since Dr. Webster's return in 1755, as follows:

1755	.	4622
1793	.	4646*
1811	.	6143
1821	.	6637

SELTZER Water. See Mineral Waters.

SEMAYLA, a gold mine in Bambouk, is a small hill about 200 feet high, and 5000 in circuit. The gold occurs in a reddish sandstone, and also in a solid bed of red marble. Though the richest mine, therefore, in Bambouk, it is of secondary value. See Bambouk.

SEMENDRIA, the name of a town and fortress of European Turkey, in Servia. It stands on the south side of the Danube, and is defended by an old castle. It was once the residence of the kings of Servia. Population 9000; east longitude, 20°, 41′, north latitude, 44°, 52′.

SEMIRAMIS. See Assyria.

SEMLIN, a town of Sclavonia, near the confluence of the Save and the Danube. It is the seat of the transit trade between Turkey and Sclavonia. The archbishop of the Greek church resides here, and the Austrian commander of the frontier military district. Population 8000.

SENECA, Lucius Annæus, a celebrated ancient philosopher, was born at Corduba in Spain, about the beginning of the Christian era. He was educated at Rome, and his father, who was himself eminent as an orator, instructed him in the study of eloquence. The study of philosophy, however, soon engrossed all his attention, and though he at first joined the Pythagorean sect, yet he afterwards connected himself more closely with the Stoics. He had acquired considerable reputation at the bar, but it is said that he relinquished it out of fear of the vengeance of Caligula, who was himself ambitious of rhetorical fame. Having obtained the office of questor, and risen to distinction in the court of Claudius, he was accused by Messalina of an adulterous connection with Julia, the daughter of Germanicus, and was sent to Corsica, where he spent eight years in exile. All the philosophy which he had acquired could not inspire him with resignation and patience, and he is said to have complained of his lot, and even to have made abject application to the Emperor for pardon.

When Claudius married his second wife Agrippina, Seneca was, at her request, recalled from banishment, and after being elevated to the prætorship, he was appointed tutor to her son Nero. As the account of his political life has been already given under our article Roman Empire, we have only to add that, being commanded by Nero to put an end to his existence, he expired, by opening his veins, in the year 65. His wife, Paulina, had refused every consolation, and had resolved to die the same death with her husband; she had even opened her veins; but the Emperor would not allow her this comfort, and she never recovered from the loss of blood which she had suffered before the arrival of the imperial prohibition.

From the great munificence of Nero, Seneca acquired prodigious wealth. He possessed innumerable villas. His house and garden were the most splendid in Rome, and he had money laid out at interest in every part of the world. If we believe Dio, he had no less than £250,000 sterling at interest in Britain, and the calling in of this sum is said to have been one of the causes of a war with that nation. In the midst of all this wealth, however, Seneca led an abstemious and quiet life.

The philosophical works of Seneca consist of 126 Epistles, and of separate treatises on Consolation, Anger, Providence, Tranquillity of Mind, Constancy, Clemency, the Shortness of Life, a Happy Life, Retirement, and Benefits. His treatise on Consolation was written in Corsica, and was addressed to his mother, Helvia, and his friend Polybius. The tragedies extant under his name, are supposed by some to have

* Dr. Douglas's Survey. It very probable that both Dr. Webster's and Dr. Douglas's returns were much too low.

been written for amusement during his exile, as he himself says, *modo se levioribus studiis ibi oblectasse;* but they are generally supposed not to be his. The 17 Epistles from Seneca to St. Paul are obviously spurious. The last editions of his philosophical works are those of Lipsius, the Variorum, 3 vols. 8vo. the Leipsic, 2 vols. 8vo. and the Bipontine edition. His seven vols. of Natural Questions, included in this edition, contain some curious observations on Egypt and the Nile, which makes it probable that he had travelled in the early part of his life.

SENECA, river of the United States, in New York, is formed by the outlets of Canandaigua, Crooked, Seneca, Cayuga, Owasco, and Skeneatelas lakes. The western and remote source of the Seneca river is Mud creek, rising in the western part of Ontario county, and flowing first north, thence north-east, and finally east, receives the outlet of Canandaigua lake at Lyons, in Wayne county, after a comparative course of 40 miles. At Lyons the stream takes the name of the Clyde, which flowing south-east by east 18 miles joins a much more considerable stream, the outlet of Crooked, Seneca, and Cayuga lakes, and assumes below the junction the name of Seneca river. Turning to a course nearly north one mile, the Seneca is crossed by the Erie canal, and one mile still lower passes the flourishing village of Montezuma, and continuing north four miles winds to the east eleven miles, receiving in the latter course the outlets of Owasco and Skeneatalas lakes. Now a considerable stream, the Seneca, turns NE. by E., and with a very winding bed joins the Oneida, and loses its name after a comparative course of about 100 miles from the source of Mud Creek.

The Seneca river gains importance from its valley being traversed 65 miles by the Erie canal, and from being the drain of the lake region of the western part of New York. The valley of the Seneca is, perhaps, as a body of productive soil unsurpassed, and embracing about 3600 square miles, sweeps over great part of the counties of Ontario, Wayne, Yates, Tomkins, Seneca, Cayuga, Courtland and Onondago counties. This region contains the saline tract of Onondago, though otherwise not very productive in minerals, though gypsum has been discovered. Geographically it extends from N. lat. 42° 15' to 43° 12', and is traversed between the Crooked and Seneca lakes by the meridian of Washington City. In regard to climate the Seneca valley is remarkable as sloping from south to north. The surface of Crooked lake is a small fraction above 700 feet, whilst the junction of the Seneca and Oneida rivers rises only about 200 above the ocean level. The country drained by the sources of Crooked, Seneca, and Cayuga lakes is elevated upwards of one thousand feet above the tide level in Hudson, consequently the higher and lower extremes of the Seneca valley differ in temperature above two degrees of Fahrenheit from mere relative height, and gives a more rigorous climate to the southern than to the northern border. See next Article.

SENECA, lake of the United States in New York, extending in a direction of nearly north and south, from N. lat. 42° 23' to 42° 54', and nearly on the meridian of Washington City. It is 36 miles long, and from 1½ to 2½ miles wide, with depth sufficient for the navigation of large vessels. The sources of this lake are some small creeks of Yates, Steuben, and Tioga counties of New York, rising on a comparatively elevated table land and rushing from ledge to ledge soon falls to the level of the lake, 445 feet above that of the ocean. The waters of Seneca are discharged from its north-east angle, and in a course of 12 miles and fall of 124 feet reaches the level and are lost in the northern extremity of Cayuga lake.

The country adjacent to both these lakes, and indeed the whole surface composing the southern part of the Seneca valley, exhibit a series of high, boldly swelling though seldom precipitous hills, extending from SE. by S. to NW. by N., nearly parallel to the lakes. The intervening valleys are evidently mere continuations of those of the lakes themselves, giving to that section of New York a very peculiar physiognomy. From the head of Seneca lake at the mouth of Catherine creek, to Newtown on the Chemung branch of Susquehannah, is in a direct line 20 miles, and though the circumjacent hills rise to upwards of one thousand, the summit level between the points is only 885 feet above the oceanic level. A canal of practicable execution, has been projected to unite the Seneca lake to the Chemung river by the designated route.

Politically, Seneca lake touches Tioga county south; has Tomkins and the southern part of Seneca county along its eastern, and Steuben, Yates, and the south-eastern part of Ontario along the western border. The fine picturesque village of Geneva, traversed by the meridian of Washington City, stands on the north-west angle of Seneca lake, and is one of the very few borrowed names of places in the United States which has an appropriate local application.

SENECA, county of New York, bounded N. by Wayne county, NE. by Seneca river, E. by Cayuga lake, S. by Tomkins county, W. by Seneca lake, and NW. by Ontario county. Length 32, and varying in width from 6 to 12 miles; area about 300 square miles. The southern part high and hilly, between the Seneca and Cayuga lakes; northern traversed by the Clyde branch of Seneca river, comparatively level. Soil fertile, and in its natural state covered by a dense forest. Chief villages Ovid and Waterloo; the former in the southern part, and latter on the outlet of Seneca lake.

Central lat. 42° 50' N. Central long. 10' E. from Washington City. The principal waters of this county have been given in the delineation of its boundaries, and it may suffice to observe, that from its limited breadth and having the two fine lakes of Seneca and Cayuga as its eastern and western limits, traversed by the outlet of the former, and on its north-eastern angle by the Erie canal, that Seneca county of New York is one of the most navigable inland counties of the United States.

SENECA, county of Ohio, on both sides of Sandusky river, having Sandusky county N., Wood NW., Hancock SW., Crawford S., and Huron E. Length from west to east 30, breadth 18 miles, and area 540 square miles. Chief village or seat of justice Tiffin. Central lat. 41° 08' N. Long. W. from Washington City 6° 12'. Face of the country level or gently waving, soil fertile. In great part unsettled. DARBY.

SENEGA. See MATERIA MEDICA.

SENEGAL, the name of a large river of Africa, already briefly described in our article PHYSICAL GEOGRAPHY. The early part of its course, and of its tributaries, is through a rugged country, intersected by numerous rivers and streams, whose sands contain much gold dust, which is extracted by the women by the process of agitation. For a distance of about 60 leagues from its mouth, below Podor, its descent is said not to exceed two and a half feet. It is here bordered by vast woods, the residence of monkeys and parrots of all kinds. The entrance of the river is defended by a formidable bar of sand, a little under water. Before it throws itself into the sea, it forms the Isle of Senegal in St. Louis, about 1000 paces long, and 60 broad. The eastern branch of the river is here about 800 yards across, and the western one from 100 to 400 yards.

SENEGAL, GOVERNMENT OF, is the name given by the French to their settlement on the island, at the mouth of the above river. This settlement was founded in 1637, under Louis XIV. and the fort thus received the name of Fort Louis. Although the island is merely a mass of white and burning sand, constantly in motion, yet its security from attack recommended it as the site of the colony. The streets, which are regular, consist of huts or thatched cottages, among which are some flat roofed houses of stone. As the island is perfectly barren, it is supplied with every thing from the continent.

In 1787, the white inhabitants amounted to about 60, and the military to about 600. The free Mulatto and Negro population was estimated at 2400, and the domestic and labouring slaves at 2400. These, with 1200 negroes always ready for embarkation to the West Indies, constituted a population of about 6000.

As gum Senegal has been found superior to all other gums, it is one of the principal objects of commerce at Fort Louis. The forests of Acacia, from which this gum exudes, are called Sahel, Al Fatack, and El Hiebar, the first producing the white gum, which is the most esteemed, and the other two the red gum. The trees are about 18 or 20 feet high, and three feet round. The gum begins to exude about the 10th of November, when the periodical rains are over. No incision is needed, but the gum flows from the cracks in the bark, and generally in drops about the size of a partridge's egg. These drops are always transparent and brilliant at the part where they are broken off; and when they have been in the mouth a few seconds, they have all the limpidity of pure quartz.

Early in December the Moors leave their habitations in the desert to the care of old men, and a few servants to tend the cattle, and set out in a tumultuous cavalcade of horsemen, camel drivers, and pedestrians. They then encamp on the borders of the gum forest, and, during a harvest of about six weeks, they fill their leathern sacks with the gum.

The great gum fair is held on a desolate plain of white and moving sands on the north bank of the Senegal, between Podor and St. Louis. The French merchants repair thither to wait the arrival of the Moors. On the morning of the fair a confused and distant noise is first heard, and about noon the whole plain is covered with an army of men, camels, oxen, and goats, surrounded with clouds of dust, with all their baggage, wives, and children. The kings are mounted on fine horses, and their wives are carried on a few chosen camels, highly caparisoned. A band of Moors, equipped with muskets and lances, escort this moving kingdom. When the tumult of the assemblage has subsided, and their camps fairly pitched, a cannon is fired as a signal for the commencement of the fair. Lies and threats of all kinds are employed by the Moors to obtain a high price for their gum, for which they receive in exchange East India cotton goods called pieces of Guinea. Between 1785 and 1787 the French obtained 800,000lbs. of gum exclusive of 400,000 carried to Portendick, and sold to the English. It is sold in kantars of about 500 lbs. and costs about two-pence per pound.

In 1786, there were exported from Senegal cloves valued at 2,640,000 livres, gold valued at 90,000 livres, and ivory and miscellaneous articles valued at 130,000 livres.

In 1756 this colony was taken by Britain, and was afterwards ceded to us in 1763. The French, however, retook it in 1779, and were allowed to retain it till the peace of 1783. They again lost it during the revolutionary war, but it was ceded to them at the restoration of the Bourbons.

SENNA. See MATERIA MEDICA.

SENNAAR, one of the divisions of Nubia in eastern Africa, is bounded by Abyssinia on the east and south, on the west by Darfur, and on the north by Dongola and the independent districts of Nubia. The part of Sennaar between the Nile and the river Tacazze formed what was called by the ancients the Island of Meroe.

The kingdom of Sennaar was founded in 1504 by a body of Shillock negroes. It has three principal governments tributary to it, viz. El-aice or Alleis, Kordofur, and Fazuclo.

El-aice, including the original country of the Shillock Negroes. The Bahr-el-abiad spreads itself over the territory, and by a great number of small channels it forms numerous little islands, on each of which is a village, the union of which constitutes the town of El-aice. The inhabitants, being all fishermen, possess a number of boats like canoes, in which they sail up and down to the cataracts. It was by means of these boats that the Shillock Negroes succeeded in conquering the Arabs in 1504.

Kordofan is next in importance to El-aice. The revenue consists chiefly in the slaves which are procured from Dyre and Tegla. Being nearest to Darfur, it has often been taken from Sennaar and retaken.

Fazuclo is bounded on the west by the river El-aice, and on the east by the Nile, and on the south by the mountains of Fazuclo, where the great cataracts are. The greater part of the revenue of Fazuclo is derived from gold obtained from the mountains.

The territory of Sennaar is remarkably fertile to a considerable distance from the banks of the river. In the rainy season, about the end of August, the appearance is delightful, the corn springs up, and the whole country appears a level green park, interspersed with lakes, and decorated with groups of villages. Through this immense plain flows the Nile, above a mile broad and full to the very brim. Upon the cessation of the rains the Dhourra ripens, the lakes become putrid and full of vermin, and poisonous winds, and burning sands, and sultry blasts desolate the plain.

The principal places are Sennaar the capital, and

Halfaia, a large, handsome, and pleasant town, built with clay, in north lat. 15° 45′ 54″, and east by 32° 49′ 15″. The houses are terraced at the top, and are about 300 in number. It stands upon a large circular peninsula, and surrounded by the Nile, which is about half a mile from the town. It derives its principal support from a manufacture of coarse cotton cloths, which serve for small money throughout the lower parts of Atbara. The people eat cats, and also the sea horse and crocodile. Their salt is extracted from the earth. Aira is another place about three or four miles from Sennaar; it is surrounded with white sand which is sown with millet. Shaddly, about twelve miles to the north north west of Sennaar, is a collection of villages; it received its name from a saint, who directed large pits to be dug, and plastered closely up with clay, for the purpose of being filled with grain when it was cheapest. These pits, called *matamores*, were plastered up at top. They occur in great numbers throughout the plain, and when there is any prospect of corn growing dear, they are opened, and the corn sold at a low price. About 24 miles to the north of Shaddly, is another more extensive establishment of the same kind, called Wed-aboud.

To the westward of Shaddly and Aboud, as far as the Abiad or El-aice, the country is covered with trees, which makes it an excellent station for camels. Near Shaddly are two mountain districts, viz. Jibbel-Moia, or the mountains of water, and Jibbel-Segod, or the Gold Mountains; the first is a considerable ridge of hills closely united and of the same height, and the second is a broken ridge, unequal and irregular. They are full of inhabitants, who enjoy a fine climate.

The dress of the people of Sennaar consists of a long shirt of blue cotton cloth, which reaches to the feet, and the only difference between that of the men and women is, that the men have the neck left bare, while the others have a shirt neck, which is buttoned like ours. Both men and women go barefooted in the house. They anoint themselves, at least once a day, with camels' grease, mixed with civet, and they sleep all night upon a bull's hide, and in a shirt dipped in grease.

Bread of flour or millet, is the diet of the poorer sort. The horned cattle are the largest and finest in the world, and are very fine, but camels' flesh is the common meat sold in the market. The liver of the camel, and the spare rib are universally eaten raw. Hogs' flesh, though not sold in the market, is publicly eaten.

Dysenteries, intermittent fever, epileptic and scirrhous livers are the principal diseases. The small pox is sometimes 12 or 15 years absent. They have a process of inoculation called *buying the small pox*.

The county has very little trade; the principal article of consumption is the blue cotton cloth from Surat. Their commerce consists chiefly in exchanging the productions of the interior of Africa with those of Arabia and Egypt. The articles from Africa are gold dust called Tibber, civet, Rhinoceros' horns, ivory, ostriches' feathers, glass and slaves. The gold is deemed the finest and best in Africa. They receive also spices, hardware, and toys, particularly black beads from Venice.

SENNAAR, a city of Africa, and the capital of the above kingdom, is situated on the banks of the Bahr-el Azrek, a river of Abyssinia, about 200 miles before it falls into the Abiad, or chief branch of the Nile. The houses are poorly built, consisting merely of clay intermixed with a little straw. They are all one story high, except those of the officers of state, which are two stories high. They have flat parapet roofs, though in other parts of the kingdom the roofs are conical to keep off the heavy rains. The palace is encircled with a lofty brick wall, but the buildings which compose it have neither order nor beauty. Splendid carpets are among their principal ornaments. Mr. Bruce has recorded the very singular fact, that neither horses, mules, asses, nor any domestic animal was bred in the town, or in any district several miles round it. Few of these animals can live there all the year round, but must be carried every half year to the sands, distant about four miles. At this place, Adelan, the actual ruler, kept his stud in good condition. A dreadful malady also prevails among the children: and it is said that there is a constant importation of slaves from the south in order to keep up the population. When the river overflows its banks, the houses near its banks are inundated, and are generally destroyed in consequence of the melting of the clay walls. Population about 160,000. The thermometer is said by Bruce to rise sometimes to 119° in the shade. East long. 33° 30′ 30″. North lat. 13° 34′ 36″. See Bruce's *Travels*.

SENS, a town of France, in the department of the Yonne, is agreeably situated on the slope of a hill, and is watered by the Yonne and the Vaune. Before the Revolution it was the see of an archbishop, and contained 16 Parish churches, and 14 abbeys and convents. The cathedral is a very fine piece of architecture, and its interior has been much admired. It contains the tomb of the dauphin, son of Louis XV., and that of Chancellor Dupradt. There is a library and museum belonging to the college. It carries on a trade in wine, corn, wood, coal, and hemp. Population 9000.

SEQUATCHE, small river of the United States in Tennessee, rises in Bledsoe, and flowing thence into Marion, which latter it traverses, and crossing the boundary line between Tennessee and Georgia, enters Tennessee river on the extreme northern border of the latter, after a comparative course of sixty miles. It is a mountain stream, rising and flowing between two lateral ridges of Cumberland mountain. DARBY.

SERAMPORE, a town of Bengal belonging to Denmark. It is agreeably situated on the west bank of the Bhagarutti or Hoogly river. The territory which belongs to it is about a mile long and half a mile broad, stretching along the banks of the river. The houses are seldom above two stories high, and are built of brick, and plastered with mortar. They have balconies, Venetian windows, and flat roofs. A handsome church is the principal public building. The town is not fortified; but there is near the flagstaff a battery of 12 pieces of cannon. A very trifling trade is carried on between this place and China and Europe. Being a sanctuary for creditors, which are British subjects, it is principally supported by them and by the missionaries. East long. 88° 26′. North lat. 22° 45′.

SERIES.

Series, in *Analysis*, is a number of quantities arranged in a certain order or succession, and so related that each succeeding quantity may be known from those which precede it.

The quantities which compose a *series* are called its *terms*, and that relation which is observable among the *terms* by which they may be successively determined, is called the *law of the series*.

Series are denominated, according to the nature of their terms, *numerical* or *algebraical*. Thus

$$1, \quad 2, \quad 3, \quad 4, \text{ \&c.}$$
$$1, \quad \frac{1}{2}, \quad \frac{1}{3}, \quad \frac{1}{4}, \text{ \&c.}$$

are numerical series, and

$$x, \quad x^2, \quad x^3, \quad x^4, \text{ \&c.}$$
$$\frac{1}{a}, \quad \frac{b}{a^2}, \quad \frac{b^2}{a^3}, \quad \frac{b^3}{a^4}, \text{ \&c.}$$

are algebraical series.

The *laws* of these series are severally obvious upon inspection, and there is no difficulty in continuing them to any number of terms.

Series are variously denominated in reference to their *laws*.

An *arithmetical series* is one in which each term is found by adding to or subtracting from the preceding term the same quantity. Such are the following:

$$1, \quad 2, \quad 3, \quad 4, \text{ \&c.}$$
$$3, \quad 6, \quad 9, \quad 12, \text{ \&c.}$$
$$a, a+d, \; a+2\,d, \; a+3\,d, \text{ \&c.}$$
$$a, a-d, \; a-2\,d, \; a-3\,d, \text{ \&c.}$$

A *geometrical series* is one in which each term is found by multiplying the preceding term by the same quantity. Such are the following:

$$2, \quad 4, \quad 8, \quad 16, \text{ \&c.}$$
$$a, \quad ax, \quad ax^2, \quad ax^3, \text{ \&c.}$$

2 being the multiplier in the former, and x in the latter.

An *harmonical series* is one in which the reciprocal of each term is found by adding to or subtracting from the reciprocal of the preceding term the same quantity. Such are

$$1, \quad \frac{1}{2}, \quad \frac{1}{3}, \quad \frac{1}{4}, \text{ \&c.}$$

$$\frac{b}{a}, \quad \frac{b}{a+d}, \quad \frac{b}{a+2d}, \quad \frac{a}{a+3d}, \text{ \&c.}$$

the quantity added being 1 in the former, and $\frac{d}{b}$ in the latter.

These three series are commonly called *progressions*. For a detailed account of their properties, see Algebra.

A *recurring series* is a general class, of which a geometrical series is a particular example. As each term of a geometrical series is produced by multiplying the preceding term by a constant quantity, so in a recurring series each term is found by multiplying a certain number of the terms which immediately precede it by as many constant quantities. Thus let A and B be any two successive terms of a recurring series, and let a and b be the constant multipliers, the next term will be $a\,A + b\,B$. Let this be called C, that is, let $a\,A + b\,B = C$; then the succeeding term is $a\,B + b\,C$. Again, let $a\,B + b\,C = D$, and the following term is $a\,C + b\,D$, and so on.

In like manner, if the series be produced by three constant multipliers, each term may be found from the three terms which immediately precede it. Let A, B, and C, be the three consecutive terms, a, b, c, the three constant multipliers, and let D, E, F, &c. be the terms which immediately succeed C. Then we have

$$\begin{aligned} D &= a\,A + b\,B + c\,C \\ E &= a\,B + b\,C + c\,D \\ F &= a\,C + b\,D + c\,E \\ &- \quad - \quad - \quad - \\ &- \quad - \quad - \quad - \end{aligned}$$

and the process would be similar if the series were generated by four or more constant multipliers.

In a recurring series the system of constant multipliers is called the *scale of relation*, and the series is said to be *a recurring series of the first, second, third, or mth order*, according as the number of constant multipliers in the scale of relation is 1, 2, 3, or m.

It is evident that a recurring series of the first order is a geometrical series.

When powers of the same letter or species enter all the terms of a series as factors, the series is called an *ascending* or *descending* series with respect to this quantity, according as the exponents of the power increase or decrease. Thus the following is an ascending series with respect to x, and a descending one with respect to a.

$$a^m, \; a^{m-1}\,x, \; a^{m-2}\,x^2, \; a^{m-3}\,x^3, \text{ \&c.}$$

The *general term* of a series is an algebraical formula, which is usually a function of the quantities which are engaged in the series, and a general symbol n, denoting the place of any term or its numerical order relatively to some term which is considered as the first term of the series, or the point of departure to which the places of all the other terms are referred. Thus in the last example, if a^m be considered as the first term, it appears that the number which is subtracted from m in the exponent of a in each term is equal to the number of preceding terms, and therefore is one less than the number which denotes the place of the term itself; and the exponent of x in each term is the number which is subtracted from m in the exponent of a in the same term. Thus if n denote the numerical order of any term T, we have

$$T = a^{m-(n-1)}\,x^{n-1}.$$

It is obvious that the formula which expresses the general term of a series also expresses its *law*, and that the terms of the series may be found by substituting the successive integers 1, 2, 3, &c. for n in this formula.

The terms of a series are generally connected together by the algebraical signs + or —, and it is to the whole thus connected that the term *series* is applied.

A series generally arises from some analytical process to which a function or formula has been submitted, and this process is called *development;* the finite *formula* is said to be *developed*, and the resulting series is called its *development.*

There are several methods of development adapted to the various forms which fractions may assume. The principal and the most general of these are the *method of indeterminate coefficients* and *the theorem of Lagrange.* Under the latter is comprehended several methods which are sometimes enumerated separately; such as, the method of division, the binomial theorem, Taylor's theorem, Maclaurin's theorem, &c. These methods the reader will find explained in the articles ALGEBRA and FLUXIONS. Numerous applications of these processes will also be found in several of our mathematical articles, as, TRIGONOMETRY, LOGARITHMS, &c.

The *summation* of a series is that process by which the algebraical sum of any number of its terms, or even of the whole series continued *ad infinitum*, may be found.

The summation of series is a subject which has engaged the attention of the most eminent modern analysts, from the time of Wallis, who seems first to have given the doctrine of series that consideration which its importance demands, to the present day. Any detailed account of these various methods of summation, which have been proposed by modern mathematicians, would exceed those limits which we find it expedient to impose on such a discussion in this work. We shall therefore confine ourselves to a few examples, illustrative of some of the principal methods.

To determine the sum of a series of fractions, whose numerators are in arithmetical, and whose denominators are in geometrical progression: the number of terms being supposed infinite.

Let the series be expressed thus,

$$\frac{a}{a'}+\frac{a+d}{a'r}+\frac{a+2d}{a'r^2}+\frac{a+3d}{a'r^3}+\cdots \quad [1]$$

By the formulæ established in article ALGEBRA, for summing a decreasing geometrical series continued *in infinitum*, we have the following results:

$$\frac{a}{a'}+\frac{a}{a'r}+\frac{a}{a'r^2}+\frac{a}{a'r^3}+\cdots=\frac{ar}{a'r-a'}$$
$$\frac{d}{a'r}+\frac{d}{a'r^2}+\frac{d}{a'r^3}+\cdots=\frac{d}{a'r-a'}$$
$$\frac{d}{a'r^2}+\frac{d}{a'r^3}+\cdots=\frac{d}{a'r^2-a'r}$$
$$\frac{d}{a'r^3}+\cdots=\frac{d}{a'r^3-a'r^2}$$
$$+\cdots=\cdots$$
$$\cdots=\cdots$$

It is evident that the proposed series is the sum of the first members of these equations. If then we express this sum by S, we have

$$S=\frac{ar}{a'(r-1)}+\frac{d}{a'(r-1)}\left\{1+\frac{1}{r}+\frac{1}{r^2}+\frac{1}{r^3}+\cdots\right\}$$

The series within the brackets, in the second member of this equation, is also a geometrical series in which $\frac{1}{r}$ is the constant multiplier. Its sum continued *in infinitum*, therefore $\frac{r}{r-1}$. Hence we obtain

$$S=\frac{ar}{a'(r-1)}+\frac{dr}{a'(r-1)^2}$$
$$\text{or } S=\frac{ar(r-1)+dr}{a'(r-1)^2}$$

The same method of summation may be applied to the case in which the numerators, instead of being in arithmetical progression, are composed of a constant quantity a, connected by addition, with terms composed of a constant factor d, and the triangular numbers 1, 3, 6, 10, &c. Thus let the series be,

$$S=\frac{a}{a'}+\frac{a+d}{a'r}+\frac{a+3d}{a'r^2}+\frac{a+6d}{a'r^3}+\cdots$$

As before we obtain the following equations by the summation of geometrical series:

$$\frac{a}{a'}+\frac{a}{a'r}+\frac{a}{a'r^2}+\frac{a}{a'r^3}+\frac{a}{a'r^4}+\cdots=\frac{ar}{a'r-a'}$$
$$\frac{d}{a'r}+\frac{d}{a'r^2}+\frac{d}{a'r^3}+\frac{d}{a'r^4}+\cdots=\frac{d}{a'r-a'}$$
$$\frac{2d}{a'r^2}+\frac{2d}{a'r^3}+\frac{2d}{a'r^4}+\cdots=\frac{2d}{a'r^2-a'r}$$
$$\frac{3d}{a'r^3}+\frac{3d}{a'r^4}+\cdots=\frac{3d}{a'r^3-a'r^2}$$
$$\frac{4d}{a'r^4}+\cdots=\frac{4d}{a'r^4-a'r^3}$$
$$+\cdots=\cdots$$
$$\cdots=\cdots$$

As before the sum of the first members is S; so that we have

$$S=\frac{ar}{a'(r-1)}+\frac{d}{a'(r-1)}\left\{1+\frac{2}{r}+\frac{3}{r^2}+\frac{4}{r^3}+\cdots\right\}$$

In the series which is within the brackets, the numerators are in arithmetical progression, and therefore its sum may be obtained by the general formula established in the preceding example. This will be effected by making $a=a'=d=1$, whence we obtain

$$1+\frac{2}{r}+\frac{3}{r^2}+\frac{4}{r^3}+\cdots=\frac{r^2}{(r-1)^2}$$

Hence we find

$$S=\frac{ar}{a'(r-1)}+\frac{dr^2}{a'(r-1)^3}$$

By dividing the former series by r, we have

$$\frac{1}{r}+\frac{2}{r^2}+\frac{3}{r^3}+\frac{4}{r^4}+\cdots=\frac{r}{(r-1)^2}$$

Hence

$$\frac{1}{2}+\frac{2}{2^2}+\frac{3}{2^3}+\frac{4}{2^4}+\cdots=2$$
$$\frac{1}{3}+\frac{2}{3^2}+\frac{3}{3^3}+\frac{4}{3^4}+\cdots=\frac{3}{4}$$

and so on.

If in the series (2), we make $a=0$, $a'=1$ and $d=1$ we obtain,

$$\frac{1}{r}+\frac{3}{r^2}+\frac{6}{r^3}+\frac{10}{r^4}+\cdots=\frac{r^2}{(r-1)^3}$$

Hence we find

$$\frac{1}{2}+\frac{3}{2^2}+\frac{6}{2^3}+\frac{10}{2^4}+\cdots=4$$
$$\frac{1}{3}+\frac{3}{3^2}+\frac{6}{3^3}+\frac{10}{3^4}+\cdots=\frac{9}{8}$$

and so on.

This method of *summation by addition* was proposed by James Bernoulli, in a tract *De Seriebus Infinitis*, published with his *Ars Conjectandi*. Bas. 1713.

Another method of summation suggested by the *Bernoullis* on the same principle, is *summation by subtraction*, of which the following is an example.

To find the sum of an infinite series of reciprocal triangular numbers. Let the series be

$$S = \frac{1}{1} + \frac{1}{3} + \frac{1}{6} + \frac{1}{10} + \cdots$$

Divide both members by 2, and we obtain

$$\frac{S}{2} = \frac{1}{2} + \frac{1}{6} + \frac{1}{12} + \frac{1}{20} + \cdots$$

$$= \frac{1}{1\cdot 2} + \frac{1}{2\cdot 3} + \frac{1}{3\cdot 4} + \frac{1}{4\cdot 5} + \cdots$$

$$= \left(1 - \frac{1}{2}\right) + \left(\frac{1}{2} - \frac{1}{3}\right) + \left(\frac{1}{3} - \frac{1}{4}\right) + \cdots$$

$$\therefore \frac{S}{2} = \left\{1 + \tfrac{1}{2} + \tfrac{1}{3} + \tfrac{1}{4} +, \&c.\right\} - \left\{\tfrac{1}{2} + \tfrac{1}{3} + \tfrac{1}{4} +, \&c.\right\}$$

$$\therefore \frac{S}{2} = 1 \qquad \therefore S = 2$$

In the preceding examples, we have applied these methods of addition and subtraction only to cases in which the series were continued *in infinitum*. We can, however, frequently employ them for the summation of a finite number of terms of a series. Numerous instances of this occur in trigonometry. The following are examples of it.

Ex. *To find the sum of the sines of a series of arcs in arithmetical progression.*

Let the proposed series be

$$\text{Sin } A + \sin(A + x) + \sin(A + 2x) + \cdots \text{Sin}[A + (n-1)x] = S. \quad [1]$$

Let both members be multiplied by $-2\sin\frac{1}{2}x$. Hence

$$-2\sin\tfrac{1}{2}x\sin A - 2\sin\tfrac{1}{2}x\sin(A+x) - \sin\tfrac{1}{2}x\sin(A+2x) - \cdots - 2\sin\tfrac{1}{2}x(\sin[A+(n-1)x] = -2\sin\tfrac{1}{2}x\cdot S.$$

Every term of this series is of the form $-2\sin\frac{1}{2}x\sin(A + mx)$,

and by the principles of trigonometry, we have

$$-2\sin\tfrac{1}{2}x\sin(A + mx) = \cos\left(A + \frac{2m+1}{2}x\right) - \cos\left(A + \frac{2m-1}{2}x\right).$$

by substituting successively 0, 1, 2, 3, --- $(n-1)$, for m in this formula we shall obtain the values of the successive terms of the above series, and it is plain that except the first and last they will mutually destroy each other; so that the result will be

$$-\cos(A - \tfrac{1}{2}x) + \cos\left(A + \frac{2n+1}{2}x\right) = -2\sin\tfrac{1}{2}x$$

$$\therefore S\sin\tfrac{1}{2}x = \sin\left(A + \frac{n-1}{2}x\right)\sin\frac{n}{2}x$$

$$\therefore S = \frac{\sin\left(A + \frac{n-1}{2}x\right)\sin\frac{n}{2}x}{\sin\frac{1}{2}x},$$

which is the sum required.

If $A = x$, the series becomes

$$\sin x + \sin 2x + \sin 3x \cdots + \sin nx = S,$$

and we have

$$S = \frac{\sin\frac{n+1}{2}x\sin\frac{n}{2}x}{\sin\frac{1}{2}x}.$$

It will be perceived that the artifice by which the summation of this series has been brought under the methods of addition and subtraction, is by converting it into another series, every term of which being double the product of two sines, admits of being resolved into two simple cosines, with different signs. In this case, one of the cosines into which each term is resolved, destroys one of the cosines into which the next term is resolved; so that however numerous the terms of the series may be, the total result can only contain one of the cosines of the first pair, and one of the last pair. If the last cosine continually diminished or approached any value as a limit, as the number of terms in the series increases, we should be entitled to conclude that the sum of the proposed series continued *ad infinitum*, would be expressed by the first cosine and the limiting value of the last. If we assume that the sum of the series is expressed by the first term alone, it is equivalent to assuming that the last term diminishes without limit.

This, however, is not the case; the last cosine alternately increases and diminishes, and changes its sign as the arc changes its relation to an exact multiple of the circumference; and therefore the series increases and decreases alternately, and approaches no limiting state. In other words, the series not being convergent, does not admit of having its sum assigned when the number of its terms are limited.

If x be commensurable with the circumference, or 2π, the series will be *periodic*: that is, after a certain number of terms, the same terms will continually recur in the same order. Let the least integers in the ratio of x to 2π be $m' : n'$; so that

$$n'x = 2m'\pi.$$

In that case, when the series [1] has been continued to n' terms, the $(n'+1)^{\text{th}}$, term will be

$$\text{Sin}(A + 2m'x, = \sin(A + 2m'\pi) = \sin A.$$

In like manner, the following term will be

$$\text{Sin}[A + (n'+1)x] = \sin(A + x + 2m'\pi) = \sin(A + x,)$$

which is equal to the second term of the series, and so the terms from the $(n'+1)^{\text{th}}$ to the $2n'^{\text{th}}$ inclusive, will be equal to those from the first to the n'^{th} inclusive.

In this case, the value of the period of the series may be found by substituting $\frac{2m'\pi}{n'}$ for x, and n' for n in the value of S, already found; which gives

$$S = \frac{\text{Sin}\left(A + \frac{(n'-1)m'\pi}{n'}\right)\sin m'\pi}{\text{Sin}\frac{m'\pi}{n'}}.$$

If $\frac{m'}{n'}$ be not an integer, the value of S must $= 0$, for $\sin m'\pi = 0$, and $\sin\frac{m'\pi}{n'}$ cannot $= 0$. Therefore, in this case, the terms of the period mutually destroy each other, or the whole period might be divided into two periods, the terms of which differ only in their signs. But if $\frac{m'}{n'}$ be an integer, then $\sin \frac{m'}{n'} \pi = 0$; and the value of S assumes the form $\frac{0}{0}$. In this case x is an exact multiple of the circumference, and the terms of the series are all equal to sin A, which is itself the period.

One meaning of "the sum of a periodic series continued *ad infinitum*," would evidently be the product of the value of the period, and an infinite integer, or the period added to itself *ad inf.* It may, however, be considered, that if continued *ad inf.* every term of the period has as strong a claim as its last term to be considered as the last term of the series. The sum of a periodic series, whose period $= 0$, continued *ad inf.* is therefore susceptible of as many *different* values as there are different terms in its period. If the last term of the series be the first term of the period, that term will be equal to the sum. If the last term of the series be the second term of the period, the sum of the series will be the sum of the first two terms of the period; and if the last term of the series be the third term of the period, the sum of the series will be the sum of the first three terms of the period, and so on. It is, therefore, evident, that the variety of values of which the sum of the series is susceptible, whether continued *ad inf.* or not, is limited by the number of different terms in the period.

Now the sum of the series continued *ad inf.* is sometimes said to be a mean of all its different values, or to be the sum of all the different values divided by their number. We shall give an instance of this in the series of which we have already obtained the sum.

If n' be the number of different terms in the series, we shall obtain the n' different values of the sum by successively substituting 0, 1, 2, - - - - n' for n in the equation.

$$\cos (A - \tfrac{1}{2} x) - \cos \left(A + \frac{2n+1}{2} x\right) = 2 \sin \tfrac{1}{2} x \,.\, S$$

Let S′ be the sum of all the corresponding values of S. Since the sum of all the corresponding values of $\cos (A + \frac{2n+1}{2} x)$, is the period, which by hyp. $= 0$ we have

$$n' \cos (A - \tfrac{1}{2} x) = 2 \sin \tfrac{1}{2} x \,.\, S'$$

$$\therefore \frac{S'}{n'} = \frac{\cos (A - \frac{1}{2} x)}{2 \sin \frac{1}{2} x}$$

This is the value of S which would be obtained by neglecting the last cosine in the investigation already instituted, and it hence appears that we cannot infer that the sum of the series *ad inf.* has this value, except when the series is periodic, and its period $= 0$, and even then the sum of the series has this value only in the sense above explained, which is, that the sum *ad inf.* is susceptible of as many different values as there are terms in the period, and that which is found above is its mean value, or the sum of all its different values divided by their number.

In general, however, the summation of a series continued *ad inf.* is, properly speaking, an analytical process wich is the reverse of *development.* As *development* is the process by which a function expressed in finite terms is converted into a series, so *summation* is that process by which, when a series is given, the function by whose development it was obtained may be assigned. The word *summation* cannot be literally applied to this process, except in the case where the series *converges*, for, except in this case, there cannot be an arithmetical equality between the function and the series. This will very evidently appear by an example. Let 1 be divided by $(1 - a)$ by the ordinary rules of algebraical division, and we obtain

$$\frac{1}{1-a} = 1 + a + a^2 + a^3 + a^4 + \cdots \textit{ad inf.}$$

If a be greater than unity, the second member of this equation is an infinitely great positive quantity, while the first member is a finite negative quantity. In this case no actual equality can subsist, and the sign $=$ only signifies that the first member is the function by whose development the series in the second member is obtained.

The method used in the last examples may sometimes be applied to the summation of a finite number of terms of a numerical series as in the following example.

Let the series be

$$S = \frac{1}{1.3} + \frac{1}{3.5} + \frac{1}{5.7} +$$

continued to n terms.

The nth term will evidently be $\frac{1}{(2n-1)(2n+1)}$

We have

$$1 - \frac{1}{3} = \frac{2}{1.3}$$

$$\frac{1}{3} - \frac{1}{5} = \frac{2}{3.5}$$

$$\frac{1}{5} - \frac{1}{7} = \frac{2}{5.7}$$

$$\cdots\cdot = \cdot\,\cdot$$

$$\cdots\cdot = \cdot\,\cdot$$

$$\frac{1}{2n-1} - \frac{1}{2n+1} = \frac{2}{(2n-1)(2n+1)}$$

The sum of the first members of these equalities is evidently $1 - \frac{1}{2n+1}$ since all the other terms mutually destroy each other, and the sum of the second members is 2 S. Hence we obtain

$$2\,S = 1 - \frac{1}{2n+1} = \frac{2n}{2n+1}$$

$$\therefore S = \frac{n}{2n+1}$$

But by far the most general method for the summation of series is that which is derived from the principles of the calculus of differences, which we shall now briefly explain and illustrate by examples.

If the successive terms of a series be expressed by u_1, u_2, u_3, &c. u_x, the number at the foot of the letter denoting the place of the term, the sum of all the terms from u_1 to u_x inclusive, may be expressed thus, $S\,u_x$. Thus we have

$$S\,u_x = u_1 + u_2 + u_3 + \ldots + u_x.$$

In like manner

$$S\,u_{x+n} = u_1 + u_2 + u_3 + \ldots + u_x + u_{x+1} + \ldots u_{x+n}$$

Subtracting the former from the latter, we have

$$S\,u_{x+n} - S\,u_x = u_{x+1} + u_{x+2} + u_{x+3} + \ldots u_{x+n}$$

by which we may express the sum of any number of terms of a series, commencing and terminating at any proposed terms.

If $n = 1$, we have

$$S\,u_{x+1} - S\,u_x = u_{x+1}$$

But

$$\Delta\,(S\,u_x) = S\,u_{x+1} - S\,u_x$$

$$\therefore \Delta\,(S\,u_x) = u_{x+1}$$

$$\therefore S\,u_x = \Sigma\,u_{x+1} + C$$

C being an arbitrary constant.

When $x = 0$, $S\,u_x = 0 \therefore 0 = \Sigma\,u_1 + C$

subtracting this equation from the last, we have

$$S u_x = \Sigma\,u_{x+1} - \Sigma\,u_1,$$

Hence it appears that the summation of a series depends on the integration of u_{x+1} and u_1 considered as differences.

In like manner, if the sum of the series from the nth to the xth term, including the latter, be required, we have

$$S\,u_x - S\,u_n = u_{n+1} + u_{n+2} + \ldots\, u_x$$

But by what has just been proved

$$S\,u_x = \Sigma\,u_{x+1} - \Sigma\,u_1$$

$$S\,u_n = \Sigma\,u_{n+1} - \Sigma\,u_1$$

$$\therefore S\,u_x - S\,u_n = \Sigma\,u_{x+1} - \Sigma\,u_{n+1}$$

We shall now give some examples of the application of these principles, to the summation of series.

Ex. 1. *To determine the sum of a series of figurate numbers of the first, second, and successive orders, beginning with unity in each series.*

For the figurates of the first order we have

$$S\,u_x = 1 + 2 + 3 + \ldots\, x$$

$$\therefore u_x = x$$

$$\therefore S\,u_x = \Sigma\,(x + 1) + C$$

But by the calculus of differences we have

$$\Sigma\,(x) = \frac{x^2}{2h} - \frac{x}{2}$$

Changing x into $x + 1$, and h into 1, we have

$$\Sigma\,u_{x+1} = \frac{(x+1)^2 - x}{2} + C$$

$$\therefore \Sigma\,u_1 = \frac{1}{2} + C$$

Subtracting this from the former we have

$$\Sigma\,u_{x+1} - \Sigma\,u_1 = \frac{x\,(x+1)}{1\,.\,2}$$

$$\therefore 1 + 2 + 3 \ldots + x = \frac{x\,(x+1)}{1\,.\,2}$$

For the figurates of the second order

$$u_x = \frac{x\,(x+1)}{1\,.\,2} \quad u_{x+1} = \frac{(x+1)\,(x+2)}{1\,.\,2}$$

$$\Sigma\,u_{x+1} = \frac{x\,(x+1)\,(x+2)}{1\,.\,2\,.\,3} + C$$

$$\therefore \Sigma\,u_x = \frac{x\,(x+1)\,(x+2)}{1\,.\,2\,.\,3}$$

no constant being added, because when $x = o$, $S\,u_x = o$.

In general, for the figurates of the nth order we have

$$u_{x+1} = \frac{(x+1)\,(x+2)\,(x+3) \ldots\ldots (x+n)}{1\,.\,2\,.\,3 \ldots\ldots n}$$

$$\therefore \Sigma\,u_{x+1} = \frac{x\,.\,(x+1)\,(x+2) \ldots\ldots (x+n)}{1\,.\,2\,.\,3 \ldots\ldots n+1}$$

$$\therefore S\,u_x = \frac{x\,(x+1)\,(x+2) \ldots\ldots (x+n)}{1\,.\,2\,.\,3 \ldots\ldots n+1}$$

which is a general formula for the figurates of any order.

The following theorem, established in the calculus of differences, is of considerable use in the summation of series.

Let the successive terms of the series be signified as before, and let x be the number of terms whose sum is required, so that

$$S\,u_x = u_1 + u_2 + u_3 \ldots\ldots + u_x$$

Let $D_1, D_2, D_3, \ldots\ldots$ be respectively the first terms of the *first, second, third*, &c. differences; then will the sum of x terms be expressed by

$$S\,u_x = x\,u_1 + \frac{x\,(x-1)}{1\,.\,2}\,D_1 + \frac{x\,(x-1)\,(x-2)}{1\,.\,2\,.\,3}\,D_2 + \frac{x\,(x-1)\,(x-2)\,(x-3)}{1\,.\,2\,.\,3\,.\,4}\,D_3 + \&c.$$

In all cases where we can arrive at a constant difference this series will be finite, and give the exact sum.

Ex. 1. Let the series be the squares of the successive integers.

$$S\,u_x = 1^2 + 2^2 + 3^2 \ldots\ldots x^2$$

$$\therefore u_1 = 1,\ D_1 = 3\ D_2 = 2\ D_3 = o$$

In this case D_2 is constant, and

$$S\,u_x = x + \frac{x\,(x-1)}{1\,.\,2}\,.\,3 + \frac{x\,(x-1)\,(x-2)}{1\,.\,2\,.\,3}\,.\,2.$$

Ex. 2. Let the series be the cubes of the successive integers.

$$S\,u_x = 1^3 + 2^3 + 3^3 + \ldots\ldots x^3$$

$$\therefore u_1 = 1,\ D_1 = 7\ D_2 = 12\ D_3 = 6\ D_4 = o$$

$$\therefore S\,u = x + \frac{x\,(x-1)}{1\,.\,2}\,.\,7 + \frac{x\,(x-1)\,(x-2)}{1\,.\,2\,.\,3}\,12 + \frac{x\,(x-1)\,(x-2)\,(x-3)}{1\,.\,2\,.\,3\,.\,4}\,.\,6$$

If we investigate this by the method of integration we shall obtain a remarkable result.

$$\Sigma\,(x+1)^3 = \frac{(x+1)^4}{4} - \frac{(x+1)^3}{3} + \frac{(x+1)^2}{4}$$

$$= \left(\frac{x\,(x+1)}{1\,.\,2}\right)^2$$

Hence we find

$$1^3 + 2^5 + 3^5 \ldots\ldots + x^3 = \left(\frac{x\,(x+1)}{1\,.\,2}\right)^2$$

But also

$$1 + 2 + 3 \ldots\ldots + x = \frac{x\,(x+1)}{1\,.\,2}$$

$$\therefore (1 + 2 + 3 \ldots\ldots + x)^2 = \left(\frac{x\,(x+1)}{1\,.\,2}\right)^2$$

$$\therefore 1^3 + 2^3 + 3^3 + \ldots\ldots + x^3 = (1 + 2 + 3 + \ldots\ldots + x)^2$$

(D. L.)

Serinagur, the name of a province in Nepaul, situated between East long. 77° and 80°, and North lat. 30° and 32°, and about 120 miles long, and 60 broad. The province consists generally of wooded hills and bare rocks, but the valleys, which are very confined, are highly fertile. The oak and most of the trees and fruits of Europe grow here, and wild elephants abound in the woods. The principal mineral productions are a good deal of copper and some gold.

The trade with the surrounding districts is carried on by means of sheep and goats, each of which carries about 12 lbs. of borax in a small sack. Flocks of 100 or 200 may be seen at a time, attended by shepherds and their dogs; and, conducted by a stout ram, having a large bell, they travel at the rate of 10 or 15 miles per day. Before the invasion of the state by the Nepaulese it was governed by a Hindoo prince, whose revenue was about L.65,000 per annum. In 1809, after a bloody battle fought at Guradwara, the Rajah of Nepaul made himself master of Serinagur, and held it in subjection by a military force. After the conquest of Nepaul by the British in 1816, the prince of Serinagur was re-established in his dominions, and the province may therefore be considered as under the British protection.

SERINAGUR is the capital of the above principality. The city stands in the centre of a valley 3 miles long, watered by the river Alcananda. It is about ¾ths of a mile long, and its streets are narrow and dirty. The houses, which are of rough stone and mud, are slated. With the exception of the palace of the Rajah, which is four stories, the houses are only two stories high. The river, which is crossed by a bridge of ropes, is only about 80 yards wide in the dry season. The celebrated temple of Ishwara stands on the opposite side of the river. With the exception of about 70 Mahomedan families, the inhabitants are chiefly Hindoos. During the rainy season foreigners quit the city on account of its insalubrity. East long. 79° 18′ North lat. 30° 11′.

SERINGAPATAM, or, Siri-runga-patan, a celebrated city of Hindoostan, and formerly capital of the province of Mysore. It is situated at the height of 2412 feet above the level of the sea, at the upper end of an island in the river Cavery, four miles long, and four and a half broad. The river is here five feet deep, and flows over a rocky bed. On the western side of this island stood the fortress, which occupied a space of 2000 yards, and contained magnificent palaces, lofty mosques, and regular outworks. Protected on its north and south sides by the river, a single rampart was found sufficient to defend this fort. But in 1792, the east and west faces, which were much weaker, were strengthened by double walls and ditches, by a circular work on the south east angle, by several formidable cavaliers, and by outworks before the gates. The rampart, which is very narrow, is from 20 to 35 feet high, and the whole of the revetement, with the exception of the north-west portico, consists of large oblong pieces of granite laid transversely in the walls with cement. A glacis of stone stretches along the northern face of the fortress, and the ditches are cut out of the solid rock. There are very few buildings of any importance within the fort, and those in the town are generally mean. The Sultan's palace is a magnificent building, in the Asiatic style of architecture; but it is deformed by a lofty wall, and the unfinished buildings which surround it. The great mosque, which is covered with the finest chunam, is adorned with lofty minarets. The ruins of the old Mysore palace have been converted into a military storehouse.

In the island is a celebrated temple dedicated to Vishnu, and in the beautiful garden called the Loll Bang, a handsome mausoleum, kept in repair by the Madras government, has been erected over the remains of Hyder Ally and his son Tippoo.

Before the siege of Seringapatam, (of which we have given some account in our article Mysore,) the population of the city and the island is said to have amounted to 150,000, including the garrison, but in the year following it was reduced to 32,000. Seringapatam now belongs to the British. It is the residence of a judge and collector, and is defended by a strong garrison. The mean annual temperature of this place is 77° 06. See *Edinburgh Journal of Science*, No. x. p. 249.

SERPENT. See Ophiology.

SERPENTINE. See Mineralogy Index, and also the *Edinburgh Transactions*, vol. x. part 1, and Dr. Brewster's *Journal of Science*, vol. i. p. 1, and vol. iii. p. 112, 126. The three interesting papers here referred to are by Mr. Haidinger, Mr. Lyell, and Mr. Herschel. See also Scotland.

SERTORIUS. See Roman Empire.

SERVETUS, Michael, a learned and unfortunate theologian, who has become celebrated principally from his having fallen a victim to the grossest religious intolerance. As we have given a full account of this transaction (which has been greatly misrepresented by the Anti-Calvinists) in our article Calvin, it is unnecessary to resume the subject at present.

Servetus was born at Villa Nueva in Arragon, in 1509, and he was burned at Geneva on the 27th October 1553.

He was not only an able man but a learned physician; and he is said to have made the nearest approach to the discovery of the circulation of the blood, having clearly mentioned the circulation of the blood through the lungs in his work *De Restitutione Christianismi*. A life of Servetus, in a series of letters to Dr. Morse from Dr. Vanderkemp will be found in the *Monthly Repository*, vol. v.

SERVIA, usually Mœsia Superior, is a province of Turkey in Europe. Belgrade, already described, is its capital. See Turkey.

SERVIUS TULLIUS. See Roman Empire.

SESOSTRIS. See Egypt.

SESSION, Court of. See Scotland.

SETHO. See Egypt.

SETCHUEN. See China.

SETTLE, a market town of England, in the west riding of Yorkshire, is situated on the eastern bank of the river Ribble, which is here crossed by a stone bridge. The principal street is built on the high road from Skipton to Kirby Lonsdale, and has several good stone houses. The smaller streets which branch from it to the north, are irregular and poorly built. The market place is spacious, and the church, which is a plain edifice, is at Giggleswick, on the other side of the river. The cotton mills here give employment to many of the inhabitants. The town stands very singularly at the bottom of an almost perpendicular limestone rock, the summit of which commands a fine prospect. Number of houses in the township in 1821 was 281. and the population 1508. See *The Beauties of England and Wales*, vol. vi.

SETUBAL or St. Ubes, anciently *Cedobriga*, a seaport town of Portugal in the province of Estramadura, situated in a bay of the Atlantic, at the mouth of the river Sandao. Having been destroyed in the earthquake of 1775, it was rebuilt in a better style, and contains several good streets with commodious houses. The whole of the town was fortified with a mound, a strong citadel called St. Philips with an excellent stream of water, besides the strong fort of Outao, and two small forts. There are in the town five churches, two hospitals, an arsenal, eleven monasteries, and an academy, founded by John V. It has a good harbour, capable of receiving any ships of burthen. It carries on a great export trade in lemons, olives, oil, Muscadel wine. but particularly bay salt, of which about 200,000 tons are annually made here, and sent to the north of Europe. In 1796, 551 vessels entered the harbour, and as many cleared out of it. Population 12,000. West Long. 8° 53′. North Lat. 38° 29′.

SEVASTAPOL, a seaport town of Russia in the Crimea, situated on a small bay of the Black Sea. After falling into the condition of a Tartar village, from being one of the principal towns of ancient Colchis, it has again risen into importance as a station of the Russian fleet. Its harbour is ranked with those of Malta and Port Mahon, and it is furnished with docks, dock yards, an arsenal. barracks, and a lazaretto. The chief bay runs about 700 fathoms into the land, and has a depth of about 10½ fathoms. It is wholly free of shoals, and is completely sheltered. This place has increased very rapidly. Population about 9000. East Long. 34° 11′. North Lat. 43° 41′ 30″.

SEVEN Oaks, a market town of England, in Kent, is situated on a gentle eminence, near the river Derwent. The town consists chiefly of two spacious streets in the form of the letter Y. Many of the houses are large and respectable looking buildings, inhabited by families in independent circumstances. The ancient market house stands near the middle of the High Street. The church, which has an elevated situation at the south end of the town, is a large and handsome edifice, and forms a conspicuous object for many miles around. The charitable establishments are an hospital and free grammar school, founded by William de Sevenoke, Lord Mayor of London in 1441. He is said to have been found on the streets, and educated by a person of this town. It was subsequently farther endowed by Queen Elizabeth, and is said to have a revenue of £800 a year. It possesses six exhibitions to either of the Universities. About thirty-two elderly trades people find an asylum in the hospital, which has also sixteen out-pensioners. Mills have lately been established here for weaving silk, which give employment to many of the inhabitants. The town house derives its chief support from the constant influx of company on their way to Tunbridge. Population of the town about 1600. See Hasted's *History of Kent*, and the *Beauties of England and Wales*, vol. viii.

SEVERN, River. See England.

SEVERN, Vale of the. See England.

SEVERUS. See Roman Empire.

SEVIER, county of the United States in Tennessee, traversed by French Broad, and drained in part by Pigeon river; bounded SE. by Smoky mountain or North Carolina; SW. by Blount county of Tennessee, NW. by Knox, NE. by Jefferson, and E. by Cocke counties. Length 33, mean breadth 20, area 660 square miles. Surface hilly and might be designated mountainous. Chief town Sevierville. Central lat. 35° 50′ N.; long. W. from Washington City 6° 34′. Sevierville stands on Pigeon river twenty-five miles NE. by E. from Knoxville, N. lat. 31° 52′.

Darby.

SEVILLE, anciently Hispalis, a large city of Spain, in Andalusia. It is situated on a beautiful and extensive plain on the banks of the Gaudalquivir. The city is of a circular form, and is surrounded by an old and high wall, consisting of indurated cement, about five or six feet in circumference, flanked with 176 turrets, and entered by 12 gates. The interior of the city is chiefly built in the Moorish style, the streets being so narrow that a person extending his arms can touch the houses on either side. The streets are crooked and ill paved, though the houses are tolerably well built. Many of the houses have large courts with a fountain in the centre, and are surrounded with galleries, in which the families live in summer when they do not spread tents in the courts. The houses, though highly embellished in the interior, have a very mean aspect when seen from the streets.

Seville contains many fine public buildings, 30 churches, 84 convents, and 24 hospitals, besides the edifices for civil and commercial purposes. The cathedral is a magnificent pile of Gothic building, erected in 1401. Its tower, 250 feet high, is deemed the finest in Spain. It was built in 1568, and is of such easy ascent, and so wide, that two horsemen may ride up abreast. On the top of it is the Giralda, a brazen image, which, with its palm branch, weighs about 1½ tons, yet moves with the slightest change of wind. The cathedral is 420 feet long by 263 wide, and its height is 126 feet. It is lighted by 80 windows with painted glass, executed by Arnao of Flanders. It contained 82 altars. The treasures of this church were, before the revolution, of considerable value; but we fear that its fine pictures, its extensive library, and its decorations of gold, silver, and precious stones, have been plundered by its merciless invaders. The organ has 50 pipes more than the famous one at Haerlem, and it is filled with air by a man walking backwards and forwards on an inclined plane. When the different pair of bellows are thus filled they supply the full organ 15 minutes.

Many of the monasteries in Seville are distinguished for their architectural beauty: that which belongs to the Franciscans is on the most extensive scale; of its 15 cloisters many are spacious and elegant, with apartments for 200 monks. The convent of Buenavista, on the opposite side of the Guadalquivir, commands a view of the mountains of Benda 70 miles distant, and of the Sierra Morena equally remote. The hospital of La Sangre, intended for female patients, is much admired for its front, which has sculptured upon it three fine figures of Faith, Hope, and Charity. The wards are spacious, and the whole establishment is remarkable for its neatness.

The principal secular buildings are the Alcazar or royal palace, built by the Moors, the Lonja or Exchange, the Roman aqueduct, the Torre del Ore, and the Plaza de Toros. The Alcazar, erected by the Moors, and extended by several Christian princes, is a spacious building, having a mean external appearance. Its interior contains various courts, with galleries, fountains, and baths. The garden, decorated with fountains and evergreens, has its walks paved with marble, and is said to have undergone no change since the time of the Moors. A collection of Roman antiquities brought from the ancient town of Italica in the neighbourhood, occupies one of the saloons. The Lonja or Exchange, designated by Herera in 1568, is an edifice of the Tuscan order, finely situated in the centre of a square. It is a quadrangle of 200 feet, having round it a corridor or spacious gallery, decorated with Ionic, and supported with the same number of Doric columns. Though built for an exchange, it has been used as a repository of the old official correspondence with America, which contains collections of letters from Cortez, Pizarro, and other Spanish generals. The aqueduct, or Canos de Carmone, built in the time of the Romans, brings water to the city from a distance of *eight* miles, and has 410 arches. According to Mr. Swinburne, it is ugly and crooked, the arches are unequal, and the architecture neglected. The conduit is so leaky that a rivulet is formed by the waste water, and yet the supply is so copious as to afford water to several mills, and give almost every house in town the benefit of it. There is still preserved here a large house, the residence of a Moorish chief, in perfect preservation. The walls are adorned with a sort of network, and the workmanship on plaster is without a flaw, though above *five* centuries old.

The university of Seville was founded in 1502, and counted among its members the celebrated Arius Montanus. The discoveries and improvements of modern science have not yet enlightened this seat of learning. The number of under graduates is extended to about 200. There is an institution here called St. Elmo, founded by the son of Christopher Columbus, and appropriated to the education of young men for the sea. There is also here an academy for the arts of painting, sculpture, and architecture, and an œconomical society, both of which were founded by Count Campomanes. About 200 pupils attend the first of these institutions.

Seville was long celebrated for its silk manufactures, but they declined in the middle and end of the 17th century. The number of looms lately at work is about 2500, the silk being brought from Granada and Valencia. The other articles of manufacture are coarse woollen cloths, leather, tobacco and snuff. The snuff manufactory belongs to government, and occupies a large building 200 yards long by 185 broad. The interior consists of 28 courts, round which are disposed the various apartments. Horses and mules are employed to drive the mills, which amount to 100. There is also a cannon foundry here belonging to government.

After the discovery of America, the monopoly of its trade was conferred on Seville, but owing to the obstruction which vessels of burden experienced in the navigation of the Guadalquivir, this monopoly was transferred to Cadiz. Large vessels are stopped at Lucar, the very mouth of the river, and those drawing more than ten feet of water are obliged to load and unload eight miles below Seville. The principal exports are wool, goat and kid skins, oranges, liquorice, oil and silk. The liquorice exported is nearly 200 tons, and a considerable part of it is said to be purchased by the London porter brewers. The articles imported are English manufactures, Nuremberg wares, Bilboa iron, and articles of colonial produce from South America. The country round Seville is very fertile, but the climate is insalubrious, generating agues and malignant fevers. The scorching solano from the African deserts is beyond measure oppressive in summer.

Seville has well built suburbs, one of which called Triana, on the west side of the river, has a communication with the city by a bridge of boats. The handsome promenade called Alameda, has three walks planted with trees, and is ornamented with seats and fountains.

The population of the city is stated by Townsend at 80,268, by Laborde at 96,000, and by others at 100,000. West long. 5° 38′ 37″. North lat. 37° 24′ 26″. See Townsend's *Travels in Spain*, Laborde's *View of Spain*, Burgoanne's *Travels*, and Swinburne's *Travels*.

SEVRES, Department of the Two, a department in the north-west of France, embracing about a third of the old province of Poitou. It is bounded by the departments of the Meuse and Loire, on the north; by that of Charente and Lower Charente, on the south; by that of Vendèe, on the east; and by Vienne, on the west. Its superficial extent is 585,273 hectares, or about 2500 square miles. It is traversed from N. E. to S. W. by a chain of lofty wooded mountains. The south-west part of it is marshy; but the rest of the department has a very fertile soil, which produces wheat, barley, rye, oats, buck wheat, and maize. Tobacco is partially cultivated. Chesnuts abound in different places; almonds occur in warm aspects, and hops grow wild in the neighbourhood of Niort. The pasturage is good, and horses, cattle, and sheep are reared in considerable numbers. The department is watered by the two Sevres, the Dive, the Loire, the Thoue, and other smaller streams. Among the valuable minerals are iron, antimony, saltpetre, marble, &c. The manufactures consist of pottery, woollen, and cotton goods, leather, saltpetre, and paper. The principal towns are Niort the capital, with 16,000 inhabitants, Parthenay, with 3213, Thouars, with 2035, and Melle, with 1800.

Population in 1822	.	.	279,845
Ditto in 1827	.	.	288,240
Increase in five years	-	-	8,395

There are 490 inhabitants for every 100 hectares.

SEXTANT.

Sextant is the name given to a graduated instrument, the divided arch of which is, in place of being a whole arch, or a Quadrant, only a *sextans*, or sixth part of a circle.

Instruments, whose divided limb is a whole circle, have been already fully described in our article Circle; and those which are only the quarter of a circle, have been described under the article Quadrant. We shall therefore limit ourselves at present to an account of Hadley's sextant, and other analogous instruments which have been invented since the preceding articles have been published, together with a description of the various artificial horizons.

CHAP. I.

DESCRIPTION OF SEXTANTS.

The history of the sextant having been already detailed in our article on Navigation, we shall add nothing farther on this subject, but proceed to the description of Hadley's instrument.

Section I.—*Description and use of Hadley's Sextant.*

This valuable instrument is shown in Fig. 5 of Plate CCCCLXXXVII. The contrivance of it is founded on this obvious principle in Catoptrics: that if the rays of light diverging from, or converging to, any point, be reflected by a plane polished surface, they will, after the reflection, diverge from or converge to another point on the opposite side of that surface, at the same distance from it as the first; and that a line perpendicular to the surface passing through one of these points, will pass through both. Hence it follows, that if the rays of light emitted from any point of an object be successively reflected from two such polished surfaces, then a third plane, perpendicular to them both, passing through the emitting point, will also pass through each of its two successive images made by the reflections; and that these three points will be at equal distances from the common intersection of the three planes: and if two lines be drawn through that common intersection, one from the original point in the object, the other from that image of it which is made by the second reflection, they will comprehend an angle double that of the inclination of the two polished surfaces.

Let RFH and RGI, Plate CCCCLXXXVII. Fig. 3. represent the sections of the plane of the figure by the polished surfaces of the two specula BC and DE, erected perpendicularly thereon, meeting at R: which will be the point where their common sections, perpendicular likewise to the same plane, passes it; and HRI is the angle of their inclination. Let AF be a ray of light from any point of an object A falling on the point F of the first speculum BC, and thence reflected into the line FG, and at the point G of the second speculum DE, reflected again into the line GK, produce GF and KG backwards to M and N, the two successive representations of the point A; and draw RA, RM, and RN.

Since the point A is in the plane of the figure, the point M will be so also, by the known laws of Catoptrics. The line FM is equal to FA, and the angle MFA double the angle HFA, or MFH; consequently RM is equal to RA, and the angle MRA double the angle HRA, or MRH. In the same manner the point N is also in the plane of the figure, the line RN equal to RM, and the angle MRN double the angle MRI, or IRN; subtract the angle MRA from the angle MRN, and the angle ARN remains equal to double the difference of the angles MRI and MRH, or double the angle HRI, by which the surface of the speculum DE is reclined from that of BC; and the lines RA, RM, and RN are equal.

Corol. 1. The image N will continue in the same point, although the two specula be turned together circularly on the axis R, so long as the point A remains elevated on the surface of BC: provided they retain the same inclination.

Corol. 2. If the eye be placed at L, (the point where the line AF continued cuts the line GK;) the points A and N will appear to it at the angular distance ALN, which will be equal to ARN. For the angle ALN is the difference of the angles FGN and GFL; and FGN is double FGI, and GFL double GFR, and consequently their difference double FRG or HRI, therefore L is in the circumference of a circle passing through A, N, and R.

Corol. 3. If the distance AR be infinite, those points A and N will appear at the same angular distance, in whatever points of the figure the eye and specula are placed, provided the inclination of their surfaces remains unaltered, and their common section parallel to itself.

Corol. 4. All the parts of any object will appear to an eye viewing them by the two successive reflexions as before described, in the same situation as if they had been turned together circularly round the axis at R, (keeping their respective distances from one another, and from the axis,) with the direction HI, *i. e.* the same way the second speculum DE reclines from the first BC.

Corol. 5. If the specula be supposed to be at the centre of an infinite sphere, objects in the circumference of a great circle, to which their common section is perpendicular, will appear removed by the two reflexions, through an arch of that circle, equal to twice the inclination of the specula, as before said. But objects at a distance from that circle will appear removed through the similar arch of a parallel; therefore the change of their apparent place will be measured by an arch of a great circle, whose chord is to the chord of the arch equal to double the inclination of the specula, as the cosines of their respective distances from that circle are to the radius; and if these distances are very small, the difference between the apparent translation of any one of these objects, and the translation of those which are in the circumference of the great circle aforesaid, will be to an arch equal to the versed sine of the distance of this object from that circle, nearly as double the sine of the angle of inclination of the specula, is to the cosine of the same.

For let OBC, Fig. 4. in the annexed figure, represent an infinite sphere, at whose centre R are placed the two specula inclined to one another in any given angle, and let their common section coincide with the diameter ORC. Let BAN be the circumference of a great circle, to the plane of which the common section of the specula ORC is perpendicular, and BR its radius; let *b a n* be the circumference of a circle parallel to BAN, and at the distance from it B *b*; draw *b* D the sine, and *b r* the cosine of the arch B *b*; BD is the versed sine of the same.

Let A be a point of an object placed in the circumference of the great circle BAN, and N the point in which its image is formed by the two successive reflexions as before described; and let *a* be a point of another object placed any where in the circumference of the parallel *b a n*, and *n* its image; and let *a b n* be an arch of a great circle passing through the points *a* and *n*. The point *a* is at the same distance from the great circle BAN, as the point *b*, *i. e.* at the distance B *b*. Draw AR, AN, RN, *a r*, *a n*, *r n*, *a* R, and *n* R.

By the fourth corollary the figures ARN and *a r n* are similar, and consequently the line AN is to the line *a n* as AR or BR is to *a r* or *b r*, *i. e.* as the radius is to the cosine of the distance B *b*. But AN is the chord of the arch AHN of the great circle BAN, equal to the translation of the point A, or double the inclination of the specula, and *a n* is the chord of the arch *a h n* of a great circle measuring the angle *a* R *n*, by which the point *a* appears removed by the two reflexions, to an eye placed in the centre R. Therefore the translation, or apparent change of place, of the point *a* is measured by an arch of a great circle, whose chord is to the chord of the arch AHN, (equal to double the inclination of the specula,) as the cosine of its distance from the great circle BAN is to the radius.

From any point C of the circumference OBC draw the chords CN and C *m*, to the same side of the point C, and equal to the chords AN and *a n* respectively, draw the radius RM, and from R and *m* draw RQ and *m* P, both perpendicular to CM, and cutting it in Q and P. RQ is the cosine, and CM double the sine of half the angle MRG, or ARN, or of the angle of inclination of the specula. The little arch M *m* will represent the difference of the apparent translations of the objects in A and *a*; and if it be very small, may be looked on as a straight line, and the little mixed triangle M *m* P as a rectilinear one, which will be similar to RMQ, because RM is perpendicular to M *m* and RQ to CM, and the angles at Q and P right angles.

The line CP may be taken as equal to C *m* and MP as the difference of the lines CM and C *m*. Therefore the little arch M *m* is to the line MP nearly as RM to RQ; but CM (*i. e.* AN) was to C *m* (*i. e.* *a n*) as BR to *b r*, and the difference MP, of CM and C *m*, to the difference BD of BR and *b r*, as CM to BR. Therefore M *m*, the difference of the apparent translations, is to BD, the versed sine of the distance B *b*, or to an arch equal to it, in the compound ratio of RM the radius to RQ, the cosine of the angle of inclination of the specula, and CM double the sine of the same to BR the radius, *i. e.* as CM to RQ.

The observation may be corrected by one easy operation in trigonometry, as will appear from the first part of this corollary, viz. by taking the half of the angle observed and then finding another angle whose sine is to the sine of that half, as the cosine of the distance B *b* is to the radius: this angle doubled, will be the true distance of the object. But as this operation, though easy, will require the use of figures, the method of approximation is better, because by that, the observer retaining in his memory the proportion of the sines of a few particular arches to the radius, may easily estimate the correction without figures, when the angle is not great, and by a line of artificial numbers and sines, may always determine it with greater exactness than will ever be necessary.

When the angle observed is very near 180 degrees, the correction may be omitted; for then it will be easy to keep the plane of the instrument so near that of the before mentioned great circle, as not to want any, if the situation of that circle be known; if it be not, the observer, when he sees the two objects together, may turn the instrument on the axis of the telescope till he finds that position of it by which he obtains the least angle; and this (if the specula are set truly perpendicular to the plane of the instrument) will always happen when the objects appear to coincide in the line *g h*, as expressed in the figure.

The instrument consists of an octant ABC, Figure 5, having on its limb BC, an arch of 45 degrees, divided into 90 parts or half degrees, each of which answers to a whole degree in the observation. It has an index ML moveable round the centre to mark the divisions; and upon this, near the centre, is fixed a plane speculum EF perpendicular to the plane of the instrument, and making such an angle with a line drawn along the middle of the index, as will be most convenient for the particular uses the instrument is designed for; (for an instrument made according to Figure 5, the angle LFM may be of about 65 degrees.) IKGH is another smaller plane speculum, fixed on such part of the octant as will likewise be determined by its particular use, and having its surface in such direction, that when the index is brought to mark the beginning of the divisions (*i. e.* 0°) may be exactly parallel to that of the other; this speculum being turned towards the observer and the other from him. PR is a telescope, fixed on one side of the octant, having its axis parallel to that side, and passing near the middle of one of the edges IK or IH of the speculum IKGH; so that half its object glass may receive the rays reflected from that speculum, and the other half remain clear to receive them from a distant object. The two specula must also be disposed in such a manner that a ray of light coming from a point near the middle of the first speculum may fall on the middle of the second in an angle of 70 degrees or thereabouts, and be thence reflected into a line parallel to the axis of the telescope, and that a clear passage be left for the rays coming from the object to the speculum EF by the side HG. ST is a dark glass fixed in a frame, which turns on the pin V; by which means it may be placed before the speculum EF, when the light of one of the objects is too strong: of these there may be several. In the distinct base of the telescope represented by the circle *a b c d e f*, are placed three hairs, two of which, *a c* and *b d*, are at equal distances from and parallel to the line *g h*, which passes through the axis, and is parallel to the plane of the octant: the third *f c* is perpendicular to *g h* through the axis.

The instrument, as thus described, will serve to take any angle not greater than 90 degrees: but if it be designed for angles from 90 to 180 degrees, the polished surface of the speculum EF, Figure 5, must be turned towards the observer; the second IKGH must be brought forward to the position NO so as to receive on its middle the rays of light from the middle of the first, in an angle about 25 degrees, their surfaces being perpendicular to one another when the index is brought to the end of the divided arch next C; and this second must stand five or six inches wide of the first, that the head of the observer may not intercept the rays in their passage towards it, when the angle to be observed is near 180°. The smaller speculum is fixed perpendicularly on a round brass plate, toothed on the edge, and may be adjusted by an endless screw.

In order to make an observation, the axis of the telescope is to be directed towards one of the objects, the plane of the instrument passing as near as may be through the other, which must lie to that hand of the observer as the particular form of the instrument may require; viz. the same way that the speculum FF does from IKGH, if it be composed according to this figure and description. The general rule is, that when the index is brought to the beginning of the scale, (*i. e.* to 0° when the instrument is designed for angles under 90°, or to 90° when it is designed for angles from 90° to 180°); if then a line be imagined to be drawn on it, parallel to the axis of the telescope, or line of direction of the sight, so as to point towards the object seen directly; whichever way this line is carried by the motion of the index along the arch from 0° toward 90° in the first case, or from 90° towards 180° in the second, the same way the object seen by reflexion ought to lie from that which is seen directly. The observer's eye being applied to the telescope, so as to keep sight of the first object; the index must be moved backward and forward till the second object is likewise brought to appear through the telescope, about the same distance from the hair *c f* (Figure 6) as the first: if then the objects appear wide of one another, as at *i* and *k*, the instrument must be turned a little on the axis of the telescope, till they come even or very nearly so, and the index must be removed till they unite in one, or appear close to one another in a line parallel to *c f*, both of them being kept as near the line *g h* as they can. If the instrument be then turned a little on any axis perpendicular to its plane, the two images will move along a line parallel to *g h*, but keep the same position in respect of one another; so that in whatever part of that line they may be observed, the accuracy of the observation will be no otherwise affected than by the indistinctness of the objects. If the two objects be not in the plane of the instrument, but equally elevated on, or depressed below it, they will appear together at a distance from the line *g h*, when the index makes an angle something greater than their nearest distance in a great circle; and the error of the observation will increase nearly in proportion to the square of their distance from that line, but may be corrected by help of the fifth corollary. Suppose the hairs *a e* and *b d*, each at a distance from the line *g h*, equal to $\frac{100}{1146}$ of the focal length of the object-glass, so as to comprehend between them the image of an object whose breadth to the naked eye is a little more than 2°¼; and let the images of the objects appear united at either of those hairs; then as the cosine of half the degrees and minutes marked by the index is to the doubled sine of the same, so is one minute to the error which is always to be subtracted from the observation. Other hairs may also be placed in the area *a b c d e f*, parallel to *g h*, and at distances from it proportional to the square roots of the numbers 1, 2, 3, 4. &c. and then the errors to be subtracted from the same observation made at each of those hairs respectively will be in proportion to the numbers 1, 2, 3, 4, &c. This correction will always be exact enough if the observer takes care (especially when the angle comes near 180°) to keep the plane of the instrument from varying too much from the great circle passing through the objects. When the angle is very near 180° the correction may be omitted, for then it will be easy to keep the plane of the instrument so near that of the before mentioned great circle, as not to want any, if the situation of that circle be known; if it be not, the observer, when he sees the two objects together, may turn the instrument on the axis of the telescope till he finds that position of it by which he obtains the least angle; which (if the specula are set truly perpendicular to the plane of the instrument) will always happen where the objects appear to coincide in the line *g h*, as shown in Fig. 6.

Such is Mr. Hadley's own description of the original sea octant, as it was called, for measuring the distances of the sun and moon from any of the fixed stars, for which purpose he proposed that it should be placed upon a stand. He has described, however, a modification of it, by which it may be held in the hand without any other support, and in which the telescope is to magnify four or five times. The object of this was to measure the altitude of the sun, moon, and stars, from the visible horizon at sea. It differed from the foregoing instrument, chiefly in placing the specula and telescope with regard to the sector and tubes. In the new form the line drawn along the middle of the index falls on the anterior surface of the larger speculum at an angle of about 4 or 5 degrees. The axis of the telescope or the line of sight falls on the surface of the second speculum at an angle of about 70 or 71 degrees. It has also a third speculum, to be used when the angle is greater than 90 degrees, for observing the sun's altitude, by means of the opposite part of the horizon. On this the line of direction of the sight falls at an angle of about 32 or 33 degrees.

Various improvements on this admirable instrument have been made since the time of its invention. Grant, Ewing, Dollond, Magellan, Ramsden, Mayer, Borda, and some of our living artists, have also improved it. It has been modified in various ways; but whether it is in the form of a quadrant, a sextant, or a circle, the principle is always the same, viz. the reflexion of mirrors placed at different distances on the plane of the instrument. In our article CIRCLE, the reader will find the fullest details of all the most important improvements which the reflecting circle has undergone. Hadley's quadrant, as now fitted up, and the method of using it, is shown in Fig. 7, where FG is the divided limb, EH the moveable index, E the index-glass or mirror, D the horizon-glass, and *b* the sight or eye-hole, where the eye of the observer is applied. When a telescope is used, it is placed in the position *b*B. The horizon-glass consists of a transparent half, and a reflecting half, as described by Hadley. In taking the altitude of the sun, let BA be the visible horizon, and S the sun. The sun's rays SCE fall on the mirror at E, which is turned round, by moving the index EH till the ray ED, which it reflects, reaches the eye at B, after a second reflexion from the reflecting half of the horizon-glass D. The observer then keeps moving the index, till the lower or upper limb of the sun thus seen by reflexion is coincident with or touches the visible horizon. The vernier H on the index will thus point out the altitude of the limb of the sun observed.* If S is the moon, and A a fixed star, the limb of the moon is brought to touch the star in the same manner, and their distance is thus obtained. When it is required to measure an angle between 90 and 180 degrees, a second fixed speculum is placed at K, so as to be at right angles to the moveable one E in its remotest situation. It will then produce a deviation of two right angles in one of the objects. Thus if *s* is a star, and *a* another star nearly opposite to it, the ray *s* E will be reflected in the direction EK, and again in the direction K *e* to the eye at *e*, which carries it in the direction *e a*. This is called the back observation, which is of great use when coasting along shores which intercept the horizon of the sea, on the side in which the sun is; but the difficulties attending the rectification of the mirrors is so great that they are rarely used, and are even suppressed upon most sextants.†

When the sun is obscured, or when the light of one of the objects is stronger than that of the other, the light is reduced by coloured glasses placed between E and D, as shown at C in Fig. 14, or between E and K.

II. *Description of Professor Amici's Prismatic Sextant.*

This very ingenious instrument is represented in Plate CCCCLXXXVII, Figs. 8, 9, 10. In Fig. 8. ABC is a prism placed before the object glass E, so that its base AB is in a line with the axis of the telescope directed to the distant object Q. The parallel rays from the object falling upon the face BC, will be refracted towards the base BA, where they will be totally reflected, and will emerge from the face AC in lines parallel to their first direction. These rays falling upon the object glass E of a telescope, will form an image of the object Q, which will coincide with the direct image of the same object formed by the rays which pass below the prism. This coincidence will give the zero of the scale which measures the angular separation of these two images. If the prism is now turned round its edge A in the direction BCA, it will show new objects in succession coincident with the object Q, until the side AC shall be parallel to the object glass E. We shall now have the super-position of all those points that are 90° distant from the point Q, and therefore it is evident that we can thus measure all angular distances as far as 90° and a little more, as far indeed as 102° with common glass.

If we now place before the other half of the object glass a second prism equal to the first, but moveable in a contrary direction, the two images of Q will be both seen by reflexion; and by the continued movements of the two prisms we can carry the measure of an angle to the double of the greatest angle measured by one prism alone, that is to 204°, if the prism is of common glass.

From this theory of the new sextant, its construction and use will be readily understood. In the perspective drawing of it in Fig. 9, ABD is a sector, greater than a quadrant, of four inches radius. It is divided into 10', which by a vernier is subdivided into 10″. Round the centre C revolves the index CE, which carries the vernier at one end, and the isosceles rectangular prism F at the other, with its edge SC directed to the centre, and perpendicular to the plane of the limb. The other prism H, similar to the first, is fixed on the instrument, so that when the index marks *zero*, the larger faces of the two prisms are perfectly parallel, and nearly in contact. A telescope N on the arm IL is moved about the centre C, and on the plane of the sector. The divisions are read off by a microscope M. By this double motion of the telescope parallel to the limb, the object glass can receive a greater quantity of rays from one prism than from the other, so that we may by this means render the images of two objects equally luminous when they happen to be of different brightnesses. This effect is similar to what is obtained in Hadley's sextant by the elevation or depression of the telescope on the limb. If an equality of light is not thus obtained, we must apply to the object glass of the telescope the cover A', half of the aperture of which remains uncovered, while the other half is filled with a plain coloured glass. This glass being turned towards the prism which reflects the most luminous object, will enable us to obtain the necessary equalization of the light.

The error of collimation may be detected in this instrument in three different ways.

1. By the coincidence of the two images of the same object, the one direct and the other reflected. The sun's disk is the best object, but any terrestrial object will answer if more than 100 yards distant, for at this distance the parallax becomes visible.

2. By the coincidence of two images of the same object externally reflected from two small faces of the prism, for when the two isosceles and rectangular prisms having their greater sides parallel at zero, have their smaller sides parallel so as to give coincident images, we have an angle of 90°.

3. By measuring two angular distances of two objects diametrically opposite to each other. The excess or defect of the sum of these two angles upon 180°, will give half the angle to be added to or subtracted from the zero point given by the vernier, in order to have the true zero or the error of collimation.

If we compare this last verification with the first, and find a difference, it must arise from an error in the division of the limb.

If the telescope is inclined to the common section of the reflecting planes of the prisms, the fourth part of the trangle will have for its sine, the sine of the fourth part of the angle given by the instrument multiplied by the cosine of the inclination of the axis.

* See OPTICS.

† See an account of the Rev. Mr. Ward's Method for the Back Observation in the *Gentleman's Magazine*, vol. lxxiv. or in the *Naval Chronicle*, 1805, vol. xiv. p. 21.

Let SR, ST be the two reflecting planes, whose common section is SQ; let SV bisect the angle of the two planes, let AB be perpendicular SQ and AD = AB = 1. From D let fall DH perpendicular to BA, and from D and B the perpendiculars DE and BC upon SB, and draw EA, CA, and HF parallel CB. Now if BA is the axis of the telescope, the angle formed by two coincident objects by reflexion, is quadruple the angle CAB, or twice the motion of the index. But if the angle has the obliquity DA, the true angle is the quadruple of the angle DAF, although the index gives the same angle as it had marked before. To find the error then, it is sufficient to determine the value of the angle DAE by means of the known angles CAB and BAD. By this construction we have AH : HE = AB : BC, or since HF = DE cos DAH : sin. DAE = 1 : sin. CAB, we have sin. DAE = sin. CAB cos. DAH. From this formula it appears that the greatest error must take place when CAB is 45°. In this case, if the axis of the telescope is inclined 1°, the angle observed will be 179°, 57′, 56″, instead of 180°; but this error, produced by a defective position of the telescope, is reduced to nothing, if we make the observation in that part of the field of the telescope where the slightest contact of the objects takes place.

The advantages of this instrument may be thus enumerated.

1. While the greater number of the sextants now made measure only to 124°. Amici's sextant can measure 180°. The former will not take double meridian altitudes of the sun at Genoa from the 7th May till the 8th August, and under the equator they can never be used for this purpose, but the latter will take their altitudes under the tropics and even at the zenith.

2. The points *zero* and 90 degrees can be verified in Amici's sextant.

3. When an artificial horizon is used, the telescope always rests in a horizontal position, so that the observer may sit at his ease before it, whatever be the altitude of the star he is observing.

4. At sea we may take all the altitudes of two opposite horizons, both the anterior and the posterior, the mean of which will correct the inequalities of refraction.

5. In Hadley's mirrors fully one half of the light is lost by reflexion, whereas in the prisms very little light is lost.

6. The mirrors are subject to flaws and cracks, and sometimes to the loss of the quicksilver, whereas nothing can injure the prisms unless a force which breaks them to pieces.

7. Amici's sextant has no parallax for objects near the observer, owing to the great proximity of the prisms.

8. The greatest of all advantages is, that we can make the *back observation* with Amici's instrument without adding a third prism. See Baron Zach's *Correspondence Astronomique*, vol. vi. p. 554.

Chap. II.—on artificial horizons.

In observing the altitudes of celestial bodies, it is necessary to see the apparent horizon, but as this is always obscured in foggy weather, and sometimes even in clear weather cannot be seen from the interposition of the coast, or an island, it became of great consequence to be possessed of what is called an artificial horizon. These have been constructed of a great variety of forms, such as vessels filled with mercury, oil, or tar, pendulums, plumb lines, and levels; some of the most useful of these we shall proceed to describe.

Sect. I.—*On the Common Fluid Artificial Horizon.*

The common artificial horizon consists of a shallow vessel nearly filled with mercury, or with any viscid fluid, such as treacle, tar, oil, &c. Instead of using a fluid, Troughton makes them of black glass, as in Fig. 11. and levels them by means of the screws SSS, with a bubble laid upon the surface. Dollond constructs them as in Fig. 12. with a plate *m n* of clear glass, concave beneath, and filled with spirits *p* 9. so as to serve as a level. These two forms of the horizon are preferable in cases where the tremor disturbs the mercury or treacle. The method of using the artificial horizon is shown in Fig. 13. where KL is the horizon and *e f g* the sextant. The image of the sun reflected at *b* from the mercury or tar passes through the horizon glass *d* to the eye at M, and is made to coincide with the image of the sun reflected from the index glass *e*, and seen by the eye at M. The angle thus measured is RM *b*, which will be twice the angle S *b* K or RSL. In Fig. 7. with the real horizon the angle observed is 35°, but in Fig. 13, with the artificial horizon, the angle is 70°. The artificial horizon will answer only for objects at a very great distance, as there will be a parallax corresponding to its distance MO from the eye.

In windy weather it is necessary to protect the surface of the mercury or tar from being ruffled by means of a cover or roof, MNO, Fig. 14, consisting of two plates, MN, MO, of parallel glass inclined nearly at right angles. After one observation the roof should be reversed, and another observation made in order to correct any error arising from want of parallelism in the surface of the plates of glass.

Sect. II.—*Description of Serson's Nautical Top.*

Mr. Serson who was lost on board his majesty's ship Victory about the middle of the last century, observed that when a top was spun, its upper surface directed itself in the course of two minutes after it was set up in a true horizontal plane: that this plane was not at all disturbed by any inclination or motion of the box on which it was placed, and therefore that it might be of great advantage as an artificial horizon.* When it was spun in the open air it continued 35 minutes in motion, but when it revolved in vacuo its motion lasted *two hours and sixteen minutes*, preserving itself perfectly horizontal for three quarters of an hour.

Serson's top, which is represented in Fig. 15. consists of three parts, the top itself, CD revolving on the pivot *p* at the end of the vertical axis P *p*; the agate cup MN in which it revolves, and the apparatus AB by which it is put in motion. The top CD is a hollow cylinder about 2¼ inches in diameter, and 2 inches high, the upper surface is a speculum, and

* *Philosophical. Transactions*, 1750. Vol. xlvii. p. 352.

the lower edge has a small rim inside to make it heavier. The axis P p is square at top, and the pivot p a cone of about 60°, and made of very hard steel. The cup of agate is about an inch in radius. When it is in use the whole is placed in a mahogany box, and a cover of glass is put on to keep off the wind.

In order to put it in motion, the brass frame AB rests with steady pins upon the edge of the mahogany box, so that the spindle S s is immediately above P, the lower end s of the spindle is a hollow square, which receives the square end P of the axis. The spindle S s has always a tendency to rise up by the action of the spring L through which it passes, the four prongs of the spring resting on the top of the frame. A lever E is brought over the knob S, at the top of the spindle, and keeps the spindle down so as to bring its lower end upon P. A ribband HG passes through a hole in the lever G, shown separately; and the end G of the ribband being put into the hole K in the spindle S s, the ribband is coiled round the spindle. It is then pulled by the end H, so as to put the spindle and the top in rapid motion, and when G quits K it pulls back the lever GF, and consequently draws the lever E from the top S of the spindle, so as to permit the spindle to rise by the action of the spring L, and quit the axis P of the top, which it leaves in rapid rotation.

This top, as made by more than one of the best artists, was tried at sea above 60 years ago by some of the first naval officers, but the hopes of success which were entertained were disappointed.

Mr. Weir, many years afterwards, revived this subject, and his instrument, made by the order, and at the expense of the board of Longitude, was tried in a king's ship by himself and an astronomer appointed by the admiralty. It was found that when the ship had any motion, the top could not be depended on, to the amount of several degrees, although it performed on shore to a smaller number of minutes. Mr. Weir's machine required a man to keep it in motion while observations were made with it. The reflecting surface was fully 12 inches in diameter. The glass rested its weight on a blunt point supported from a chest below. The train of wheels that gave motion to the glass were connected to the latter by means of leather thongs; and the motion of the ship stretching one of the thongs, and relaxing the opposite one, drew the glass from its due position through the angle above mentioned.

About the beginning of 1818, Mr. Troughton began his experiments on the nautical top. His first efforts were very flattering; for by means of an easy adjustment, he brought the planes of reflexion and rotation parallel to each other, which it requires good workmanship to effect. The form which Mr. Troughton gave to the top was that of a hollow cylinder of brass, open at the bottom, and terminated above by a circle of dark glass. The inner diameter of the cylinder was $4\frac{1}{2}$ inches, the outer diameter $4\frac{6}{10}$ inches, its height $1\frac{1}{2}$ inch, and the diameter of the reflecting glass $4\frac{1}{2}$ inches. Mr. Troughton afterwards surrounded the cylinder with a solid brass ring, fastened to it by four projecting arms. The upper surface of the ring was on a level with the circle of black glass, which formed the surface of the top; and the inner curved surface of the ring was concentric with the outer curved surface of the top. In this form the top was sent out to the Arctic Regions with Captain Ross, but it did not give such satisfactory results as were expected. Mr. Troughton has since improved it, by giving it the form of an inverted frustum of a cone. The base or lower surface of the frustum is about 6 inches in diameter, the upper surface about 4 inches, and its height about $2\frac{1}{4}$ inches. The thickness of the metal which forms the cone is 1-8th of an inch. The reflecting plane which occupies the whole upper surface of the conical frustum, rests in a steel cup half an inch wide, and on a steel point which descends about half an inch below the upper surface of the frustum. The top is put in motion by an apparatus analogous to that used by Serson: but in place of a ribband, a series of wheels is used, the first and largest of which is put in motion by a winch or handle placed on its circumference. The velocity of the circumference of the base has been calculated at about 30 miles an hour.

Sect. III.—*Account of M. Ducom's Cylindrical Artificial Horizon.*

The instrument consists of two parts, one of which is a copper disk, six inches in diameter, with three feet. The second part is a cylindrical cover or drum, which performs the part of the glass roof in the common horizons for sheltering the fluid from the action of the wind. From the middle of the first part, or copper disk, there rises a hollow cylinder of white iron $4\frac{1}{2}$ inches high, and $2\frac{1}{2}$ inches in diameter. Upon this cylinder, which is open at top, there is placed a small round disk of white iron, (or of boxwood, where mercury is used,) which goes into the top of the cylinder, but is prevented from descending by a ledge on which it rests. This disk contains the mercury, wine, or prepared syrup, which is employed. These cylinders are adjusted in such a manner, that the surface of the fluid is exactly $2\frac{1}{2}$ inches above the first disk. On the copper disk are fixed two brackets, to which is fastened the cylindrical roof or drum. This drum, which is made of white iron, is six inches in diameter, and $2\frac{1}{2}$ wide, and is so placed that its centre is in the surface of the fluid in the round disk. In the middle of the width of the drum, there are two bands of white iron, perforated by two circular openings diametrically opposite to one another, and an inch in diameter, the one for letting in the incident rays, and the other for letting out the reflected ones. They have a circular motion by a rack and pinion on the surface of the drum, for the purpose of being adjusted to the height of the sun or the star.

When there is not much motion in the air, two small funnels, or truncated cones, are placed in the small tubes in the circular apertures, and these have the effect of protecting the fluid surface from every agitation. When the wind is considerable, the funnels are kept on, and a small glass with parallel faces is placed at the end, by which means the incident rays are admitted; but if the wind is very high, the funnels are taken off, and a piece of wire gauze is placed in the tube. This permits the external air to be in regular communication with the internal air, which is favourable to the accuracy of the observation.

Sect. IV.—*Description of the Level Sextant.*

Among the various contrivances for artificial horizons as applied to the sextant, one of the simplest is that shown in Fig. 16, which is a view of part of a sextant constructed by Mr. Troughton. A small level LL is fixed between the index glass E and the horizon glass D, and there is a hole in the side of the brass tube containing the level through which the bubble can be seen by the observer at E, by reflexion in the horizon glass, as shown in Fig. 17. where a line r is drawn across the glass where the contact is to be made, at the same time that the image of the bubble is to be bisected by the same line. This apparatus is said to have given the altitude within 5 minutes of the truth.

Sect. V.—*Description of Mr. M. Adam's Inverting Sextant Telescope, with Nautical Eye-Tube.*

" This telescope, represented by AB, Plate CCCCLXXXVII. Fig. 18, consists of three parts; viz. 1st, The eye-tube AE, to the lower side of which a spirit-level $k\,x$ is attached by the screws o, p, passing through the extremities C and D of the frame of the level tube; 2d, The object tube FB, which is attached to the sextant by the screw at y; and, 3d, The middle, or connecting tube EF, represented separately by GH, Fig. 19, of which the part EH enters the object tube, at F, and the part EG is screwed into the eye tube at E by means of the screw EK, and thus brings the small glass G into its proper place at b near the field of the telescope. The reduced diameter of the part GK permits the upper side $k\,l$ of the level tube to enter 1-8th of an inch within the lower side of the eye tube, and thus brings the bubble, seen directly through the eye glass at A, as near as possible to the field of the telescope. In the centre of the field two cross hairs of silk intersect each other at right angles, the one horizontal and the other vertical; and the point of their intersection is adjusted exactly into the line of vision through the telescope by means of the screw nails c, d, acting on the diaphragm, the edge of which, seen at e, is filed quite thin on the farther side, for the purpose of more easily admitting the direct light of a lamp through the aperture, $a\,b$, to illuminate the cross hairs at night. $h\,i$, $q\,r$, and $s\,t$, are rectangular apertures in the frame of the level tube, and $t\,v$ is a reflector placed below $s\,t$ to illuminate the spirits, and to show more distinctly the position of the bubble. The lines f and g are painted on the level tube at opposite extremities of the bubble, when it is in the middle; and, as the level is applied so that the line f is placed at the focal distance of the eye glass, the eye end of the bubble can be distinctly seen at f, and at 1-3d of an inch on either side of it. When, therefore, $k\,l$, the upper side of the level tube is adjusted parallel to AB, the line of vision through the telescope, if the eye end of the bubble be observed, and kept at f, the line of vision AB must then be truly horizontal, or parallel to the horizon. In order to take the altitudes at sea by a quadrant or sextant, furnished with this telescope and level, which may be made capable of distinguishing 10″, the observer should hold the sextant, as usual, in a vertical plane, passing through the celestial object whose altitude is required, the telescope being horizontal, and then bring the reflected image of the sun, moon or star, into the field by the motion of the index on the limb of the instrument, which, after some experience, he will generally be able to do upon the first or second trial. When the celestial object is thus brought into the field, and the near end of the bubble seen at f in the level tube, the observer should clamp the index on the limb, and, by means of the tangent screw, while the near end of the bubble is kept at f, bring the lower limb of the observed object to touch the horizontal hair passing through the centre of the field; the required altitude of the lower limb of that object, affected only by refraction, will then be found, as usual, on the limb of the sextant.

To enable the observer to keep the eye end of the bubble at f till the required contact is observed, a light mahogany rod, about $2\frac{1}{2}$ feet in length, attached to the sextant, and parallel to the telescope, is pressed against some fixed object on deck, which enables him gently to elevate or depress the telescope till the bubble is brought into the required position, and kept there as long as may be necessary. For this purpose, an iron staunchion, about six feet in length, should be made to screw, when required, into different parts of the deck near midship, with a sliding projection, about two or three inches in length, which may be fixed by a finger-screw at any required height, so as to afford a convenient prop, against which the sextant rod may be pressed by the observer when taking observations. To show the cross hairs, and the position of the bubble, when taking night observations, a small lamp, made for this purpose, is applied to the right side of the eye tube by means of a brass rod fixed to the lamp, which slides in a square socket, attached to the cylinder on the right of the holder of the telescope. The quantity of light thrown upon the bubble and cross hairs, is easily increased or diminished, by moving the lamp rod a little forward or backward in the socket. The same lamp, when detached, enables the observer to read off his observations.

The screw $o\,m$, acting through the near end C of the level frame, gives it its vertical adjustment; and the two screws at p, acting horizontally against each other through the farther end D, give it its lateral adjustment. The accuracy of the vertical adjustment may be examined by comparing meridian altitudes of a celestial object, taken by means of the level, with those taken at, or nearly at, the same time, by means of an artificial horizon. At sea, the accuracy of this adjustment may be examined by moving the index backwards off the limb, as many minutes as are equal to the dip of the horizon, and then observing whether the reflected horizon of the sea is brought up to the horizontal hair in the centre of the field, when the eye end of the bubble is at f in the level tube; if not, its distance $\pm$ from it is equal to the error of the vertical adjustment, which may either be corrected by the screw, or allowed for, like an index error of the sextant.

To examine the latter adjustment, screw the object tube FB firmly into the sextant holder of the telescope by means of the screw at y, or fix it steadily, by other means, in a horizontal position, which is easily determined by the vertical adjustment of the level. Move the united eye and middle tube a few degrees round in it to the right and left; and observe whether the bubble, formerly in the middle, now moves to either end of the level tube. If it does not, the lateral adjustment is already made. If it does, correct the observed motion by means of the adjusting screws at p. If this adjustment is not made, a slight deviation of the plane of the sextant from the vertical plane, which the observer cannot detect, when shut out from the horizon of the sea, may cause a considerable error in the observed altitude. To prevent this, let a plummet be suspended behind the plane of the sextant, which will readily detect any deviation of the instrument from the vertical plane.

If EH, the middle tube of the telescope, be moved forward or backward in the object tube FB, so as to place the object glass a little too near, or too far from the cross hairs in the centre of the field, the image of the observed object may thus be brought nearer to or farther from the eye than the intersection of these cross hairs, without causing any apparent indistinctness of the image. In this case, when the eye is slightly elevated or depressed, it will cause the contact of the image with the horizontal hair to appear either too close or too open, and may thereby cause an error of one or more minutes in the observation, according to the distance of the image on either side of the cross hairs.

To avoid this source of error, care must be taken to mark on the middle tube EH a line εζ, to which the middle tube should be moved, so that the image of a celestial object may be formed exactly at the cross hairs; for then, any elevation or depression of the eye will cause no sensible change of the apparent contact of the limb of the image with the horizontal hair. The proper distance of the object glass is a constant quantity for all celestial objects, but it varies with the distance of terrestrial objects. As considerable care and application are necessary, in order to acquire correctness and facility in the practice of this method of observation, it will be proper, when practicable, that the observer should accustom himself to take observations by this method on shore, before he proceeds to sea."

Sect. VI.—*Account of Dr. Brewster's Improvement upon the Nautical Eye Tube.*

In using the preceding very ingenious instrument, the eye sees, by direct vision, the contact of the sun with the horizontal wire, and by oblique vision the contact of the bubble with one or both of the marks on the level. This double and simultaneous observation is difficult to make; but independent of this difficulty, there is a property of vision, in virtue of which an object seen obliquely disappears, as if it had been completely annihilated.

On this and other grounds, says Dr. Brewster, Mr. Adam's eye tube has always appeared to me susceptible of improvement. The first idea of this kind which occurred to me is shown in Fig. 20, where the field of view, ABCD, is contracted, and consists of a perforation in the reflecting mirror. The parts are then adjusted, so that when the wire AB touches the sun, the bubble AMBN is concentric with the field of view ACBD. This approximation of the bubble to the observed limb of the sun is an obvious advantage; but as it is liable to the objection formerly stated against oblique vision, I thought of the method shown in Fig. 21. In this method I dispense entirely with a metallic reflector, and I form the image of the bubble by a plate of parallel glass PD, lying between the eye and the field CD, and inclined 45° to the axis of the tube. By this means the bubble EF may be brought in contact with the wire AB; and the parts are adjusted, so that the axis of the telescope is horizontal when the wire AB is in contact with the lower end of the bubble and the upper limb of the sun. The only objection to this construction is, that the glass plate PD reflects little light; but this may be completely remedied, by placing the darkening glass anterior to the field of view, or by throwing an additional light upon the bubble of the level.

For farther information on sextants and artificial horizons, see Hooke's reflecting quadrant, in his *Animadversions on Hevelius*, 4to, Lond. 1675; Newton's paper on a *Reflecting Instrument Like Hadley's*, *Phil. Trans.* 1742, p. 153; Hadley's Sextant, in *Phil. Trans.* 1731, p. 147, and 1732, p. 32; Ewing's *Improvement of Hadley's Quadrant*, *American Transactions*, vol. i. p. 126; Maskelyne on *Hadley's Quadrant* in *Phil. Trans.* 1772, p. 99; Magellan *Description des Octans et Sextans Anglais*, 4to; Atwood's *Theory of sextants* in *Phil. Trans.* 1781, p. 375; Ludlam on *Hadley's Quadrant*, 8vo; Ward *on Correcting the Sextant for the Back Observation*, *Phil. Trans.* 1733, vol. xxxviii. p. 167; Leigh in *Phil. Trans.* 1738, vol. xl. p. 417; Short *on Serson's Top*, *Phil. Trans.* 1751, p. 352; Little's *Artificial Horizon*, in *Irish Transactions*, vol. viii. p. 77; Gould's *Patent Artificial Horizon*, *Repertory of Arts*, ii. vol. i. p. 98; Mr. Adam's Sextant in *Edinburgh Journal of Science*, No. vii. p. 95; Dr. Brewster's *Improvement on it*, *Id.* No. xii. p. 250; Ducom's *Artificial Horizon*, *Id.* No. x. p. 341.

SHADOWS, Coloured. See Optics.

SHAFTESBURY, First and Third Earl of. See Cooper, Anthony Ashley.

SHAFTESBURY, or Shaston, a borough and market town of England, in the county of Dorset, is agreeably situated on a very high hill, which commands extensive views in Dorsetshire, Somersetshire, and Wiltshire. The principal streets are built on the roads from Wincanton, Warminster, Salisbury, Blandford, and Sherbourne, forming as it were a star. The houses are generally built of stone quarried on the neighbouring eminences; but they have a poor appearance, and the streets are narrow and irregular. The most important public buildings are four churches, St. Peter's, Holy Trinity, St. James', and St. Rumbold; St. Peter's, distinguished by the elegance of its proportions, as well as by its ornaments, is defaced by modern alterations. Part of the high embattled wall which enclosed the park and the abbey church still remains. The town-hall is a handsome building supported on five arches. There are also here three meeting-houses for Presbyterians, Methodists, and Quakers. The water which supplies the town is brought from the adjoining parish of Gillingham on horses' backs. They have therefore in several houses vast reservoirs for holding rain water. Lately, however, very good water has been obtained at the depth of 125 feet.

The charitable establishments here are a free-school, alms-houses for 16 women and 10 men, and other three of great antiquity converted into a poors' house.

The only manufacture in Shaftesbury is that of silk buttons, which gives employment to about 1200 persons.

The government of the town is vested in a corporation, composed of a mayor, recorder, 12 aldermen, a bailiff, and common councilmen. It sends to parliament two members, elected by about 300 voters paying scot and lot.

The eminence to the west of the town, called Castle Green, is supposed to have been the site of a castle. A small mount on the brow of this hill has been regarded as a Roman work. Many Roman coins have been found in the town. Population in 1821, 583 houses, 634 families, 388 in trade, and 2903 inhabitants.

SHAGREEN, or Chagreen, is the name of a kind of grained leather made in Astracan by the Tartars and Armenians, and much prized for forming covers for cases, books, &c. It is a close and solid substance, covered over with papillæ or little roundish grains. The following method of preparing it is a brief abstract of the method described by Professor Pallas.

The hinder back piece of the hides of horses and asses is cut off immediately above the tail, in the form of a crescent. The only part that is useful is about a Russian ell and a half across the loins, and a short ell along the back. The skins thus cut are soaked for several days in pure water till the hair drops off. They are then extended, and the hair and epidermis removed with a scraper. After a second soaking the flesh side is similarly scraped, and the whole cleaned till nothing but the pure fibrous tissue remains. The skins thus prepared are stretched in a wet state on wooden frames, with the flesh side downwards, and over the upper side are scattered the hard, black, and smooth seeds of the *chenopodium album*, or *goose foot*. A piece of felt is then spread over them, and the seeds are trodden into the leather. The frames are then placed against a wall with the seedy sides next it, and in this way they are perfectly dried. When the unpressed seeds are beaten off, the skin is full of indentations, which produce the grain of the shagreen.

The dried skins are next scraped with a piece of sharp iron bent like a hook, till all the inequalities are removed, and this process is repeated with a finer scraper till only faint impressions of the seeds remain.

In this condition the skin is put into water for 24 hours, and the effect of this is to swell the faint impressions of the seed, and raise it above the surface acted upon by the scrapers, a considerable part of which has been removed. The depressed parts which have lost none of their substance being thus elevated, constitute the grain of the shagreen.

The skins are now immersed several times in a strong warm ley, obtained by boiling a strong alkaline earth called *schora*. They are then piled upon one another while warm, and in some hours they swell and become soft. They are afterwards rendered exceedingly white and beautiful by 24 hours immersion in a strong pickle of salt.

The next step in the process is to give the skins their final colour. The following is the method for the most common colour, which is sea-green. Let the skins, when taken from the pickle, have their flesh or unprepared sides well washed with a saturated solution of sal ammoniac. A thick layer of copper filings is then strewed over them. Each skin being rolled up in a piece of felt, the rolls are all laid together in proper order, and pressed down for 24 hours by some heavy body. During the time the sal ammoniac has dissolved a sufficient quantity of the coppery particles sufficient to give the skin a sea-green colour.

In order to give the *blue* colour, two pounds of finely powdered indigo are dissolved in cold water. Five pounds of pounded alakar, or crude soda, is then dissolved in it, along with 2 lbs. of lime and 1 lb. of pure honey. The whole is put several days in the sun and often stirred. The skins to be dyed blue are to be moistened only in the strong ley of schora, and not in the salt brine. When moist they are filled up and sewed together at the edge, the flat side being innermost, and they are dipped thrice in the remains of an exhausted kettle of the same dye, the superfluous dye being each time squeezed out, and after this process they are dipped in the fresh dye prepared as above, which must not be squeezed out. The skins when dried and pared are finished.

In order to make *black* shagreen, the skins when moist from the pickles are thickly bestrewed with pulverized gall nuts, and then folded together and laid over each other for twenty-four hours. Each skin is next dipped several times in a new ley of the *schora*, after which they are again bestrewed with rounded gall nuts, and placed in heaps till the galls have thoroughly penetrated them. When freed from the dust of the galls by beating, they are rubbed over on the shagreen side with melted sheep's tallow, and exposed to the sun to imbibe the grease. When the superfluous particles have been scoured by a blunt wooden scraper, and the skins have lain some time, the shagreen is moistened on both sides with a solution of sulphate of tin, by which it receives a beautiful black.

In order to make *white* shagreen, the skins are first moistened on the shagreen side with a strong solution of alum, and then daubed over on both sides with a paste made of flour. The paste, when dried, is washed off with alum water, and the skin is then dried in the sun. When the skins have imbibed sheep's tallow, as described in the last paragraph, the superfluous fat is scraped off with a blunt wooden instrument, when the skins are wet with warm water.

This white shagreen is intended for receiving a dark red colour. In this case the skins must not be immersed in the solution of *schora*, but after being whitened they are washed in the pickle of common salt for 24 hours. About a pound of the best dried *tschagann*, *(saloia iricoides,)* is now boiled a full hour in about four common paillfulls of water, which thus acquires a greenish hue. The herb being taken out, half a pound of pounded cochineal is put into the kettle, and the liquor boiled a full hour with frequent stirring. About 15 or 20 drachms of orchil is added, and after a little more boiling the kettle is removed. The skins taken from the pickle are then placed over each other in troughs, and the dye liquor is poured over them four times, and rubbed into them with the hands. The liquor is expressed each time, after which they are dried, and are much more valuable than any of the other kinds of shagreen.

Shagreen has sometimes been made of the skins of fishes, such as the angel fish, the greater dog fish, and the sea calf.

The best shagreen is that which is brought from Constantinople, which is of a brownish colour; the white is not esteemed good. Shagreen is frequently counterfeited by Morocco, but the counterfeit is distinguished by its peeling off, which the other never does. See M. B. Valentini *Museum Museorum*, &c. p. 439. Ray's *Synopsis*, *Mem. Quadr.* p. 63. Willoughby's *Ichthyol.* and Pallas's *Travels*. See also our article Astracan.

SHAINT, or Holy Isles, three small islands of the Hebrides, or Western Islands of Scotland, are situated in the Channel between the islands of Lewis and Sky, in the parish of Lochs, and county of Inverness. One of them called *IlUan Mouir*, or St. Mary's Island, has a small chapel upon it, dedicated to the Virgin Mary, and exhibits traces of having been more populous than at present. These islands are remarkable for their sheep and pasturage. For the purpose of breeding the cattle one family resides in a wretched hut. The mineral Wavellite was first found in Scotland on this island.

SHAKSPEARE, William, the celebrated father of the English drama, was born at Stratford-upon-Avon, on the 23d April 1564. About ten weeks after his birth the plague broke out in the town, but fortunately did not reach the house where he lay. He was the son of John Shakspeare, a considerable dealer in wool, and whose family "were of good figure and fashion." His mother was the daughter and heir of Robert Arden* of Wellingcote. He appears to have been bred for some time at a free school, where he is said to have acquired what Latin he was master of. Being designed to follow his father's profession, he left school to assist him in his business.

About the eighteenth year of his age young Shakspeare married Ann Hathaway, a lady eight years older than himself, and daughter of a substantial yeoman residing at Shottory, a hamlet to Stratford. By her he had three daughters, Susannah, baptized May 26, 1583, and Judith and Hannah, twins, who were born on the 2d February, 1584-5.

About this time our Poet, according to Rowe, fell into bad company, and aided his associates in carrying deer from the park of Sir Thomas Lucy of Charlcote, near Stratford. A prosecution was on this account raised against him, and carried on with such severity that he was obliged to fly from home, to avoid arrest and imprisonment.† On this account he went to London, where he had a relative and kinsman, Thomas Green, a "celebrated comedian." Here he seems to have accepted of a subordinate office in the theatre, and it is said that he was first engaged while the play was acting to hold the horses of those who had rode to the theatre.

From this humble occupation Shakspeare soon rose to that of an actor, as appears from some old plays in which his name is printed among those of the other players. We are not informed, however, of the parts which he acted; but it is said that the part which he performed best was that of Hamlet's ghost, and that he also played the character of Adam in *As You Like it*. There is reason to believe that he performed the part of Old Knowell in Ben Johnson's *Every Man in his Humour*, and Malone has concluded that he commonly played the parts of old men. So late as 1603, his name appears among the players of Ben Johnson's tragedy of Sejanus.

It is a remarkable circumstance that neither the name of his first play, nor the date of its publication is positively known: and the greatest uncertainty exists relative to the chronological order in which the whole series were composed, acted, or published.

We are indebted to Malone for the first attempt to assign to them the dates of their composition; but as our learned countryman, the late Mr. George Chalmers, has controverted some of his positions, we shall give a table and the dates affixed to the different plays by both these authors.

	Malone.	Chalmers.
The ‡*Second* Part of Henry VI. was written in	1591	——
The *Third* part of Henry VI. - -	1591	1595
A Midsummer's Night's dream - -	1592	1599
Comedy of Errors - - -	1593	1591
Taming of the Shrew - - -	1594	1598
Love's Labour Lost - - -	1594	1592
The Two Gentlemen of Verona - -	1595	1595
Romeo and Juliet - - -	1595	1592
Hamlet - - - - -	1596	1597
King Lear - - - -	1596	1598
King Richard II. - - - -	1597	1596
King Richard III. - - -	1597	1595
First Part of Henry IV. - - -	1597	1596
Second Part of Henry IV. - -	1598	1597
Merchant of Venice - - -	1598	1597
Alls Well that Ends Well - -	1598	1599
King Henry V. - - - -	1599	1597
Much Ado about Nothing - -	1600	1599
As You Like it - - - -	1600	1599
Merry Wives of Windsor - -	1601	1596
King Henry VIII. - - - -	1601	1613
Troilus and Cresside - - -	1602	1600
Measure for Measure - - -	1603	1604
Winter's Tale - - - -	1604	1601
King Lear - - - - -	1605	1605
Cymbeline - - - -	1605	1606
Macbeth - - - - -	1606	1606
Julius Cæsar - - - -	1607	1607
Antony and Cleopatra - - -	1608	1608
Timon of Athens - - -	1609	1601
Coriolanus - - - - -	1610	1609

* According to John Aubrey, who was entered a student at Oxford in 1642, only 26 years after Shakspeare's death, and who says that he derived his information from some of his neighbours, "his father was a butcher, and when he was a boy he exercised his father's trade, but when he killed a calf he would do it in a high style, and make a speech."

† Shakspeare is said to have reflected upon Sir Thomas by writing a satirical ballad, which so exasperated the baronet, that he carried on the process against him with double eagerness, and forced him to quit Stratford. The first stanza of this ballad is said to have been preserved by tradition, and to have been as follows:

A Parliament Member—a Justice of Peace,
At home a poor Scarecrow—at London an asse.
If lowsie is Lucy as some folke miscall it,
Then Lucy is lowsie whatever befall it.
He thinks himself greate,
Yet an asse in his state,
We allow by his ears, but with asses to mate.
If Lucy is lowsie, as some folks will have it,
Sing lowsie Lucy whatever befall it.

‡ Malone is of opinion that the *First* Part of Henry VI. published in 1589, was not written by Shakspeare, though it might have been corrected by him.

Othello	1611	1614
The Tempest	1612	1613
Twelfth Night	1614	1613

Besides the preceding plays, *thirty-five* in number, Shakspeare wrote the following poetical pieces, which were published separately.

Venus and Adonis, printed in	1593
The Rape of Lucrece	1599
The Passionate Pilgrim	1599
A Lover's Complaint	without date
A Collection of Sonnets	1609

The first and second of these poems were dedicated, as the *first piece of my invention*, to Henry Wriothesley, Earl of Southampton, who, according to the statement of Sir William D'Avenant, presented Shakspeare with the sum of £1000 to make some purchases. Queen Elizabeth and King James I. seem also to have been well aware of the great talents of our dramatist. Queen Elizabeth frequently commanded his plays to be acted before her, and she was so much delighted with the character of Falstaff in the 1st and 2d parts of Henry IV. that she requested the poet to represent the fat Knight in love. In this way he was led to compose the *Merry Wives of Windsor*. King James likewise attended the performance of several of Shakspeare's plays, and, as Sir William D'Avenant informs us, Sheffield, Duke of Buckingham, wrote with his own hand *an amicable* letter to the poet.

At the commencement of the reign of this monarch, Shakspeare had become one of the principal managers of the playhouse, an office which he continued to fill for several years. As soon, however, as he had acquired a moderate fortune, he quitted the stage, and gave up all other employment, that he might spend the rest of his life in rural pursuits. He accordingly went to Stratford in 1612, where he had purchased a house called *New Place*, in which he spent the rest of his life as a private gentleman. The only event which disturbed the serenity of his latter days was the great fire at Stratford in 1614, which consumed the greater part of the town, and from which he had the good fortune to preserve his own residence.

In the beginning of the year 1616, Shakspeare seems to have anticipated his approaching dissolution. He then made his will,* and he died on the anniversary of his birthday, on the 23d April 1616. On the second day after his death he was intered among his ancestors on the north side of the chancel of Stratford church, where the monument erected to his memory still remains. It is partly of marble and partly of stone, and consists of a half length bust of the poet, with a cushion before him, placed under an ornamental canopy, between two columns of the Corinthian order, supporting an entablature on which is sculptured in bold relief the Shakspeare arms and crest. Beneath the bust are the following lines:—

Judicio Pylium, genio Socratem, arte Maronem,
Terra tegit, populus mœret, Olympus habet.

Stay passenger, why goest thov by so fast,
Read, if thou canst, whom enviovs death hath plast
Within this monvment, Shakspeare: with whome
Qvick natvre dide; whose name doth deck ys tombe
Far more than coste: sieh all yt he hath writt
Leaves living art, bvt page to serve his witt.
Obiit Anno Doi. 1616. *Ætatis* 53, *die* 23 *April.*

The following inscription, which tradition ascribes to Shakspeare himself, is on the flat stone which covers his grave:—

Good frend, for Jesus' sake forbeare,
To digg the dust encloased heare:
Blest be the man that spares these stones,
And curst be he that moves my bones

Malone is of opinon that this imprecation might

* In this will, which still exists in the prerogative court in London, and is dated March 25, 1616, Shakspeare made the following bequests:

To his daughter Judith he gave £150 of lawful money; £100 to be paid in discharge of her marriage portion, within one year after his decease, and the remaining fifty upon her giving up, in favour of her eldest sister, Susanna Hall, all her right in a copyhold tenement and appurtenances, parcel of the manor of Rowington. To the said Judith, he also bequeathed £150 more, if she or any of her issue, were living three years from the date of his will: but in the contrary event then he directed that £100 of the sum should be paid to his niece Elizabeth Hall, and the proceeds of the fifty to his sister, Joan, or Jane Hart, for life, with residue to her children. He further gave to the said Judith a broad silver gilt bowl.

To his sister Joan, besides the contingent bequest above mentioned, he gave twenty pounds, and all his wearing apparel; also the house in Stratford, in which she was to reside for her natural life, under the yearly rent of twelve pence. To her three sons, William Hart———Hart, and Michael Hart, he gave five pounds a-piece, to be paid one year after his decease. To his grand-daughter, Elizabeth Hall, he bequeathed all his plate, the silver bowl above excepted.

To the poor of Stratford he bequeathed ten pounds; to Mr Thomas Combe, his sword; to Thomas Russel five pounds; to Francis Collins, Esq. thirteen pounds, six shillings and eight pence; to Hamlet (Hamnet) Sadler, twenty-six shillings and eight pence, to buy a ring: and a like sum for the same purpose, to William Reynolds, gent., Anthony Nash, gent , John Hemynge, Richard Burbage, and Henry Cundell, his "fellows;" also twenty shillings in gold to his godson, William Walker.

To his daughter Susanna Hall, he bequeathed New-Place with its appurtenances; two messuages or tenements, with their appurtenances, situated in Henley-street; also all his barns, stables, orchards, gardens, lands, tenements, and hereditaments whatsoever, situate, lying, and being, or to be had, received, perceived, or taken within the towns, hamlets, villages, fields, and grounds of Stratford-upon-Avon, old Stratford, Bishopton, and Welcombe, or in any of them, in the said county of Warwick; also all that messuage or tenement, with the appartenance, wherein one John Robinson dwelleth, situated, lying, being in the Blackfriars, London, near the Wardrobe; and all my other lands, tenements, and hereditaments whatsoever: to have and to hold all and singular the said premises, with their appurtenances, unto the said Susanna Hall, for and during the term of her natural life; and after her decease, to the first son of her body lawfully issuing, and to the heirs-male of the body of the said first son, lawfally issuing: and for default of such issue, to the second son of her body lawfully issuing; and to the heir-male of the body of the said second son lawfully issuing; "and so forth, as to the third, fourth, fifth, sixth, and seventh sons of her body, and their heirs-male;" and for default of such issue, the said premises to be and remain to my said niece Hall, and the heirs-male of her body lawfully issuing; and for default of such issue, to my daughter Judith, and the heirs-male of her body lawfully issuing; and for default of such issue, to the right heirs of me the said William Shakspeare.

To the said Susanna Hall and her husband, whom he appointed executors of his will, under the direction of Francis Collins and Thomas Russel, Esqs he further bequeathed the whole of his "goods, chattles, leases, jewels, and household stuff whatsoever," after the payment of his debts, legacies, and funeral expenses, with the exception of his "second best bed with the furniture," which constituted the only bequest he made to his wife, and that by insertion after the will was written out.

have been suggested by the dread that his remains might some day or other "be added to the immense pile of human bones deposited in the charnel house at Stratford."

In the year 1740, a magnificent monument was erected at Westminster Abbey at the public expense, to the memory of Shakspeare. A very large sum for this purpose was obtained from the exhibition of the tragedy of Julius Cæsar at the Theatre-Royal, Drury Lane, on the 28th April 1738.

The first collection of the plays of Shakspeare was published in London in 1623, in folio, by Isaac Jaggard and Ed. Blount, under the title of "Mr. William Shakspeare's Comedies, Histories, and Tragedies." It was edited by John Hemynge and Henry Condell, and was dedicated to the Earl of Pembroke and the Earl of Montgomery. On the title page is an engraving of the poet by Martin Droeshout and on the opposite page are the following lines by Ben Jonson.

> This figure that thou here seest put,
> It was for gentle Shakspeare cut,
> Wherein the graver had a strife
> With nature to outdoo the life:
> O, could he but have drawn his wit
> As well in prose as he hath hit
> His face; the print would then surpasse
> All that was ever cut in brasse,
> But since he cannot, reader, looke
> Not on his picture, but his booke.

A second folio edition of Shakspeare was published in 1632, a third in 1664, and a fourth in 1685, and not many years ago, the first edition was reprinted in close imitation of the original, by Vernon and Hood, London.

In 1709 Nicolas Rowe published an edition in 7 vols. 8vo. to which was prefixed a biographical memoir of Shakspeare. Another edition, by the same editor, appeared in 1714 in 9 vols. 12mo.

In 1725 Pope published an edition in 6 vols. 4to. with critical and commendatory notes; and in 1725, the same editor published another edition in 10 vols. 12mo. with additional notes and corrections.

In 1733 Theobald brought out an elaborate edition in 7 vols. 8vo., and a second in 1740 in 8vo. with corrections and additions.

In 1744 Sir Thomas Hanmer published an edition in 6 vols. 4to.

In 1747 Warburton published his edition in 8 vols. 8vo.

In 1765 Dr. Johnson published an edition in 8 vols. 8vo. with an able preface on the character of Shakspeare's writings.

In 1766, Stevens published the *Old Plays* in 4 vols. 8vo.

In 1768, Mr. Capell published an edition in 10 vols. crown 8vo.

In 1771, Sir Thomas Hanmer published a second and improved edition in 6 vols. 4to.

In 1773 Jonhson and Purves published conjunctly an edition in 10 vols. 8vo. of which a second edition appeared in 1778, and a third in 1785, revised and corrected by Mr. Reed.

In 1786, Joseph Roan published the first volume of the Dramatic Works of Shakspeare, with notes. This work was completed in 6 vols. 8vo. in 1799.

In 1784, there was published by Stockdale an edition in 1 vol. royal 8vo. with a copious index of passages by the Rev. Mr. Ayscough.

In 1788, appeared Bell's edition in 20 vols. 12mo.

In 1770, Malone published his edition in 10 vols. crown 8vo.

In 1773, a fourth edition, revised and augmented, was published by Mr. Steevens in 15 vols. 8vo.

In 1803, there was published a fifth edition in 21 vols. 8vo. from the text, and with the notes of Johnson, Steevens, and Reed. Another edition of the work appeared in 1813.

In 1805, an edition was published in 10 vols. 8vo. with a prefatory essay by Alexander Chalmers, F. S. A. In this edition each play is illustrated with a print designed by Fuseli.

Besides these editions, a splendid one was published by Boydell in 9 vols. folio, embellished with 100 engravings, executed by the most eminent artists. A quarto edition of the work was also printed. An edition of Shakspeare, printed by Whittingham, has also been published in 1814, in 7 vols. 18mo. illustrated with 230 engravings on wood, with remarks on the life and writings of Shakspeare, by John Butters, F. S. A. It has been calculated that at least 100,000 copies of Shakspeare's works have been printed and sold.

The following excellent character of Shakspeare as a Dramatic Writer, has been drawn up by the able pen of Dr Johnson.

"Shakspeare is above all writers, at least above all modern writers, the poet of nature; the poet that holds up to his readers a faithful mirror of manners and of life. His characters are not modified by the customs of particular places, unpractised by the rest of the world; by the peculiar writers of studies or professions, which can operate but upon small numbers; or by the accidents of transient, factitious, or temporary opinions: they are the genuine progeny of common humanity, such as the world will always supply, and observation will always find. His persons act and speak by the influence of those general passions and principles by which all minds are agitated, and the whole system of life is continued in motion. In the writings of other poets a character is too often an individual; in those of Shakspeare it is commonly a species.

It is from this wide extension of design that so much instruction is derived. It is this which fills the plays of Shakspeare with practical axioms and domestic wisdom. It is said of Euripides, that every verse was a precept; and it may be said of Shakspeare, that from his works may be collected a system of civil and economical prudence. Yet his real power is not shown in the splendour of particular passages but by the progress of his fable, and the tenor of his dialogue; and he that tries to recommend him by select quotations, will succeed like the pedant in Hierocles, who, when he offered his house for sale, carried a brick in his pocket as a specimen.

Upon every other stage the universal agent is love, by whose power all good and evil is distributed, and every action quickened or retarded. But love is only one of many passions; and as it has no great influence upon the laws of life, it has little operations on the dramas of a poet who caught his ideas from the living world, and exhibited only what he saw before him. He knew that any other passion, as it was regular or exorbitant, was a cause of happiness or adversity.

Characters thus ample and general were not easily discriminated and preserved; yet perhaps no poet ever kept his personages more distinct from each other.

Other dramatists can only gain attention by hyperbolical or aggravated characters, by fabulous and unexampled excellence or depravity, as the writers of romances invigorated the reader by a giant and a dwarf; and he that should form his expectations of human affairs from the play or from the tale, would be equally deceived. Shakspeare has no heroes, his scenes are occupied only by men, who act and speak as the reader thinks that he should himself have spoken and acted on the same occasion: even where the agency is supernatural, the dialogue is level with life. Other writers disguise the most natural passions and most frequent incidents; so that he who contemplates them in the book will not know them in the world: Shakspeare approximates the remote, and familiarizes the wonderful. The event which he represents will not happen, but if it were possible, its effects would probably be such as he has assigned; and it may be said, that he has not only shown human nature as it acts in real exigence, but as it would be found in trials to which it cannot be exposed.

This, therefore, is the praise of Shakspeare, that his drama is the mirror of life; that he who has swayed his imagination in following the phantoms which other writers raise up before him, may here be cured of his delirious ecstacies by reading human sentiments in human language, by views from which a hermit may estimate the transactions of the world, and a confessor predict the progress of the passions."

Those who wish for farther information respecting the life and writings of Shakspeare, may consult, in addition to the works mentioned in the course of the preceding outline, the following:—*A Guide to Stratford-upon-Avon*, by R. B. Wheler, 1814, 12mo. *Critical, Historical, and Explanatory Notes on Shakspeare, with Emendations of the Text and Metre*, by Zachary Gray, L.L.D. 1755, 2 vols. 8vo. *Observations and Conjectures on some passages of Shakspeare*, by Thomas Tyrwhitt, Esq. 1764, 8vo. *An Essay on the Learning of Shakspeare*, by the Rev. Dr. Richard Farmer. Three editions of this work were published by the author himself, and it has been since frequently reprinted in different editions of Shakspeare. *An Essay on the Writings and Genius of Shakspeare, compared with the Greek and French Dramatic Poets, with some remarks on the Misrepresentations of M. de Voltaire*, by Mrs. Montague, 8vo. A sixth edition of the work appeared in 1810. *Essays on Shakspeare's Dramatic Character* by W. Richardson, M. D. 1812, 8vo. *Remarks, critical and illustrative, on the Text and Notes of the last edition of Shakspeare*, (1778), by Mr. Ritson, 1783, 8vo. *An Enquiry into the Authenticity of certain Miscellaneous Papers*, published Dec. 24, 1775, by Edmond Malone, Esq. 1796, 8vo. This volume gave rise to the two following works. *An Apology for the believers in the Shakspeare papers*, by George Chalmers, 1797, 8vo. *A Supplemental Apology for the believers, &c.* by the same Author, 1799, 8vo. *Illustrations of Shakspeare and of Ancient Manners*, by Francis Doucel, 1807, 2 vols. 8vo. and *Shaksperiana*, Lond. 1827.

SHAMMY, or Chamois, a soft and highly prized kind of leather, prepared from the skin of the Chamois, or *Antelope Rupicapra*, already fully described in our article Mazology.

An imitation of the shammy leather, by using sheep, goat, and kid skins, has been long successfully carried on about Orleans, Marseilles, and Thoulouse, and it there constitutes a particular profession under the name of *Chamoisure*. The following is the method employed :

Having washed and drained the skins, and strewed quick lime over the fleshy side, they are then folded in two lengthwise, the wool being outwards, and left to ferment 3 days, or 15 days, if they have been dried after flaying. When again washed out and drained, they are half dried, laid on a wooden horse, and the wool stripped off; they are then laid for 24 hours in a pit, in which the lime, from having been used before, had lost a great part of its strength. When taken out and allowed to drain 24 hours more, they are put into a pit with stronger lime, they are then taken out, drained, and put in again by turns, a process which is continued for six weeks in summer, or three months in winter, in order to dispose them to take oil. At the end of this period they are laid on the wooden horse, and are made softer by peeling off the surface of the skin on the wool side. Being now made into parcels, they are steeped a night in the river in summer, but longer in winter, and are then stretched six or seven above one another on the wooden horse, and the knife passed strongly over the flesh side, in order to remove any superfluous matter, and give smoothness to the skin. Then they are steeped, as before, in the river, and the same operation is repeated on the wool side; they are then thrown into a tub of water with bran in it, which is brewed among the skins till the greatest part stick to them, and then separated into distinct tubs till they swell and rise of themselves above the water. By this means the remains of the lime are cleared out: they are then wrung out, hung up to dry on ropes, and sent to the mill with the quantity of oil necessary to scour them: the best oil is that of stock fish. Here they are first thrown in bundles into the river for twelve hours, then laid in the mill trough, and fulled without oil till they be well softened; then oiled with the hand one by one, and thus formed into parcels each, which are milled and dried on cords a second time; then a third, and then oiled again and dried. This process is repeated as often as necessity requires; when done, if there be any moisture remaining, they are dried in a stove and made up into parcels wrapt up in wool: after some time they are opened to the air, but wrapped up again as before, till such time as the oil seems to have lost all its force, which it ordinarily does in 24 hours. The skins are then returned from the mill to the chamoiseer to be scoured; which is done by putting them in a lixivium of wood ashes, working and beating them in it with poles, and leaving them to steep till the ley has had its effect, then they are wrung out, steeped in another lixivium, wrung again: and this is repeated till all the grease and oil be expelled. When this is done, they are half dried and passed over a sharp edged iron instrument placed perpendicular in a block which opens, softens, and makes them delicate. Lastly they are thoroughly dried and passed over the same again;

which finishes the preparations, and leaves them in the form of shammy.

In the same manner kid and goat skins are shammoised, excepting that the hair is taken off without the use of any lime; and that when brought from the mill they undergo a particular preparation called *ramalling*, which is the most delicate and difficult of all. It consists in this that as soon as the skins are brought from the mill, they are steeped in a pit lixivium, taken out, stretched on a wooden leg, and the hair is scraped off with the knife. This makes them smooth and causes them in working to cast a kind of fine knap. The great difficulty of this process is to scrape the skin with sufficient evenness.

SHANNON, see IRELAND.

SHANSCRIT, or SANSCRIT LANGUAGE, see our article LANGUAGE.

SHAPINSHEY, see ORKNEY ISLANDS.

SHARK, see ICHTHYOLOGY.

SHARPE, James, Archbishop of St. Andrews, was born in 1618, and was descended from a respectable family in the county of Banff. Being intended for the church, he was educated at the university of Aberdeen. In 1638, when the solemn league and covenant was formed, he united with several of the learned men of the university in opposing it, and from the unpopularity which this cast upon him he retired to England.

The commencement of the civil wars induced him to return to his native county, where through the influence of Lord Oxenford and Lord Kelly, who was delighted with his conversation, he obtained a professorship in the university of St. Andrews. The Earl of Crawford soon afterwards gave him the church of Crail, where he performed the functions of the ministry in an exemplary manner.

Attached to the name of royalty, Mr. Sharpe had for some time maintained a correspondence with the king, and on the death of the pretender, he had frequent communication with General Monk. Previous to the restoration, the presbyterians sent Mr. Sharpe to London, in order to support their cause, and at the request of General Monk and the principal Scottish presbyterians, he was sent over to the king at Breda, in order to prevail upon him to establish presbyterianism in Scotland. Upon his return from this mission he declared to his constituents that "he had found the king very affectionate to Scotland, and resolved not to wrong the settled government of the church: but he apprehended they were mistaken who were about to establish the presbyterian government."

After the unconditional restoration of Charles, both he and his ministers resolved upon the re-establishment of prelacy, and Mr. Sharpe was prevailed upon to abandon the cause of his constituents, by the bribe of the Archbishoprick of St. Andrews.

Thus convicted of perfidy by his own acts, the name of the archbishop became odious throughout Scotland. Many of the wanton cruelties which were afterwards perpetrated, were ascribed to his influence; and it is at least certain, that after the battle of Pentland, when he had received an order from the king to stop the execution, he kept it in his possession for some time before he gave it to the criminal.

The object of such general detestation as the archbishop had now become was not likely to escape from popular vengeance. One Mitchell, a preacher, and an ardent zealot, resolved to assassinate him. He fired a pistol at him while sitting in his coach in Edinburgh, but the bishop of Orkney raising his hand at the instant interrupted the ball. The assassin walked leisurely home, and, throwing off his disguise, again mixed with the crowd.

Some years afterwards the archbishop observed a person looking at him with unusual sternness, and suspecting his design, ordered him into custody. Two loaded pistols were found upon him, and, upon examination, it proved to be Mitchell. A pardon was offered to him by the primate if he would confess his crime. Mitchell complied with the request, but heedless of his promise, the archbishop carried him before the council. A promise of pardon was again offered him by the council if he would discover his accomplices. This he also did, but it appeared that only one man, who had died since, was acquainted with his intentions.

The culprit was next brought before a court of justice and being commanded to make a third confession he declined. After suffering imprisonment for several years he was again tried, and convicted by his own confession. He urged in his defence the illegality of the evidence, and the promise of pardon which had been twice made to him: but the council having taken an oath that they had given no such promise Mitchell was condemned and executed.

This unprincipled transaction, which was carried through by the influence of the primate, was destined to meet with speedy punishment. In the year 1779, one Carmichael, a servant of the archbishop, having made himself odious to the presbyterians, nine men entered into a plan of waylaying him in Magus muir, about three miles from St. Andrews. While they were laying in ambush for the servant, the primate himself appeared with very few attendants. This was considered as a declaration of heaven in their favour, and calling out "The Lord has delivered him into our hands," they ran up to the carriage, and fired at him without effect. They then tore him from his carriage, and despatched him with their swords, regardless of the tears and supplications of his daughter by whom he was attended. Although this murder, for which no apology can be made, was entirely unpremeditated, yet the whole body of the presbyterians was accused of being parties to the crime, and several individuals who were entirely innocent, suffered death, as the perpetrators of the deed.

SHARP, Abraham, a celebrated English mathematician and astronomer, was born in 1651, at Little Norton, near Bradford. Having been apprenticed to a merchant in Manchester, he devoted all his leisure to mathematics, and acquired such a passion for them, that, with the consent of his master, he abandoned his profession, and went to Liverpool to pursue his mathematical studies.

Having heard of Sharp's mathematical acquirements, a London merchant, in whose house the celebrated astronomer Flamstead resided, engaged him to keep his books. In this situation our author acquired the friendship of Flamstead, through whose influence he obtained a lucrative situation in the dock-yard at Chatham. Mr. Sharp's talents, however, were of too high an order to be thrown away upon such an occupation, and Mr. Flamstead accordingly took him as his own assistant. Having a great mechanical genius, he was employed in the construction of the mural sextant, 6½ feet radius, which he finished in 1689, in the course of 14 months, to the entire satisfaction of Mr. Flamstead. See our article GRADUATION.

While in this situation Mr. Sharp assisted the astronomer royal in writing the celebrated catalogue of 3000 fixed stars; but owing to the fatigue of nightly observation, and to the weak state of his constitution, his health was greatly impaired, and he retired to his house at Norton.

When he had sufficiently recovered from his indisposition, he fitted up an observatory of his own, and furnished it with telescopes, the lenses of which he ground and adjusted with his own hand.

Our author likewise assisted Flamstead in computing most of the tables in the second volume of the *Historia Celestis*, and he executed fine drawings of the constellations which were sent to Amsterdam to be engraved, but though done by the hand of a master, the originals are said to have far exceeded them in minuteness and beauty.

In the year 1717, Mr. Sharp published a work entitled *Geometry Improved*, illustrated with a variety of copperplates, neatly engraved by his own hands. This work contained, 1. A large table of segments of circles, with the method of its construction and its uses in the solution of various different problems, and 2. A concise treatise of Polyedra or solid bodies of many bases.

Mr. Sharp was never married, he spent his life in a recluse manner, and exhibited many singularities which it would be out of place here to record. He died on the 18th of July 1742, in the 91st year of his age. See the *General Biography*, and Hutton's *Dictionary*, for farther information.

SHARPE, GRANVILLE, celebrated for his unwearied exertions in the great cause of the abolition of the slave trade, was born in 1734, and was the son of Mark Sharpe, Archdeacon of Northumberland, and the grandson of John Sharpe, archbishop of York. He was educated for the bar, but he did not follow the law as a profession. He was the author of some works of little importance. He died in July 1803, in the 79th year of his age. On the 6th July 1826 a bust of him by Chantry was placed in the Council Room at Guildhall, with the following inscription:—

GRANVILLE SHARPE,
to whom
England owes the glorious verdict of her
highest Court of Law,
that
the Slave who sets his foot on
British ground
becomes at that moment
FREE.

The details of his life will be found in the *Monthly* and *Gentleman's Magazine* the *Edinburgh Review*, vol. xii. Clarkson's *History of the Abolition of the Slave Trade*, and Rees' *Cyclopædia*, ART. SHARPE.

SHAT-el-ARAB, or CHAT-el-ARAB, Arabic name of the Euphrates and Tigris below their junction. As delineated in our modern maps, these two rivers form their main junction at N. lat. 31° nearly, and about long. 47° E. from London. In a country of moving sands and flat surface, and on which the efforts of human labour have been often exerted in the lapse of perhaps 40 centuries, great changes must have taken place. Pliny as quoted by Malte Brun, supposed the Euphrates to have once entered the Persian Gulf without receiving the Tigris and Ahwas. This opinion Niebuhr has revived, but the probability is that similar to the Mississippi and Red river in the United States, and the Ganges and Burrampooter in Asia, that the Euphrates and Tigris having one common recipient, always mingled their waters, though extensive revolutions may have taken place in partial channels. In their actual state, the Euphrates and Tigris unite as already stated. The union is made below Korna, where the stream turns to north-east a few miles, and receiving the Gyndes or Ahwas from the north, turns to SE., passes Bassorah, and after a course of about 100 miles falls by three principal and several smaller mouths into the Persian Gulf. The southern channel is the deepest, but shifting sands render the entrance of this great river dangerous. The tide ascends the Shat-el-Arab into the Euphrates and Tigris.

DARBY.

SHAW, GEORGE, an eminent British naturalist, was born at Bieston in Buckinghamshire, where his father was vicar, on the 16th December 1751. In 1765 he entered Magdalene Hall, Oxford, and in 1772 he took his degree of M. A. Although he was ordained deacon in 1774, and performed his duties regularly at two chapels, yet he quitted the clerical profession, and went to Edinburgh, where he studied medicine for three years. Upon his return to Oxford, he was appointed by Dr. Sibthorp, deputy botanical lecturer, and on the death of that gentleman he would have succeeded to the chair, had it not been a law that no person in holy orders could be elected. After taking his degree of bachelor and doctor of medicine, in 1787 he went to London to practise as a physician. On the establishment of the Linnean Society, he was made one of the vice-presidents, and he afterwards contributed various papers to its transactions.

In 1789, Dr. Shaw began the Naturalist's Miscellany, a monthly publication, which he continued to superintend till his death. In the same year he was elected a fellow of the Royal Society of London, and in 1791 he was appointed deputy-keeper of natural history in the British Museum.

Between the year 1792 and 1796, he published the different parts of a work, entitled *Musæi Leveriani Explicatio Anglica et Latina opera et studio Georgii Shaw, M. D. F. R. S. Adduntur figuræ eleganter sculptæ et colorotæ. Impensis Jacobi Parkinson.* He also published in "the Zoology of New Holland," and a work entitled "Cimelia Physica," "Descriptions of the Quadrupeds, Birds, &c." of which Miller had published the drawings in 60 large plates.

In the year 1800, Dr. Shaw began his principal work, entitled "General Zoology, or Natural History, with plates from the best authorities, and most select specimens." Of this work nine volumes were published in the author's lifetime, and the ninth was left ready for publication.

In 1807, Dr. Shaw published in two vols. 8vo. a course of Zoological Lectures which he had delivered in 1806 and 1807. Upon the death of Dr. Gray in 1807, he was promoted to the situation of keeper of natural history in the British Museum, an office which he filled till his death. When Dr. Hutton and Dr. Pearson projected, in 1809, an abridgment of the *Philosophical Transactions*, Dr. Shaw undertook the department of natural history. In the discharge of this duty he abridged 1500 distinct articles, in which he inserted the Linnean and specific names with occasional annotations and frequent references. This was the last separate work in which our author was engaged. An illness, which lasted but for a few days, carried him off on the 22d July 1813, in the 62d year of his age. See the *Gentleman's Magazine*, 1813, p. 290, and our article Mazology.

SHAWL GOAT, is the name given to the goat of Thibet, which is merely a variety of the common goat. Its wool, however, is celebrated for its excellent quality, being the material from which the fine Indian shawls are manufactured. As some attempts, though unsuccessful, have been made to introduce them in Scotland, our readers will naturally expect some information on the object.

The animal has a large head, long and slightly bent horns, which lie backwards, and a straight back, with delicate limbs. The coat consists of a thick external covering of long coarse hair, which conceals the fine wool, which is curled up close to the skin; the fleeces are shorn with a knife about the end of spring, they are then sorted according to the colour and quality. The long hairs are all picked by the hand from the wool; the wool is then washed in a warm and weak solution of pot ashes, and afterwards in water; it is then bleached on the grass, carded and prepared for spinning. The wool to be dyed receives its colour before carding: It is then dyed a second time before spinning, and once more when manufactured into the shawl. In Tartary it is spun by the hand with the distaff and spindle, and great care is taken not to spin the thread too hard, as the softness of the shawl depends upon this being properly done. A superfine shawl requires 5lbs. of wool, a shawl of the second quality requires 3 lbs., and one of inferior quality 2lbs.

An attempt was made some years ago to imitate the Indian shawls in this country. For this purpose some bales of shawl wool were imported, but the Norwich manufacturers could not spin it so as to produce a thread of equal fineness and quality with that from the merino lamb's wool, though the staple was at least five times as long. Mr. Main of Bow Lane, however, contrived machinery by which he produced threads superior even to those of Thibet manufacture.

The Duke of Athol made two attempts, one in 1815, and a second in 1816, to naturalize the shawl goat at Blair and Dunkeld in Scotland. Mr. Dunlop of Balnakeil in Sutherland, made another attempt in 1817. His flock was entirely black. It prospered for two years, and was purchased by some persons in France.

Mr. Macpherson Grant of Ballindalloch made another experiment in 1816, but the result of this does not seem to have been more favourable than those which have already been mentioned.

A more detailed account of these attempts will be found in a paper by Dr. Macculloch, in Brande's *Journal*, vol. ix. p. 330.

SHEEP, See Agriculture, Index, and our Article Mazology.

SHEERNESS, a sea-port and market town of England, on the Isle of Sheppey and county of Kent, is situated at the mouth of the River Medway.

In order to defend the entrance of this river, a fort was erected at Sheerness in the time of Charles II. In 1667 the works were greatly strengthened, but the Dutch having sent a fleet to the port in 1668, destroyed the fortifications, and having sailed up the Medway as high as Upnor Castle, did considerable damage to the shipping. This hostile enterprize induced the government to erect a regular fortress, and to mount it with a line of large and heavy cannon. Several smaller forts were built at the same time at different parts on the banks of the river, and since that time Sheerness has been progressively strengthened by new works, and now constitutes a regular garrison, commanded by a governor, lieutenant-governor, and fort-major. Adjacent to the fort is the king's yard or dock for repairing vessels, and for building frigates and smaller ships from 40 guns downwards. The chapel is a modern building erected by government for the use of the garrison, but all marriages and burials are performed at Minster.

A number of old line of battle ships have, for a considerable time, been stationed as breakwaters. They are inhabited by about 80 families, and present a very singular aspect to the stranger, from the chimnies being raised 38 feet of brick from the lower gun decks.

The chief supply of water having been brought in vessels from Chatham, the garrison and the inhabitants were often put to great inconvenience from the scarcity of that necessary article. It was resolved, therefore, by the Board of Ordnance in 1781, to sink a well within the fort. After digging to the depth of 328 feet, the auger with which they were boring dropped down, and the water rushed up with such velocity that the workmen could scarcely be drawn up in time to save them from being drowned. In six hours it rose 189 feet, and in a few days it rested within 8 feet of the top. The supply since that time has never failed. The water is of a pure and soft quality, and its temperature is somewhat higher than that of other wells. Population in 1821, 817, a decrease having taken place from the reduction in docking and ordnance establishment. See Hasted's *History of Kent*, the *Beauties of England and Wales*, vol. vii. and our article Kent.

SHEFFIELD, a large manufacturing town of England in Yorkshire, is situated on an eminence at the confluence of the Sheaff and Don, each of which is crossed by a stone bridge, that of the former consisting of one arch, and the other, called Lady bridge, with six arches. Sheffield extends about a mile in length from north to south, and nearly as much in breadth from east to west. It occupies principally an oblong hill, but it stretches over the adjoining valleys, and again ascends the hills at each end. In the old part of the town, the streets are narrow, but they are in general regular, running in a direct line, and containing many respectable, handsome, and uniformly built houses.

The principal public buildings are the town hall, the cutlers' hall, the general infirmary, the barracks, the assembly rooms and theatre, three churches and a chapel, and seven dissenting meeting-houses, besides a unitarian church, and one for methodists, one for quakers, and one for Roman catholics. The town hall is a handsome new edifice built of stone, and stands in Castle Street near the fish market place. The cutlers' hall, built in 1776, stands on the south side of St. Peter's church-yard. The general infirmary begun in 1793, is a splendid, large, and commodious building, built of fine white freestone. It stands about half a mile to the west of the town. It was finished in a few years from poors' funds derived from subscriptions and legacies. The situation is very healthy, and the establishment is in every respect on the very best footing. Near the banks of the Don, on the north east of the town, are the military barracks, which were built about the same time as the infirmary. The building forms a very handsome pile, with an esplanade in front. The assembly room and theatre are contained in an elegant building in Norfolk Street, on the south side of the town. They were first created in 1762, but they were taken down and rebuilt on a greater scale. The churches are St. Peter's, or Trinity church, St. Paul's, and St. James's, and the chapel of the Duke of Norfolk's hospital. St. Peter's, which is the parish church, stands near the centre of the town, and is a gothic building with a spire. The Shrewsbury chapel, containing a monument of the earl of Shrewsbury, is on the south side of the chancel. At the entrance to the same division of the church is interred William Walker of Darnel, who is said to have been the executioner of Charles I., but who is supposed by Mr. Hunter to have been the translator of the *Vindiciæ contra Tyrannos.* St. Paul's is a handsome Greek building, finished only in 1771, though begun in 1720. St. James's Church, built by subscription, was finished only about 1790. The chapel of the Duke of Norfolk's Hospital is very large, and of an octagonal form. It was opened in 1777. The hospital itself, which stands on the eastern side of the Sheaff, was founded in 1670, by Henry, Earl of Norwich, but was more amply endowed in 1770 by Edward Duke of Norfolk. It consists of two quadrangles, each containing eighteen dwellings for the accommodation of eighteen men, and as many women, each of whom receives five shillings a-week, with clothing and coals. There is also another hospital for poor cutlers, founded in 1703, by Mr. Thomas Hollis of London; a free grammar school, erected in 1649; a writing school for poor boys, and two charity schools, one for boys, and another for girls. There are likewise in Sheffield two schools, one on Bell's and the other on Lancaster's plan. In the first, 450 boys and 350 girls are taught, and in the second 700 boys, and 600 girls.

A large market-place, with convenient shambles, was completed in 1786. Among the new buildings in Sheffield, may be enumerated the works of the Sheffield Gas Light Company, erected in 1819, near Sheaff Bridge; and in the vicinity, the warehouse, basin, and wharf of the new canal from Tinsley, opened in 1819.

This town has been long celebrated for its manufactures, for carrying on which it is particularly adapted, both from its situation on a navigable river, and from the abundance of coal, iron-stone, and lead in its vicinity. The hardware manufactures of Sheffield constitute the great source of its wealth. They consist of cutlery, and plated goods, the former comprehending the trades of making edge tools, joiner's tools, files, fenders, anvils, knives and forks, penknives, pocketknives, razors, scissors, snuffers, saws, scythes, hay and straw knives, sickles, sheers, awl-blades, bellows, nails, hafts, inkstands, buttons, cases, combs, together with the refining of steel. Under the head of plated goods, are comprehended candlesticks, tea-urns, coffee pots, saucepans, tankards, cups, and various articles of table furniture. Lenses and optical instruments are also manufactured here; and there are in the town and its vicinity, extensive foundries for iron, brass, and white metal.

Since the year 1297, Sheffield seems to have been the staple for iron manufactures; but for several centuries its trade was very limited, and consisted chiefly of the manufacture of sheath knives, scissors, scythes, and sickles. Early in the sixteenth century, iron tobacco boxes, and Jews' harps were manufactured; and in 1625, the master manufacturers were incorporated by the title of "The Company of Cutlers of Hallamshire," which is the only corporate body in Sheffield. Previous to 1750, the manufactures had not extended beyond Great Britain; but in that year, Mr. Broadbent opened a direct trade with the continent, which was greatly facilitated by the opening of the river Don in 1751, and within three miles of the town. The silver plating of brass and copper articles was now begun by Mr. Bolsover; and in 1758, the silver plated manufacture was set on foot by Mr. Hancock, on the most extensive scale. The wealth and population of the town increased with great rapidity, and have advanced with progressive steps, till Sheffield obtained its present elevated condition among the trading manufacturing towns in Britain.

During the civil wars, Sheffield was defended by a castle; but upon its surrender to the parliamentary army, it was demolished.

The scenery in the neighbourhood of Sheffield is of a variegated and romantic character. The ruins of Sheffield manor-house, the ancient seat of the Earls of Shrewsbury, and the place of Cardinal Wolsey's residence, a short time before his death, is situated about $1\frac{1}{2}$ mile to the east of the town. Wharncliffe park, the seat of J. A. Stuart Wortley, now Lord Wharncliffe, stands on the Don, about six miles to the north-west of the town. It is remarkable for the elegance of the mansion house, and the beauty of its grounds. The view of Sheffield, from the height over which it is entered from Wakefield, is very fine. There are some alum mines in the neighbourhood, and in the vicinity of the town is a quarry which yields excellent grindstones for cutlery.

Population in	1801	31,314	Increase.
	1811	35,840	4526.
	1821	42,157	6317.

See Aitken's *Description of the Country round Manchester*, 1795, *and the Beauties of England and Wales*, vol. xvi.

SHELBY, county of the United States in Ohio, bounded N. by Allen, E. by Logan, S. by Miami, SW. by Darke, and N. W. by Mercer: it is about equal to a square of twenty miles, or comprises an area of 400 square miles. This county is watered by the sources of Great Miami River. Population, 1820, 2,106. Seat of justice Sydney. Central Lat. 40° 20′ N., Long. W. from Washington City 7° 12′.

SHELBY, county of the United States in Kentucky, bounded N. by Henry county, E. by Franklin, S. by Salt river or Nelson, SW. by Bullitt, and by Jefferson W. Length 26, mean width 20, and area 520 square miles. The surface of this county is broken, with a productive soil, drained by the extreme northern branches of Salt river. Seat of justice Shelbyville. The centre of the county is at N. Lat. 38° 12′, Long. W. from Washington City 8° 07′. Population, 1820, 21,047.

SHELBY, county of Tennessee, occupying the south-west angle of the state, having Hardeman county E. and Madison N, the Mississippi river W. and the state of Mississippi south. Length 34, width 30, and area 1,020 square miles. This large county is yet but thinly inhabited, having by the census of 1820, 354 inhabitants, or only one to near three square miles. The western border, along the left bank of the Mississippi river, is in part composed of flat overflowed, though very productive soil. That particular feature called Bluffs here reach the margin of the Mississippi, at the mouth of Wolf river, where formerly stood Fort Pickering, now the village of Memphis. These Bluffs have from the Mississippi the aspect of hills, but are, however, only the western termination of the general level of the interior country, and are really parts of an immense buttress, reaching from Baton Rouge to near the mouth of Ohio. Wolf and Loosahatchie rivers rise in Hardeman, enter and traverse Shelby county, and unite immediately above their common influx into the Mississippi at Memphis.

The 13th degree of Long. W. from Washington City, and N. Lat. 35° 10′, unite in the western part of this county. The climate is here considerably within the limit of cotton cultivation, which with Indian corn are the principal objects of farming. Seat of justice Raleigh.

SHELBY, county of the United States in Indiana, on the waters of the Blue river branch of White river, having Rush county E., Decatur SE., Bartholomew S., Johnson W., Marion NW., and Madison N. Length from north to south 24, breadth 18, and area, 432 square miles. Shelbyville, the seat of justice and principal post office, stands on Blue river, 25 miles SE. from Indianopolis, N. Lat. 39° 31′, and Long. W. from Washington City 8° 40′.

SHELBY, county of the United States in Alabama, having the Coosa river E., Bibb county S., Tuscaloosa SW., Jefferson NW., and St. Clair N. Length 40, breadth 36, and area 1440 square miles. Population, 1820, 2416. Chief village or seat of justice Shelbyville. Central Lat. 33° 17′ N., Long., Washington City, 9° 42′ W.

SHELBY, county of the United States in the central part of the state of Illinois, boundaries not known to the writer. By the post office Register, the seat of justice, Shelbyville, is 35 miles from Vandalia, the seat of government for the state.

SHENANDOAH, river of the United States in Virginia, rising at N. Lat. 37° 56′, in the extreme southern angle of Augusta county. The various sources, however, spread over, and drain the far greater part of Augusta and Rockingham counties. In the latter rises also a large though secondary branch, the North-Fork. Both streams issue separately from Rockingham, and flowing nearly parallel to each other, in a north-east direction, over Shenandoah county, the North Fork inflects to the east and joins the main stream near the south-east border of Frederick county. At their junction the Shenandoah has flown by comparative courses about 90, and the North Fork 60 miles. Now a fine mountain river, the Shenandoah, continues its direction to the north-east 40 miles, over Frederick and Jefferson counties, to its final influx into the Potomac, at Harper's Ferry, 39° 18′ N., having traversed 82′ of latitude. The level of Shenandoah and Potomac, at Harper's Ferry, is 182 feet above tide water in the latter: and comparing the sources of the former with those of James river, the elevation of their dividing ground must be at least 2,000 feet above the Atlantic tides: therefore, in a course of 82 minutes of latitude, the Shenandoah falls upwards of eighteen hundred feet.

This river and its branches flow from the fine valley between the Blue Ridge and Kittatinny mountain; the sources of the main stream in its entire course draining the north-west slopes of the former mountain. The Shenandoah valley in particular, comprises an area of very nearly 2500 square miles, and by the census of 1820, it then sustained a population of nearly 80,000 inhabitants, or 32 to the square; exceeding the general distributive population of Virginia 16 to 9. Occupying a part of the great limestone region stretching along the northwest base of the Blue Ridge, the Shenandoah valley is a grain and fruit producing country, and in a state of very rapid improvement. The climate it must be evident from its northern slope, is, in respect to temperature, inverse to the latitude. The sources in Augusta, elevated 1800 feet above the mouth, must influence the temperature equal to at least 4 degrees of latitude. Rising therefore from Harper's Ferry, though the advance is southward and length of the valley only 82 minutes of latitude, the seasons of spring, harvest, and autumn, and even winter, evince a change from a milder to a colder temperature, amounting to an equivalent to 2½ or 3 degrees of latitude.

SHENANDOAH, county of the United States in Virginia, and most correctly named, as it is in all its extent drained by the confluents and main stream of the river of the same name. This county stretches across the valley between the Blue Ridge and Kittatinny mountain, about 30 miles wide, with a length of 36 miles down the valley in a similar direction with the mountains and streams. Area 1080 square miles. The surface is generally mountainous or hilly, though considerable tracts of very productive soil skirt the streams. The population, in 1820, being 18,925, or nearly 19 to the square mile, evinces the existence of arable land of good quality. Central Lat. 38° 47′, Long. W. from Washington City, 1° 30′.

Darby.

SHELLS, See Conchology.

SHENSTONE, William, an English poet of some celebrity, and the eldest son of a country gentleman, who farmed his own estate, called the Leasowes, was born at Hales Owen in Shropshire, in November

1719. He received the first elements of instruction from the village "schoolmistress," whom he has made the subject of a poem under that title; and such was his ardour for reading when he was a child, that a new book was always brought to him by any member of the family that went to market. When that happened to be neglected, his mother was obliged to pacify him for the night, by wrapping up a piece of wood of the same form. At the grammar school of Hales Owen, he acquired the elements of a classical education; but he was afterwards placed under the charge of Mr. Crumpton at Solihues, who greatly improved his taste, and extended his classical acquirements. In 1732, he entered Pembroke College, Oxford, where his poetical genius first showed itself in some composition of considerable merit. With the view of taking a degree, he continued his name there for ten years; but having, in consequence of the death of his father in 1724, come into early possession of his estate, he did not professionally wear the civilian's gown which he had merely put on.

Content with his small patrimony, his talents were never called into vigorous action, and he was therefore led to devote himself to the enjoyment of domestic life, and to the pleasures of cultivating his mind, and of embellishing his grounds.

In 1737, he published anonymously a small volume of miscellaneous juvenile poems, but it did not excite much notice. His next work was the Judgment of Hercules, dedicated to Lord Lyttelton, which was published by Dodsley in 1740. This was followed, in 1742, by "The Schoolmistress," already alluded to, which is thought the best of all his productions.

From his friend, Mr. Graves of Mickleton, in Glocestershire, Shenstone is said to have derived his passion for rural embellishments, which he carried on without any regard to his pecuniary means. The Leasowes, which he thus extravagantly adorned, obtained great celebrity; and as it became a place of interest and public resort, he was involved in expenses, which held him under the constant pressure of poverty. His hospitality, or more properly speaking, his bounty, created wants which he could not supply; and tormented with the desire of doing more, and appearing better than he really could, he became the wretched tenant of the paradise which his own taste had created. The following account of Shenstone is from the pen of Gray,—"Poor man! he was always writing for money, for fame, and for other distinctions; and his whole philosophy consisted in living, against his will, in retirement, and in a place which his taste had adorned, but which he enjoyed only when people of note came to see and commend it. His anxiety of mind, which sprung out of his pecuniary necessities, seems to have thrown him into ill health; and though application was most properly made to Lord Bute to procure him a pension from the privy purse, yet, before this was granted, he was carried off by a putrid fever, in February 11, 1763, and was buried by the side of his brother in the church-yard of Hales Owen.

The "Works" of Shenstone "in Verse and Prose," were published in 1764, in 2 vols. 8vo., and a third volume, consisting of letters, appeared in 1769. Shenstone was a poet possessed of taste and a cultivated mind, but his works exhibit none of the *mens divina* which characterize the productions of true poetical genius. His prose writings contain acute remarks and just observations, and have the same general character as his poetical labours.

SHEPPEY, Isle of, an island of England in the county of Kent, is situated near the mouth of the Thames, and is separated from the mainland by a narrow arm of the sea, called the Swale, which bounds it on the south, and which is navigable for vessels of 200 tons burthen. It is about eleven miles long and eight broad. About one-fifth of the island only is arable, consisting chiefly of a deep stiff clay. The other four-fifths consists of marsh and pasture lands. The chief towns in the island are Sheerness and Queenborough, already described under these articles. See also Kent.

SHEPTON, Mallet, a market town of England in Somersetshire. It is situated about five miles east of Wells, in a low recluse valley, well watered by several branches of the river Brue. It contains above twenty streets and lanes, the most important of which are spacious and tolerably built, and meet in the form of a cross on the roads from Bristol and Bath to Ilchester, and from Frome to Wells. The smaller streets are narrow and dirty. The church, which stands on the east side of the market place, is a large and handsome edifice, in the pointed style of architecture, having a tower at the west end surmounted by a spire. The pulpit and font are each cut out of one solid stone, and seem to be of great antiquity from the rudeness of the workmanship. The monuments in the church are numerous but not remarkable. The market place contains a curious stone cross erected in 1500. It is composed of five arches, sustained by five-sided pillars, with a six-sided column in the centre. From the roof, which is perfectly flat, there arises a lofty pyramidal spire ornamented with Gothic arches, and terminating with an oblong entablature, containing a figure of our Saviour on the cross, &c. There are here also places of worship for the Methodists, Presbyterians, and Quakers. This place has been long celebrated for its manufacture of broad cloth and knit stockings, carried on both in the town and its vicinity. Nearly 200,000 yards of broad cloth were manufactured annually, and employed nearly 5000 hands. The county bridewell is within the town; and besides a well endowed free school, it has an alms-house for eight poor people. Population 5104. See the *Beauties of England and Wales.*

SHERARD, James. See Botany.

SHERARD, William. See Botany.

SHERBOURNE, a market town of England, in Dorsetshire, is agreeably situated, partly on the declivity of a hill, and partly on the fertile vale of Blackmore. The town is of a square form, the principal streets, which extend east and west, being crossed by smaller ones extending north and south. The church, which is the principal public building, is a large and magnificent one, built entirely of freestone, in the form of a cross. Though it displays various styles of architecture, yet the greater part of it is in the pointed style. The principal part of the building is nobly ornamented with tracery work, and the interior is light, spacious, and lofty. Within it are interred Ethelbald and Ethelbert, two of our Saxon kings. Among its numerous monuments, is one to a daughter of William Lord Digby, on which is inscribed the beautiful and well-known epitaph of Pope,

Go, fair example of untainted youth, &c.

The other public buildings are the market house, the free grammar school, a meeting house for dissenters, the work-house, and an alms-house. The two masters of the free school must be clergymen, and graduates of either university. The school occupies part of the site of the ancient abbey. There are also here two charity schools, three benefit societies, and a very peculiar association, called the *Green Girl's Society*, founded 1771 by Mr. Toogood. The members of this institution wear a green dress, and straw hats, and levy a small sum weekly, till they reach a certain age. At 18 they may leave the society; and those married before 25 receive L. 12 at their wedding. Those who continue unmarried till 25, receive the same sum.

Previous to the reformation, the woollen manufacture flourished here. A silk mill was established in 1740; and the silk manufactory, which is still carried on, occupies part of the buildings of the ancient monastery. The linen manufacture is likewise carried on here. Population of the town above 2000.

SHERIFF, See Law. See also our article Scotland.

SHETLAND.

This province is so little known, though, from causes which we shall explain, daily acquiring greater political importance, that we shall afford to the description of it a greater space than, under other circumstances, we are justified in doing. The account we now give is chiefly derived from Dr. Hibbert's volume on Shetland, to the examination of which country he devoted nearly two summers.

The cluster of islands and rocks which, under the name of Shetland, form the northern barrier of the British kingdom, are, with the exception of two of them only, contiguous to each other. If these be excluded from the number, the rest may perhaps be placed, (for we have no good charts of the country,) between 59° 48′ 30″, and 60° 52′ north latitude, and between 52′ and 1° 57′ of west longitude from London. The two remote islands are named Fair Isle and Foula. Fair-Isle is situated about twenty-four miles to the south of the mainland in Shetland, and Foula about twenty miles to the west.

The largest island of Shetland is named the Mainland, which stretches from north to south to the distance of sixty English miles, while its breadth from east to west varies from three to twenty-four. Yell is the next in extent, and afterwards Unst. Lesser islands are Fetlar, Whalsey, Mickle Roe, Foula, and Fair-Isle. But there are countless other islets, holms, and skerries, which it would be in vain to enumerate. Lerwick is the chief town, but the acknowledged seat of legislative authority is Scalloway.

The deficiency of good charts of Shetland is severely felt in the navigation of the northern seas. A want of light-houses was also long complained of, but this grievance has been in part remedied. On the southerly extremity of the Mainland, at Sunburgh head, a lighthouse has been recently erected, under the direction of Mr. Stevenson, civil engineer, whose projection of the Bell light-house is a monument of skill so honourable to the architecture of Scotland; and it is to be hoped that other beacons, equally required on the north and west of the coast, may render these islands no longer the terror of the northern mariner, who, fearing to be benighted near their destructive cliffs, chooses to brave the elements on the open sea, rather than make the still more perilous attempt to steer for the security which the numerous harbours of Shetland are well calculated to afford.

I. Natural phenomena and productions.

Geology and Mineralogy.—The geology and mineralogy of the Shetland islands have been very minutely detailed by Dr. Hibbert in his description of the country. The rocks are for the most part of the primary class. Granite, gneiss, and primary trap, are very abundant in the Mainland. Gneiss is a prevailing rock in Yell and Whalsey, it also occurs in Unst and other places. Mica slate and clay slate are in several places found. Primary limestone is met with in most of the islands. Serpentine rock and diallage rock prevail in Unst and Fetlar, and occur at Feideland and Hillswick. Quartz rock and primary sandstone are very abundant in the district of Walls in the Mainland, and in Foula. More rare rocks are talcose schist, and chlorite schist, which occur in the districts where serpentine prevails. The old red sandstone and secondary porphyry are the rocks of Papa Stour, and the west of Northmavine.

The highest hill in Shetland is Roeness hill, which attains an elevation of 1447 feet. The hill of Foula is next in height, being about 1300 feet.

In this singular group of islands, nature has assumed her wildest dress. We everywhere see barren and leafless mountains, rocks piled upon rocks, affording in their hollows deep lodgements for water: woodless tracts, the haunt of wild mountain sheep, the prospect being closed by the northern ocean, varied only by wild skerries. By the action of the sea upon the coast scenery is formed of the sublimest description. In the island of Papa Stour there are numerous romantic caverns produced from this cause. On the east of this island a high insulated rock is perforated through and through, and as we endeavour with a boat to trace through a frightful gloom its various sinuosities, a break of day light suddenly rushes through an irregular opening made from the summit of the crag, which serves to light up the entrance to a dark and vaulted den, through which the ripples of the swelling tide in their passage through it, are converted, by an echo, into low and distant murmurs. On the north-west of the island, Lyra Skerry, Fulgœ Skerry, and other insulated rocks and stacks, rise boldly out of the sea, richly clothed on their summits with stripes of green turf, but presenting perpendicular sides, and entrances into dark caverns that resemble the vaulted arches of some Gothic crypt. In Lyra Skerry, so named from the multitude of lyres or puffins by which it is frequented, there is a perforation throughout its whole breadth: yet so violent are the currents that force their way through it, that a passage is forbidden to the explorer, except when the ocean shows no sterner wrinkles than are to be found on the surface of some sheltered lake. On the west of Northmavine a large cavernous aperture, 90 feet wide, is the avenue to two immense perforations, named the Holes of Scraada, where, in one of them that runs 250 feet into the land, the sea flows to its utmost extremity. Each has an opening at a distance from the ocean, by which the light of the sun is partially admitted. Not far distant, Doreholm rises from the surface of the sea, hollowed out on the west by the incessant action of the waves into an immense arch 70 feet high. Again, at Burrafirth, in the island of Unst, a large cavern communicating with the water, exhibits a grand natural arch, which is the entrance to a passage that admits of the sailing of a boat to a distance of 300 feet. In the vicinity of Magnussetter Voe appears the small holm of Eagleshaw, where a perpendicular vein of greenstone, softer than the included mass of the same kind within which it is contained, has yielded to a progress of disintegration, so as to convey the idea of a deep rent, dividing the island into two unequal parts. Nearly the whole of the west coast of the island of Mickle Roe is shaped into deep winding caves, some of which are of singular beauty and grandeur. The isle of Eshaness or Northmavine, which is exposed to the uncontrolled fury of the western ocean, presents a scene of unequalled desolation. In stormy winters, huge blocks of stones are overturned, or are removed far from their native beds, and hurried up a slight acclivity to a distance almost incredible. In the winter of 1802, a mass, eight feet two inches by seven feet, and five feet one inch thick, was dislodged from its bed, and removed to a distance of from eighty to ninety feet. The bed from which a block had been carried away in the year 1818, was seventeen and a half feet by seven feet, and the depth two feet eight inches: the removed mass had been borne to a distance of thirty feet, when it was shivered into thirteen or more lesser fragments, some of which were carried still farther, from 30 to 120 feet. A block, nine feet two inches by six and a half feet, and four feet thick, was hurried up an acclivity to a distance of 150 feet. A mass of rock, the average dimensions of which may perhaps be rated at twelve or thirteen feet square, and four and a half or five feet in thickness, was first moved from its bed, about fifty years ago, to a distance of thirty feet, and has since been twice turned over. But the most sublime scene is where a mural pile of porphyry, escaping the process of disintegration that is devastating the coast, appears to have been left as a sort of rampart against the inroads of the ocean;—the Atlantic, when provoked by wintry gales, batters against it with all the force of real artillery, the waves having in their repeated assaults forced for themselves an entrance. This breach, named the Grind of the Navir, is widened every winter by the overwhelming surge, that finding a passage through it, separates large stones from its side, and forces them to a distance of no less than 180 feet. In two or three spots, the fragments which have been detached are accumulated in immense heaps like the produce of some quarry. In Lunna several large detached rocks, named the Stones of Stephouse, appear at some little distance from the sea: they are the *transported* or removed stones of geologists. The largest of them is about twenty-three feet in height, and ninety-six feet in circumference. Near Quendal bay, the phenomena of blowing sand are in a remarkable manner exhibited: here may be detected the ruins of scattered buildings which have long since yielded to the removal of the light sand that laid bare their foundations. In 1768 there were evident signs of a submarine volcanic eruption in the vicinity of Shetland, though of small extent. Vast quantities of shell fish of different kinds were thrown ashore along with conger eels and other kinds of fish; at the same time the water in the bays was so black and muddy for eight successive days, that when the fishermen were hawling haddock, or any small fish, they could not discern them until taken out of the water. It is highly unfortunate that no naturalist then existed in Shetland capable of instituting a scientific research into the circumstances connected with a phenomenon so novel to the British islands.

The minerals found in Shetland are various. At Sandlodge, copper mines were, in the year 1802, wrought by a party of Welsh miners; and in the course of two years, 470 tons of copper ore were exported to Swansea. It appears that brown hæmatite was a plentiful production of the vein, but copper pyrites constituted the object of search. Near Fitfiel Head, is a large vein of iron mica, about 12 feet broad, which traverses strata of clayslate; this has been described by Dr. Fleming, as well as a vein of copper which occurs in Fair Isle. A very thick bed of iron pyrites, nine yards broad, occurs at Garthness, which was empirically worked, at a great expense, in the hopes that it would ultimately change its character, and turn out a copper mine. In the year 1817, Dr. Hibbert discovered that the hills of Unst and Fetlar abounded with that valuable substance the chromate of iron, which is in great demand, for the purposes of dyeing, and for a pigment used in the arts; for this service rendered to the natural resources of the British islands, he received from the society of arts and commerce their gold medal. Another rare mineral which he discovered at the same time, was the hydrate of magnesia, occurring at Swinaness in Unst. Its mineralogical characters were described by Dr. Brewster. Actynolite, cyanite, amianthus, garnets, (in very fine crystals,) talc, &c. are plentifully found. The native oxide of chrome was first noticed by Dr. MacCulloch.

Seas.—The phenomena connected with the tides are well worthy attention. At Sumburgh-head, on the south of the mainland, there is what is named a *roust*, the term being of Scandinavian origin, said to signify a strong tumultuous torrent, occasioned by the meeting of rapid tides. This phenomenon may be considered in connection with the wave of tide, which is propagated from the great diurnal undulation of the Atlantic, and which, in the progress of completing its circuit round Britain, is described by naturalists, as passing to the west of Orkney, from thence to the north of the British isles, and then taking a southerly direction, so as to form a ridge that extends between Buchan and the Naze of Norway. The tides of Shetland are induced by lesser currents, generated during the progress of this wave along the westerly, northerly, and easterly parts of the country; and these set in nearly an hour sooner on the west than on the east coast of these islands. At the beginning of the flood, the tide in the roust is directed to the eastward, until it passes the promontory of Sumburgh; it then meets with a south tide, that has been flowing on the east side of the country, when a divergement takes place to the south-east, and lastly to the south. At high water, there is a short cessation of the tide, called the *still;* the ebb now begins, first setting north-west, and then north, until the commencement of the flood. In short, the various directions of tide, modified as they are by the number and form of the headlands of the coast, show that the currents are propagated at successive intervals of time; it is evident, therefore, that at the northerly and southerly extremities of the Shetland archipelago, they will be opposed to each other. Thus, a sloop has been five days becalmed between Fitfiel Head and Sumburgh, (two headlands in the southerly extremity of Shetland,) without being able to pass either point, one current carrying the vessel into the eastern, and the other into the western ocean; and although the vessel was often transported by the tide very near the shore, yet another tide always carried her off again. But although there is an opposition of currents, which extends from Sumburgh even to Fair Isle, the proper roust is that part of the stream which lies at a small distance from the promontory, the force of which is increased by its proximity to the coast, and by the shallowness of the water. Here there is always a heavy sea; but in a storm, the waves rise mountains high.—A second spot where a roust occurs, is at Scaw, the northerly extremity of Scotland.—A third is in the tumultuous channel of Blomel Sound, which separates the west of Unst from Yell. As this channel communicates with both the eastern and western seas of Shetland, tides propagated during the circuit of the great wave, at successive intervals of time, will here be naturally opposed to each other. Sir Robert Sibbald has long since remarked, that the tide in Uyea Sound, on the east of Unst, flows an hour later than that of Blomel Sound on the west, though only two miles distant; and Mr. Gifford has also stated, that when the great current in the middle of the Sound sets north, there is an eddy, deriving its course from opposite shores, that sets as fast south, and so shifts about as the great current alters.

Again, with regard to the great wave of tide itself, it is a curious circumstance, that while specimens of pumice, thrown on the shores of Shetland, indicate directions of current from Iceland, the West Indian products, known by the name of molucca beans, which float to the coast, should give tokens of extensive and opposite currents, branching from the gulf streams that are directed from the south-west. Three descriptions of the seeds that are cast on the shores of Shetland have been enumerated by Mr. Patrick Neill; the first of them belongs to the *Mimosa scandens* of Linnæus, the second to the *Dolichos urens*, and the third to the *Guilandina Bonduc*.

Other marine phenomena worthy notice, are those which are connected with the occurrence of innumerable low rocks that lie a little below the surface of the water. Inequalities of this kind, named in Shetland *Baas*, and in Feroe *Boffves*, which interrupt the currents of tide, and raise immense high waves that break, may be found at various depths, some of them having upon them as much as twenty fathoms of water. When the sea is disturbed, the breaking is repeated a few times, not exceeding seven, and before it recommences, a long interval of stillness succeeds. It is a popular opinion, that the breaking of a Baa may be induced by hot weather;—that when it takes place in calm weather, an approaching storm is indicated, and that though a Baa appear perfectly still, if a boat approach or go over the place, where it lies, a breaking, often fatal to the crew, immediately ensues. DEBES, in his history of Feroe, notices the latter circumstance, and with much ingenuity supposes, that a magnetic sympathy possessed by the hidden rock, attracts the iron of the boat, which the shallow water, in its magnetic antipathy, "not being able to endure, riseth itself." The Shetlanders, whose imaginations have conceived of strange wonders in the seas, entertain similar notions of the existence of submarine magnetic rocks.

Meteorology, &c.—We are not aware that the mean temperature of Shetland has ever yet been determined. The climate is very variable. In summer the days are of such a great length, that the morning and the evening, to use the words of a poet, "seem to melt into each other." It has been remarked by the late Mr. Mouat of Gardie, that in winter, the sun is five hours and twenty-five minutes above the horizon, but owing to refraction, the daylight is, in clear weather, prolonged to about seven hours and a half. But the most decided indication of winter is the brilliancy with which the evening is lighted up by the aurora borealis, streamers of a reddish-yellow colour darting over the heavens with a tremulous and curved motion. Whether these meteors are *heard* as well as seen, is a question still *sub judice*. There is not an inhabitant of Shetland that does not confess to the evidence of sound. Mr. Dalton of Manchester, from his experiments on the great height of the aurora borealis, as it was noticed some years ago in the north of England, maintains the negative, and that there must be some fallacy in the popular notion.

Botany.—Shetland, according to Mr. Neill, cannot boast any very remarkable plants. Nor are there any groves; the wild and remarkable scenery that this country exhibits being formed from mere rocks and water. Native willows are dwarfs; they appear only a few inches high; when they attain a greater height, it is owing to some particular shelter that they have accidentally acquired. Still, it is evident that larger trees once flourished. On the low land near Girth's voe in Delting, the encroachment of the sea, long since exposed the remains of a very ancient forest, consisting of hazle and several larger aquatic plants, the stocks of which were from half an inch to eight inches in diameter, that struck their roots into a bed of gravel, while above them was an accumulation of peat-moss about ten feet in thickness. It is also proved in digging for peat, that certain kinds of small trees, such as hazles, willows or birch, once braved with success the cutting blasts of Shetland. The causes that have led to the disappearance of these trees, is involved in mystery; it may be in part referred to the cattle that roam abroad. In the gardens of Busta and Scalloway, several trees, such as mountain ashes, planes, and elders, thrive, owing to the protection which they receive from a high wall; but no sooner do they get above it, than they are stunted. What the result could be if trees, instead of being brought from Scotland, were derived from the colder regions of Norway, no experiment has yet determined. In the parish of Delting some few small mountain ashes, (supposed to be native ones) may be found in sites where they are well sheltered and secure from the attacks of cattle.

Zoology.—The Zoology of Shetland has hitherto met with far less examination than it deserves. The shelty, the diminutive horned cattle, and the small hogs, will be noticed in our description of the agriculture of Shetland. The shores of Shetland afford numerous coverts for sea-otters, whose food, which they collect from the sea, principally consists of the conger eel. Their skins were once in great requisition as an article of commerce by the Hamburghers. The Phoca Barbata, about seven or eight feet in length, is a frequent visitant. The lesser seals are exceedingly abundant, covering in droves the ledges of the rock. The seas again abound with the mightier inhabitants of the deep. The finner is not unfrequently seen, though this may consist either of the *Balænoptera* Gibbar, the *Jubartes* or *Rorqual* of La Cepede. One of the latter kind was killed a few years ago in Unst. The *Delphinus Orca* or *Chaffer*, anciently the dread of the boatmen, the *Squalus Maximus*, the *Delphinus Deductor* or *Ca'ing* whale, with huge porpoises, add to the formidable list. The large lake of Strom, that has no communication with the sea but by an inlet, a very few feet in breadth, and which abounds with marine animals, is rendered interesting by the researches of Dr. MacCulloch, who has thereby strengthened his notion, that cod and other fish may be habituated to an element of fresh water.

The ornithology of Shetland is highly interesting. The eagle, the bonxie, or scua gull, and the *strix bubo* are among the larger of the feathered natives. The low lands, remote from the sea, are frequented by parasitic gulls that build among the heather, while the surface of the hills swarms with plovers, royston crows, sea pies or curlieus. The skerries and rocks that rise but a small height above the water, are the resort of the tern or the *Sterna hirundo*, named by the Shetlanders the tirrock. The taller cliffs, as of Eshaness, Fair-Isle, Papa Stour or Foula, abound with other kinds, as gulls, scarfs, the tomnorry, the kittywake, maws, lyres, sea parrots or guillemots. Fair-Isle was in the beginning of last century noted for hawks, affirmed to be the best in Britain. Mr. Lawrence Edmonstone has written some interesting papers on the ornithology of Shetland.

Animals of the crustaceous, shelly, and coralline species have hitherto met in Shetland with little examination, except from Dr. Fleming, who, during the time he held a living in Bressay, enriched the Zoology of Britain with several new acquisitions.

II. History and antiquities of Shetland.

Civil History and Antiquities.—The history of Shetland is much involved in that of Orkney. Near the close of the first century, when Agricola sailed round Britain, Orkney was inhabited by a people, of whose race, whether Celtic or Gothic, not the least light is to be elicited from the pages of history. Agricola saw Shetland from the shores of Orkney, and gave it the name of *Thule*, (*Dispecta est et Thule*,) an appellation that was applied to other northern countries, of which the Romans had little information. Orkney and Shetland were next the lurking places of Saxon rovers, who were routed in the year 368 by Theodosius. That the Romans actually visited the coasts of Shetland, is highly probable, from the coins of this people which have been discovered. These are of Galba, Vespasian, Trajan, and Ælius Cæsar. The remains of a very small Roman camp are to be detected in the island of Fetlar.

The Northmen, whose piracies were for several centuries formidable to Europe, were the next people who succeeded to the possession of Shetland; its numerous bays or *voes* affording secret refuge for their vessels. Indeed from this latter circumstance, they acquired the name of Vikingr, (*i. e.* bay-kings.) From this place, as well as Orkney and the north and west of Scotland, the Northmen made descents upon the rich coasts of Europe, and devastated them with fire and sword. By these pirates, Shetland was said to have been first named. "Hialtlandia vel Hiatlandia," says Torfæus, "prisco sermone semper usurpatur an a capulo gladiorum, qui *hiallt* appellatur, denominata sit incolæ viderint." Hence arose *Yealtaland*, the name that the natives gave to their country a century ago or more. Another name was Hetland, signifying the *high* or *lofty* land. Norwegian writers say that Shetland is a corruption of this word.

The remains of the forts which the Vikingr erected in Shetland are very numerous, and form some of the most remarkable remains of antiquity to be found in Europe. The burgh of Mousa, situated in the island of that name, has been described by Dr. Hibbert. "The burgh of Mousa occupies a circular site of ground, somewhat more than fifty feet in diameter, being constructed of middle-sized schistose stones of a tolerable uniform magnitude, well laid together, without the intervention of any cement. This very simple round edifice attains the elevation of forty-two feet; it swells out, or bulges from its foundation, draws smaller as it approaches the top, when it is again cast out from its lesser diameter; which singularity of construction is intended to obviate the possibility of scaling the walls. The door that leads to the open area contained within the structure, is a small narrow passage, so low that an entrance is only to be accomplished by crawling upon the hands and knees; and in creeping through it, the wall appears to be of the great thickness of fifteen feet, naturally leading to the presumption of a vacuity within. The open circular area included within this mural shell, has a diameter of about twenty-one feet. On that part of the wall within the court, which is nearly opposite to the entrance, the attention is excited by a number of small apertures resembling the holes of a pigeon-house. There are four vertical rows of them, having each an unequal proportion of apertures, varying from eight to eighteen in number. On examining the interior of the mural shell it was found to contain chambers, to which these holes imparted a feeble supply of light and air. Beneath the whole, at a little distance from the ground, an aperture led to a winding flight of some steps, of the width of three feet, which communicated with all these apartments; the shell of the burgh being composed of two concentric walls, each of about four and a half to five feet in breadth, while a space of nearly a similar dimension was the width of the enclosed apartments. These steps wound gradually to the top of the wall, communicating at regular intervals with many chambers or galleries, one above another, that went round the building; they were severally of such a height, that it was possible to walk within them upright. The roof of the lowest chamber was the floor of the second, and, after this manner, seven tiers were raised. No roof had ever protected the summit of the building, so that the burgh of Mousa was originally nothing more than a circular mural shell, open to the top. The height of the inside wall was thirty-five feet, being seven feet less than that of the outside; which difference was partly owing to the accumulation of stones and earth which had filled the inner court.

The mode was now evident in which the burgh had been intended to give security to the persons and property of the ancient Vikingr of Shetland against the sudden landing of their incensed enemies. The tiers of galleries contained within the thick walls would afford a shelter to females and children from the missile weapons of the besiegers, besides being repositories for grain and other kinds of property. Here also were kept the stores whereby a long siege might be sustained. The low narrow door within the court, which admits of no entrance but in a creeping posture, was easily secured at a short notice by large blocks of stone. It is indeed recorded of the rude forts of the Scandinavians, that they were seldom taken by an enemy, unless by surprise, or after a long blockade; that frequently terraces and artificial banks were raised on that side of the wall which was the lowest, and that the besiegers were then annoyed with arrows, stones, boiling water, or melted pitch being thrown from the fort;—which weapons they did not fail to return. The history of the burgh of Mousa confirms this observation. Its high walls bulging out from their centre, defied any attempt to scale them; for, when they were encompassed by one of the earls of Orkney, he had no hopes of inducing the fortress to surrender, but by cutting off all supplies of food, and then waiting the event of a long siege."

The burgh of Burroland is a place of defence that seems to have been originally of greater extent than that of Mousa. The inside diameter of this circular fort is about forty-eight feet, and it is formed of concentric walls, each from ten to twelve feet in width, between which are many chambers. The fort is situated on a point of rock near the sea, the land side of which was originally defended by a stone rampart.

"The fortalice of Cullswick is constructed of unhewn stones of granite, closely built, without any cement; it exhibits a double concentric wall, inclosing a space twenty-six feet and a half in diameter. The thickness of the outer wall is four feet, and of the inner wall three and a half feet, while the interval is two feet wide. Its original height is unknown. The mural construction is supposed to have been the same as that of Mousa. The burgh was surrounded by a ditch now filled up, the breadth of which was thirteen feet. An outer rampart, nineteen and a half feet broad, secured the whole.

Other burghs have a more simple structure; they are destitute of stairs within, and merely contain one tier of chambers, accessible from the inner area. Thus the burgh of Burrafiord is formed of uncemented stones, having a single wall 13 feet thick, with 11 small round apartments, each of the diameter of five feet, which were entered from within the internal area of the burgh: the roof of each were formed of stones, that, projecting over each other, drew to a point; the area included within the fort was 31 feet. The burgh was situated on a holm, or small islet, being well protected by the sea on all sides.

Near Houbie in Fetlar are the ruins of two burghs. One of them was a circular fort, formed by a double wall, with chambers between them; it was situated on a bank close to the sea, being further protected by segments of three concentric ramparts, and by one cross or flanking wall.—Frequently also the foundations of numerous houses may be traced on sites adjacent to a burgh, which appear to have been under the protection of this fortalice.—Other varieties might again be noticed, but they would occupy too much space in our pages.

Some remarkable indications of the presence of the Vikingr are the *Steinbartes* or stone axes, which were in use by all the Gothic tribes of Europe even so late as the eighth century. Fine specimens of these weapons are preserved in the museum of the Society of Scottish Antiquaries.

Another description of antiquities, of a very remote date, consists of the watch towers which cover the summits of the high hills, as of Roeness Hill, Saxavord in Unst and other places. The watch tower of Roeness hill, wantonly destroyed a few years ago by some soldiers, was of a circular shape, composed of rude uncemented stones of granite, and capable of containing within it about six people. But probably a much older construction of this kind is on the summit of a hill, in the island of Veinentry. It was about fifteen feet in diameter; within, was an irregular cavity that was entered by a strait passage, about two feet long, and one broad, being narrow near the entrance, but widening out at its opposite extremity. The height of its external cavity was ten feet; its narrowest width five, and its greatest ten feet; it appears to have been roofed with large flat pieces of granite. The cavity was probably intended for the purpose of containing within it the peat or fuel necessary for lighting a fire on the alarm of invasion. This was the province of the *ward madher*, or watch-man, a sort of sentinel, who stood on the top of a Vord Hill, and challenged all who came in sight. We read in early Orcadian Annals, of a spy being landed on Fair-Isle, who was commissioned to secretly drench the wood which had been stored up for the purpose of being kindled whenever an enemy appeared off the coast.

In the tenth century, the Scandinavian pirates of Orkney and Shetland, began to turn their arms against the mother country of Norway; but Harold Harfagre visited their haunts, and annexed the whole of these islands to Norway.

The Shetlanders were then *Udallers*, so named from the conditions under which they held their lands, the word *udal* being compounded of *œde* and *dale*, signifying a waste or uninhabited dale. Originally, any Norwegian might occupy such land as was uninhabited or waste: an Udaller, therefore, was at first nothing more than the proprietor of land previously accounted waste, which he had enclosed for his own use. But as land became more valuable, the expression gradually lost its primary signification; and when military tenures were introduced, it was merely used as a term in contradistinction to that of feudal; the word udal, in its application to land, meaning *absolute property*, that of *feudal*, stipendiary property. The udal rights were likewise protected by definite laws. The law of inheritance was in Shetland the same as in Norway;

by the latter Scottish settlers, it was thus explained, "it was a law in all times bygone, that, when any landed man departed this mortal life, his whole lands and heritage, immediately after his decease, were equally divided among his whole children, as well sons and daughters, counting always two sisters' parts for one brother's part: and being so divided, the eldest brother had no further prerogative above the rest of his brothers, except the first choice of the parts and parcels of the land divided."

It appears, however, that Harold Harfagre had placed some limitations in Orkney and Shetland to the free manner in which enclosed land was held. From the numbers of sheep which grazed on the uninclosed heaths and moors, the monarch levied a tax or scat; hence the name given to the land of *Scathold:* but the land which was actually enclosed for cultivation became free from scat, and retained for itself the true character of udal land. During the time that Shetland was under the influence of successive earls of Orkney, few events are recorded except insurrections against the yoke of Norway, intestine factions mixed with bloodshed, or descents upon the Scottish shores. Shetland being by a wide and stony channel separated from Orkney, had a distinct prefect or governor, appointed over it, who acquired the name of Foude, an office which likewise included in it the guardianship of the revenues of the country. The country, at the same time, acquired the name of a *Foudrie.* In the lake of Strom in Shetland, is shown a small holm, on which are the remains of an ancient burgh, where, according to tradition, a son of one of the Earls of Orkney fled in order to evade the wrath of his father; but, meeting with pursuers, was slain in a contest with them on the strath of Tingwell. When tidings of the event were brought to the Earl, he ordered the perpetrators of the deed to be instantly put to death, and erected a large stone where the slaughter had been committed. The stone is still remaining.—The relics of antiquity connected with the Norwegian government of Shetland are various. Courts of judicature, or tings, were held in the open air, being for the most part constructed of loose stones, which were piled together in a circular form. Of these tings, the sites of many of which are still visible, there were three kinds. The lowest was a Herad or parish ting, over which the *Foude* of the parish presided; an officer, who, in the Scottish period of the history of these islands, afterwards assumed the name of bailiff. The foude was assisted in his magistracy by a lawright man, whose particular duty it was to regulate the weights and measures, and by a number of men named Ranselmen. The ting to which these men gave their service, could only doom or give judgment in small matters, namely, in those which related to the preservation of good neighbourhood, as in questions of minor trespasses on land, poundage of cattle, &c. &c. A higher court was a circuit ting, over which the Earl of Orkney presided, or, in his absence, the *great* foude, so named in contradistinction to the subordinate or parish foudes. In his judicial capacity the great foude was the lawman of Shetland, and gave doom according to the Norwegian Book of the Law. The lawman made his circuit round the whole of the more comprehensive juridical districts of the country, named *ting sokens:* each ting soken including several minor districts, which were severally under the subordinate jurisdiction of parish foudes. He here heard appeals against the decrees of parish tings, and tried weightier offences, such as were visited with heavy fines, or confiscations, and capital punishment. A third ting was named the *lawting*, because it was a legislative assembly. This was held once a year, and here also the lawman presided. All the udallers owed to it suit and service. The law ting was held within a small holme or islet, situated in a fresh water lake, the communication with the shore being by stepping-stones. The valley in which the law ting was situated, bore the name of Thingvollr, now corrupted into *Tingwall.* Here the udallers exercised the power of reversing the decrees of inferior courts, of trying important causes, and of legislating, or making bye-laws for the good of the whole community. The highest appeal was to the king at Bergen.

Interesting remains of these tings are to be traced at the Hill of Crucifield in Unst, at the island of Fetlar, and other places. The holme of Tingwall still exhibits the circle of stones where the law ting was held. (*For a description of the tings of Orkney and Shetland, see a Memoir by Dr. Hibbert, published in the second volume of the Transactions of the Society of Scottish Antiquaries.*)

In 1379, owing to the failure of the male line of the Earls of Orkney, Henry, Earl of Sinclair, received an investiture of the Earldom from the King of Denmark and Norway, and afterwards the right of Denmark became pledged to the Scottish crown, with a stipulation that the ancient laws of the udallers should be preserved inviolate. Scottish settlers then gradually introduced themselves into Orkney and Shetland. The latter province was styled *Hialtland*, but more commonly Yealtaland; which name, by the new comers, was shortened into Yetland: hence the transition of Yetland into Zetland was an easy one, the Z in the ancient Scottish dialect, and even still in vulgar pronunciation, sounding like Y.

In 1391 there was contest between Henry Sinclair, Earl of Orkney, and his cousin, Malis Sperre, relative to a question affecting the right of the former to the Earldom. The scene of the rencontre was in Shetland: Malis and seven of his companions were killed, while other seven fled in a six-oared boat, and took refuge in Norway. Owing to this event, the government of Orkney was intrusted to other hands, and Henry Sinclair and his successor, rendered their acknowledgments to King Eric of Norway for Shetland only; but in the year 1434, William Sinclair was reinstated in the undivided possessions of the family.

In the year 1530, King James the Fifth was induced to make an hereditary grant of the estate of the crown in Orkney and Shetland to his natural brother, James Earl of Moray. When the islanders saw that a feudal superior was intended to be interposed between them and the sovereign, they were alarmed that the ancient laws of the country were about to suffer a corresponding change: headed, therefore, by Sir James Sinclair the governor of Orkney, they arose in arms to resist the arbitrary innovation. Among the Shetland insurgents were Edward Sinclair of Strom, and Sinclair of House Island. The Earl of Caithness and his kinsman Lord Sinclair were sent out against them: the udallers met their opponents on the confines of Steinhouse; and in a sanguinary conflict, the Earl of Caithness and five hundred of his followers were slain, and the rest taken prisoners. It is honourable to the memory of the king, that he became convinced of the just cause of the udallers, in consequence of which the governor of Orkney was restored to the royal favour, and a complete reconciliation took place. Edward Sinclair of Strom (according to an old deed lately extant) along with thirty companions in arms, received a respite from the king for a nominal term of nineteen years.

In the year 1565, Queen Mary made an hereditary grant of the Crown's patrimony in Orkney and Shetland, to her natural brother Robert Stewart, son of James V. by Euphemia daughter of Lord Elphinston, who was the twenty-seventh and last abbot of Holyrood.

About this time the deposition of the queen took place; and Bothwell, sailing from Dunbar, sought a refuge in Shetland, where he met with a welcome. Bringing with him a number of retainers, an ox and two sheep out of each parish were allowed for their maintenance. But indigence at length overtaking the outcast husband of Mary, he ventured into the northern seas, and sought, by piracy, to procure a subsistence. Kirkaldy of Grange, in a vessel named the Unicorn, was sent after the noble pirate, whom he met with in Bressay Sound. Bothwell took flight, and insidiously directed his course close to a hidden rock, upon which the ship of his pursuer broke. The shoal has since been named *the Unicorn Rock*.

In 1587, the lands of Brugh were given to Hugh Sinclair and his heirs; and, in a clause of the grant, there was a special provision, that they should not descend to the family according to the laws of udal succession, but according to the rule of primogeniture adopted in Scotland. The Sinclairs maintained in Shetland an establishment of no small degree of splendour. A part of the chapel which they built adjoining their mansion-house still remains. At this time the Scottish settlers, who had gradually introduced themselves into Orkney and Shetland, endeavoured to set aside the old laws of udal succession, and to introduce newer ones more favourable to primogeniture.

In 1588, the dispersion of the famous Spanish Armada in the northern seas took place. The vessel which conveyed the Duke di Medina the commander, suffered shipwreck on Fair-Isle, where, owing to want of provisions, the crew suffered all the horrors of famine. They were afterwards released from this place, and conveyed to Quendale Bay on the mainland, where the Duke received hospitable treatment in the house of a worthy Scottish gentleman, Malcolm Sinclair. Here he remained until his vessel could be equipped. Another galleon was wrecked on the west of Shetland, the crew of which, during their detention, fortified themselves in a small island named Kirkholm, and built a small chapel, which they dedicated to the holy Virgin.

Lord Robert Stewart only resided occasionally in Shetland. He erected a house, the walls of which were remarkable for their thickness, near Sumburgh Head. For thirty years he was the indefatigable persecutor of the ancient udallers of Orkney and Shetland, in his endeavours to subvert their laws, and to wrest from them their landed possessions. These oppressions it would be a long and painful task to recount. He was several times deposed from his honours and emoluments for gross tyranny; but on account of his being a favourite at court, as often re-instated. He was created Earl of Orkney, and Lord of Zetland, and died in the year 1595. His son and successor in the earldom was Patrick Stewart, who endeavoured to complete the task his father had begun, and planned the most unjustifiable schemes for wresting udal possessions out of the hands of the unfortunate proprietors, in which he but too well succeeded. About this time Lawrence Bruce, son of Bruce of Cultmalindie, having slain a gentleman in a duel, sought refuge in Shetland. He was a half-brother of Robert, earl of Orkney, and having bought up a quantity of land from the distressed udallers, completed, in 1598, the spacious mansion of Mouness, which is built in the castellated style of that period. Over the door-way is to be yet seen an undefaced inscription:

> "List ze to knaw this building quha began?
> LAWRENCE the BRUCE he was that worthy man.
> Quha arnestlie his ayris and afspring prayis,
> To help and not to hurt this work alwayis."

But the request was in vain: owing to the imprudence of Lawrence Bruce's posterity, the estate of Mouness has passed into other hands; the castle then became uninhabited, and the rank weeds of desolation were allowed to fix their roots among its walls, and to wave with every wind.

About the year 1600, in consequence of the insecure and sandy foundation of the house which the late earl had built having given way, Earl Patrick Stewart commenced the erection of Scalloway castle; and it is scarcely possible to conceive of a more flagrant exercise of oppression than that which occurred during the execution of this structure. A tax was laid upon each parish in the country, obliging the Shetlanders to find as many men as were requisite for the building, as well as provisions for the workmen. The penalty for not fulfilling this requisition was forfeiture of property. Mr. Pitcairn, the minister of the parish of Northmavine in Shetland, then came to pay his respects to the lord of the new mansion. The earl desired him to suggest a motto for this gateway. This was an occasion of which the minister availed himself to lay before the founder of the castle the sinful enormity of that oppression which had enforced its completion. The earl's wrath was kindled, and in his rage he threatened the devout pastor with imprisonment; but afterwards, Mr. Pitcairn said to him "Well, if you will have a verse, here is one from Holy Scripture,—"*That house which is built upon a rock shall stand,—but built upon the sand it will fall!*" Earl Patrick would not receive the motto in its moral sense, but applied it to the cause which first led to the building of the new castle. "My father's house was built upon the sandy shores of Sumburgh; its foundations have given way, and it will fall; but Scalloway castle is constructed upon a rock, and will stand." Accordingly, upon the lintel stone of the gate appears the following inscription:

PATRICIUS STEUARDUS, Orcadiæ et Zetlandiæ
COMES, I. V. R. S.
Cujus fundamen saxum est, Dom. illa manebit.
Labilis e contra, si sit arena perit.
A. D. 1600.

Scalloway Castle is a square formal structure composed of freestone brought from Orkney, and of the fashion of many houses of a similar date in Scotland; it is three stories high, the windows being of a very ample size; on the summit of each angle of the building is a small handsome round turret. Entering the mansion by an insignificant door-way, over which are the remains of the Latin inscription, we pass by an excellent kitchen and vaulted cellars, while a broad flight of steps leads above to a spacious hall; the other chambers however are not large. The castle is now a mere shell. The court-book of Earl Patrick Stewart during his exercise of power exhibits nothing but a horrid picture of confiscations, banishments, and capital punishments pronounced upon the inhabitants of this distracted country. At length the distresses of the udallers became so insupportable, that notwithstanding the strict guard which was placed over all ferries, so as to prevent any complaints of tyranny and oppression reaching the royal ear, a few Shetlanders made their escape, attired in the usual skin garbs of the country, and in this dress found their way to the court of James, and submitted to him, with true native eloquence, their oppressed condition. These complaints met with attention; and soon afterwards a representation from the whole of the inhabitants of Orkney and Shetland was forwarded. The Earl of Orkney was arraigned on the charge of usurping in his government the king's prerogative, and had justice administered to him too much after the manner in which he himself had dispensed it in the courts of his own Earldom. After a very unfair trial he was beheaded at Edinburgh.

Orkney and Shetland were next annexed to the crown, only to be granted to greedy farmers or tacksmen, under whom the distressed Islanders experienced no alleviation of their calamities. Afterwards the Earl of Morton, on account of money, advanced to the unfortunate Charles during his troubles, acquired possession upon mortgage of the crown estates of these islands, and usurped a direct superiority over the udal lands. But the process of feudalization was completed in the reign of Charles the II., by Douglas of Spyne, factor of the crown rents, who obliged all the udallers to take out charters from the crown, by the granting of which he raised in Shetland alone, a sum of not less than £15,000 Scots. About this time, Denmark failed for the last time in obtaining an acknowledgment from the government of Britain, that Orkney and Shetland had been merely surrendered by her on a redeemable pledge. In 1669, Orkney and Shetland were by an unjustifiable act of parliament, cancelling at once the claims of the Morton family, re-annexed to the crown, and they were again let out to tacksmen; but in the year 1707, the Morton family had sufficient interest to get reinstated. In the year 1742, the Earl of Morton, on the plea that the emoluments arising from Orkney and Shetland were not sufficient to pay the interest of the sum for which they had been originally mortgaged by the crown, obtained a discharge of the reversion; an act was therefore passed, making the whole of the estates in which he was in possession, heritable or irredeemable. Nine years afterwards, this nobleman was deprived of the jurisdiction of these islands, for which he received a sum of money in compensation, and soon afterwards he was involved in extensive suits at law with the heritors, relative to the fraudulent increase of weights and measures that had gradually taken place by the ancient oppressors of these islands: he gained his suit, but these litigations became so oppressive to him that in the year 1776 he sold all his interests in Orkney and Shetland to Sir Laurence Dundas. The new possessor afterwards conceived that his powers of superiority were too limited, and, in order to extend them involved himself in an extensive suit at law, in which he completely failed.

Such is a very faint political history of these islands. It may be added, that in 1669, when nearly all the lands were feudalized and annexed to the crown, the province then became in every respect subject to British laws. It was rendered liable to a land-tax, which was in vain disputed, on the plea that the scat already paid was a proper equivalent, and that no other could be in justice demanded. Orkney has always paid two-thirds of the cess, the remaining one-third having been rendered by Shetland; but the latter country having no valued rent, by which the right of individuals to vote can be ascertained, is denied any share in the election of a member of Parliament. Lord Dundas is the Lord Lieutenant of Orkney and Shetland: and with regard to the internal legislation of the latter country, it may be briefly remarked, that the offices of Justice of Peace have been lately revived, that the Sheriff-substitute holds a regular court, and that there are separate admiralty and commissary jurisdictions.

A century and a half ago, the town of Lerwick rose into existence. In the dutch war of 1665 a citadel had been built near Lerwick, to defend Bressay sound from the Dutch, and it was well garrisoned; but in the commencement of the 18th century, a Dutch frigate burnt the fort and several houses in the town. In 1781, it was completely repaired, and named Fort Charlotte. Since the last peace, it has become the manse of the very respectable minister of the parish.

Ecclesiastical History and Antiquities.—It is almost needless to remark, that the ancient religion of the Scandinavian colony of Shetland embraced the mythology of the Edda. Some of the antiquities indicative of the existence of this religion are the numerous cairns raised over the graves of the distinguished, which mode of sepulture prevailed throughout the whole of northern Europe. It was one of the commands of Odin, that over the remains of men of rank huge heaps of earth should be raised; but that over those who had performed extraordinary achievements, high stones should be erected, inscribed with Runic characters, which ever commanded in Scandinavia a superstitious awe. A stone of this description, bearing upon it mysterious signs, was taken from its site, and infixed in the wall of the parish kirk of Sandness. It was also a custom of Shetland, (certainly of Pagan Origin,) when any one met a funeral, to lift up three clods, and to throw them one by one after the corpse. In the isle of Uyea, some beautiful urns, wrought from a soft steatitic stone, were found in a tumulus.

Orkney and Shetland were very late in embracing the tenets of Christianity. On the south of the mainland of Shetland, the foundations appear of an old chapel dedicated to St. Ninian, commonly named Ronan. St. Ninian was a Cambrian, and zealously preached Christianity in the fifth century to the Britons of the province of Valencia or shire of Galloway. Mr. Chalmers conceives, that the chapel might have been founded by some pious Columbians of the sixth century in their visit to Shetland; but this is very doubtful. In a very early period, certain Irish papæ, or priests, sought places of refuge, during some commotion of their country, in Shetland, where three islands yet bear the name of Papa, the largest of them being called Papa Stour, or the Great Papa. But whether these priests brought over many Shetlanders within the pale of Christendom, is very doubtful. In a later period, Sigismund Bretteson, a hero whom the northern Scalds, in marvellous stories of his prowess, have celebrated in their songs, was commissioned by Olaus, king of Norway, to baptise the heathens of Shetland. But the great Christian saint of Orkney and Shetland was Magnus, once partaker, in the 13th century, with Hacon, his cousin, in the earldom of Orkney. He was a meek ruler, worthy a throne in the period of the millenium, since he refused to fight against men from whom he had received no injury. Hacon was his deadly foe; Magnus, attended with unarmed men of peace, went to meet him, by appointment, in an island of Orkney, hoping for conciliation. Hacon repaired thither, with warriors well accoutred, and instantly doomed his cousin to death. The martyr bent forward his head, and an executioner cut it off at a single blow. After his death, he was sainted by the pope; a grand cathedral was dedicated to him in Kirkwall, and numbers repaired to his tomb, where, with the assistance of proper oblations and ceremonies, they were cured of their diseases.

When a bishop of Orkney was appointed, Shetland would of course be included in the diocese. Tingwall, Whiteness, and Weisdale, formed an archdeaconry. Their union is indeed still perpetuated, by their being formed into one parish.

All the ecclesiastical buildings of Shetland appear to have been devoid of the least show and ornament, the ingenuity of the architect extending no farther than in constructing a vaulted roof, and steeples like the round ecclesiastical towers of Ireland. The pointed arch, the pinnacled buttress, or the rich stone canopy, never dignified the chapels of Hialtland. The number of them was remarkably great. The parish of Yell boasted twenty chapels, where only two or three are used at the present day. Many of these buildings may be attributed to wealthy udallers, who had a private oratory contiguous to their dwellings; others were erected by foreign seamen, in fulfilment of their vows to some tutelar saint, who had been miraculously preserved on these dreaded shores from shipwreck or from death. They were variously dedicated, to our Lady, to St. Olla, to St. Magnus, to St. Lawrence, to St. John, to St. Paul, or to St. Sineva. Near Papa Stour an insulated rock, named *Frau-a-Stack*, or the Lady's Stack, inaccessible to all but the best of scalers, is crowned on the summit by the remains of a small building, that was originally built by a Norwegian lady, to preserve herself from the solicitations of suitors, when she had entered into a vow of pure celibacy. The ascent to the house was considered almost insurmountable, except by the help of ropes. But a dauntless lover, an udaller from Islesburgh, contrived in the dark secrecy of evening, to scale the cliff, and, after the first surprise was overcome, successfully ingratiated himself in the fair devotee's affection. When the consequence of the lady's *faux pas* could no longer be concealed, Frau-a-Stack became the scoff of the island, and was deserted by its fair and frail tenant. The house was afterwards unroofed and reduced to ruin, in contempt of the vow of chastity that had been broken.

Runic inscriptions over the graves of distinguished Norwegian colonists were common; one only now remains, namely, at Crosskirk in Northmavine.

Orkney and Shetland were late in receiving the reformed religion; and when at length it was introduced by such an unworthy professor of it as Lord Robert Stewart, the *ci-devant* abbot of Holyrood, no wonder that it should be necessary, at a very late period, to issue out acts in Kirkwall, forbidding, under severe penalties, all idolatry, such as walks and pilgrimages. In the commencement of the last century, many Popish festivals were still preserved, particularly those of Halloween, of St. John's Mass, or of Whitsuntide. The people had their fasts, in which they eat fish, or, in conformity with an ancient church decree, indulged themselves with the flesh of seals, which was admitted as a lawful substitute, whenever it could be proved that these animals, in having been pursued, had betaken themselves for safety to sea in preference to dry land. Many old chapels, that had been dedicated to particular favourite saints, were resorted to so late as the beginning of the last century. The devotee would cast among the ruins of the church, as a religious offering, a small image of silver, representing any particular part of his body that might be afflicted with illness; a recovery was then fully anticipated. Even the shell-snails that infested the walls were supposed to be possessed of particular healing powers;—they were dried, pulverised, and administered for the cure of jaundice. It was also customary, long after the abolition of Popery, to walk at Candlemas to the chapel, in the dead of night, with lighted candles. Our Lady's kirk at Weisdale was resorted to in completion of promises made during perilous navigation, or during sickness. "It was much frequented," says Brand, "by women, who, when they desired to marry, went to this church, making their vows and saying their prayers there, so assuring themselves that God would cause men to come in suit of them." The mariner also placed his confidence in the offerings which he might make within the pale of the church, trusting that they would secure for him a happy voyage. Within these walls the supplicant would light candles, and even when the shrine had been destroyed, would drop money among the ruins, or would parade around the kirk on his bare knees. Nor has the custom of making oblations at Our Lady's kirk of Weisdale ever yet ceased. In the pulpit of the church a great quantity of all the different currencies of Shetland has been found, from the guilder down to the stiver; and although the building is now almost razed to the ground, the anxious fisherman still drops a pecuniary offering among its loose fragments.

In 1697, the Presbyterian form of church government was introduced into Orkney and Shetland. All lands belonging to the church then returned to the crown; but since they were not annexed to it, they were liable to be disposed of by the sovereign at pleasure. Three years afterwards, in consequence of a commission being despatched to these islands by the general assembly in Scotland, nearly the whole of the ministers conformed to Presbyterianism. The bishops' rents in Orkney were retained by the crown, but the stipends to ministers were paid out of the church funds, though in a less proportion.

The parishes into which Shetland is divided are Unst; Fetlar and North Yell; South and Mid Yell; Northmavine; Delting; Lunnasting, Westing, Skerries, and Whelsay; Aithsting, and Sandsting; Walls, Sandness, Papa and Foula; Tingwall, Whiteness, and Weisdale; Lerwick, and Gulberwick; Bressay, Burra, and Quarff; Sandwick and Dunrossness.

Parish Schools.—A century ago there was not even a school for the wealthier classes, "whereby," says Brand, "many promising and pregnant ingenys were lost;" but shortly afterwards the poor were taught by a master sent over by the Society for the Propagation of Christian Knowledge. In the year 1724, the landholders of the country met and established a school in each parish, obliging parents, under a heavy penalty, to send their children thither. Afterwards, for a long period, the education of the poor was again neglected. At the present day many schools are established in different parts of the country, although some of them appear to be ill attended.

III. The state of land and landed tenures in Shetland.

State of Land.—A more complex inquiry than this cannot possibly be imagined, and without a sacrifice of greater space in the present article than we are justified in making, we must despair of rendering the subject intelligible to our readers. In making, therefore, a general reference to Dr. Hibbert's volume for detailed information concerning the Shetland tenures, a very slight sketch must at present suffice.

In a very early and rude state of society in Scandinavia and her colonies, a *mark of land* was a measure of no definite extent, but such a portion as was considered equal to a mark of *wadmel*, (or coarse cloth); which mark of wadmel consisted of 48 ells. A newer standard of comparison which succeeded to the wadmel was a certain *mark weight* of some inferior metal, which was divided into eight ounces, each ounce being equal to six ells of wadmel.

From each mark of land in Shetland, equal in value to 48 ells of wadmel, or a mark weight of some inferior metal, Harold Harfagre levied a *scat* or tax. The scat was originally paid in a certain quantity of wadmel, but afterwards in some rude description of coin, which bore the name of pennings or pennies.

But the scat which Harold Harfagre exacted was limited to pasture or grazing land, whence the name applied to such land of *scathold*: but in order to encourage husbandry, the land which for cultivation had been separated from the scathold, and enclosed by a fence, became exempt from the scat or tax, and thus was strictly *udal*. At this early period, therefore, the quantity of scathold contained within a mark, for which a scat was due, became expressed by the number of pennies which the King of Norway actually received: thus the largest extent of scathold incidental to a mark of land was liable to an impost not exceeding 12 pennies or three ells of wadmel; while the least extent of scathold owed a tribute of not less than four pennies, equivalent to one ell of wadmel. Hence the number of pennies at which a mark of land was rated indicated the proportion of scathold or common land to which the proprietor was entitled. A considerable number of these assessments must have occurred in succession during early times, in proportion as land became enclosed for cultivation, and was by this means rendered scat-free; but as the distinction has for nearly two centuries ceased to be acknowledged, the last appreciation serves the purpose of the present landed proprietor, who estimates from the amount of the pennies by which each mark of land is still designated, his proportion of scathold or common.

This assessment has again served another purpose. When the King of Norway, who originally possessed much land in Shetland, or when the Earl of Orkney, or any other proprietor, chose to let out land upon a tenure, the rent was regulated by the number of pennies at which each mark of land was valued. One general rental of Shetland was, therefore, acknowledged. The rents originally paid were in wadmel, but afterwards butter was accepted. The weight of butter was estimated by marks, each mark containing eight ounces, while 24 marks formed a *lispound* of 12lb. weight. In a still later period, rent was less frequently paid in kind; and for the wadmel, Scots money was often substituted. After this commutation had taken place, the ancient rental of Shetland stood as follows:

Description of Land, per each Mark.		Rent due in Butter.		Computation in Money.	
12	Penny Land,	12	Marks in Butter,	16s.	Scots.
10	do. -	14 2-3	do. -	14s. 8d.	do.
9	do. -	12	do. -	12s.	do.
8	do. -	10 2-3	do. -	10s. 8d.	do.
7	do. -	9½	do. -	9s. 4d.	do.
6	do. -	8	do. -	8s.	do.
4	do. -	6	do. -	6s.	do.

But although the *nominal* rents have not been raised since the islands were annexed to the crown of Scotland, yet collusive means have effected the purpose quite as well. A lispound, the measure in which butter or oil was paid, was originally of 12lb. weight. The Stuarts, Earls of Orkney, raised it to 18lb.; the oppressive exacters of the crown rents, and needy farmers, made it 24lb. and it has since been gradually increased to 32lb. "As a consequence of this increase, says the author of the grievances of Orkney and Shetland, "numberless little heritages, and some fair estates also, are swallowed up, the crown rents having so increased with the weights, that, when the years are not very plentiful the whole fruits of the ground are not sufficient to satisfy them."

The history of the feudalization of udal lands has been given. Some very ancient patrimonies, which have never been held by a charter from the crown, are still in a limited degree udal; and those which, in a later period, were feudalized by the Earl of Morton, are enjoyed on tenures that are comparatively light. With regard to the crown lands, in the earliest tenures that were granted, the asperities of feudality were so softened down, as to be scarcely perceptible. The lands that devolved to the crown, by the virtue of the treaty of James III. in the fifteenth century, with Earl Sinclair, were named property-lands; and the king, in letting them out in triennial leases, subjected them to an annual rent, named *land-maills*, estimated according to the general rental of the country, and to a fine or composition, named *grassum*. But if a tenant wished to convert his lease into an heritable feu, the triennial compensation of grassum was dispensed with, and he merely paid the annual tribute of land-maills. When also lands were ley and not laboured, the land-maills were humanely remitted. The earliest feuars of the crown estates were named The Kindly Tenants of the King. A change, however, too soon occurred. When the superiority of the country was granted to mesne-lords, and when the revenues of the king were let out to farmers, crown-lands paid rent whether they were ley or laboured; and, in the course of time, the terms on which the rentallers of the crown were allowed to possess their lands, became very rigorous.

The rents and duties of Shetland may now be stated. All landholders still pay the scat that was rendered to the king of Norway. Lands are let subject to the ancient rental of Shetland, the materials which are still paid in kind, being estimated by the lispound of 32lb. The grassum for the king's land is now converted into an annual demand of eight shillings Scots for each mark of land. All landholders pay a duty named *wattle*, in commemoration of the prayers of a good sainted lady, which the Shetlanders, in Popish times, purchased as an intercession for their manifold sins; they also pay the ox and sheep money that was granted as a compliment to the Earl of Bothwell, when he obtained a refuge in Shetland. The average of scot, wattle, and ox money, for each mark of land, is said to be about 8d. sterling; some marks being charged so high as 1s. 4d. An old claim of trilling amount, named hawk-money, originally paid to the king in support of his hawks, is waved. The landholders pay one half of the cess or land-tax, and rogue money, a premium for killing eagles, ravens, and hooded crows; bounty to seamen and other casualties, with a proportion of schoolmaster's salary, which may altogether amount to about 6d. sterling per mark of land. The duties to the superiors, which were originally exigible in the *ipsa corpora*, are regulated by the rise or fall of butter and oil, according to the prices of the market.

Tenures.—We may now describe the manner in which lands are let in Shetland. While a proprietor has been in the habit of setting his land, according to the ancient rental of the country, he has appended the king's ancient requisition of grassum, to the amount of his land-maills, and has taken for his precedent all the other exactions incidental to the crown estates. The payment of a hen for every mark of land has been also introduced. This is the *Cane-fowl* of the south of Scotland. The landed proprietor has likewise been accustomed to exact, in addition to cane-fowls, the labour of each tenant for three or six days in the year, for the purpose of casting peats, or other labours of husbandry. This practice has been very properly condemned by Dr. Edmonstone, as one that "keeps alive the recollection of feudal oppression, and stifles the feelings of generous freedom."

But lands are most frequently let with fishing obligations attached to them. These we shall now describe.

The remarkable fishing tenures of Shetland had their origin in its former impoverished state. In the middle of the last century, owing to certain customhouse regulations which affected the foreigners who fished on the shores of Britain, there was a cessation of the periodical visits which the Hamburghers made in this country for the purpose of trading in cod and ling. There was also a decline of the Dutch herring-fishery, which gave great support to Shetland, and the weights and measures were more than double their ancient standard. The landlords, therefore, saw nothing but ruin threatening them, unless they availed themselves of the encouragement given by successive acts of parliament, towards the promotion of the British fisheries. Accordingly, they were compelled, in their own defence, to be the proper successors of the foreign merchants, who had, for the uninterrupted period of two centuries, been the chief supporters of the Shetland fishermen. But at the same time, the peasantry, from the causes stated, were in such an impoverished state, that their landlords were obliged to furnish them on trust with boats and lines necessary for carrying on the fisheries of the country. This system has been perpetuated to the present day. The landlord lets his land for one year only, in consideration of a certain rate that is regulated by the ancient rental of Shetland; he undertakes, at the same time, to advance a tenant the articles necessary for the ling-fishery, such as boats and lines, requiring from him the same profit that a buyer would expect from a seller; but in lieu of these advances, the tenant must enter into an obligation to deliver to his landlord all the fish which he takes at a stipulated price. A system such as this cannot but be objectionable; the excuse for it has been the debased political state of the country. That it opens a wide field for oppression, against the temptation of which no country, where human passions prevail, is proof, it would be absurd to deny. An unfavourable state of the weather occurring throughout the short summer season in which the fishermen repair to the fishery,—a loss of lines or boats,—any of these incidents, may oblige the tenant to become a debtor to his landlord, and, actuated by a threat of distraint or ejectment, he may assent to any slavish conditions which a task-master may choose to dictate. These are certainly very possible results that must arise from such a system.

The late Mr. Cheyne, however, of Tanwick, who was both a considerable landholder himself and a tacksman, made his dependents forget the power that the tenures of the country threw into his hands, by attending to their wants, and by encouraging their exertions in so many different ways, that, before he died, he had the satisfaction of seeing the tenants under his influence pre-eminent in the country as an industrious, enterprising, and contented race of people. His example has been imitated with success by other gentlemen in Northmavine. But this circumstance argues little in favour of the tenures of Shetland. A people may flourish under a good king, though the system of the government be arbitrary; but a system is not to be defended on this account, for a successor may rule with a rod of iron. It is, however, creditable to the present race of Shetland landlords, that they are fully sensible of the advantages to be derived from letting land at a definite price, independent of the obligation of fishing, and of paying tenants a regular price for their fish, that may correspond with the fluctuations of the market. Yet, after all, the introduction of any new description of tenures must be necessarily a slow process; the objection against it chiefly arising on the part of the tenants themselves, who, being familiarized all their lifetime to a system which they are conscious is a bad one, are, notwithstanding, unwilling to exchange it for one of which they have had no experience. It was long ago remarked by a writer, strenuous for the support of the present state of Shetland tenures, that the fishermen were so poor, that they durst not fish for themselves, fearing, that if they were deprived of the support of their landlords, they should perish for want. This assertion affords the best argument that can be produced for the necessity of a change of system. A sense of dependency in the human mind is too often the forerunner of an inactive and unenterprising state of indigence.

Hr. Hunter of Lunna, was one of the first who attempted to introduce into Shetland a freer description of tenures. But the obstacles he met with originated from an unexpected source,—from the tenants themselves, who, being by no means prepared for so sudden a change of condition, much abused the liberality they experienced. This event shows, that a domestic reform, like a political one, should be a gradual process. Mr. Gifford of Busta has also very recently followed the example. We shall be most happy to hear that the experiment will equal the hopes of this liberal-minded proprietor.

But many tenures, free from the obligations of fishing, have of late years been granted on advantageous leases, which have no precedent in the older rentals of the country. This is one of the happy consequences of the Agricultural Society, lately instituted in Shetland.

Teinds.—The teinds of Shetland are partly of corn; these are paid by some lands in every tenth sheaf, after being cut down; in other lands, the teinds are compounded for in butter and oil, and in a few lands only in money. For every thirty sheafs, three marks of wool and one lamb are exacted. For each cow, three marks of butter on an average, and for each calf, one shilling Scots. Each six-oared boat pays of teind, fifteen ling, and each four-oared boat, ten ling. In the last place, the minister claims a right to three days work from each family in the parish, for the purpose of casting, raising and bringing home his peats.

There are no poor rates; the poor are quartered upon the parishes in rotation, living in each family for periods, varying from one week to a month.

Wrecks.—In the case of wrecks on the coast, there is an admiralty court, which is empowered to judge of all circumstances relative to them, consisting of a judge, a clerk, and a procurator-fiscal. When a wreck happens, and none of the mariners are saved, it is the duty of the procurator-fiscal to state the circumstances to the judge, who appoints a person to take charge of what part of the property may remain, to sell it, and to advertise publicly that the proceeds are lodged in court, until an owner appears; and if, after the lapse of a year and a day, no claim be made, the property devolves to the Admiral. In the old law of the country, it was ordered that a third of the ship and cargo which might go ashore should accrue to the proprietors of the ground, a third to the salvers, and a third to the owner. But, throughout Britain, the provisions regarding wrecks are undergoing many wholesome regulations.

IV. State of agriculture in Shetland.

The fishing tenures of Shetland having been at length explained, a ready inference suggests itself, that they afford no possible stimulus whatever to the cause of agriculture. Indeed the natives, as husbandmen, differ little from that humble state of advancement, which has been described in a Teutonic poem of the eighth century.

> "Suis rebus contenti
> Domos edificarunt et liberos genuerunt,—
> Sæpibus segetes cingebant,
> "Agros oblimabant,
> Sues nutriebant,
> Capras custodiebant,
> Et cespites effodiebant."
> *Translation to the Song of King Eric.*

Weights and Measures.—Under this head may be included a description of the Bysmer, still greatly in use, by which was estimated Lispounds. It is of the greatest antiquity in Norway, being described by Olaus Magnus. The late Mr. M'Kenzie in his "Grievances of Orkney," has after the following manner described the Shetland Bysmer: it is a lever, which at one end is about three inches in diameter, and at the opposite end, to which it tapers, is only one inch. From the middle to the smaller extremity, it is marked with small iron pins, at unequal distances from one mark to twenty-four, or a lispund. The commodity to be weighed is hung by a hook attached to the small end of the Bysmer. The lever is then horizontally suspended by a cord going round it; the weigher shifting the cord this and that way, till the commodity equiponderates with the gross end of the Bysmer. Thus the pin nearest the cord, at the time of equilibrium, shows the weight in marks.

Public Roads.—Here is a blank.—There is no road in Shetland deserving the name of one. The only *attempt* which has been made is to no greater a distance than five or six miles to the west of Lerwick. In some parts of the country, the fine voes that penetrate far into the land, render roads almost unnecessary. But there can be no question that Shetland suffers materially by the absence of good communications between Lerwick and the westerly and north-westerly districts. Again, the want of roads is much felt from another cause. In no part of Great Britain is boat-travelling more extravagant than in Shetland. There are no regular ferries; and although the magistrates of the country have attempted to fix a rate of fares, and to express their determination, in case of any disputes coming before them, to make it their standard of reference, the regulation is altogether a dead letter. There are few gentlemen who, in the trips that they make, are not rowed by their own tenants; and they take this opportunity of ingratiating themselves in the favour of their dependents, by paying them above their due; it is, therefore, unfortunate that the sum thus given is the least that is demanded from the stranger.

Construction of Dwellings.—The oldest Shetland dwellings are built of rude stones, with a cement of clay, or they are still more coarsely formed of stones and clods. After the wooden rafters have been laid, they are often roofed with what are provincially called *flaas*, which are compact vegetable layers, consisting of the short fibres of mossy or heathy roots, closely interwoven with each other. The removal of a layer of this description from the surface of dry moss land, is never accomplished by cutting, but by tearing away. When layers composed of flaas are doubled, they are considered to be impervious to rain, and in this state are placed upon the rafters of the houses. But, instead of flaas, the Shetlanders often substitute what they call *pones*, or swards of earth cut very thin, upon the surface of which grows a short grass. A roof, formed of thin turf, has long been considered the peculiar characteristic of the Scandinavian cottage. Occasionally, however, the Scotch method of thatching is introduced, in which case, the straw is laid over the pones or flaas, and afterwards secured with *simmonds*, or straw-bands.

Towns or Rooms.—It has been remarked that the scat which Harold Harfagre exacted from the ancient inhabitants of Shetland was under certain limits; it was demanded from all pasture or grazing land, whence the name it took of Scathold; but in order to encourage husbandry, the land which for cultivation had been separated from the scathold, and inclosed by a fence, became exempt from the scat or tax. This exempt land was named by the ancient udaller a *town;* and it was not necessary that a single house should indicate its site. But when settlers from Scotland appeared, a town was named by them a *room;* the expression indicating a limited space inclosed from the commons for culture. Most of the *towns* or *rooms*, which had originally belonged to the small udallers of the country, fell, in the course of time, into the hands of some rich settler from Scotland, who attempted to connect the various small inclosures that had been made by a single dike. At this day, therefore, nothing can well surpass the irregularity of such circumscriptions, which often wind in every direction in the most zigzag manner. One dike may include thirty or forty towns; and every farmer is obliged to repair a certain extent of his fence, proportional to the land which he occupies.

Fences.—The materials of which the fences are composed, generally consist of *fails*, which differ from *pones*, used for roofing houses, in the following respect: Fails are the thickest portions of turf that are cut, being used for the construction of walls and dikes: Pones have always a covering of grass; they are thinner than fails, and they are never used for the construction of dikes, but for the sole purpose of roofing; but so imperfect are these inclosures, which consist of turf or stone, that by the incursions of sheep, horses, and swine, they are thrown down every year.

Town Mails.—There is generally a piece of green pasturage, never dug up, that is attached to each house, which, in the ancient language of the country, was named a *setter* or *seater;* the Shetlander now names it his *town mails*. On this spot horses are always tethered, when wanted for immediate use, or upon the close of a summer's day, the small horned cattle of the country are in like manner secured, previous to their being lodged for the night within the byre. These last named animals we shall next consider.

Horned Cattle.—The black cattle of Shetland are of a very diminutive breed; a cow is said to weigh from two to three hundred weight upon an average; an ox from three to four, but not exceeding five hundred weight. These animals have long small horns, and are of a brindled white, brown, or black colour, rarely displaying an uniform hue.

Cows are kept in the house every evening during the year. In the summer they are tethered during the day time in some adjoining pasture. Upon the conclusion of the ling fishery, which is generally in August, the Shetlander repairs to his scathold, and cuts down a large quantity of grass and short heath, which he spreads abroad upon the hills to dry; it is afterwards stored within the inclosure of his *room* or *town*, being piled into stacks like hay. When intended for use, the heath is strewed along the floor of the byre, for the purpose of being well mingled with the dung that accumulates from the cows. The wet stratum is then covered over with a layer of *duff mould*, or dry decomposed moss, which substance, in like manner, remains until it is well moistened with the dung that falls, when the whole is again covered with a layer of heath; and after this manner, successive strata of heather and mould, mixed with the ordure of the animal, are allowed to accumulate to a considerable height, until the pile attains such an elevation, that its removal is necessary, in order that the cattle may find sufficient head-room beneath the roof of the byre; but how far the effluvia of putrid matters may conduce to the health of the animals that inhale the tainted atmosphere of such confined places, is a question of unnecessary discussion. When the compost is removed, it is well blended together with a spade, and is then applied to the land destined for cultivation.

The food of the cows is in general so little, that during very severe winters, numbers have been known to perish for want. When Dr. Kemp travelled through the country a few years ago, so great was the dearth of food, that he witnessed a kind of mash served up for a cow, consisting of a pail filled with boiled fish-bones, which had been broken down. Such an unnatural mess, however, though by no means uncommon in Iceland, is much less frequently seen in Shetland.

Operations of the churn.—The quantity of milk given in the day by the Shetland cow is very inconsiderable, not amounting, in the middle of summer, to more than from three to five English quarts in the day. The operation of churning takes place every second or third day. A little time before the butter is about to part from the serum, the dairy-maid throws red-hot stones into the churn, by which the separation is hastened, and rendered more complete. The attention she pays to the purity of the butter depends upon its destination,—whether it is intended for consumption within the house, or must be rendered in payment for feudal duties, or for teinds; thus the proverbial quality of teind-butter, which is fit for little else than for greasing cart-wheels, is proverbial.

Into the *bledoc* or buttermilk that remains in the churn, boiling water is poured; the caseous part, or curds, then fall to the bottom of the churn and are used for food, often instead of bread. The mixture of serum and water that is left, forms a common drink, named *bland*, which, when allowed to rest, undergoes a slight degree of fermentation, and acquires, in the course of a few months, a remarkable degree of transparency, and along with it a very acid yet agreeable taste. A similar beverage is familiar at the present day to the Icelanders, among whom it is known by the same appellation that it bears in Shetland. Another product of the dairy is obtained by adding to a quantity of sour cream some sweet milk: the mixture then undergoes a fermentation, after which the whey or serous part is poured off, and more new milk is added. The process is thus repeated several times, until the firmer part resembles a custard of a sub-acid and highly pleasant taste.

Poultry and Swine.—A very great abundance of poultry is kept on almost every farm, these being very frequently inmates of the house. The most common tenants, however, of the inclosures are the small swine peculiar to the country, which are of a dunnish-white, brown, or black colour, with a nose remarkably strong, sharp-pointed ears, and back greatly arched, from which long, stiff bristles stand erect. The hog is said to weigh from 60 to 100lb. Being often very lean, his flesh is as food proportionally coarse: but when fattened the meat is sufficiently sweet and delicate, and when cured forms excellent hams.

Horses.—The little barrel-bellied, broad backed *equuleus*, of a brown or black colour, which Buchanan has described as "*asino haud major*," is well known under the name of *Shelty*. He is left to feed on the hills during the whole year: and in the most inclement weather of winter, is never admitted within the warm walls of a stable, being frequently compelled to subsist on the drift ware that is left by the ebb. In the spring these animals are often in such a half-starved state, owing to their scanty supply of winter food, that the growth of the summer herbage becomes necessary before they can so far recover their strength as to bear a rider over the moors of the country.

The shelties are seldom more than from nine to eleven hands high. They are generally used for carrying peat from the moors or manure to the fields. For this purpose a saddle is contrived, named a *klibbar*, which differs in construction from the klibbar of the Feroe islands. The Shetland klibbar consists of two flat pieces of wood that meet on the ridge of the shelty's back, being rounded off on their summit, and connected together by means of two long attached pieces of wood, which transversely fit into each other and project upwards; the boards are then secured below by girths that pass under the animal's breast and tail, while from the two cross pieces of wood that rise from the top of the saddle, are suspended a couple of *cassies*, or baskets, made of straw. These cassies are filled with the materials intended for transportation. But when hay or any light bulky substance is to be carried, *maisays* are used, which are made of ropes prepared from *floss* or rushes, these being reticulated in meshes of some inches in width. A net of this kind is passed round the horse, so as to secure the hay or other light substance that rests upon the boards of the klibbar. This ancient saddle is also found of use when the shelty is required by the female rider to bear her to the parish kirk: she then throws over his back a native coarse manufacture of the country, woven into the shape of a saddle-cloth, and when, upon this covering the klibbar is fixed, its projecting pieces of wood, which the female holds by, form it into a kind of side-saddle.

When a journey on horseback is meditated, the Shetlander goes to the scathold, ensnares the unshod shelty, occasionally equips him with a modern saddle and bridle, and hangs on his neck a hair cord several yards in length, well bundled up, from the extremity of which dangles a wooden short-pointed stake. The traveller then mounts his tiny courser, his feet being often lifted up to escape the boulders strewed in his way, and when arrived at his destination, he carefully unravels the tether attached to the neck of the animal, seeks for a verdant piece of soil, and fixes the stake into the ground. The steed is then considered as comfortably disposed of, until his master shall return.

Cutting of Peat.—It was in an early period of the historical annals of this country that the want of wood was experienced. The first Norwegian colonists were acquainted with no other kind of fuel than that which they had collected from the forests of their own native mountains, and when Einar, Earl of Orkney, pointed out to them that a fuel was to be obtained from dried peat, he was almost deified for the discovery, having ever afterwards the honorary title prefixed to his name of Torf.

It is in the time of *Voir* or spring that the Shetlander generally repairs to his scathold for the purpose of cutting his peat. Thus, there is an ancient law in the country, "that none cut floss before Lammas-day in their own scathold, without due advertising of their neighbours belonging to the same scathold, under the pain of 40s. Scots *totius quoties*." When the natives are assembled to cast their peat, their first object is to pair off the vegetating moss, named the *feal*: this is always called *flaying the moor*. For this purpose an ancient description of spade is used, the shaft of which is long and light, while the iron-plate at the bottom of it is of a different shape, and much narrower than that which distinguishes the common spade of England and Scotland. There is one man, who, with this implement, makes a ditch seldom wider than two feet, while another is employed in disengaging the feal that has been cut, which he throws on the delver's right hand-side, in the most slovenly manner. When the moor is thus *flayed*, an ancient Scandinavian implement of husbandry is used for casting the peats, named a *tuskar*: its shaft is rather longer than that of a common spade, while to the bottom of it is affixed a sharp iron-plate, styled a *feather*, which projects from one point seven inches, and from another little more than an inch. Thus, when the Shetlander, in wielding his tuskar, pushes down the feather into the moor in a perpendicular direction, a corresponding shape and size is given to the peat that is cut; he then, with the greatest activity, lifts up each portion as it is severed, and while it rests upon his tuskar, throws it abroad on his left hand-side, or piles it in such a manner that proper intervals may subsist for the admission of air. The ditch is dug very narrow, and its depth rarely extends beyond the depth of two peats. When this labour is finished, the peats appear in loose slovenly heaps, (being but seldom deposited at the bottom of the ditch,) with the verdant surface upwards, so that vegetation is continued. With regard to the length and direction of the excavations, they are governed by no rule, the tenant having the unrestricted liberty of making what devastation he chooses upon his pasture. Often, as Mr. Shirreff in his Agricultural survey has remarked, the cuts are at right angles across a declivity, so as to catch all the surface water that runs down the slope, and to prove traps for drowning sheep; or not unfrequently the water bursts over the lower sides of the trenches, and converts the ground, for a considerable distance, into an unsightly gulley. In the course of a fortnight or three weeks after the peats have been cast, they are set up on one end, that the drying may be completed: but the close of the process is in the middle of the summer, when the Shetlanders build up their peats in large stacks near the place where they were dug, or, by means of the little shelties of the country, carry them home.

There is one practice which occurs in a few parts of Shetland, particularly in Bressay, that deserves particular notice. When a moss is but one peat deep, the inhabitants, after obtaining from it their fuel, lay the sods with which the peat was covered in a fine clay bottom, press them down with the feet, and derive from them good crops of grass, or, when broken up, good crops of corn.

Manure.—The manure intended for tillage is a midden, consisting of dung, of heather that had been cut up for litter, of sea-weed, and of earth or dry decomposed moss, named *Duff-mould.* This compost, which has been known from the remotest antiquity, is an object of such importance to the Shetlander, that the ill-judged sacrifice which he often makes in order to obtain the ingredient of earth, might be considered as exaggeration, if it were not attested by a committee of the Shetland Agricultural Society, appointed in the year 1818 to adjudge the premiums for a certain district of the country: they state, that they were concerned to observe the extent to which the pernicious practice, too common all over the country, is carried, of cutting up the uncultivated grounds in the neighbourhood of the principal farms for manure; that it happens unfortunately to be the most improvable ground which is thus sacrificed, and that one man was observed to have destroyed his very town-maills for this purpose, when the earth was not more than two or three inches deep.

When manure is to be carried to the fields, a klibbar or wooden saddle, of the form which has been described, is fixed on the back of each shelty, to which cassies or straw-baskets are appended. Sometimes the manure is carried to the land by women.

Infield and Outfield.—The arable land generally preferred for culture is described as sandy, or composed of a mixture of clay and gravel that approaches to a soft loam; but often it consists of a black mould resting on clay alone, or on clay and sand. It is usual to give to land a distinction that was no doubt introduced into the country by the Scottish settlers; that is, into *infield* and *outfield.* In Scotland, the land lying near the homestead was kept for successive years in tillage, and, under the name of *infield*, received all the manure, mixed with earth, which the farm afforded. Thus also in Shetland many inclosures near the houses have been dunged every year, and have been sown in the end of April with bear and oats for more than half a century, without ever lying fallow, or having produced a different kind of grain; but the Shetlanders have not imitated certain Scottish districts, in allowing no manure to any part of the land but that which was properly *infield.* In Perthshire, for instance, any portion of land which lay in a valley at a distance from the house, and was sufficiently free from stones, was, under the name of *outfield*, alternately kept in corn, and natural ley or weedy wastes, without receiving the smallest return of manure, except that which was afforded by cattle, when it was used for the purpose of folding. But the outfield of the Shetlander, which is often mossy, and seldom drained, has long received each year a portion of dung, mixed with duff-mould, earth, or sea-weed. The ground is slightly harrowed; it is then sown in the end of March or beginning of April with black oats. The dung which has been carried out to the land during the winter is afterwards applied to the surface of the sown ground, and not being incorporated with the soil, wastes away by the action of the sun and rain. During the next season the outfield lies fallow; and thus in alternate years it is under tillage and in ley. Sometimes the ground is two years laboured, and lies two years ley. It has been also long customary in the country to adopt in the outfield a mode of marking out beds for oats that resembles the lazy-bed way of Scotland, incidental to the cultivation of potatoes. Moss-earth, sand, &c. are thrown up from an adjacent ditch, and upon this substance oats are sown, which thrive remarkably. In the year 1750, potatoes were introduced for the first time into Shetland, when it became customary to obtain from the infield, in alternate years, a crop of this vegetable; and at the present day, oats, potatoes, and bear, are not unfrequently produced in succession. Of late years cabbages have been much less cultivated, their use as a food being superseded by potatoes.

Ploughing.—The Shetland plough is single-stilted, like one that is represented by Olaus Magnus as common to northern nations. A crooked piece of wood bent to a right angle forms the beam of the plough, which has a length of six feet, and a height of two feet and a half; the single stilt at the top of it consists of an oak stave seven feet long. Through the lower end of the beam a square hole is cut, for the introduction within it of a piece of oak about 22 inches in length, named the Mercal, to which is affixed the sock and sky. The coulter stands nearly perpendicular to the sock, while a wedge driven below or above the mercal regulates the depth of the furrow. A slender machine of this sort, which one man may lift with ease is driven by four oxen abreast. Two yokes, joined by a double rope, are laid on their necks; a large one on the two outermost animals, and a small one on the two innermost. The draught or chain with which their necks are bound to the plough is from 18 to 24 feet long. With this strange instrument two labourers take the field. The holder of the plough stands on the left of the pliable stilt. The driver or *caller*, as he is named, goes before the oxen, walking backward: the sound of his whip sets the cattle in motion: the holder of the stilt lies on with his side: the earth is turned over; the work is executed to admiration, until a large stone encounters the coulter, and then crack go the joints of the framework. All hands are now pressed into service for repairs, and the plough is again set to rights. A lash of the caller's whip again causes the beasts to resume their tardy pace. Every thing is carried on smoothly until a stiff furrow appears, when another impediment takes place. It is now necessary that the stubborn glebe should be broken down; this is accomplished: the labour of the plough is again resumed, and, by the help of heaven, is at length happily accomplished. Such being the operation of this primitive machine, every antiquary must regret that an implement of this description, elucidative of the earliest state of Scandinavian agriculture, is going fast out of use, chiefly owing to the innovating spirit of the Shetland New Agricultural Society.

But for turning up land, the plough has been often laid aside, and the ancient, slender, and long-shafted spade of Shetland, which has a blade a quarter of the breadth of the common garden spade of Scotland, and a convenient projecting piece of wood for the application of the foot, is in much greater requisition, being indeed well enough adapted for the rugged and stony ground of the country.

Reaping and Harvest.—In August, after the expiration of the ling fishery, the natives first begin to cut heath, mixed with various plants of the hills, for winter fodder. The grass is mown with a small scythe, of a construction peculiar to the country. So severe is the climate, that the corn harvest often begins very late. Instead of the crop being in the yard in the middle of September, this event rarely occurs before the end of October or even November. The corn is then cut down with a very small sickle, the sheaves are put up in small *stooks* until dry, carried into the corn yard, built in large stacks, taken into the barn when wanted, threshed with a flail, winnowed and dried on kilns.

The causes which prevent the Shetlanders from reaping the produce of their labours are various. The swine of the country, wild boars in miniature, a race of little, ugly, brindled rangers, not much larger than terriers, are too often suffered to roam abroad, and destroy the fruits of the earth. The imperfect dikes, constructed of turf or stones, easily yield to these animals, their assaults being supported by wild shelties and sheep. In the south of the island, rabbits have continued to increase the desolation of the sand-flood, which there prevails. Instead of the growth of plants, which have a tendency to resist the escape of the levigated particles of the subsoil, being encouraged, the reeds, which grow among the sand, are for the laudable purpose of making besoms, still dug up by the roots; numerous herds of swine are allowed to roam at large, and dig in the sand, while rabbits even meet with a hospitable protection.

But, unfortunately, the elements militate most against the Shetland husbandmen. Heavy gales, combining with the spray of the sea, often destroy the crops in a single night. "When the winds blow with great force," says a writer on Shetland, "the surges rise in proportion, dashing violently against the rocks. The white salt froth which is forced up against the highest promontories, mixes with the air in circulation, is carried over lands under cultivation, falls, as it passes, on the corns, dries and hardens upon them, by which its farther growth is impeded, and the most sanguine hopes of the poor farmer destroyed. The straw even, as well as the hay, becomes unfit for any purpose in husbandry." From this cause, a very distressing winter famine has not unfrequently occurred.

Mills.—The ancient quern is still used in Shetland. A hand-mill of this kind consists of two stones about 21 inches in diameter, that rest on a kind of table. Near the edge of the upper stone, is a handle which the grinder, (generally a female of the house,) seizes and turns round with a sort of centrifugal movement, whilst the left hand is employed in supplying with corn a hole in the centre. The meal then flies outwards, and drops from between the stones on the table, when it is every now and then scraped together and taken away.

Water-mills, probably as old as the time of Harold Harfagre, likewise exist. The innumerable slender rills that pay their tribute to each voe, occasionally serve to supply some small mill, the presence of which is signified by a low shed of unhewn stones, that stretch across a diminutive streamlet, over which it is possible in many places to stride; compared indeed with a water-mill of Scotland or England, the grinding apparatus of Shetland seems designed for a race of pigmies. The millstones are commonly formed of a micaceous gneiss, being from 30 to 36 inches in diameter. Under the frame-work by which they are supported, is a sort of horizontal wheel, of the same diameter as the millstones, named a *Tirl*, which consists of a stout cylindrical post of wood, about four feet in length, into which are mortised twelve small float-boards, placed in a slanting direction, or an oblique angle. It has a pivot at its under end, which runs on a hollowed iron plate, fixed on a beam. A strong iron spindle, attached to the upper end of the tirl, passes through a hole in the under millstone, and is firmly wedged in the upper one. A trough conducts the water that falls from the hill upon the feathers of the tirl, at an inclination of 40° or 45°, which, giving motion to the upper millstone, turns it slowly round. To the hopper that surmounts the upper millstone, there is a log of wood fastened, which, striking upon the uneven upper surface of the stone, shakes this repository for the corn, and makes it come out, while too quick an escape is checked by a device for lessening the size of the aperture. But sometimes there is no hopper at all, and a man patiently feeds the mill with his hand.

Bread.—From the oats and bear raised by the natives, a very coarse and ponderous bread is made; but sometimes the grain, after it has been ground by the quern, is passed through a sieve with much care, and is then formed into small cakes, very round and thick, named *Broonies.*

Sheep.—The wild sheep of the country, of true native breed, resemble in their form, their nimbleness and fleetness, the argali, or wild sheep of Siberia. They are celebrated for their small size, and known by naturalists under the name of the *oves cauda brevi*, that at the present day range among the mountains of modern Scandinavia and Russia: in very few places are the Shetland sheep mixed with a Northumberland breed. Their colour is exceedingly various, being grey, black, dunnish brown, white, or they are streaked and speckled in the most curious manner with a combination of various tints and shades. Besides the distinctive character which they possess, from the shortness of their tails, their horns also are very small. In summer, they collect from the pastures that kind of food which the natives still designate by the ancient Scandinavian term of *Lubba*, expressive, in the original sense, of coarseness or roughness. Lubba consists of those common productions of the hills which are found where heath is absent; thus it comprises several kinds of Carices, of *Nardus stricta*, *Eriophoron* or cotton-grass, which is the food of sheep in spring, and of other plants. *Burra*, which is the provincial name given to the *Juncus squarrosus*, serves the animals during the winter. But besides these plants, the *Erica vulgaris* and *tetralix* are the last resources. The sea also affords provision for the wild inhabitants of the Shetland scatholds, and there almost appears to be a peculiar instinct, which, in the severer months of the year, prompts them, upon the ebbing of the water, to fly to the shore, where they remain feeding on marine plants until the flow of the tide; they then return to the hills. The diseases to which they are subject are as various as in the several districts of Scotland; thus they are afflicted at times with what the Scotch call *braxy*, or an inflammation in the bowels, with the *sturdy*, or water in the head, with blindness, from which they frequently soon recover, and with the rot. About forty or fifty years ago, the scab was unfortunately introduced into the Mainland, and proved very fatal, reducing the number of these animals in some places to a third. The natural enemies of the young lambs are eagles (named Ernes), ravens, hooded crows, and the black-backed gull. Of these, the sea-eagle *(Falco ossifragus)*, and the ring-tailed eagle *(Falco fulvus)*, are the most formidable: nor is the *Vultur albicilla*, or white-tailed eagle, unknown as an assailant of the Shetland pastures. Other formidable invaders of the flocks are the swine, which are suffered to roam uncontrolled over the scatholds, and to dye their tusks in the blood of young lambs when just dropped.

The sheep are allowed to run wild among the hills during the whole of the year, herding and housing being almost wholly unknown in Shetland. No food is provided for the poor animals during deep falls of snow, nor is there any friendly shepherd to drive them to some *buill*, or dry place of shelter, where the lives of numbers of them might be preserved. Upon the approach of a storm, a sense of common danger causes them to congregate for self defence beneath the shelter of some rock on the sea shore, where they protect themselves from the cold, by the warmth which arises from their bodies during a crowded state; or, if they are covered with snow, hunger impels them to tear portions of wool from each other's backs.

Whenever it is requisite to catch any sheep, they are hunted down with dogs, trained for the purpose, which Wallace, the historian of Orkney, describes as a sport both "strange and delectable." When a flock is in sight, the Shetlander seizes hold of his *had-dog*, (the ancient Scandinavian name for a sheep-dog,) and points out to him a particular sheep. The dog then bounds after his prey: the flock are immediately alarmed, but soon perceiving the particular individual that is the intended victim, they restrain their flight, and allow the pursuit to be uninterruptedly confined to one object of selection. The poor animal is then chased from hill to hill, until he falls into the power of his pursuer, who is taught to seize him by the foot, the nose or the ear; or perhaps he perishes by tumbling over some precipice, where he is either dashed to pieces upon the stones, or falls into the sea.

As the sheep of one scathold, island, or parish, constitute a promiscuous flock, which may belong to more than a hundred individuals, it is remarkable that more frequent disputes should not have arisen, respecting the rights of possession. No property of this kind was ever secured without the means of had-dogs, it was therefore a proper regulation that none of these animals should be kept in secret. The next object of the ancient legislators of the country, was to see that each dog which might be kept to take sheep, was under proper control, and that he was not what was named a *running dog*, whom the old acts of Orkney characterized as "a dog that runs frae house to house, or through the country chasing the neighbours' sheep;" such a dog would be not only prompt to seize a sheep for his master, but would have little hesitation in providing mutton for himself. But since this act was framed, a sort of demoralization has taken place in the character of the canine race of Shetland,—and it would be difficult to say, at the present day, what dog was not a *running dog*. Mr. Shirreff, in his agricultural survey of the country, has complained with great justice, of a rapacious ranger of this kind that came under his observation, who, without any order from his master, would break off at the first unfortunate sheep that he saw, throw him down, give him a good biting, and then return, unchided for his cruelty to his owner, who seemed to consider the treatment as a matter of course. "The fact is," adds the narrator, "that there is so little profit arising from sheep stock, in the present state of landed property, compared with fishing, that the land-owners and tacksmen do not put as much value on a sheep, as in Great Britain on a hare."

When sheep were considered of more value than they are at present, it was of great consequence that no wild or *scar* sheep should be at large in any particular district, which might have the tendency of dispersing a flock. But, at the present day, most of the sheep of the country are so wild, that the old distinction of scar sheep seems to be nearly lost; and as summer herding is almost unknown, these animals are by no means in a progressive state of tameness.

Again, as the seizure of sheep took place by means of dogs, it was necessary for the preservation of individual property, that no capture should be private. Every proprietor in claiming his share of a promiscuous flock, had a particular mark of his own, that was formed by various kinds of incisions, which were inflicted on one or both of the animal's ears; these received such names as a shear, a slit, a hole, a bit out of the right or left ear, before, behind, or from the top. In this way an infinite variety of private marks was devised, but none of these could be lawfully used without the sanction of the bailiff of a district, or civil officer, whose duty it was to insert in a public register a descriptive account of all the tokens which any individual wished to adopt, for the recognition of the particular share which he had in a joint stock of sheep. It was, therefore, a proper regulation, that the marking of sheep should be a public act, and that no property could be thus claimed, but in the sight of a whole district. The period appointed for marking lambs, was when all the proprietors for flock were assembled for the purpose of *rueing*, or tearing off with the hand the wool from sheep, after it had naturally begun to loosen: this was about the middle of May, or near midsummer. The time of marking and rueing is still publicly proclaimed, and on the day fixed, all the men of a district turn out, and drive their common flock, without any preparation of washing, into rude inclosures, named *punds* or *crues*. If the *punding* be delayed too long, the sheep become so wild that they are hunted down and taken by dogs: but when at last they are secured within the *crues*, the civil officers (who were in former days the bailiff and ranselmen of a district) appear as arbiters of all disputes. Each owner now searches the crue for his property, which the civil officers confirm by their register, and also claims the lambs that are produced from the particular stock that he possesses, in order that his right to them may be secured by a proper ear-mark. At the same time the general *rueing* begins; the proprietor seizes hold of each sheep in turns, and, disdaining the use of shears, pulls up the wool by the roots from the struggling animal's back; and if the fleece has not begun to naturally loosen, which is too frequently the case, the operation is attended with excruciating pain. Such a cruel mode of fleecing, which is of true Scandinavian origin, is at the present day retained in Iceland, as well as in Shetland.

Thus it is shown, that no claims of individual property among sheep could, by the ancient laws of Shetland, be sanctioned, if made in secret. According to the old act, if any person use a sheep-dog, and run therewith after his own sheep unaccompanied; if he mark, rue, or take any home without showing the mark, or if he kill a sheep without first showing the mark to a ranselman, "or other honest man," he was liable to be fined, and, for a repetition of the offence, to be punished as a common thief, and prevented in all time coming from keeping a sheep-dog. It is a pity that, in reference to the undivided state of the scatholds, the salutary tendency of these good laws has not been perpetuated. It has been remarked by Mr. Shirreff, that the Shetlander, who may possess the best sheep-dog, is by repute the greatest sheep-owner in Shetland; and that thieves are greater enemies to the sheepstock than either defect of food or the inclemency of the weather:—he produces as an example, some natives of Yell, who, for several years, had contrived to secure for themselves, on an average, two sheep each week.

The carcass of the Shetland sheep is very small, being said not to weigh more than thirty pounds. The flesh is peculiarly sweet, and may rival in flavour the best Welsh mutton, that is so esteemed in England. But, owing to the crooked policy of proprietors leaving none but the worst lambs, which are unacceptable to the table, for breeding rams, the race of Shetland sheep has been long suspected to be in a state of degeneracy. The wool is short, yet very fine From the amount of the tithes paid in this commodity to the Pope, so early as the 14th century, it has been supposed that the breed of sheep in this country was much greater in ancient times than at the present day. Their wool, which was manufactured into the coarse cloth, named wadmel, afforded the means this ancient colony of Norway possessed of paying the tribute which was due to the King of Denmark, under the title of *scat*. No walk-mills existed, and the web was sometimes thickened by the hands and feet, and at other times it was securely spread along the bottom of a narrow passage among the rocks through which the tide ebbed and flowed, so that the action of the sea, which, in such pent up channels was much increased, might *walk* or full the cloth. When thus prepared, the fabric acquired the name of *Tuvaca-thor*. Early in the last century, the Earl of Morton ordered a walk mill to be built, but the manufacture of wadmel was then much on the decline. There is at the present day, a considerable quantity of white woollen cloth made for home use, which supplies the place of linen.

The chief use to which the Shetland wool is applied is for the stockings and gloves that are knit. The fleece of the sheep, which is remarkably soft, has been wrought into stockings so fine, that they have been known to sell as high as 40*s*. per pair. The price of the most common quality, however, is about three or four shillings, whilst they are manufactured so coarse as to be worth no more than fivepence or sixpence. The knitted covering for the head, resembling a common double nightcap, which the master of a family wears, is an object of the Shetland manufactures. The variegated and fantastical colours which it displays are produced by native dyes. The lichen *Tartareus* yields a lit or dye, that was formerly an object of commercial notice, named Korkelit; it is scraped from the rocks after a fall of rain, reduced to a powder, steeped for many days in stale householdley, and kneaded into balls of the weight of a pound and a half, which are dried. When boiled with cloth, it communicates to cloth a reddish purple colour. The lichen *Saxatilis* (provincially named *Old man*,) when treated partly in the same way, yields a yellowish or reddish brown colour. The lichen *Parietinus* (named by the Shetlanders *Scriota*) dyes cloth of an orange colour. The lichen *Omphaloides* is also occasionally used for the purpose of affording a brownish or blackish purple colour. From a collection of plants, among which is the marygold, a yellow colour is procured. A good black is extracted from the mossy earth of the country, when found much impregnated with bog iron ore. Another sort of woollen cloth manufactured is expressed by the term *Kiverins*, or *coverings* for the beds of the peasantry. These are composed of very coarse materials. Sometimes they form a ground, into which different coloured worsteds are sewed, so as to display various figures of more or less beauty, according to the taste or ingenuity of the operator. Manufactures of this kind are then used for rugs and hearth-covers; when intended for better coverlids, the figures of them are, with a view to warmth, produced by thicker threads, the thrums of which are left about two inches long. The last use for which kiverins are designed, is for saddle-cloths; these are placed under a klibbar, when the shelty is mounted by a female rider. The skins of the Shetland sheep are in requisition, for the purpose of affording the fisherman a sort of surtout, that covers his common dress. The *tormentilla erecta* has been long used in the process of tanning.

Pasturage.—Regarding pasturage little need be remarked. The best pasturages are to be found where limestone prevails. Natural red and white clover, with ryegrass and the *Vicia Sepium* may be observed growing spontaneously in many parts of Scotland. Many of the islets of the sea, named holms, afford a very fine succulent pasture for black cattle, and for sheep destined for the table, such spots being indeed the chief places where they are fattened. So great indeed is the value attached to these holms, that, by the ancient laws of the country, trespasses on them are punished with severity.

The famous holm of Noss deserves particular notice. This holm, which is about 500 feet in length, and 170 in breadth, rises abruptly from the sea in the form of a perpendicular cliff 160 feet in height. The chasm which intervenes between it and the no less precipitous banks of Noss is 65 feet across. The original temptation to reach the holm was to acquire possession of the eggs of the numerous sea birds by which it was annually frequented. A fowler succeeded in scaling the cliff, bearing with him two stakes which he fixed into that part of the bank which was nearest to the opposite rock. When this was achieved, a firm cordage was applied to it so as to form the medium of transport from bank to bank. In the next place an oblong box named a cradle was contrived, through the extremities of which two holes were made in order to allow ropes to pass along each of its sides. By this means, the machine was properly slung. The cradle is large enough to contain one man and a sheep; and as there is a slight descent from the cliff to the holm, the man easily moves forward, and, by means of the lateral cords, regulates the celerity of his conveyance. In returning, he is assisted by persons stationed on the opposite bank, who draw him up by means of a rope that is for this purpose attached to the cradle.

Kelp.—Very little kelp is produced in Shetland. For the preparation of it, a hole about six feet long, and about half the dimension in breadth, is dug in the earth for the reception of the sea-ware, and when the ignited matter acquires a glutinous consistency, it is stirred up with a rake, and then allowed to cool.

Shetland Agricultural Society.—The institution of this very useful society took place a few years ago, and a better system of farming may be in time expected. The attention of the gentlemen of the country is laudably directed to a division of commons, as the groundwork of all agricultural improvements; but in the meantime, the premiums that are given for the growth of turnips, which are found to succeed remarkably well,—for the breaking out of waste ground,—for the improvement of live stock,—and for the cultivation of artificial grasses,—already promise the most beneficial results. Not long ago leases were unknown; and although annual tenants still continue to be the greatest portion of land-cultivators, yet much longer terms may in many parts of the country be easily procured.

V. Fisheries of Shetland.

After having described the husbandry of Shetland, we shall next introduce the Shetlanders to our readers as fishermen, which is the true character of this remarkable people. But first we shall notice the construction of their boats.

Boats.—The Scandinavian origin of the natives is illustrated in the form and lightness of their boats or yawls, the planks of which are still imported from Norway, so modelled by the hands of the carpenter, that, when they arrive in Shetland, little more labour is required than to put them together. These boats are generally about eighteen feet in keel, and about six in beam; they carry six oars, and are furnished with a square-sail. Their extreme buoyancy, and the ease with which they cut the waves, are the circumstances insisted on by the fishermen, as rendering their construction particularly adapted to the stormy seas upon which they are launched. Many of the boats are, however, less in size, being adapted only for four oars.

Fishery for Sillocks.—The annunciation of a fine Shetland evening is always expressed by numerous boats covering the surface of each bay, the crews of which are engaged in angling for the small fry of the coal-fish, or *gadus carbonarius*, known in Shetland by the name of Sethe. These swarm in myriads within the numerous creeks and sounds of the Northern Archipelago. They first appear in May, scarcely more than an inch long, and in comparatively small quantities, but gradually increase as the summer season advances, when about August they become very abundant, measuring at that time from six to eight inches in length. During this time the fry are distinguished by the name of Sillocks. About the month of March ensuing, they are found to have grown to the length of about fifteen inches, when they acquire the name of Piltocks. After this period they thrive very fast, attaining the ordinary size of the cod-fish: a profitable fishery then takes place of them in deep tideways, under the name of *Sethes.* Although the fry of the sethe frequent all parts of the bays, yet the fishermen assert that their favourite resort is among the constant floods and eddies which occur near sunken rocks and bars, that are alternately covered and laid bare by the waves. The fishery for sillocks or piltocks is, therefore, occasionally fatal to the more adventurous boats, which, in quest of them angle in such perilous situations. But, besides frequenting tide-ways and currents of all kinds, these small fry appear to covet the security of thick plantations of sea-ware, within the shelter of which they are protected from the keen look-out of their natural enemies of the feathered race.

There is, probably, no sight more impressive to the stranger who first visits the shores of Shetland, than to observe, on a serene day, when the waters are perfectly transparent and undisturbed, the multitudes of busy shoals, wholly consisting of the fry of the sethe, that Nature's full and unsparing hand has directed to every harbour and inlet. As the evening advances, innumerable boats are launched, crowding the surface of the bays, and filled with hardy natives. The fisherman is seated in his light skiff, with a rod in his hand and a supply of boiled limpets near him intended for bait, or he occasionally angles from the ledge of a rock. A few of these limpets are carefully stored in his mouth for immediate use. The baited line is thrown into the water and a fish is almost instantaneously brought up. The finny captive is then secured; and while one hand is devoted to wielding the rod, another is used for carrying the hook to the mouth, where a fresh bait is ready for it, in the application of which the fingers are assisted by the lips. The same manual and labial routine goes on with remarkable adroitness and celerity, until a sufficient number of sillocks are secured for the fisherman's repast. But, in any season of the year, the limpet bait may be superseded by the more alluring temptation of an artificial fly. The rod and line are then handled with a dexterity not unworthy the fresh-water talents of a Walton or Cotton. It may also be of some interest to "brothers of the angle," as Isaac Walton calls his companions, to learn that the Shetland fly, to which sillocks rise, is rarely intended to represent any particular species observed in nature. The Shetlander assures us confidently, that two wings are necessary for the insect, the fish distinguishing nothing more. The inference is, that there is an intellectual gradation among the finny tribe, and that the fry of the sethe are not so clear-sighted as the more wary and knowing inhabitants of pellucid trout-streams. For the construction of the bait, the white feather of the common gull, or of the goose, is sometimes used. But the fibres of the tail or back fin of the dog-fish, which, when cleaned, shines like silver, is preferred to any other kind of materials, being considered by the fishermen as particularly enticing. The fly is attached to a white hair line, and when this cannot be procured, to a brass wire.

So easily are captures made of these small fry, that while active manhood is left at liberty to follow the more laborious occupations of the deep water fishery, or to navigate the Greenland Seas, it is to the sinewless arm of youth, or to the relaxed fibres of old age, that the light task is consigned of wielding the sillock-rod.

The lavish abundance in which the fry of the sethe visit the inlets of Shetland, affords sufficient matter for contemplation to the reflecting mind. Among islands, the severe climate of which is too often fatal to the labours of husbandry,—where the reduced rate of labour, resulting from the debased political state of the country, precludes the purchase of meal at a cost much above the usual price in commercial districts,—under such circumstances, what is there that can possibly render a few insulated rocks capable of supporting a population of more than 20,000 souls? The reply is not difficult. That kind Providence,

"—————who pours his bounties forth
"With such a full and unwithdrawing hand,
"Thronging the seas with spawn innumerable,"

has not neglected the obscure shores of Hialtland. Amidst the occasional visitations of famine, the severity which overwhelms in despair the commercial population of the south, prompting to every act of civil insubordination, the Shetland peasant has only to launch his skiff on the waters which glide past his own dwelling, and he finds that a bounteous supply awaits him at his very door. The fry of the sethe, in a scarce winter, has constituted the breakfast, the dinner, and the supper of the Shetland peasant. The livers are also converted to an important use; being collected in a tub, they are boiled for oil, and the overplus is sold. "Thus," says a female writer of Thule (Mis Campbell) with much eloquence, "the two articles most required in a climate like that of Shetland, have been abundantly provided,—these are fire and light. The natives have for their labour, as much fuel as they can consume. Whatever wants may be in a Zetland hut, their is seldom or never a good fire wanting. The fish which they catch, almost at their doors, supply them with the means of light. The cold and darkness of their long winters are thus mercifully robbed of their terror; and in the mud-walled cottage of the Zetlander, the providence of God is as conspicuous, and as surely felt, as in those favoured lands which flow with milk and honey, and where the sun shines in all its glory."

Cole fishery.—The *gadus carbonarius*, cole-fish, or Shetland sethe, is the sillock full grown. The fish is of a large size, sometimes attaining the length of three feet, having a small head, sharpened snout, and a lower jaw exceeding the upper in length. Being a great frequenter of tide-ways, the rousts of Sumburgh and Scaw, where conflicting tides meet, offer for him attractions of no common kind. Cole-fish are here found in great numbers; while in quest of them, the dauntless Shetlander launches his light skiff among the white waves of contending tides. The manner in which the fishery is conducted, is well described in a pamphlet, published A. D. 1787, entitled "Considerations on the Fisheries in the Scottish Islands."

"The yawl contains three and sometimes four men, for the cole-fishery. Each of the boats is rowed by two men; the others are placed one at the stern and another at the head, with floating lines thrown out on the tide-side; the hook being baited with the whitest part of the belly of the cole, cut nearest to the size of a herring. The rowers direct the boat as close to the edge of the broken water as they can with safety; for were they to fall into the tide they must perish, as no assistance could be given them. They exert their utmost strength on this occasion to keep the hook always on the surface, whilst the fishers fix their eyes on the bait, as the more the water is raised by the force of the tide, the more successful the fishing proves, as the deceit is better concealed. Whenever the coles come to the surface of the water, they are then in quest of herrings; and if the fishers find any in their stomachs, they deem it a treasure, and apply small pieces of it over the other bait. When the tide is run, and the fish follows, he drags for it by putting to the line a lead or *sinker*, which is commonly a pound and a half weight; this being let down into the water to the depth of twenty fathoms or more, he hauls it up with all quickness possible. Thus, the deception takes place most powerfully; and the fish, aiming at the herring in motion, and seemingly running away, is the more easily taken. This species always plunges deeper into the waters, in proportion as the tide wears weak."

The taste of the cole-fish, when in a fresh state, is not relished; but, when cured for sale, is better. It is sent to the Scotch market, where it sells cheaper than cod or ling.

Ling-fishery.—This is the great fishery of Shetland. It has been explained, while describing the causes and nature of fishing tenures, that the landlord allows his yearly tenant to be in debt to him for the boats and fishing lines necessary for the taking of ling, but requires from him the obligation, that all the fish which he may take during the customary season, shall be sold to him at a stipulated rate; which complicated relation of landlord and tenant has ever since prevailed in the country.

It is well known that the ling frequent the deep vallies of the sea: the cod resort to the high banks. Another fish caught along with the ling, and resembling it, is the *gadus brosme*, or *Torsk*, commonly named *Tusk*: but it does not obtain the same length. In this fishery, cod is also taken, though sparingly.

The ling fishery commences in the middle of May, and ends on the 12th of August. The fisherman then equips himself in his boat dress, which is not a little striking. A worsted covering for the head, similar in form to the common English or Scotch nightcap, is dyed with so many colours, that its bold tints are recognised at a considerable distance, like the stripes of a signal flag. The boatmen are also invested as with a coat of mail, by a surtout of tanned sheep skin, which covers their arms, and descends from below their chin to their knees, while, like an apron or kilt, it overlaps their woollen *femoralia*:—for with the latter article, it is needless to observe, the Shetlander is better provided than the Highlander. This sheep-skin garb has generally an exquisite finish given to it by boots of neat-skin materials, not sparing in width, reaching up to the knees, and altogether vying in their ample dimensions with the noted ones of Charles the Twelfth. A nobleman, who visited Shetland a few years ago, was indeed so struck with the fishing-garb of the natives of the place, that he afforded it a place in his museum, at no remote distance from kindred illustrations of the habits of the Esquimaux or of the New Zealanders. This leathern dress is certainly of Scandinavian origin: a similar one is still worn in the Isles of Feroe, and Bishop Pontoppidan describes the same as being common in his time among the peasantry of Norway.

For the prosecution of the ling fishery convenient sites on the coast are selected. The fishermen are allowed by law to build for themselves huts on any site which may be uninclosed, uncultivated, and at a distance of not more than 100 yards from the high water-mark. These are severally constructed of rude stones, without any cement, being no larger than is sufficient to contain a boat's crew of six men. They form the roof of thin pieces of wood, on which they lay turf; they then strew a little straw upon the ground, in order to snatch from their severe labours a short repose. One of the most noted of these fishing stations is a narrow isthmus of low marshy land, that connects the peninsula of Feideland to the Mainland. Here are interspersed, with all the disorder of a gypsy encampment, a number of these savage huts, named *summer lodges*, and in the centre of them is a substantial booth, used by a factor for curing fish. Feideland is a place possessing no little interest; a remarkably busy scene being presented by the numerous crews sailing to the Haaf, or returning from it laden with fish. Some men are busily engaged in weighing the stock of ling, cod, and tusk, as it is brought in to the factors; others in spreading their lines on the rocks to dry, or in cooking victuals for their comrades, who are employed on the haddock grounds, or in brushing, splitting, and salting the fish that are brought to the door of the booth.

The ling fishery will be now described as it is prosecuted at THE HAAF.

The *Haaf* is a name applied to any fishing-ground for ling, cod, or tusk, on the outside of the coast. The men employed are from 18 years of age and upwards. On the 25th of May, or on the 1st of June, the fishermen repair to their several stations. They either endeavour, with rod and line, to procure for bait the fry of the cole-fish, of the age of 12 months, named piltocks, or they obtain at the ebb muscles and limpets; and then going out to sea six miles or more, lay their lines for haddocks, and after obtaining a sufficient supply of these fish, reserve them for bait. When piltocks or haddocks cannot be procured for bait, which is a rare circumstance, halibut, cod, tusk, and even ling are substituted.

The Feideland Haaf being 30 or 40 miles from land, the fishermen endeavour to leave their station in the morning of one day, so as to be enabled to return in the course of the day following. And if, owing to boisterous weather, they have suffered long detention in their lodges, the first boat that is launched induces every weather-bound crew to imitate the example; it is therefore no unusual circumstance to see, in a fleet of yawls, all sails set and all oars plied nearly at the same instant of time. When, after a tug of 30 or 40 miles, the crew has arrived at the Haaf, they prepare to set their *tows*, which is the name by which they designate the lines that are fitted with ling hooks. Forty-five or fifty fathoms of tows constitute a *bught*, and each bught is fitted with from nine to fourteen hooks. It is usual to call 20 bughts a *packie*, and the whole of the packies that a boat carries is a *fleet of tows*. Thus, while a boat in the south or east of Shetland carries only two or three packies, a fleet of tows used on the Feideland Haaf amounts to no less than six, these being baited with seldom less than 1200 hooks, provided with three buoys, and extending to a distance of from 5000 to 6000 fathoms.

The depth at which ling are fished for varies from 50 to 100 fathoms. In setting the tows, one man cuts the fish used for bait into pieces, two men bait and set the lines, and the remaining two or three row the boat. They sink at certain distances what they call *cappie-stanes*, the first that is let down being called the *steeth*. These keep the tows properly fixed to the ground. When all this labour is finished, which in moderate weather requires three or four hours, and when the last buoy has floated, the fishermen rest for nearly two hours. It is here lamentable to think, that their poverty allows them nothing more for sustenance than oat-meal bread baked, and a few gallons of water.

At length, one man, by means of the buoy-rope, undertakes to haul up the tows,—another extricates the fish from the hooks, and throws them in a place near the stern, named the shot,—a third guts them, and deposits their livers and heads in the middle of the boat. Six to ten wet lings are about a hundred weight, and hence six or seven score of fish are reckoned a decent haul,—fifteen or sixteen a very good one,—twenty scores of ling are rarely caught; but, in such a case, garbage, heads, and small fish, are all thrown overboard, nor can these lighten the boat so much as that she will not appear, according to the phrase of the fishermen, just *lippering* with the water. When all the tows are heaved up, they are deposited in the bow of the boat.

If the weather be moderate, a crew does not need to be detained at the Feideland Haaf more than a day and a half. But too often a gale comes on, the men are reluctant to cut their lines, and too many females have to lament the loss of a husband or of a son at the distant Haaf. The dangers there encountered are the frequent theme of the Shetlander's conversation, and his recital of them beguiles the tedious hours of a long winter's evening.

About sixty years ago decked vessels, named succouring vessels, were employed to obviate these dangers. They accompanied the boats to the Haaf, and gave opportunities to the men to procure refreshment and sleep. But from mismanagement the plan was abandoned.

During the fishing-season there is full employment from the Monday morning until the Friday or Saturday following, but few hours for rest. On the return of a boat from the Haaf, the fishermen are first engaged in spreading out their tows to dry; a part of the men catch piltocks with a rod and line, or procure other kinds of bait at a distance from shore: others again mend the tows and cook victuals for the next day's journey to the Haaf. Owing to all these successive and rapid demands on the time of a crew, their sleep seldom exceeds two or three hours in the twenty-four.

The fish are next conveyed to their destination for the purpose of being dried. A beach, formed by large water-worn pebbles cast from the sea is selected, or, in the absence of this convenience, an artificial beach of the same character is constructed, often at a considerable expense.

The curing and drying of fish is conducted with great regularity. When a boat arrives, the ling, cod, and tusk that have been taken at the Haaf, are in a gutted state, and with their heads taken off delivered by weight to the factor. A *splitter*, as he is called, with a large knife, cuts a fish open from the head to the tail, and takes out half the back bone next the head: he then hands it over to the *washer*, who, with a heath brush, and the assistance of the sea water, clears away every particle of blood. When all the fish are in this way split and washed, they are allowed to drain; after which comes the *salter*, who places at the bottom of a large wooden vat a stratum of salt, and over it one of fish with the skin-side undermost, until the chest is filled with alternating layers, and above all are laid heavy stones to keep the fish under the pickle. After remaining in the vat some days, they are taken out, well washed and brushed in a direction from the shoulder to the tail, and put up in small heaps called *clamps*, in order to allow the water to drain off. The fish are next spread out with the skin-side undermost, and exposed to the action of the sun, on a beach composed of round stones, where they are again clamped, and thus alternately spread out, turned, and disposed into piles of a gradually increasing size, until dry. They are afterwards built into a large stack named a *steeple*: and, for the sake of equal pressure, the steeple is again taken down and rebuilt, by which means the fish that were the uppermost in one steeple, are the undermost in another. When the drying, or *pining* as it is called, has been completed, which is indicated by a white efflorescence on the surface, named the *bloom*, the fish are transported to a dry cellar lined with wood, and there piled up closely, or shipped off immediately to a market. A well cured fish is said to be of a greenish-white colour, and when held in the light is translucent.

Shetland Cod Bank.—The Shetland Cod Bank is described as having a breadth averaging from fifteen to twenty miles, as commencing from the west of Westray, in Orkney, and as having been traced in a direction nearly north by west, until Foula lies somewhere about east by south; but it is very doubtful if its extent be known. The depth of the water on the bank is estimated from forty-six to seventy fathoms, its surface being in some places rocky, and in others sandy: it is also covered with buckies, mussels, and razor-fish.

There can be little doubt but that this bank was known to the Dutch and to other early enterprisers who resorted to the Shetland coast; but owing to the languid state of the British fisheries during the close of the seventeenth and commencement of the eighteenth century, it was at last forgotten that ever such a valuable resource existed.

It was long after the departure of the Dutch from the Shetland coast, that the cod fishery, by means of decked vessels, was languidly revived. About ten or twelve years since, a few vessels, from six to thirty-five tons burthen, and carrying from six to eight hands, prosecuted a fishery for cod off the coasts of Shetland, using hand lines, baited with two or three hooks. They seldom went farther to look for fish than the immediate neighbourhood of Foula or Fair Isle; their search was highly desultory, and their success proportionably uncertain; it rarely happened that vessels of only ten or thirty tons, after being employed a week in fishing, returned to their several harbours, like the Dutch doggers described by an old English writer, "so full laden as they could swim."

About nine years ago, one or two fishing sloops accidentally met with the bank: and Dr. Hibbert, who was then conducting his geological surveys of Shetland, instituted particular inquiries relative to its situation, extent, and productiveness, and first communicated the discovery to the public. He remarked that "the discovery of the cod bank had already proved of great importance to the country: employment having been given to many seamen, and an opportunity afforded them, by purchasing small shares of vessels manned by themselves, of investing, to the greatest advantage, the profits of their severe labours in remoter climates; that the improved state of our coasting navigation justified the expectation, that from this source, an economical and nutritious food would eventually come within the reach of the populous districts of our manufacturing counties, the alleviation of whose wants has always actively engaged the attention of the most enlightened of our countrymen."

This prediction has been fulfilled. Before the Bank was discovered, only four or five vessels belonging to Shetland were employed in the cod fishery. Three or four years afterwards no fewer than forty were upon the Bank, who met with the greatest success whenever the weather was favourable; and during the summer of 1826, the following very grateful intelligence has appeared through the medium of the public journals.—"The cod fishery in Shetland this season has been uncommonly successful. In one week lately there were 50,000 cod caught by the vessels employed in the deep sea fishing, and we understand that they have been even more successful since that time. Independently of the fishings carried on by proprietors and their tenants, and in boats, there are at present fifty-seven decked vessels engaged in this department of the Shetland fisheries, giving employment to nearly 600 seamen; and, including these, the persons altogether engaged in it are about 1500 or 1600. The value of the vessel is from L.200 to L.500 each. They belong generally to the fishermen themselves, and were purchased with the fruits of their industry. This branch of the fishery has sprung up within the last twelve years; so that, besides the support which their adventures have afforded to them and their families, and the profits derived from this employment, property in shipping to the amount of nearly L.20,000 has been created by this national and important branch of industry, and is now enjoyed by the Shetland fishermen. A new regulation has been adopted by the fishery board, which is strictly enforced,—that all the fish shall be put in salt within forty-eight hours after being caught; so that only a perfectly good and wholesome commodity can now be brought into the market from that country."

It has been always supposed that the cod prepared in Shetland will maintain its pre-eminence over that of other places. The Newfoundland fishermen are described as exposing their fish, after it has been salted, on standing flakes, made by a slight wattle, and supported by poles often twenty feet from the ground. But the humidity is not near so well extracted from the fish as when, according to the Shetland method, they are carefully laid out upon dry beaches, the stones of which have been, during winter, exposed to the abrading action of the ocean, and are thus cleared from vegetable and animal matter.

The Shetlanders have been very successful in obtaining the prizes offered by the commissioners for the fisheries in Scotland, who offer annually rewards for the greatest quantity of cod taken in vessels of sixteen tons or upwards.

Herring Fishery.—The herring fishery carried on by the Dutch off the Shetland coast was in ancient times an undertaking of the greatest importance. In the year 1633, there were 1500 herring busses, each of eighty tons burden, and a fleet of dogger boats, to the number of about 400, each of sixty tons burden; but owing to wars and other causes these gradually dwindled away, until in the year 1774 the number of Dutch vessels only amounted to 200. The diminution even went on until the fishery scarcely deserved a name; since the last peace some attempts have been made towards its revival.

The commercial intercourse resulting from the annual visits paid by the Dutch greatly assisted the Shetlanders in struggling for a bare subsistence, when the weights and measures of their country had been raised by the hand of power to more than twice their ancient standard.

In 1750, the British government first directed their attention to the herring fishery; and a company incorporated in the same year, entitled, the *Free British White Herring Company*, fitted out vessels that visited the Shetland coasts. They were, by means of bounties, so feebly encouraged by the British government, that the twenty busses which they at first owned gradually dwindled to eight, at which number they stood for several years. The undertaking was eventually given up, after the loss of half a million of money sterling. Lately, the herring fishery of Britain has revived under much greater encouragement, but it is generally conducted off more southerly coasts of Britain than those of Shetland. A few vessels have been fitted out for the purpose from Lerwick; but the herring fishery is by no means a favourite pursuit in this country.

Capture of the Delphinus Deductor, or Ca'ing Whale.—An interesting frequenter of the Shetland seas is the large animal lately named in systems of natural history *Delphinus deductor*, styled by the Shetlanders the *Ca'ing whale*, and by the natives of Feroe the *Grindaqualur*. Adult whales of this kind, which have been often slain on the sands of the Voes in Shetland, seldom exceed twenty to twenty two feet in length. They are of a shining black colour, though frequently white or grey about the belly. The skin may rival in softness the texture of silk. The head is round, short, and thick, having the under jaw shorter than the upper by three or four inches. The eyes are remarkably small; the teeth, which are of the average length of an inch, and of a sharp subconoid form, vary with the age of the animal, being, in the largest, about twenty-four in number. There is a blow-hole near its neck, from which it is able to spout water to the height of a few feet. It has a tail that is cleft and vertical, a short stiff dorsal fin, and two long narrow pectoral fins. The females have two nipples, although they are much concealed by an adipose substance. These whales often appear in a gregarious concourse. We shall quote Dr. Hibbert's account of the capture of these animals: "I had landed at Burra Voe in Yell, when a fishing boat arrived with the intelligence that a drove of Ca'ing Whales had entered Yell Sound. Females and boys, on hearing the news, issued from the cottages in every direction, making the hills reverberate with joyful exclamations of the event. The fishermen armed themselves with a rude sort of harpoon, formed from long iron-pointed spits;—they hurried to the strand, launched their boats, and, at the same time stored the bottom of them with loose stones. Thus was a large fleet of yawls soon collected from various points of the coast, which proceeded towards the entrance of the Sound. Some slight irregular ripples among the waves showed the place where a shoal of whales was advancing. They might be seen sporting on the surface of the ocean for at least a quarter of an hour, disappearing, and rising again to blow. The main object was to drive them upon the sandy shore of Hamna Voe, and it was evident that the animals, with the enemy in their rear, were taking this direction: most of the boats were then ranged in a semicircular form, being at the distance of about 50 yards from them, with the exception of a few skiffs which acted as a force of reserve, keeping at some little distance from the main body, so as to be in instant readiness to intercept the whales, should they change their course. The sable herd appeared to follow certain leaders, who were now inclined to take any other route but that which led to the shallows on which it was intended they should ground. Immediately the detached crews rowed with all their might, in order to drive back the fugitives, and, by means of loud cries and large stones thrown into the water, at last succeeded in causing them to resume their previous course. In this temporary diversion from the shore, the van of the boats was thrown into confusion; and it was a highly interesting scene to witness the dexterity with which the Shetlanders handled their oars, and took up a new semicircular position in rear of the whales. Again the fish hesitated to proceed into the inlet, and again a reserve of boats intercepted them, in their attempt to escape, while a fresh line of attack was assumed by the main body of the pursuers. It was thus that the whales were at length compelled to enter the harbour of Hamna Voe. Then did the air resound with the shouts that were set up by the boatmen, while stones were flung at the terrified animals, in order to force them upon the sandy shore of a small creek; but before this object could be effected, the whales turned several times, and were as often driven back; none of them, however, were yet struck with the harpoon; for if they had felt themselves wounded in deep water, they would at all hazards betake themselves to the open sea. The leaders of the drove soon began to ground, emitting at the same time a faint murmuring cry, as if for relief: the sand at the bottom of the bay was disturbed, and the water was losing its transparency. The shoal which followed struck the shore and increased the muddiness of the bay:—

they madly rolled about irresolute from the want of leaders, uncertain of their course, and so greatly intimidated by the shouts of the boatmen, and the stones that were thrown into the water, as to be easily prevented from regaining the ocean. Crowds of Shetlanders of each sex, and of all ages, were anxiously collected on the banks of the voe, hailing with loud acclamations the approach of these visitants from the northern seas;—and then began the work of death. Two men, armed with sharp iron spits, rushed breast-high into the water, and seizing each a fin of the nearest whale, bore him unresistingly along to the shallowest part of the shore; one of the deadly foes of this meekest of the inhabitants of the sea then deliberately lifted up a fin, and beneath it plunged the harpoon that he grasped, so as to reach the large vessels of the heart. A long state of insensibility followed, succeeded by the most dreadful convulsions; the animal lashed the water with his tail, and deluged the land for a considerable distance: another deathlike pause ensued; throes still fainter and fainter were repeated with shorter intermissions, until at length the victim lay motionless on the strand. The butchers afterwards set off in a different direction, being joined by other persons bent on the same errand. Female whales now appeared, by their hasty and uncertain course, to have been wrested from their progeny, while sucklings were no less anxiously in pursuit of those from whose breasts they had received their nutriment; but, by the relentless steel of the harpooner, they were severally arrested in their pursuit. Others which had received their death-wound soon lined the bay, while a few at a greater distance were rolling about among the muddy and crimsoned waves, doubtful whether to flee, and appearing like oxen to wait the turn of their slaughterer. Wanton boys and even females, in their anxiety to take a share of the massacre, might be observed to rankle with new tortures the gaping wounds that had been made. At length the sun set upon a bay that seemed one sheet of blood: not a whale was allowed to escape; and the strand was strewed over with carcases of all sizes, measuring from six to twenty feet, and amounting to not fewer than the number of eighty. Several of the boatmen then went to their homes in order to obtain a short repose; but as the twilight in this northern latitude was so bright as to give little or no token of the sun's departure, many were unremittingly intent upon securing the profit of their labour, and were engaged in separating the blubber, which was of the thickness of three or four inches. It was supposed that the best of these whales would yield about a barrel of oil; and it was loosely computed that they were, on an average, worth from two to three pounds Sterling-a-piece, the value of the largest being as much as six pounds."

According to the old laws of Shetland, no whale was a droit of admiralty unless it was too large to be drawn by four oxen. One share belongs to the salvers, and another to the proprietor of the ground; the minister claims tithes of the whole. Formerly the bailie claimed the heads. But it is difficult to say how the division is now made.

A few years ago, the carcases of captured whales were allowed to taint the air until they were completely devoured by gulls and crows, but it is an indication of the improved state of Shetland husbandry, that they are now prized by the agriculturist. The bones have been lately exported to England. At Feroe, the flesh of these animals is cured like beef, which it is said to resemble in taste, and is considered as a great dainty; and in the year 1740, a time of great scarcity, it was eaten from necessity by the natives of Northmavine.

Capture of Seals.—The coasts of Shetland swarm with the smaller seals, or *Tangfish*, so named from being supposed to live among the *Tang*, or larger fuci that grow near the shore. These animals, when taken young, are said to be easily domesticated, when they readily assume the habits of the dog, showing attachment to particular individuals of the human species, repairing to the water in quest of fish, and returning to the roof where they have experienced kindness. These seals are often shot, or are enclosed by nets fastened to the mouth of the caves to which they resort, where they are deliberately put to death. In Papa Stour, there is an annual capture of the larger seals, or *Haaf-fish*. To the north of an inlet named Hamna Voe, high cliffs appear, which are shaped by the water of the sea into a continual recurrence of excavations. The most remarkable of these is Christie's Hole, which, when surveyed from the summit of a cliff, appears a cavity of some hundred feet deep, and about 120 feet in length, being situated at a distance of 180 feet from the sea. It can be explored by means of a boat,—a labour that is only to be accomplished in the calmest weather. A large arch first presents itself; and, after rowing through dark vaults, the light of the sun bursts in from the lofty opening above;—here the water is no less than nine fathoms in depth. The boat then pursues its gloomy course through another extensive perforation, which at length expands into an immense cavern, where the light of the sun is wholly excluded. In the innermost recesses, there is a steep beach, which terminates in small dens, where the larger seals, or Haaf-fish, couple, and where the females produce their young, and suckle them, until they are able to accompany their dams to sea. It is customary for two boats' crews of the island of Papa to go to this place, at certain seasons, armed with clubs; one boat only enters, which is provided with candles. The crew attack the seals with clubs, stun them by a blow on the head, and, in this state of insensibility, put them to death. The females boldly step forward in defence of their young; they face their destroyers, and, with their teeth, often wrench the clubs out of their enemies' hands. But the attempt is vain; the walls of these gloomy recesses are stained with their blood, while those who attempt to escape, are met by another boat's crew stationed at the mouth of the cave, when a similar slaughter ensues.

VI. Fowling.

Fowling is still practised in Shetland, though by no means so much as formerly. One island in Shetland is named Fughloe, (*Foula*) or Fowl Island, from the numbers of the feathered tribe that make it a place of resort. On reaching the highest ridges of the rocks, the prospect presented on every side is of the sublimest description. The spectator looks down from a perpendicular height of 1100 or 1200 feet, and sees below the wide Atlantic roll its tide. Dense columns of birds hover through the air, consisting of maws, kittiwayes, lyres, sea-parrots, or guillemots: the cormorants occupy the lowest portions of the cliffs, the kittiwakes whiten the ledges of one distinct cliff, gulls are found on another, and lyres on a third. The welkin is darkened with their flight: nor is the sea less covered with them, as they search the waters in quest of food. But when the winter appears, the colony is fled, and the rude harmony produced by their various screams, is succeeded by a desert stillness. From the brink of this awful precipice, the adventurous fowler is by means of a rope tied round his body, let down many fathoms; he then lands on the ledges where the various sea-birds nestle, being still as regardless as his ancestors of the destruction that awaits the falling of some loose stones from a crag, or the untwisting of a cord. It was formerly said of the Foula man, "his *gutcher* (grandfather) *guid before*, his father guid before, and he must go over the Sneug too."—The high banks of Burra Firth in Urst, and the stacks contiguous to it, are frequented by numberless birds, such as gulls and scarfs; and along with these the lyre, or *Procellaria puffinus*, the Tomnorry, or *Alca arctica*, and the kittiwake, or *Larus tridactylus*. Their nests are annually visited by the nimble and adventurous rockmen, who, for the sake of plunder, land with boats at the foot of the most hideous precipices, which they easily scale, or are let down from the summit of them by means of ropes. The eggs thus obtained, are considered as a great dainty: the carcases of the young birds serve for grosser food, and the feathers form an article of commerce.

VII. Greenland Sea Fishery.

Each year the vessels who go to the Greenland sea fishery touch at Shetland, and procure great numbers of active seamen, who, as boatmen, are held in the highest estimation.

VIII. Commerce.

Commerce.—Before entering on this subject, we may observe, that, with the exception of Lerwick, where there is a manufactory for straw-plaiting, few or no distinct trades are to be found in the thinly inhabited districts of the country; almost every peasant, being the fabricator of his own rivlins and shoes, as well as his own tailor, and his own carpenter. Shetland receives from Scotland and England the materials which she requires for the use of her fisheries, for clothing, &c.

The exports of Shetland consist chiefly of dried fish which are sent to Scotland and Ireland, and from thence find their way to the foreign markets, also a little kelp. The recent discovery of the cod-bank has been the most considerable source of wealth.

The researches of Dr. Hibbert relative to the chromate of iron, have also been a valuable acquisition to the resources of Shetland. This ore is of commercial importance, on account of the use to which it has been converted by the manufacturing chemists for procuring a yellow pigment; and since the experiments of M. Lessaigne, it has been applied to the purpose of dyeing silk, cotton, linen, and woollen fabrics. It had been previously imported from America, but the expense of bringing it over was considerable. Shetland now rivals Baltimore in supplying Great Britain with this important acquisition to the arts.

To the earlier commerce of Shetland, the town of Lerwick seems to have owed its rise. It was first built about the beginning of the 17th century, when Bressay Sound was annually visited by not less than 2000 busses. For the sake, therefore, of an easy traffic with these ships in stockings and fresh provisions, houses close to the shore were erected; and hence the great irregularity which results from ranging the buildings agreeably to the indentations of the coast. The town has since gradually increased, and it now presents a lively appearance owing to the number of shops with which it is filled, and the sailors of all nations, who are engaged in making small purchases, while their vessels are moored in the harbour. Lerwick is, indeed, the seat of the commerce of Shetland, being also much indebted for its support to the vessels which touch at Bressay Sound in their voyage to the northern seas, and on their return home: among these are chiefly Greenlanders. In consequence also of the small barters that are made with foreign vessels, Danish and other coins pass more freely in the country than British money.

IX. Population.

The number of inhabitants was estimated in the year 1755 at 15,210; in the year 1793 at 20,186; in 1810 at 23,000; and in 1821 at 26,145.

X. Popular Manners and Customs.

Before we conclude this article, we shall attempt to give a sketch of the popular manners and customs of Shetland.

Physiognomy.—The men are rarely very tall, but remarkably well proportioned, light and nimble. In relinquishing, however, most species of domestic drudgery for the adventurous occupation of fishery, they have caused a more than ordinary portion of labour, fatal to the preservation of a delicate and symmetrical form, to devolve upon the poor females. The features of the Shetlanders are rather small, and have nothing of the harshness that so peculiarly distinguishes many of the Anglo-Saxon provincials in the north of England, or in some of the lowland districts of Scotland. The constitutional temperament of the Scandinavians is generally conceived to be sanguine, and since its characteristics are supposed to consist in a florid complexion, a smooth skin, and hair brown, white, or slightly auburn, the natives of Shetland give satisfactory tokens of their national descent. The elder Linnæus's description of the northern Europeans well applies to them: "Gothi corpore proceriore, capillis albidis rectis oculorum iridibus cinereo-cœrulescentibus."

Language.—When Orkney and Shetland were transferred from the government of Norway to that of Scotland, the Scandinavian natives of these islands gradually abandoned the Norse language: but they still retain many Norwegian terms, and, along with these, their own national accent, which is distinguished by an acuteness of tone and an elevation of voice, that has much of the spirit of the English mode of utterance, while their pronunciation partakes of the still more modulated and impasssioned tones of the Irish. But among none of the natives is to be found the Scotch peculiarity of expression, which is less diversified by alternations of grave and acute accents, owing to the effect of emphasis being conveyed in a prolonged utterance.

Dress.—The peculiar leathern dress used by the Shetlanders in their fishery at the Haaf has been described. Their common attire differs little from that of the inhabitants of the sea-coast of Scotland. To men whose chief occupation is fishing, the common sailor's jacket is a favourite garb. The red cap, which is a distinctive badge of the master of a family, merits particular attention. It is made of worsted, somewhat resembling in form a common double nightcap, but much larger, and gradually tapering to a point, while it hangs down the back after the fashion of the head-dress of a German hussar. It is also dyed with numerous colours. Frequently the men wear on their feet *rivlins*, which are a sort of sandals made of untanned seal-skin, being worn with the hair-side outwards, and laced on the foot with strings or thongs of leather. Their lightness is particularly adapted for treading with velocity over the soft heaths or scatholds of the country. The dress of the women merits little attention, since it does not differ materially from the fashion of the Scotch peasantry. The woollens which are worn are generally imported from Lancashire or Yorkshire, while some are manufactured in the country.

Moral Traits.—The natives of Shetland, considered as parishioners, are in general discreet and orderly. The influence of the minister has certainly been much strengthened by kirk-sessions, and the heavy penalties of the ancient country acts denounced against such offences as violations of the Sabbath, or the refusals of a householder to afford his family instruction in religion and morality: but it has been also increased by the services that he renders to his flock on all occasions of sickness. The reverence with which he is consequently held among the people, of whom he is a real guardian, has rendered the occasional public censures which he bestows, a punishment of the most dreaded kind.

A few of the unfavourable traits in the character of the Shetlanders have already come under notice. When a vessel is wrecked, they differ little from Cornishmen or Welshmen in their efforts to plunder. Of a similar character are their gross impositions practised upon strangers in their charges for boat fare. Indeed it is impossible to bind the Shetlander down to any specific agreement: whatever sum he may contract for as a fare, he endeavours during the whole of the passage to increase, which adds to the annoyance that is otherwise experienced; he is also in the habits of considering the extortion to which he makes the stranger submit, as of the same nature as the right that he assumes to plunder a wreck, and enumerates under the blasphemous title of "*God-sends*," a wreck, a drove of whales, and a boat-fare. Yet, after all, these revolting features of character are not peculiar to Shetland; they are to be found in too many districts of Scotland and England, which arrogate to themselves the character of being better informed.

But if the pillage of wrecked vessels be reconciled to a Shetlander's conscience as a *god-send*, or the pilfering of sheep out of a scathold be excepted from the prohibition contained in the eighth article of the Decalogue, it would be an injustice to his character not to state, that against other temptations to dishonesty, he is proof to a remarkable degree. "About two miles from Onzie Frith," remarks Dr. Hibbert, "the contents of my trunks, owing to the loss of my keys, were indiscriminately exposed, in a small house to more than a score of eyes, for several days together, but I was perfectly easy with regard to the safety of my property; nor was I in this or any other instance of the like kind, deceived in the confidence I had placed in the cottagers of Shetland."

Another amiable moral trait of this country is its great hospitality: this has been celebrated in the Northern Sagas, and there still remains all the practice of it that is recommended in the Havamaal of Odin. "To the guest who enters your dwelling with frozen knees, give the warmth of your fire: and he who hath travelled over the mountains hath need of food and well-dried garments." It is the best proof of the estimation in which this virtue is generally held, that the alleged absence of it in a very small district, named Coningsburgh, should render the inhabitants of it liable to unmeasurable reproach. In this province, the traveller, who, in the close of the evening, might have been compelled to supplicate for a night's lodging, met with a chilling reception, and was awakened at the first dawn of the day by a harsh-sounding warning to depart, expressed in the ancient Shetland language: "*Myrkin i livra: lurein i liunga; timin i guestin i geunga.*"—It is dark in the chimney, but it is light along the heath; it is now time for the stranger to be gone. "It thus became a custom," said Mr. Low of Orkney, who has recorded this expression, "when any one wanted to dismiss a stranger from his house if he staid too long, to recite in Norse the Coningsburgher's phrase." Again, in travelling through Shetland, there is the greatest scarcity of inns, and he who proceeds with a true spirit of independence, will find no great difficulty in inducing the cottagers to accept of an adequate remuneration for receiving him beneath their roof: but he must submit to great inconvenience, chiefly owing to the want of cleanliness in the Shetland hovels. This want of comfort, however, he will at any time prefer rather than be reduced to the necessity of seeking for gratuitous comfort in more commodious habitations; yet too frequently is the reluctance subdued, by the generous invitation which has met on his lonesome way the weary stranger.

Marriages.—Marriages take place in Shetland with little concern for the future. This was attempted to be corrected so early as the year 1680, by a law that might have been dictated by Malthus himself. Every person who had not forty pounds of free gear, or some lawful trade, was forbidden to marry: and none were allowed, under the penalty of ten pounds Scots, to set them house or land. It was formerly the custom for a young married couple to beg from each of their neighbours a supply of domestic articles, as a set-up for housekeeping; but this plan was obviated, by rendering it liable to the rigour of a law that punished with the stocks and juggs all tiggers (or beggars) of wool, corn, fish, &c. whoever they might be, and that inflicted the penalty of ten pounds Scots to any one who might grant them service or hospitality.

Patronymics.—Not many years since, it was very easy to know all the native inhabitants of Shetland, who distinguished themselves from Scottish settlers, by retaining in their names the use of patronymics. Thus, if the father's name was Magnus, the son's name (Laurence) would be Laurence Magnuson; and in the old records of the country it appears that the names of daughters were subjected to the same rule; there were, for instance, in ancient deeds, such appellations as *Madda Scuddadaughter* and *Freia Erasmusdaughter*.

Food.—It has been remarked that the food of the natives is chiefly Sillocks, or the small fry of the cole-fish, with which every voe swarms, and which seldom fail at any time to fill the *buidy* or fishing-basket with a meal. The result, however, of the ling fishery affords the means of purchasing flour from Scotland, to compensate for the deficiency of crops, which autumnal storms may destroy in a single night. The sources whence the Shetlander derives his support is, indeed, no where so happily illustrated as in the toasts that he gives in the hours of conviviality, the most popular of which is, "Death to da head that wears nae hair;" or, in less enigmatical words, *Death to the fish*. It was usual about sixty years ago, when a party was assembled at Johnsmas to drink success to the ling-fishery, for the principal person of the feast to address his comrades after the following manner: "Men and brethren, lat wis raise a helt. Here's first to da Glory o' God an da guid o' wir ain puir sauls, wir wordy land-maister, an wir lovin meat-mither, helt ta man, death to fish, and guid growth i' da grund." About Lammas, when from the length of the nights, and the rapidity of the tides, lines were often lost, the convivial sentiment was, "Helt ta man, death ta fish, and detriment ta nae man." But when the natives were about to quit the ling fishery, and to return home to the harvest, the hope expressed in the cottager's cups was, "God open da mouth of da gray fish, an haud his haund about da corn."—The last toast may require explanation. The *gray fish* are the fry of the coal-fish (Piltocks and Sillocks,) so named in contradistinction to ling, cod, tusk, hallibut, haddock, &c. which are called white fish. The ejaculation that God may *haud his hand about da corn*, implies the wish that the hand of the deity may preserve the grain from destructive tempests.

Among the dainties of a Shetland table, the tusk fish must be always considered pre-eminent: it is the most delicious of the Gadus species, and Thule no less deserves a pilgrimage to it from the epicure on account of this dish, than Plymouth, for the sake of eating John Dories. Another favourite Shetland dainty is known by the name of *Cropping moggies*, consisting of the liver of the cod mixed with flour and spice, and boiled in the fish's stomach: this preparation, when met with at the houses of the more opulent inhabitants, is excellent:—in the plainer form of *livered moggies*, the flour and spice being absent, it regales the fishermen at their summer lodges. The ancient Scandinavian beverage of bland, prepared from the serum of milk, is met with at almost every house. There is a great variety of shell-fish to be found in Shetland, that might add to the varieties of the table, particularly lobsters, which occur in abundance near Papa Stour, but none of these are very favourite kinds of food. In former times every dwelling had adjoining to it a skeo, which is a small square house formed of stones without any mortar, with holes through which the air may have a free passage; for which purpose the building was erected on a small eminence, being at the same time protected from the rain by a roof. Cod and ling were then caught near the shore, and the best of them being intended for sale, under the name of *stock-fish*, were hung up unsalted on poles, within a drying house of this kind, that the wind, in issuing through its crevices, might cure them: but as these fish could not always be preserved from putrefaction, they were at first, perhaps from necessity, consumed by families, until a relish for tainted food would naturally result from their constant introduction at meals. It is probably then from this cause, that though skeos are now in ruins, fish in a semi-putrescent state, named *sour fish*, or *souked fish*, are at the present day as agreeable to the Shetlanders as the tainted flavour of venison is to an English stomach. It was also customary before using beef or mutton, not to salt it, but to hang it up in one of these skeos, or in some cave within which the tide flowed, named a *helyer* or *hiallar*. But all the skeos are now roofless and in decay.

Habitations.—An account has already been given of the construction of the Shetland dwellings: they are built of rude stones, with a cement of clay, or they are still more coarsely formed of stones and clods. In most of the Shetland cottages the fire place is in the middle of the room. Windows are become much more general than they were some years ago; for, among some of the oldest habitations, no other light is received than through the aperture which allows an egress to the smoke. To this opening is given the Scottish name of *lumb*, but in the obsolete language of Shetland, it was called the *livra*,—a word resembling the ancient *liuren* or light-hole of the Norwegians. Yet many old Shetland houses are not destitute of that notable improvement of domestic architecture known by the name of chimney, an invention ascribed in northern annals to king Olaf Kyrre who lived in the eleventh century.

The byre or cow-house generally adjoins the dwelling, and is frequently entered by a common door, that introduces the stranger first to the cattle, and afterwards to the apartment devoted to the use of the family. In most of the Shetland habitations a partition of turf runs across the room, which is occasionally carried up to the height of the house, being intended as well for the purpose of storing up victuals as for a separate dormitory. But generally the beds, which consist of a few coarse blankets or straw, are placed in any convenient angle of the cottage. One or two cumbrous wooden chairs, designed for the heads of the family, with the addition of a few benches, constitute the heavy part of the furniture. Such is a specimen of the ancient cottage of Shetland: but in the south of the Mainland better dwellings of this kind are occasionally found. A melancholy want of cleanliness is too general a characteristic of the hovels of Thule.—The habitation of a farmer holding some little rank, has been described by Dr. Hibbert after the following manner. "His house was situated on the south side of the hill of Aithsness, upon the brow of the acclivity. A steep brown hill rose to the north, washed at its base by a transparent pool. The farm-house was built of the rough unhewn stones of the country; much green outfield, well cultivated, appearing in various patches along the valley. Stone-dikes ran round the dwelling in a zig-zag direction, enclosing it like so many outworks of a fortification. On a small adjoining eminence were the remains of a skeo, where was once prepared the blown fish and vivda that furnished a delicious repast for the ancient udaller. Before the door were placed a few stepping stones, somewhat difficult to trace, and intended to prevent a plunge, knee-deep, into the immense bed of compost that lay reeking all around. The visiter, after entering a dark and gloomy byre, which forms a part of the tenement,—after grazing the heels of the cows on the left of him, and feeling carefully along the surface of a partition to his right, may detect the latch of a door that leads to a spacious apartment containing a fire-place in the middle of it,—where the floor is of clay,—where the walls are thickly coated over with soot,—where are two long forms, on which the servants of each sex are seated, the mistress of the house being distinguished by a high and separate chair,—where, in one corner, is a favourite calf quietly regaling itself with a bowl of milk,—and where are two or three surly had-dogs stretched on the hearth, perfectly happy in the society of a miraculous quantity of cocks, hens and chickens, a sow and a playful litter of young ones. A rude partition divides from the main room a small private apartment, including within the recesses of its walls two or three press beds. The state dormitory, however, reserved for the opgester, is reached by scaling a wooden ladder, on each side of which are stored barrels of meal or oats, dusty tows, fishing-nets, sillock-rods, and various kinds of hand-lines; the middle of the room being reserved for a curtainless bed. There may the inmate, after commending himself to the guardianship of all good spirits, consign himself to repose, and rise in the morning cheered by the unobstructed rays of the sun, that light the room from an open fissure in the roof."

But, according to the same writer, the ancient Udaller, or small landed proprietor, lives in rather greater state. "When visiting the voe of Burrafiord," he adds, "I was, by the extreme lateness of the evening, under the necessity of availing myself of the custom of the country, where a stranger is perplexed for a lodging, which was to seek for hospitality in the nearest convenient house on my way. My boatmen led me to a small creek at the head of Burrafiord, where the setting sun brightened into a fine purple, a wild intermixture of crag and lake. The smoke arose from a low house, built of unhewn stones, after the most ancient fashion of the country; it was the *Head Buil* or manor-house of a small landed possessor of Aithsting, named the Laird of Fogrigate. On opening the door, I passed through a double range of servants of both sexes, who occupied forms disposed along each side of the room, and made suitable obeisance to the *hoy sædet*, or high seat of the house, filled by the laird himself, with all the patriarchal dignity, worthy that primitive state of manners described in an ancient poem of the 8th century.

Ipse insedit Ad utrumque latus,
Medio scamno; familia domus.

"Native Shetland ale was introduced, which was the first I had tasted in the country. It was not many days old, and had such a pleasant briskness in it, that it might have been seasoned with the tops of heather, after the recipe, as learned antiquaries would tell us of Pictish ale. But there was no other ingredient in it except malt; it was, as an Englishman in Harry the Eighth's time would have said, "As good as the King's ale, for it contained neither hops nor brimstone." The room to which I was shown for repose, served the double purpose of being a dormitory for the opgester (or guest,) and a granary for the family. A quantity of straw was strewed on the floor, and upon this was laid a sufficient number of *Kiverins* and blankets, with clean white sheets. The morning was announced by the grinding of the quern. Breakfast was got ready: my trunks furnished me with tea and sugar, and to a thrifty female I was indebted for cakes.

"Protulit tum Edda
Conspectum cinere panem,
Ponderosum et crassum
Plenum furfuribus."

It is almost needless to add, that the Shetland gentlemen of rank possess residences that may vie with many in Scotland. The house of Mr. Mouat of Bressay is a structure of much elegance.

Festivities.—The delight of the ancient Udaller's convivial hours, was in the recitation of Norwegian ballads. Shetland was from time immemorial celebrated for its native poets. Ronald, Earl of Orkney, being in the year 1151, shipwrecked near Gulberswick, was visited by two poets, Oddi Glumson the Little, and Armodr. The earl, who composed verses himself with great fluency and elegance, found them so well skilled in the same art, that he received them among the number of his retainers, and took them with him on his travels to the Holy Land. On the occasion of a public feast, he gave to Armodr, as an acknowledgment for his poetic talents, a golden spear. Not longer ago than seventy years, a number of popular historic ballads existed in Shetland; the last person who could recite them being William Henry, a farmer of Guttorm, in the island of Foula. Some kinds of poetry, as the historical ballads and romances which this old man could recite, were never sung but on a winter's evening at the fire-side. Others, under the name of Visecks, formed the accompaniment to dances, that would amuse a festal party during a long winter's evening. When the corn-waters of Hamburgh had gone merrily round, the tables labouring at the same time under the weight of skeo-dried vivda, sillocks, gammon, and reeked trout,—when the *gue*, an ancient two-stringed violin of the country, was aiding the conviviality of Yule, then would a number of the happy sons and daughters of Hialtland, take each other by the hand, and while one of them sung a Norn Viseck, they would perform a circular dance, their steps continually changing with the tune. In the middle of the last century, the Norwegian language remained in the country; and these visecks being soon lost, they were followed by playing at cards all night, by drinking Hamburgh waters, and by Scotch dances. The reel, upon being introduced, became highly popular; and a few original melodies adapted to it, were composed by native musicians of Shetland, the most popular of which was the Foula reel. To this tune, a song was afterwards adapted, named the Shaalds of

Foula, allusive to a profitable fishery that was long conducted upon these *shaalds*, or shoals, for cod; the words of which sufficiently express the freedom with which the Shetlander spent, in the conviviality of a winter, the hard-earned savings of a summer in the perilous fishery of the Haaf. When the ancient Udaller gave an entertainment, it was open to the whole country; but the strangers from the south, with more rigid notions of economy, corrected the generous custom, by rendering such feasts liable to the officious interference of the Ranselman, who was empowered to levy a fine upon any one who came to feasts uninvited. Marriages also, which were chiefly contracted during the winter, served to draw together a large party. It was, on these occasions, usual for the bridegroom to have his feet formally washed in water by his men; and in wealthy houses wine was used for the purpose. A ring was thrown into the tub,—a scramble for it ensued, the finder being the person who was to be first married. On the night before the marriage, the bride and bridegroom were not allowed to sleep under the same roof; and on the wedding-night, the bridegroom's men endeavour to steal the bride from her maidens, and a similar design on the bridegroom was made by the bride's maids. Last of all took place the throwing of the stocking, and "many other pretty sorceries." These customs are now gradually subsiding.

One sport, however, still retained on occasions of festivity, deserves particular notice. Olaus Magnus, in his account of the manners of the northmen, describes an ancient military dance as being common to them, which seems to have been achieved by six persons. It was accompanied by a pipe and song, the music being at first slow, and gradually increasing in celerity. The dancers held their swords, which were sheathed, in an erect position,—they then danced a triple round,—released their blades from the scabbards,—held them erect,—repeated the triple round, —grasped the hilts and points of each others swords, and extending them, moved gently round,—changed their order, and threw themselves into the figure of a hexagon, named a *rose*. They again, by drawing back and raising their swords, destroyed the figure which they had made, in order that over the head of each other a four-square rose might be formed. Lastly, they forcibly rattled together the sides of their swords, and by a retrograde movement ended their sport. The sword-dance performed by the Curetes of Papa Stour is not unlike the one now described; but since the residence of Scottish settlers in this country, it has sustained some modification, by being made the sequel to a sort of drama performed by seven men, in the characters of the seven champions of Christendom. This interesting masque is still performed by the inhabitants of Papa Stour in Shetland, but in a very few years it will cease to exist; on which account, we cannot help feeling some regret that the Highland Society, who, in their annual exhibitions, are laudably anxious to keep alive the ancient amusements of the north, should have never once thought of showing, that one of the oldest dances of Europe, truly worthy a warlike people, does not merely exist in the pages of the Waverley Novels, but can find a real illustration. The sword-dance has been minutely described by Dr. Hibbert.

After the sword-dance has been performed, it is not unusual to hear of the announcement of the guisards. A number of men enter the room dressed in a fantastic manner, their inner clothes being concealed by a white shirt as a surtout, which is confined at the waistband by a short petticoat, formed of loose straw, that reaches to the knee. The whole are under the control of a director, named a Scudler, which is an ancient name given to the pilot of a scuda, or twelve-oared boat. The scudler is distinguished from his comrades by a very high straw cap, the top of which is ornamented with ribbons. He is the proper *arbiter elegantiarum* of his party, regulating their movements, and the order in which they should alternately dance with the females assembled. The amusement thus afforded is the same that may be found in any politer masquerade, since it depends upon the guisards being able to conceal from the company who they are. The custom of paying visits to parties under the disguise of a mask, is described in Olaus Magnus's History of the Northern Nations.

Superstitions.—No country in the British dominions contains so many superstitions as Shetland, to which peculiar interest has been imparted since the publication of "the Pirate." Orkney and Shetland were for many centuries only semi-christianized; we therefore read, even in their present superstitions, the Pagan tenets which they originally entertained. In Orkney it was customary, even in the last century, for lovers to meet within the large circle of stones that had been in the earliest times dedicated to the king of the gods: through a large hole in one of the pillars the hands of contracting parties were joined, and the faith they plighted was named the promise of Odin, to violate which was infamous. Other mythological personages have in Shetland a considerable influence over the minds of the people even at the present day. The diminutive race of supernatural beings who inhabit the interior are described by the natives of Feroe as *Foddenskemand*, or underground men; in the Icelandic Edda they appear under the name of Duergar or Dwarfs. The Shetlander still *sains* or blesses himself as he passes near their haunts. They are described at the present day as a people of small stature, gaudily dressed in habiliments of green. They partake of the nature of men and spirits, yet have material bodies, with the means, however, of making themselves invisible, and they multiply their species.

Of mermen and merwomen many strange stories are told. Beneath the depths of the ocean, an atmosphere exists adapted to the respiring organs of certain intelligences, resembling in form the human race, possessed of surpassing beauty, of limited supernatural powers, and liable to the incident of death. They dwell in a submarine portion of the globe's surface, over which the sea, like the cloudy canopy of our atmosphere, loftily rolls, and they possess habitations constructed of the pearls and coralline productions of the ocean. Having lungs not adapted to a watery medium, but to the nature of atmospheric air, it would be impossible for them to pass through the volume of waters that intervenes between the submarine and supra-marine world, if it were not for the extraordinary power that they inherit, of entering the skin of some animal capable of existing in the sea, which they are enabled to occupy by a sort of demoniacal possession. One shape that they put on is that of an animal, human above the waist, yet terminating below in the tail and fins of a fish. But the most favourite form is the large seal or Haaf fish; for, in possessing an amphibious nature, they are enabled not only to exist in the ocean, but to land on some rock, where they frequently lighten themselves of their sea dress, resume their proper shape, and with much curiosity examine the nature of the upper world belonging to the human race. Unfortunately, however, each merman or merwoman possesses but one skin, enabling the individual to ascend the seas, and if, on visiting the abode of man, the garb should be lost, the helpless being must unavoidably become an inhabitant of our earth. Thus the Ve Skerries on the west of Shetland are, according to popular belief, the particular retreat of the green sons and daughters of the sea, where they are defended by a raging surf, that continually beats around them, from the obtrusive gaze and interference of mortals; here they release themselves from the skins within which they are enthralled, and, assuming the most exquisite human forms that were ever opposed to earthly eyes, inhale the upper atmosphere destined for the human race, and, by the moon's bright beams, enjoy their midnight revels.—The Shoopiltee is another mythological personage. He is the demoniacal Neptune of the north, who in Shetland assumes the form of a beautiful shelty, inviting some one to mount him, when he immediately rushes into the sea: at other times he assumes something of a human shape, though inclining to the nature of a horse, and is decked with fuci and various products of the seas; again, in the decided form of a shelty, he makes his haunts near water-mills, but when observed hastily withdraws himself into the burn, or vanishes in a flash of fire. This deity is the same to whom the Edda recommends the offering of a prayer for success in navigation, hunting, or fishing, since he gives to his votaries treasures, and even kingdoms. In Unst, it was customary to visit the head of a stream, named Yelaburn, or the Burn of Health, and to throw, as an acknowledgment to the water god, three stones on an adjoining site of ground. The pool of Helga Water appears to have been originally visited with the same intent. The natives were wont to walk round it in the course of the sun, observing strict silence in their perambulations, taking up water in their hands, and casting it on their heads.—Another spirit was named Brownie. In most northern countries, there was scarcely a family that in former times had not a domestic spirit. The Samogitæ, a people formerly inhabiting the shores of the Baltic, who remained idolatrous so late as the 15th century, had a deity named *Putscet*, whom they invoked to live with them, by placing in the barn every night a table covered with bread, butter, cheese, and ale. If these were taken away, good fortune was to be expected: but if they were left, nothing but bad luck. A similar tall "lubbar-fiend," in Shetland was inhabited in a brown garb of wadmel, and was accustomed by his influence to ensure a good grinding of corn, a good brewing of ale, a good separation of butter during churning, and protection for corn stacks against the greatest storm that could blow. In return, therefore, for these benignant offices, it was usual to apply to brownie's use a sacrificial stone, within which was a small cavity for the reception of a little wort, upon the occasion of every brewing; or when milk was churned, it was necessary that a part should be sprinkled with the same intent, in every corner of the house.

Magic was originally sanctioned in Scandinavia by Odin, and, during the Pagan state of Orkney and Shetland, was practised by individuals of the highest rank. The mother of Thorfin, Earl of Orkney, who lived in the 11th century, gave to her son a standard, embroidered with the signal of a raven, telling him, that if the fates had intended he should have lived for ever, she would have nursed him much longer in his cradle; but that life was finished more honourably with glory, than lengthened out with dishonour;—that although the standard on which she had expended all her magic art portended victory to him before it was carried, yet it might bring death to the bearer. The females, who, in Scandinavia or its colonies, had most distinguished themselves in the art of divination, were deified after their decease under the name of Nornies or destinies; and it was supposed, that upon the completion of their apotheosis, they had the power of controlling human events. In Shetland, the magic which existed so late as the last century derived its origin from the mythology of the Edda. It was the boast of the ancient Scandinavian sorcerer that he could understand the language of birds. Odin had always in attendance two ravens, who would fly the world over, and at dinner time return for the purpose of whispering in his ears all the occurrences they had either heard or seen. In like manner a witch of Shetland, who lived about the middle of the seventeenth century, was seen going to and from Brecon to Hillswick, accompanied by two familiars "in the likeness of two corbies that hopped on each side of her all the way." This appearance was deemed contrary to the nature of "wild fowls," and formed one of the charges against the unhappy woman, for which she was condemned to be worried at a stake. Another spell by which the magician of Shetland obtained a power over nature's operations was by means of knots, the superstitious regard for them seeming to have arisen from the use to which they were, from the remotest period, applied as memorials of events, or as inviolable pledges of agreement. Brand relates, that a Shetland witch on seeing a fowl which a sea-eagle was carrying through the air, took a string, and casting some knots upon it, the bird of prey let its intended victim fall into the sea. The application of a woollen thread, by way of charm, round a sprained limb, and the use of a certain number of mysterious knots, is a superstition still familiar to most of the northern countries of Europe. It was also usual with the Shetland magicians, like those of Scandinavia, to use incantations. "I know a song," said Odin, "of such virtue, that were I caught in a storm, I can hush the winds, and render the air perfectly calm." But the warlocks and witches of Thule used, by the same means, to raise tempests. About fifty years ago, a woman of the parish of Dunrossness, known to have a deadly enmity against a boat's crew that had set off for the Haaf, took a wooden basin, named a *cap*, and let it float on the surface of a tub of water; then, to avoid exciting suspicion, she went on with her usual domestic labours, and, as if to lighten the burthen of them, sang an old Norse ditty. After a verse or two had been recited, she sent a child to the tub, and bade him tell her if the cap was *whummilled*, or turned upside down. Intelligence was brought to her, that the water was moved, but that the bowl was afloat. She then continued her incantation, and once more broke it off, by requesting the child to again go to the tub, and tell her what he saw. The little messenger returned with the news that there was a strange swell in the water, and that the bowl was sadly tossed about. The witch then sang still more loudly, and, for the third time, sent the child on the same errand, who soon hastened back with the information that the water was frightfully troubled, and that the cap was whummilled. The enchantress, with an air of malignant satisfaction, then ceased her song, and said, "The turn is done." On the same day, news came that a fishing yaul had been lost in the roust, and that the whole of the crew had been drowned.—Again, the witch of Shetland had, like Odin, the great father of Scandinavian magic, the power of undergoing a transmutation of shape resembling that of various animals. Marion Pardon of Hillswick, conceived a malice against the crew of a fishing boat, and transforming herself into the likeness of a piltock-whale, under this form upset their vessel. She was convicted of the crime by the confession of another witch, and by the well-known test of the *bahr-recht*, or law of the bier. Being commanded, along with Swene, her husband, to lay their hands on two of the dead bodies that were found, one of them bled at the *craig-bane*, and another in the head and fingers, "gushing out bluid thereat, to the great admiration of the beholders, and revelation of the judgment of the Almightie." On this irrefragable proof of murder, admitted, as the indictment expressed, not only in this country but likewise in most foreign kingdoms, the unfortunate woman was executed.

In short, the light of Christianity was feebly opposed to the phantoms of the Scandinavian mythology. When popery commenced its influence over the minds of the people, a belief in the existence of gods, giants, or dwarfs, still remained, with this qualification only, that they were fallen angels of various ranks belonging to the kingdom of darkness, who, in their degraded state, had been compelled to take up their abode in mountains, springs, or seas. These were tenets conveniently subservient to the office of exorcism, which constituted a lucrative part of the emoluments of the inferior Catholic clergy, with whom Orkney and Shetland were in ancient times overrun.

Demons were thus kept in order by a kind of spiritual police, which prevented them, owing to the interference of exorcism, spells, or charms, from breaking into human habitations, or trespassing on the lands of the udallers, to the injury of live stock and the fruits of the earth. But Brownie was tolerated even by the most zealous Catholic. He was an inmate in every house, assisting in the operations of threshing, churning, grinding malt or mustard, and sweeping the house at midnight: a standing fee being required for him each night of white-bread, and milk or cream, spread upon a table. There was also another reason for not offering him any disturbance. According to Olaus Magnus, the northern nations regarded domestic spirits of this kind as the souls of men who had given themselves up during life to illicit pleasures and transgressions, and were doomed, as a punishment, to wander in the shape of spirits for a certain time about the earth, and to be bound to mortals in a kind of servitude. It would have been, therefore, an opposition to the decree of heaven, to refuse the penal labours of such slaves, and a sorry description of policy to turn away an useful servant, although an unearthly one, who could be kept at the cheapest of rates.

The early Christian preachers seeing the influence which the mythology of the Edda had over the minds of the people, gave to all the pagan gods, giants, or dwarfs, the name of *trols*, a term indicative of the seductive or alluring influence which they possessed over the souls of mankind. The word still preserves its general import, as the trol or *trow* of Shetland designates either a fairy of the hills, a merman or merwoman, or the shoopiltee of lakes and burns. It was also supposed, that witches and warlocks, by a compact with Satan himself, were enabled to command the assistance of the demons of the pagans, who, having been driven from heaven, had taken shelter in caverns, seas, and lakes, or had become the drudging domestic spirits of particular families: and when the magic of Odin was modified by the introduction of Christianity, it was imagined that many diseases were induced by a sort of demoniacal possession that took place in different parts of the body, and that a cure was to be effected by obliging a demon to enter the body of some other animal. It was also a belief, that if any person was emaciated with sickness, his heart was wearing away, which was attributed to the agency of a demon, who took for that purpose, the form of a worm; and that if a new habitation could be procured for the evil spirit, a cure would take place. A Shetlander then sought out a charmer, who, after melting some lead, and using mysterious forms, allowed it to drop through an open sieve into cold water, and if an image, bearing some faint resemblance to the heart, was, after repeated trials, produced, it was worn by the patient as an amulet, to entice the demon to quit the vital organ which he was tormenting. If, by no ingenuity, the figure of a heart could be effected, the chance of recovery was proportionally diminished. This superstition, under a few modifications, still prevails.—But eventually, the true warlocks were the priests, who by means of crosses, benedictions, amulets, prayers, and other godly gear, could at any time produce supernatural effects, that in days of paganism depended on incantations, knots, or runic characters: and when reformation was introduced in the land, and the rites and ceremonies of popery condemned as idolatrous, it was still found not very easy to shake the popular faith in the efficiency of many of the ancient ceremonies of the Roman Church used to insure good success in fishery and a good harvest. The charmer of Shetland would mutter some religious words over water, in imitation of the practice of the Catholic priest, and the element was named *fore-spoken water*: boats were then sprinkled with it, and pains in the limbs, by being washed with it, were *healed*. If a beast was wounded with elf shot by the trows, the charmer would find out the hole, inscrutable to common eyes, in which the arrow entered, and would wash the place with forespoken water. By the application of this fluid were the effects counteracted of an evil eye, or of an evil tongue.

The last modification which took place of witchcraft, arose from a doctrine taught by the reformers, that the light of the gospel could penetrate by its effulgence into the very domiciles of unclean spirits, and expel them to unknown regions. When a view like this gained ground, it will scarcely create surprise that the Bible should become no less useful an instrument in the hands of charmers than crosses, forespoken water, and benedictions. It was recommended, that the lonely wanderer by night among the bleak scatholds of Thule, should bear in his hands the holy scriptures, as a means of screening himself from the attacks of the trows or demons of the hills. But the magic of Thule was in no way so successfully combated as by the terror of the law. The rapacity of Earls Patrick and Robert Stewart caused them to make a diligent search after all witches, in order to obtain possession of their estates, which became due to them by forfeiture; nor was their example unfollowed, for thirty or forty years afterwards, by those who succeeded them in the government of the country. Even so late as the commencement of the last century, the Shetland witches were, as Brand says, talked of so much anent their devilry, that he was told it was dangerous going to or living in that country.

But the ancient superstitions of Shetland are gradually passing away, a belief in the trows of the hills, or in mermen and merwomen being limited to remote districts, where there is less intercourse with the world. A few warlocks or witches still exist, who have the power of taking away the profits from corn or cattle. A fear is entertained of an evil eye, and a person has been known to fall ill upon being cursed by an enemy. Parents have a dread of their children being praised or complimented on being fat, thinking that children so lauded are doomed to die; this notion is a very old one, having been ascribed by Gellius to a people of Africa. Charmers also exist, who find stolen goods, and by means of knots, cure diseases. But all these illusions must eventually yield to the force of education.

Diseases.—In so variable a climate as that of Shetland, phthisis pulmonalis, pneumonia, croup, and scrofula are, as we might expect, very frequent. There is a great variety of cutaneous complaints, tinea capitis being the most common. The very interesting disease of sibbens, important in the history of syphilis with which it has been confounded, often prevails in Shetland. Owing to some peculiarity of food, conjoined with the nature of the climate, dyspepsia and liver complaints are very common. Occasionally fever rages in the cottages; and from their close construction, by which air is excluded, the contagion proves highly fatal. Every member of a family has been known to be attacked with typhus; and as the dread created among neighbours is very great, the situation of a family left without succour to linger, or perish, is too painful to contemplate. Cases of this sort have too often occurred. Nor is the assistance of a medical man always to be obtained; for when patients do not live on the mainland, but in detached islands, ferries must be crossed, upon which no boat in winter, with the least chance of safety, can venture. In some parts of Shetland, divine worship is interrupted by fits resembling hysteria, which spread from one female to another; but as these paroxysms are easily counteracted by inducing such opposite states of mind, as arise from a sense of shame, they are under the control of any sensible preacher, who will expose the folly of yielding to a sympathy so easily resisted, or of inviting such attacks by affectation. The small pox has at intervals been very fatal in Shetland; and it is to be lamented that vaccine inoculation is far from being universal.

Longevity.—Cases of great longevity in Shetland have, at various times, been recorded, particularly in the statistical accounts published, and in Buchanan's history. How far they are to be depended upon, it is difficult to say. Ages appear from 90 to 105, and even 120. A native of Walls, of the name of Laurence, is said, at the age of 100 to have married a wife, and when 140 years old to have gone out to sea in his little boat. But Brand, the honest missionary, heard of a case far more wonderful;—a man of the name of Tairville, who lived 180 years, and during all this time never drank beer or ale. He was descended from a family remarkable for their longevity, his father having attained even a greater age than him self.

Native Medicines.—In Shetland there are several popular medicines. Scurvy grass is used in cutaneous complaints, butter-milk in dropsy, shells of whelks calcined and powdered in dyspepsia, and a variety of steatite, named in the country kleber, in excoriations. A man now dead in Northmavine, was a successful inoculator with variolous matter, which he was accustomed, with the view of depriving of its virulence, to dry in peat-smoke; he then covered it with camphor, buried it in the earth, and before applying it, retained it in this situation for so long a period as seven or eight years. But the mode of letting blood, known from time immemorial, deserves the most particular notice. It has been described by Dr. Copland in a Medical Thesis. When the native chirurgeon is called in, he first bathes the part from which the detraction is to be made with warm water, and then draws forth his cupping machine, which consists of nothing more than the upper part of a ram's horn perforated at the top, and bound round with a soft piece of cotton or woollen rag. In applying it to the skin he sucks out a little of the included air, takes off the horn, makes upon the surface of the part that has been gently raised, six or seven slight incisions, again fixes the cupping instrument, freely draws out the air by the reapplication of his lips to it, and either by insinuating his tongue within the perforation, or by twisting round it a piece of leather or bladder, prevents the ingress of fresh air. He next uses coarse cloths, wrung out with warm water, to stimulate the flowing of the blood, and when the horn is half filled it leaves the skin and falls off. The same process is repeated several times, until a sufficient depletion has been made. It is worthy of remark, that the African negroes described by Park have a similar mode of cupping; but it would be passing an undeserved affront to the natives of Thule to add, that, on the theory of a philosopher, who maintains that the manners of an uncultivated people are in all periods and countries the same, such a coincidence ought to have been expected.

We have at length concluded our view of the history and present state of the Shetland islands, which form a neglected and (strange to add!) an unrepresented province of the British dominions; but we may hope that a better acquaintance with the natural advantages which they possess in their fisheries, mines, and other sources of natural emoluments, may recommend this country to the attention of a liberal and enlightened legislature, and that it may be advanced to a state of political importance which it has not yet had the good fortune to experience.

SHETLAND, New South, an extensive tract of uninhabited land, situated to the south of Cape Horn. It is said to have been first discovered by Gherritz, a Dutch navigator, in 1599, but some doubt exists with regard to this fact. It was rediscovered in 1819, by Mr. Smith, the commander of an English merchant vessel, in a voyage from Monte Video to Valparaiso. The circumstance which gave rise to the name of New South Shetland being applied to these islands, was their lying in nearly the same degree of south as the Shetland islands are in north latitude. Its appearance is that of a succession of islands, stretching in a northwest direction.

The ingredients of the rock of which the Shetland islands are formed, appear to be quartz, with disseminated iron pyrites, and quartz in prismatic concretions, copper green, and copper pyrites. Among the minerals, is a rose coloured apophyllite, which has not the tesselated structure so common to this substance. The islands, which are almost all intersected with icebergs, and some of them covered with snow, present a rocky and barren appearance, and, with the exception of a few patches of short grass and some moss, are almost totally devoid of vegetation. These islands also exhibit volcanic appearances, as smoke had been observed issuing from the clefts in the rock of one of them. In consequence of the scarcity of herbage, it is impossible that any terrestrial animal could exist. But there are several species of amphibious animals, the principal of which are the sea elephant and the fur seal. The first of these acquired its name from the male having a cartilaginous substance, about five or six inches long, extending from the nose, similar to the trunk of the elephant. The birds are not numerous. They consist of a small species of penguin, fresh water ducks, Port Egmont hens, white pigeons, aglets, snow birds, and grey and blue peterels. See Weddell's *Voyage towards the South Pole*, 2d edition, p. 129.

SHIELD, see Armour.

SHIELDS, North, a market and sea-port town of England, in the county of Northumberland, is situated on the northern bank of the Tyne, about one and a quarter mile from its entrance into the German Ocean. The oldest part of the town is a long narrow street on the side of the river, but the town now contains several excellent streets, two handsome squares, and a market place unusually spacious. The most fashionable part of the town is Dockuray Square, which is neatly built, and is inhabited by wealthy shipowners. On one side there is a commodious quay, at which ships of 300 tons may unload, and another side is decorated with a fine stone edifice, now used as an inn. The parish church was built in 1659. It is situated on the north side of the river, and is a plain but commodious edifice; a steeple was erected upon it some years ago, and musical bells placed in it. There is in the town a commodious Scotch church, an elegant Catholic chapel near the north entrance to the town, and a meeting house for Independents. There is here also a theatre, a new market place, a good subscription library, a dispensary, a large Lancasterian schoolhouse, a lying-in hospital, an asylum for sick and friendless women, several charity schools, and many thriving benefit societies.

The principal manufacturing establishments in this town are yards for ship and boatbuilding, a rope and sailcloth manufactory, a cast iron foundry, a tobacco manufactory, a tannery, a skinnery, a manufactory of glass and fur. The harbour can accommodate 2000 vessels, and during spring tides, ships of 200 tons can pass the bar. The principal trade of this port consists in exporting coals, though a few vessels were employed in the American and Baltic trade. The want of a custom-house is severely felt here, as all vessels are obliged to clear out from Newcastle, a distance of nine miles up the river.

The following was the population in 1821:

Inhabited houses - - -	853
Families - - - -	2081
Ditto employed in trade - -	762
Ditto in agriculture - - -	1
Males - - - -	3815
Females - - - -	4360
Total population - - -	8205

There are at the foot of the town two lighthouses, which are kept up by the Trinity House of Newcastle. Near the lighthouses stands Clifford's Fort, built in 1672, which completely commands all vessels that enter the river. See the *Beauties of England and Wales*, vol. xii. part i. p. 89.

SHIELDS, South, a market town of England, in the county of Durham, is situated near the mouth of the Tyne, almost opposite to North Shields. Most of the streets of this town, with the exception of those on the Bank top, and in the market place, are narrow and the houses indifferently built; and its appearance is greatly disfigured by a number of artificial hills, stretching to the east and south sides, and formed by the accumulated cinders of the salt-works, the refuse of the glass houses, and the ballast and gravel thrown out by the light colliers. Some of these hills have been built up, and have a very singular appearance when seen from the south. The church of St. Kilda, which is a chapel of ease to Jarrow, was, with the exception of its plain and square tower, rebuilt in 1811 at an expense of £5000. Though rather heavy externally, it is neat and commodious within. On the chain above the chandelier is a very elegant model of the life boat. It stands on the south side of the market place, which is a spacious square, having in its centre the town house, with a colonnade beneath it, erected at the expense of the dean and chapter of Durham. There are here several dissenting meeting houses, the chief of which is that belonging to the Methodists, finished in 1809 at an expense of £3800, and capable of holding 1700 persons. There is likewise in this town a new theatre, several public schools and thirty benefit societies. Subscription assembly rooms are opened every winter. The whole town, with the exception of three houses and a meeting-house, is held by lease under the dean and chapter of Durham.

The principal establishments for manufactures of South Shields are yards for shipbuilding, glass works for flint and crown glass, soap works, salt works, salammoniac works, extensive roperies and breweries. Salt was formerly manufactured here to a very great extent. About sixty years ago, no fewer than 200 large pans were fully occupied. There are however only four or five pans at present employed. The ground formerly occupied by the salt works has been converted into docks and yards for building and repairing ships. There are no fewer than *eleven* of them which are capable of holding sixteen vessels. The number of ships belonging to this town is about 500. Among the machines for taking ballast from ships, is one erected by Messrs. Newmarch and Company, which carries it through a tunnel several hundred yards long. The life boat was invented here, as already described in our article Boat. The town of South Shields is built almost exactly on the site of the Roman station *ad Tinam*, which occupied the eminence on the south point of the harbour.

The following was the population in 1821:

Inhabited houses	724
Families	2286
Ditto employed in trade	2243
Ditto in agriculture	2
Males	3638
Females	5247
Total population	8885

See the *Beauties of England and Wales*, vol. v. p. 153.

SHIPBUILDING.

INTRODUCTORY OBSERVATIONS.

In no period of the world has the subject of naval architecture had higher claims on public attention than the present, and to our own country in particular, it is an art of such transcendent importance, that no means ought to be left untried to give to it every perfection of which it is susceptible. Nor is it only in a commercial point of view that shipbuilding is valuable to man, since by the enterprise that fortunately characterises the modern navigator, the ocean is become one of the high roads of civilization,—perhaps the highest; and therefore in the successful cultivation of the various arts connected with navigation and commerce, every lover of human improvement must feel an interest proportionate to the influence which they are now universally allowed to exercise on the improving destiny of man.

There are three capital points of view in which naval architecture may be contemplated. *First*, as regards the means it affords for the purposes of war; *secondly*, as it relates to commercial enterprise and speculation; and *thirdly*, as it is connected with human improvement, the enlargement of geographical knowledge, and the extension of the blessings of civilization. The cultivation of the first is unfortunately rendered necessary by the peculiar condition of the world; and perhaps the second and third are in some degree protected and assisted by it; but it is the successful advancement of the latter, that renders the study of naval architecture most pleasing, and elevates it to a rank with those arts which essentially minister to the happiness and well being of man. Commerce indeed is productive of unnumbered blessings. Its theatre is the world; and the wide spreading waters of the ocean form the links of social harmony and love. The most distant nations are by its means connected;—national jealousies and prejudices become softened;—the wandering savage learns to value the blessings of social life; and the various productions which the wisdom and beneficence of the Supreme has rendered peculiar to particular climates and countries, are, by the arts connected with shipbuilding, distributed through every part of the globe, to which the wide spreading enterprise of man has penetrated.

Little more than a century and a quarter have elapsed since the theory of mechanics was first applied to the construction and management of vessels, in a work published at Lyons in 1696 by Paul Hoste,* and entitled, "*Theorie de la Construction des Vaisseaux.*" Prior to the publication of this interesting treatise, experience and imperfect observation were the guides of the shipbuilder. The torch of geometry had not then illuminated his path: nor were the maxims of mechanical science applied to his daily labours. Ships were constructed by rules, which a long succession of centuries had esteemed as infallible, and no man ventured to question their accuracy and origin. After a long night of darkness, however, arose Bernouilli, Bouguer, and Euler, who joined to the highest theoretical attainments, clear and definite conceptions of the practical applications of analysis to some of its most important elements. In the hands of Euler in particular, the subject first assumed a regular and systematic form; yet from the peculiar difficulties connected with the inquiry, much, very much remains to be done, to give to its theoretical investigations those capabilities of application which the inquiry so particularly demands. Since the time of Euler, it has been enriched by the labours of Clairbois, of Chapman, of Atwood, and of some others; and the labours of the two latter have done much for its advancement. Its precepts and rules, however, are still too much influenced by caprice, by prejudice, and chance. The rigid and scrutinizing spirit of geometry calls for a more precise application of its rules;—and where, we would ask, can its severe and unalterable precepts meet with a more extended field of application?

At the present moment indeed, a spirit of inquiry seems to be awakened respecting shipbuilding, which no antecedent period ever exhibited. The public attention has in a peculiar degree been drawn towards it, partly, perhaps, from apprehensions respecting the possible rivalry of other states; partly from the successful applications of mechanical science to its various branches, by the genius and intelligence of Sir Robert Seppings; and partly from the establishment of the school of naval architecture in Portsmouth dock yard, and from the admirable union of theory and practice which characterises the course of instruction employed in that most useful institution.

It is the judicious and proper union of theory and practice that is wanted to carry this very important art onwards to perfection. "Practical knowledge alone would be insufficient, nor would the highest theoretical skill be all that would be required. The two must be united,—cordially and harmoniously united. Practice must not decline the assistance of theory, nor must theory disdain to be taught by the lessons of practice."† "There are many principles," says Mr. Atwood, "deducible from the laws of mechanics, which it is probable *no species of experiment, or series*

* Pere Pardies, and the Chevalier Renaud, published some partial observations on the theory of naval architecture prior to 1696, but the treatise of Paul Hoste was the first work in which the subject was considered in a systematic manner.

† Harvey on Naval Architecture, Annals of Philosophy, vol. viii. p. 445, new series.

of observations, however long continued, would discover; and there are others no less important, which have been practically determined with sufficient exactness, the investigation of which it is scarcely possible to infer from *the laws of motion*; the complicated and ill-defined nature of the conditions, in particular instances, rendering analytical operations founded on them liable to uncertainty." It is true indeed, as the same writer remarks in another place, that "although all results deduced by strict geometrical inference from the laws of motion, are found, by actual experience, to be perfectly consistent with matter of fact when subjected to the most decisive trials, yet in the application of these laws to the subject in question, difficulties often occur, either from the obscure nature of the conditions, or the intricate analytical operations arising from them, which either renders it impracticable to obtain a solution, or, if a result is obtained, it is expressed in terms so involved and complicated, as to become in a manner useless as to any practical purpose. These imperfections in the theory of vessels are amongst the causes which have contributed to retard the progress of naval architecture, by increasing the hazard of failure in attempting to supply its defects by experiment; for when no satisfactory estimate can be formed from theory, of the effects likely to ensue from adopting any alteration of construction that may be proposed, doubts must unnecessarily arise respecting its success or failure, which can be resolved only by having recourse to actual trial; a species of experiment rarely undertaken under the impressions of uncertain success, when the objects are so costly, and otherwise of so much importance. To the imperfections of theory may also be attributed that steady adherence to practical methods, rendered familiar by usage, which creates a disposition to reject, rather than to encourage proposals of innovation in the construction of vessels: the defects or inconveniencies which are known, and have become easily tolerable by use, or may perhaps be the less distinctly perceived for want of comparison with more perfect works of art, being deemed preferable to the adoption of projected improvements, attended by the danger of introducing evils, the nature and extent of which cannot be fully known. These are amongst the difficulties and disadvantages which have concurred in rendering the progress of improvement in the art of constructing vessels extremely slow, and left many imperfections in this practical branch of science which still remain to be remedied."*

Another important consideration which has tended to retard the progress of naval architecture, is the immense variety of vessels, which the peculiar circumstances of climate, varieties in the extent and depth of waters and of seas, have rendered necessary to man; each variety differing in proportion and form, in their methods of rigging, and in their modes of navigation; some being adapted for limited voyages in narrow and contracted channels, others for voyages the most extended in the widest oceans; some for winds of almost a permanent character, and others for all those uncertain varieties of weather, which mark so many of the regions of the earth.

Amidst this almost infinite diversity, we may however trace, in numerous instances, indications of something like general laws. In those vessels, for example, which are destined for extended voyages, we find their extreme breadths to be between a third and fourth of their lengths. In vessels of a smaller size, the breadth bears a greater proportion to the length, than in ships of a higher class. The elevation of the deck above the surface of the water has likewise limits, which are regulated by the peculiar destination of the vessel. All ships, moreover, have their maximum of breadth, a little before the middle; the forms of their forward and after parts are variable, but still distinguished in all cases by this peculiar feature, that the figure of the latter part is more slender, or as it is technically expressed, is leaner than the former. In ships destined to bear heavy burdens, the bottom is fuller to admit of greater capacity for stowage, in opposition to those which are built for speed and velocity, which have uniformly their lower parts of a sharper figure. The line of the keel also does not run in a plane parallel to the fluid surface, but has a greater draught of water in the after-part of the vessel, than in the forward; that both the stem and the stern have a rake or inclination between certain limits: that in the rigging of ships, some have one mast, others two, and most three masts, adapted in their diameters and altitudes, to their peculiar circumstances; that the centres of gravity of all vessels are found a little before the middle of their lengths, and that the centre of gravity of the sails is uniformly met with before the centre of gravity of the ship.

Thus it appears, that amidst the seeming diversity characterising the numerous branches of this very important subject, there are indications of general laws to be found, which experience, in a long succession of ages, has taught the navigator to follow, in order to succeed in his adventurous enterprises. And it is remarkable in how many instances the results of uneducated men have anticipated the soundest deductions of the most enlarged theories; and how unconsciously they have employed, even in their pastimes and sports, those very principles on which the philosopher raises the noblest monuments of his fame. "The savage who never heard of the accelerating force of gravity, yet knows," says Mr. Stewart, "how to add to the momentum of his missile weapons, by gaining an eminence; though a stranger to Newton's third law of motion, he applies it to its practical use, when he sets his canoe afloat, by pushing with a pole against the shore; in the use of his sling, he illustrates with equal success, the doctrine of centrifugal forces, as he exemplifies (without any knowledge of the experiments of Robins) the principle of the rifle barrel, in feathering his arrow." And just so is it in the steps which have marked the progressive advancement of naval architecture. The practical knowledge which the framer of the canoe exercises, "is obtruded on the organs of external sense by the hand of nature herself." He found, for example, that a particular disposition of the sail of his little bark would give to it a greater velocity than any other. A change of position of his own body, or of a stone in the bottom of the canoe, would alike influence its sailing qualities. These to him would be maxims of great practical value; would be treasured up and recollected, applied on every necessary occasion; in time communicated to his fellow-navigators, and at last identified with the general habits of his tribe. From such be-

*Philosophical Transactions for 1798, pages 203, 204.

ginnings it is, that naval architecture has arisen; and the philosophical observer endeavours to draw from the maxims which have guided even uneducated men in a long course of ages, those general laws, which, when moulded into a systematic form, enable him to perceive relations still more extended and general.

It is remarkable however, that although experience seems to have taught mankind, that certain general relations in the formation of ships, are necessary to be observed, in order to insure success in their construction; yet within the limits which this experience has revealed, so many varieties of form have been produced, as to create in the qualities of the vessels constructed the greatest diversity. Some ships, when constructed with only a tolerable approximation towards the limits which experience seems to have approved, appear to possess every good property we can desire; whereas others, framed apparently with equal care, and with no visible deviation from the limits before observed, will nevertheless, from differences in the mode of stowage, and from different methods of management when at sea, display qualities altogether at variance with the former. It often happens also, that constructers, in order to avoid one defect, create another, and sometimes, too, when endeavouring to get rid of a bad quality, the evils arising from it are augmented; and so intricate are the conditions connected with any theoretical investigation of the cause, that any attempt to account for it in such a way, has but slender chances of success. The great object indeed in the construction of a vessel, is to secure to it as many good qualities as possible; that if it be necessary in one case to sacrifice any portion of an acknowledged good property, in order to secure a more advantageous application or extension of another, care must be taken, that no greater proportion of the first should be abandoned, than the actual necessities of the second require; in other words, that the aggregate of *both* should approximate as nearly to a maximum as possible.

We have seen, however, that experience has taught us certain principles in shipbuilding, which may be safely adopted as data, on which to ground systems of reasoning connected with the properties to which those principles refer: and is it not therefore possible, by careful attention, to discover *other* properties, at present classed with the accidents and chances attendant on fortunate constructions; but which would, nevertheless, in the hands of one competent to the undertaking, be found to possess some definite relations to other general laws? All ships, it has been before remarked, have their centres of gravity a little before the middle of their lengths. This is known in a general way; but the precise quantity of the deviation of this very important point, from the centre of the length, cannot, in the present imperfect state of our knowledge, be made known. Would no useful results therefore flow from an experimental inquiry into the exact position of this centre? Or rather, might we not say, would not many conclusions of the first importance to naval architecture, be obtained from a digest of the properties of a few of the best ships of each class of the British navy? Mr. Major, at present foreman of Chatham dockyard, and formerly of the school of naval architecture, published, in the Annals of Philosophy for November 1824, a paper on this very important subject; setting forth the advantages that would accrue to shipbuilding, by obtaining, experimentally, many of its leading elements, such as the foreign and light displacements of our ships of war; their principal dimensions, such as the greater axis of the load water plane, the breadth and draught of water; the forms and areas of the load water, and midship sections; the place of the centre of gravity of the entire ship—*not from hypothesis, but experiment;* the position of the centre of gravity of the displacement; the elevation of the metacentre, at the mean height of the ports out of the water; the dimensions of the masts and sails, with the position of the centre of effort of each sail, the force of stability at some determined angle, &c. &c. These elements, it must be admitted, are of the highest importance to naval architecture; and from their correct and accurate determination, would result much useful knowledge. Mr. Harvey, in the number of the same Journal, for January 1826, has a paper on the same subject, and in which he particularly insists on the advantages likely to result from a practical exemplification of Mr. Major's plan. Mr. Harvey proposes to have all *the elements that may be deemed necessary to be determined* as well as *the essential steps on which they depend*, methodically arranged in tables, according to the relation which the different forms bear to each other. "I know of nothing," observes Mr. Harvey, "that at the present moment would so much tend to increase our stock of information on shipbuilding as Mr. Major's proposal: since it would be carrying at once into the very heart of shipbuilding, that spirit of genuine induction, which in so many other branches of knowledge, has produced such mighty consequences."—"Let us inquire," says Mr H., "how we obtain information in other cases; how the philosopher works in his difficult investigations, and what are the instruments and methods employed by him when tracing the hidden mysteries of nature? Are they not *Experiment,—Observation,*—a careful watching after resemblances and relations of every kind? Does he not analyze every principle, separate every part, and in the end collect into general and connected laws, the individual results which his sagacity has discovered?" "Just so," continues Mr. H., "ought it to be in the pursuit of naval architecture; for there are about that subject, elements of a very peculiar kind, whose individual properties and collective laws, it is of the highest importance to determine. Much may indeed be said about theory; *but pure theory has yet done little for shipbuilding; what we want is a theory founded on the basis of experiment and observation.* The first mathematician in Europe may speculate for ever on the forms of floating bodies; he may dazzle his imagination with his ideal creations; he may multiply his analytical combinations, and pile his highest orders of integrals on each other; and yet, when called upon to make his practical applications, his formulæ almost lose their identity, and all his golden speculations vanish. But place in the hands of such a man a well-digested body of experimental results; show him how, in numerous instances, one property of a vessel has been invariably found connected with another; give to him those *constants* which are to link together the disjointed elements of his problem; furnish him with *experimental data* on which he can depend, and from which he can with confidence draw such results as his growing investigations require; and we shall find in the end a striking contrast to his former results. The data supplied to him will have disclosed relations never before anticipated, and conclusions never before imagined. Naval architecture would thus be in a high degree benefited; and an art which, it is not too much to say, is of the very *first importance for the British nation to cultivate and encourage*, would be freed from the trammels of uncertain and antiquated rules, and placed on a basis better suited to its dignity and value."

But, it may be asked, to what causes are we to attribute so singular a neglect of an art, so essential to the welfare of Great Britain, as the art of shipbuilding confessedly is; and how is it that states, confessedly our inferiors in maritime importance and strength, should excel us in the construction of their ships? To this it may be replied, that our triumphant superiority on the ocean affords a ready solution. Our superiority has induced neglect, while other nations, jealous of our nautical power, have strained every nerve to rival and surpass us, and *have endeavoured to make up the want of numbers by superior constructions.* The French, for example, have endeavoured, and in many cases have succeeded, in producing better sailers; and the Americans, by enlarging the scale of their different ships of war, are endeavouring to turn the balance against us. France, to obtain all superiority, wisely enlisted on her side the genius and science of her geometers. By prizes, by public rewards, by honourable distinctions, by every thing that could excite emulation and scientific enterprise, she invited her geometricians to consider all the great problems connected with shipbuilding; and to transfuse into the practical operations of her dock-yards, all that the most enlightened theories could teach. Some advantage surely must result to an art to which such a mind as D'Alembert's could direct its attention. It is impossible for a mind, accustomed to the higher orders of human thought, to descend to the lower walks of human contemplation, without the latter being in some degree improved. A mere theorist, applying his speculations to the practical details of an art, can do nothing; but a man, whose habits and modes of thought are built upon the genuine principles of inductive science,—who looks at shipbuilding, for example, neither with the eye of a merely speculative curiosity, nor with the blank intelligence that too often unfortunately characterises the daily operators in the mechanical arts, can scarcely direct his attention to any one of its departments, without in some degree imparting to it a benefit.

Shipbuilding, to Britain, may with perfect justice be styled a National Art. It is one even more necessary to our national existence than those miracles of mechanical skill which have placed our arts and manufactures on so proud and elevated a level. Destroy our naval superiority, and our lofty pre-eminence in commerce will soon be humbled in the dust. The navy is the sinews of our strength—the arm that gives us all our political importance, and makes the name of Britain known, respected, and feared in the remotest regions of the globe. And what, we would ask, is the proud term Navy, which as Britons we so often quote with exultation and hope, but a name identified in the closest and strongest way with the art which it is the object of this paper to illustrate? Give to our navy, therefore, we would say, *not only numbers, but every advantage which science and intelligence can bestow.* Let naval architecture be regarded peculiarly as a *national art.* Let its first elements, its feeblest beginnings, as well as its highest attainments, be fostered and encouraged. Let public honours and national rewards be bestowed on those who add to its perfection. Let our men of science be induced, like Euler, Bouguer, and D'Alembert, to look to it as an object to which their high attainments may be applied, with the full and certain prospect of honour and renown.

Some steps towards this most desirable end may, however, be traced in the establishment of the College of Naval Architecture in Portsmouth Dock-yard, an institution which has already done much good, and which, if continued with energy and spirit, will do much more. Before the establishment of this college, the officers and leading men of our dock-yards were drawn from the working men of those establishments; and *they* were recruited by means of apprentices, destitute, in many cases, of the commonest rudiments of education. From such men, excepting perhaps a few highly gifted minds, what else could be expected but the same blind routine of practice that distinguished their forefathers? Accordingly, we find that the commissioners appointed in 1795 to revise the civil affairs of the navy, remarked, that the class of persons from whom the foremen, the master shipwrights, and the surveyors of the navy were chosen, "had no opportunity of acquiring even the common education given to men in their rank of life; and that they rise to the complete direction of the construction of ships, on which the safety of the empire depends, without any care or provision having been taken, on the part of the public, that they should have any instruction in mathematics, mechanics, or in the science or theory of naval architecture." The death-blow to this most lamentably imperfect system, was however given by the establishment of the college before alluded to; and we have only to hope that the success of the institution will be commensurate to the wishes of its most sanguine admirers. The candidates for admission are examined before the commissioners of the dock-yard, the professor of the Royal Naval College, and the lieutenant-governor. They are required to be intimately acquainted with the English language, so as to write it grammatically, and from dictation; they are to be able to read and translate the French language; they must be well grounded in the first six books of Euclid, together with the eleventh, and algebra as far as quadratic equations. At the period of examination also, a printed paper is placed before each candidate, containing a number of geometrical and algebraic problems, which he is required to work out on paper; and those are selected as the successful candidates who have displayed the greatest talent in the examination. During the seven years that they remain in the establishment, they resume the study of geometry with its applications; enter on a more enlarged course of algebra, pursue trigonometry, examine the theoretical and practical details of mechanics and hydrostatics, and close their inquiries on this interesting head, by an enlarged course on the differential and integral calculus. In the theory of naval architecture, they study the admirable papers of Atwood, contained in the *Philosophical Transactions*,* and also some of the best continental works on the subject. After obtaining sufficient elementary knowledge, they are employed in constructing original designs of ships of war, ascertaining their displacements, the centres of gravity of their displacements, and of the whole masses of the ships and their equipments, considered as heterogeneous bodies. To this is added, the most exact and accurate inquiries connected with the stability, both according to the metacentric method of Bouguer, and to the more perfect and precise investigation of Atwood. Comparisons also are instituted—the qualities of English ships are compared with those of a foreign built—their several properties are analyzed—the good qualities are combined so as to remedy the bad, and to produce in their ultimate application the most perfect design.

But it is not to theory only that their attention is directed. The practical details of the art receive a large proportion of their attention. They are effectually taught how to lay off ships in their practical construction, and in making the drawings which are necessary for the execution of the work in the progress of the building. The adz and the line are put into their hand like the humble operative at the dock side, and a vigilant practical shipwright examines into the minutest details of their duty. Engaged therefore in the morning, we will suppose, in studying the theory of their profession—in calculating the displacement—in investigating the properties of the midship section—estimating the power and influence of the sails—or endeavouring to catch a glimpse of the deep and recondite laws that regulate the resistance of fluids—they turn in the afternoon to the practical details of their art—in shaping and adjusting timbers —filling up the component parts of Seppings' diagonal framing—bolting together the timbers of his circular sterns, and observing in those numerous cases which the eye of theoretic intelligence is in general so ready to catch, the actual application of rules which occupied their morning thoughts. What else, we would ask, is necessary to make a complete and perfect shipwright? He has the amplest and best theories known continually before him, and the most enlarged practice, to exemplify their application. During this course of rigorous and unrelaxing labour, both of body and mind, annual examinations are held before the commissioner of the dock-yard, the admiral of the port, the lieutenant-governor of the college, and the first lord of the Admiralty. These examinations, both in mathematics and the theory and practice of shipbuilding, are very severe, and considerable study and preparation are required to pass them with credit. After finishing their course of studies at the college, they are removed to the different dock-yards, to fill the situation of subordinate officers; from which situations it is the professed intention of Government to promote them to those of the higher offices, and eventually to that of surveyor of the navy.

But the studies of the members of this college are, however, but begun, when the term which marks their apprenticeship has expired. Naval architecture is a jealous mistress, and requires the undivided man. Not the devotion of a few years, but of a life, consecrated to its pursuit. Year after year, with unwearied zeal, must be devoted to its interests; and the cordial and uninterrupted pursuit of its varied details, must meet with that reward which attends industrious labourers in other departments of the arts.

It has been objected, however, to this institution, that its establishment has a tendency to check those honest and praiseworthy exertions which many among the great mass of the operative shipwrights in the dock-yards were formerly stimulated to make, by the hope of filling those situations which are to be now occupied by the members of the college. But to this it may be replied, that the Admiralty and Navy Board, with a wise and proper forethought, have by no means closed the avenues of promotion to this useful and deserving class of men. Very recently, indeed, we have seen an example of an operative promoted to the rank of a foreman, and a draughtsman of the old institution of things promoted to a similar situation. And this is just as it should be. Among the many operatives which a dock-yard presents, there must be some few at least deserving of a better fate, than to spend the long term of their lives in a perpetual state of unceasing labour—some, too, though working at first as humble shipwrights, yet deserving from their talents to rise to command. The great object in a well-regulated community, is to encourage ability wherever it appears; and we are persuaded that the welfare of the country will be essentially promoted by fostering native talent wherever it appears.

The objections, however, that are sometimes raised against the College of Naval Architecture, that science is unnecessary to a shipbuilder, and that time is misspent in cultivating mechanics, hydrostatics, and fluxions, are too ridiculous to merit a serious refutation in this place; and they are only alluded to, that the future historian of naval architecture, when tracing the effects and influence of the establishment of the college, may class it among the anomalies which distinguished its history. To suppose for a moment, that in a fabric so massy and stupendous as a ship, destined for all the terrible purposes of war, or to bring to us, from the most distant regions of the globe, cargoes of the most bulky and unmanageable kind;—which in its progress has to cross wide and immeasurable seas, agitated at times by the unbridled fury of the wind,—that no science is necessary in her construction, is to imagine an anomaly of the most monstrous kind. Science is the basis of every well-ordered machine. Science was the groundwork of all that Watt, Smeaton, or Wren ever achieved; and can science be unnecessary in the formation of a ship? Science indeed has hitherto been too much neglected in our dock-yards. We have trod long enough in the blind and uncertain steps of our forefathers; and the establishment of the College of Naval Architecture must be numbered among one of the most fortunate events of the age; and, though not found in the ranks of its members, we look to it with pride and satisfaction.

In concluding these introductory observations, we would remark, that naval architecture is in so peculiar a degree *a national art*, that we could wish to see a society formed for its particular cultivation. There are so many advantages to be derived from the co-operation of numbers in the prosecution of scientific pursuits—advantages first pointed out by the prophetic mind of Lord Bacon, and which the experience of the last two centuries has so abundantly confirmed, that it seems wonderful no attempt has been made to organize a society on a great and permanent scale for the improvement of shipbuilding. And Mr. Harvey has remarked, in the *Journal* of the Royal Institution, "that there is perhaps no subject which requires more essentially the aid and co-operation of numbers than naval architecture; involving as it does so extensive a field for inquiry, and so beset, as all its elements are, with difficulties of so peculiar and intricate a

* It is much to be desired that these admirable dissertations were reprinted in a separate form, and enriched by appropriate notes, for the use of our students in Naval Architecture.

kind. At the present moment also, there is a spirit of inquiry abroad respecting shipbuilding, which no antecedent period ever exhibited, and which, if taken at the flood, and before the causes that have awakened it subside, must produce consequences of a very important kind. What therefore seems to be wanting," continues Mr. Harvey, "is a sort of focus, or common point of union, to rally the disjointed and insulated speculations now afloat respecting it, and to concentrate the efforts of those who feel interested in its advancement. This might be most readily and effectually done, by instituting a society, the object of which should be, to encourage theoretical and experimental inquiries connected with naval architecture; and to publish from time to time in its transactions, such papers of approved merit as might be laid before it at its meetings."

The hint contained in this quotation is too important to be forgotten; and we earnestly hope to see it perfectly realized at no very distant time. We have seen, in the cases of the Astronomical and Geological Societies of London, how much their formation has contributed to quicken the cultivation of the interesting objects for which they were instituted; how by the one the astronomer has been stimulated to watch the celestial concave with greater earnestness and zeal; and how the other has tended to unfold, by gradual and successive steps, the nature and constitution of the crust of this lower world. Now why, we would ask, could not the same objects be attained for naval architecture? If the union of numbers has quickened geological, and added to the splendour of astronomical science, why should not an association of men, devoted to the theoretical and practical cultivation of shipbuilding, produce similar effects? The single subject of the resistance of fluids requires it alone; and when we see the magnitude of the obstacles that impede the march of the great national art we allude to, we earnestly hope that no endeavours will be wanting to surmount them.

It shall now be our object to enter into some of the theoretic and practical details of this important subject; and as we would on the one hand endeavour to avoid every thing which bears the aspect of *merely speculative inquiry, with no practical object in view*, so we would on the other avoid any description of those merely practical details of the art, which can only be acquired at the dock side, or which have been already minutely and clearly detailed by the practical writers on the subject. We shall therefore begin with the consideration of the displacement, an element which meets us on the very threshold of the inquiry.

OF THE DISPLACEMENT.

We refer to the article Hydrostatics for the consideration of the principle, that a body specifically lighter than water will sink in the fluid, until it has displaced a portion of it, equal in *weight* to the entire body itself. On this simple elementary law of Hydrostatics is primarily founded the process commonly employed by naval architects for determining the *displacement* of a vessel.

By the displacement of a ship we are to understand the cubical contents of that part of it which is below the water's surface, and which, it is obvious, must be more or less, according to the degree in which the ship is immersed, by the variable conditions of its lading.

In making a design for a ship, the first object of the constructer must be, to form as accurate an estimate as possible of its weight; and if this is to be done without any assistance derived from former constructions, exact calculations must be made of the dimensions and specific gravity of all the materials to be employed in her formation; the number of guns she is destined to carry; her complement of men; and the quantity of provisions and stores necessary for her complete equipment. When her total weight is thus determined, the constructer must endeavour to obtain for her a corresponding displacement, and at the same time secure to her such dimensions, as shall impart to her every property he may desire, and, if a ship of war, to ensure her lower deck guns a sufficient elevation above the water's surface. The displacement therefore is a fundamental element in shipbuilding, and on its right determination depends many important considerations.

If the form of the body immersed in the fluid were generated according to any known and determined law,—if, for example, it partook of the figure of any solid of revolution, the application of the particular rule of mensuration belonging to that figure, would readily furnish the solidity of the part immersed. But there is no certain form yet determined for a ship's bottom: and, accordingly, no approximate formula has yet been devised, which can furnish, by a short and convenient operation, the displacement. Bouguer it is true, attempted an approximation of the kind, by assimilating a ship's body to a spheroid; and then estimating the contents of its displacement at $\frac{11}{21}$ of the rectangular solid formed by the three principal dimensions of the ship—its length at the water's surface, and its breadth and depth estimated at and from the same plane. This method, however, although it might afford tolerably correct results for ships whose fulness of figure approached nearly to a spheroidal form, yet in vessels of a sharper class, the errors arising from its application would be too considerable to admit of its employment in any other way than as an approximation of the roughest kind.

Accordingly, constructers have had recourse to the well-known method of equidistant ordinates; a process contrived by mathematicians to obtain the areas and cubical contents of bodies, whose forms are destitute of symmetry and proportion. It consists essentially, in the case of a solid, in dividing it into an *unequal* number of laminæ or sections of uniform thickness, and determining their aggregate solidity by means of the formula

$$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3},$$

in which Σ denotes the sum of the *first* and *last* ordinates, S the sum of the *even* ordinates, s that of the *odd* ordinates, and i the *common interval* or distance between the ordinates: and we shall now proceed to exhibit its application, by calculating the displacement of a seventy-four gun ship. This may be enunciated as a

PROBLEM

To determine the displacement of a vessel, having her *Sheer plan* or *Elevation*, and *Body plan* or *Plan of Projection* given.

Solution.

The displacement of a vessel may be calculated by *horizontal* laminæ or sections, or by laminæ or sections estimated *perpendicularly*: or as is most desirable, by sections both horizontally and perpendicularly, and taking the mean of both, should the two results not exactly agree. This latter mode will be adopted in the succeeding investigation.

To accomplish it, let the sheer draught represented in Fig. 1. Plate CCCCLXXXVIII. be referred to, and in which W *w* denotes the intersections of the plane of the water's surface, with the plane of projection, or in other words, the water line of the ship, and at the common interval of one foot, let other planes be supposed to pass parallel to the plane of flotation, through the points 2°, 3°, 4° . . . . 20°, 21°, 22°, and 23°. This mode of operation will therefore divide the portion of the ship immersed into twenty-three uniform laminæ, the lowest of which is denoted by the dotted line X x. The same series of sections or water lines are also represented as passing transversely through the points 1°, 2°, 3° . . . . 21°, 22°, 23°, in the body plan denoted by Fig. 2; and the contour or bounding figure of each section is denoted by the curve lines which pass respectively through the points . . . . 10°, 13°, 16°, 19°, &c. in Fig. 3 of the same plate. The water line, or that which corresponds to W *w* in Fig. 1, is denoted by the external curve in Figure 3.

The different curves produced by these water sections, are, it will be perceived, of very variable forms, and their ordinates therefore must be of variable magnitudes. To ascertain these at uniform intervals, the ship is supposed in the next place, to be intersected

TABLE OF ORDINATES AND RESULTS OF CALCULATIONS

Numbers denoting the horizontal sections.	Semi-horizontal areas abaft vertical sect. 5'.	Horizontal ordinates between vertical sections 1' and 5'. Common interval 1 foot.	Ordinates of vertical sections between 5' and 1'. Common interval, 3.4249.					Semi-horizontal areas between vertical sections 5' and 1'.	Horizontal ordinates between vertical sections 1 and 27. Common interval 1 foot.	Ordinates of Vertical Sections between													
			5'	4'	3'	2'	1'			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1°	3.15		.8	5.1	10.9	14.8	17.4	136.54		17.4	20.1	21.7	22.5	22.95	23.25	23.55	23.75	23.95	24.1	24.25	24.4	24.5	24.55
2°	3.27		.8	4.2	9.0	13.1	16.1	118.84		16.1	19.3	21.3	22.2	22.8	23.2	23.55	23.8	24.0	24.2	24.35	24.5	24.6	24.65
3°	3.39		.8	3.5	7.45	11.4	14.6	102.63		14.6	18.2	20.5	21.8	22.6	23.15	23.25	23.85	24.05	24.25	24.4	24.5	24.65	24.75
4°	3.50		.8	3.0	6.25	9.9	13.3	89.27		13.3	17.1	19.65	21.2	22.25	22.95	23.45	23.8	24.0	24.2	24.35	24.5	24.65	24.7
5°	3.55		.75	2.55	5.15	8.5	11.6	76.32		11.6	15.75	18.55	20.35	21.75	22.6	23.25	23.65	23.9	24.15	24.3	24.5	24.6	24.7
6°	3.60		.75	2.2	4.3	7.3	10.1	65.58		10.1	14.4	17.4	19.4	20.95	22.0	22.8	23.35	23.7	23.95	24.15	24.3	24.4	24.5
7°	3.64		.75	1.8	3.6	6.25	8.8	55.88		8.8	13.1	16.2	18.3	20.05	21.3	22.2	22.85	23.3	23.6	23.8	23.95	24.1	24.2
8°	3.67		.7	1.6	3.0	5.2	7.5	47.26		7.5	11.6	14.85	17.15	18.95	20.4	21.4	22.2	22.7	23.0	23.35	23.5	23.65	23.8
9°	3.70		.7	1.4	2.55	4.3	6.4	39.96		6.4	10.3	13.55	16.0	17.8	19.4	20.55	21.45	22.0	22.4	22.75	22.95	23.1	23.2
10°	3.74		.7	1.22	2.2	3 6	5.4	34.00		5.4	8.9	12.15	14.7	16.6	18.3	19.5	20.45	21.1	21.65	22.0	22.25	22.4	2.5
11°	3.78		.7	1.1	1.85	3.05	4.5	29.11		4.5	7.6	10.8	13.4	15.4	17.15	18.5	19.5	20.25	20.8	21.3	21.5	21.65	21.8
12°	3.82		.7	1.0	1.6	2.55	3.75	24.94		3.75	6.5	9.4	12.0	14.15	15.95	17.45	18.5	19.3	19.9	20.4	20.7	20.85	21.0
13°	3.85		.65	.9	1.4	2.2	3.15	21.69		3.15	5.45	8.0	10.6	12.8	14.7	16.2	17.35	8.25	18.8	19.3	19.7	19.85	20.0
14°	3.78		.65	.8	1.2	1.8	2.55	18.27		2.55	4.5	6.8	9.15	11.45	13.45	15.0	16 12	117.1	17.75	18.3	18.7	18.85	19.0
15°	3.71		.65	.7	1.1	1.6	2.15	16.21		2.15	3.7	5.6	7.7	9.9	11.9	13.65	14 8	15.9	16.6	17.1	17.5	17.75	17.
16°	3.64		.65	.7	.95	1.35	1.75	14.27		1.75	3.0	4.45	6.2	8.2	10.25	12.1	13.5	14.5	15.1	15.7	16.2	16.5	16.
17°	3.57		.65	.65	·8	1.15	1.5	12.50		1.5	2.4	3.4	4.7	6.1	8.15	10.0	11.6	12.7	13.4	14.1	14.55	14.9	15.1
18°	3.50		.62	.62	.7	1.0	1.2	11.07		1.2	1.85	2.45	3.5	4.4	5.8	7.4	9.0	10.3	11.2	11.9	12.4	12.8	13.
19°	3.43		.62	.62	.65	.77	1.0	9.68		1.0	1.4	1.8	2.4	3.1	3.8	4.7	5.8	6.8	7.8	8.8	9.5	10.0	10.
20°	3.40		.6	.6	.6	.7	.8	8.80		.8	1.0	1.3	1.6	2.0	2.35	2.7	3.05	3.4	3.5	3.6	3.6	3.6	3.
21°	3.38		.6	.6	.6	.6	.7	8 33		.7	.8	.9	1.0	1.1	1.2	1.3	1.35	1.35	1.35	1.35	1.35	1.35	1.
22°	3.36		.57	.59	.61	.63	.65			.65	.7	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	[illegible]
23°	3.34		.57	.59	.61	.63	.65			.65	.7	·75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	[illegible]
Semi-solidity abaft vertical sect. 5'.			15.09 +.63	33.15 +.61	61.15 +.59	94.53 +.57	126.42 +.56	Semi-solidity between sects. 1' & 5'		126.42 +.56	177.87 +.54	221.02 +.50	255.72 +.45	284.97 +.41	310.77 +.34	332.17 +.34	340.86 +.30	361.70 +.26	370.65 +.22	378.27 +.18	383.58 +.15	387.12 +.10	389. +
90.04		Semi-vertical areas between sections 1' & 5'.	15.72	33.76	61.74	95.10	126.98	892.30	Semi-vertical areas between sections 1 & 27.	126.98	178.41	221.52	256.17	285.38	311.15	332.51	349.16	361.96	370·87	378.45	383.73	387.22	389

by transverse planes perpendicular to the water's surface, passing through the points 5', 4', . . . 1, 2, 3, ... 25, 26, 27 . . . . . . 4'', 5''; those between the points 1 and 27 being at the common interval of 6 feet from each other; those abaft the plane 1, at the equal interval of 3.4249 feet; and those before the plane 27, at the equal interval of 1.5 feet.

These sections, therefore, intersecting the body transversely, must disclose, from the variable form of the ship's hull, new curves for their respective boundaries. These are represented in the body plan, Fig. 2; the main section passing through ⊕ 15, in Figures 1 and 3, being denoted by the external curve in Figure 2. In like manner, the sections passing through the several points 5', 4', . . . 1, 2, 3 . . . 25, 26, 27 . . . 4'' 5'', in Figures 1 and 3, are represented by corresponding curves in Figure 2. Thus by the horizontal and vertical planes, which by the conditions of the investigation are made to intersect the body, two series of curves are produced, mutually intersecting each other. From these points of intersection are derived the various ordinates contained in the following table, and which we shall now proceed to describe.

FOR FINDING THE DISPLACEMENT.

1 and 27.				Common interval 6 feet.								Semi-horizontal areas between vertical sections 1 and 27.	Horizontal ordinates between vertical sections 1'' and 5''. Common interval 1 foot.	Ordinates of vertical sections between 1'' and 5''. Common interval 1.5 feet.					Semi-horizontal areas before section 5''.	Semi-horizontal areas before section 25.	Total areas of semi-horizontal sections.
16	17	18	19	20	21	22	23	24	25	26	27			1''	2''	3''	4''	5''			
24.55	24.55	24.5	24.4	24.3	24.25	23.95	23.4	22.15	20.15	16.9	11.0	3577.6		11.0	9.0	6.6	3.9	.75	38.27+3.15 =41.42		3758.71
24.65	24.65	24.65	24.6	24.5	24.35	23.95	23.25	21.9	19.75	16.15	10.1	3561.0		10.1	8.1	5.6	3.15	.3	33.3+2.91 =36.21		3719.32
24.75	24.75	24.75	24.65	24.5	24.3	23.8	23.0	21.5	19.2	15.35	9.15	3530.3		9.15	7.1	4.85	2.5	.0	28.62+2.68 =31.30		3667.62
24.7	24.7	24.7	24 6	24.4	24.1	23.55	22.6	21.0	18.5	14.45	8.1	3483.0		8.1	6.2	4.1	1.85	−.4	24.05+2.45 =26.50		3602.27
24.7	24.7	24.65	24.5	24.25	23.8	23.15	22.05	20.3	17.65	13.4	7.1	3421.6		7.1	5.25	3.35	1.1		15.72+6.21 =21.93		3523.40
24.5	24.5	24.4	24.25	23.9	23.3	22.6	21.35	19.45	16.7	12.3	6.1	3366.8		6.1	4.3	2.6	.6		12.95+4.77 =17.72		3453.79
24.2	24.2	24.05	23.8	23.35	22.7	21 95	20.55	18.5	15.7	11.15	5.15	3235.1		5.15	3.5	1.87			10.51+3.45 =13.96		3308.58
23.8	23.75	23.6	23.3	22.8	22.05	21.1	19 6	17.45	14.55	10.0	4.3	3114.6		4.3	2.7	1.15			8 12+2.78 =10.95		3176.43
23.2	23.1	22.9	22.6	22.0	21.2	20.1	18.5	16.3	13.3	8.8	3.45	2978.3		3.45	2.0	·4			5.92+2.25 =8.17		3030.13
22.55	22.5	22.3	21.9	21.3	20.45	19.2	17.5	15.2	12.2	7.75	2.65	2836.3		2.65	1.2				5.85		2872.89
21.8	21.7	21.5	21.0	20.9	19.5	18.1	16.35	14.0	10 9	6.55	1.9	2686.2		1.9	.4				4.7		2723.79
21.0	20.8	20.55	20.1	19.4	18.45	17.0	15.2	12.75	9.6	5.5	1.1	2522.5		1.1					3.6		2554.86
20.0	19.9	19.55	19.1	18.4	17.4	15.9	14.0	11.5	8.35	4.5	.6	2351.7		.6					2 87		2380.11
19.0	18.7	18.4	18.0	17.25	16.15	14.6	12.7	10.1	6.9	3.5	Areas between sections 1 and 25.	2131.3								44.50	2197.81
17.9	17.6	17.3	16.85	16.1	15.0	13.4	11.35	8.75	5.65	2.6		1958.4								34.40	2012.72
16.7	16.4	16.1	15.6	14.8	13.7	11.9	9.85	7.25	4.5	1.8		1768.1								25.32	1811.37
15.1	14.8	14.5	14.0	13.2	12.0	10.2	8.0	5.7	3.3	1.0		1538.8								18.37	1573.24
13.2	12.9	12.5	12.0	11.1	9 85	8.0	6.0	4.25	2.35			1267.9								13.32	1295.79
10.3	10.0	9.4	8 7	7.6	6.5	5.3	4.0	2.8	1.4			914.8								9.21	937.11
3.6	3.5	3.4	3.3	3.15	.0	2.7	2.4	1.65	.7			398.2								7.38	417.89
1.35	1.35	1.3	1.2	1.1	1.0	.9	.8	.7	.6			164.8								6.90	183.41
.75	75	.75	.75	.75	.75	.75	.75	.7	.65			106.8								5.5	
.75	.75	.75	.75	.75	.75	.75	.75	.7	.65			106.8								2.2	50230.88
389.90 +.0	387.37 —.03	383.48 —.07	377.18 —.10	367.08 —.15	352.13 —.18	330.57 —.22	302.05 —.26	263.25 —.30	212.83 —.34	146.13 —.38	69.15	Semi-solidity between sections 1 and 27.		69.15	49.72	31.21	15.05	5.60	Solidity of part below section 21. Semi-displacem't by horiz. sect's.		260.15 50491.03
																			Semi-solidity between sections 1'' and 25''	Semi solidity before sec. 5''.	
																			198.12	13.7	Semi displacem't by vert. sections.
389.90	387.34	383.41	377.08	366.93	351.95	330.35	301.79	262.95	212·49	145.75	69.15	49292.74	Semi-vertical areas between sections 1'' & 5''.	69.15	49.72	31.21	15.05	5.60			50486.90

This table, it will be perceived, is divided both horizontally and vertically. The *horizontal* sections, which in Figures 1 and 2, were supposed to pass through the points 1°, 2°, 3°,......21°, 22°, 23°, are designated by corresponding characters in the first *vertical* column. And in like manner, the first *horizontal* series of numbers,

5′, 4′ . . . . 1, 2, 3 . . . . 25, 26, 27 . . . . 4″, 5″

represents the *vertical* sections alluded to above.

To explain the method by which the ordinates are measured and recorded, let the horizontal section denoted by 16° in Fig. 3. be selected. This section, like every other section of the same kind, being from the nature of the transverse section, intersected by them, let the sections which pass through the points 6, 12, 18 and 24 be selected for the purpose of illustration, and let C, D, E and F, denote also the points in which they meet the contour of the horizontal section assumed. If then the ordinates C 6, D 12, E 18, and F 24, be severally measured by means of the scale attached to the drawing, they will furnish respectively the measurements recorded in the horizontal column denoted by 16°, and the vertical columns denoted by 6, 12, 18, and 24, and which measurements are respectively 10.25, 16.2, 16.1, and 7.25. In like manner let the horizontal section denoted by 10° be assumed; and let the vertical sections selected be those which pass through the point 2′, 5, 20, and 2″, and their intersections with the horizontal section in the points G, H, I, and K. If, therefore, the ordinates G 2′, H 5, I 20, and K 2″, be respectively represented on the scale of equal parts, the numbers 3.6, 16.6, 21.3, and 1.2, will be obtained, as recorded in the horizontal column 10° of the table, and vertical columns 2′, 5, 20, and 2″.

But the same measurements might have been obtained from the body plan, fig. 2. For let the horizontal plane denoted by 10°, be again referred to, and let the curves produced by the transverse sections 2′, 5, 20, and 2″, be those denoted by the same numbers on the body plan; and let the points of intersection be G, H, I, and K, as before. If the ordinates GO, HO, IO, and KO, be measured from the proper scale of equal parts, the values 3.6, 16.6, 21.3, and 1.2, will be obtained as before. And according to either of these methods, therefore, may the different ordinates be obtained, which are recorded in the several columns of the table.

In the next place, we shall proceed to show how the areas of the different sections may be obtained both horizontally and vertically, by means of the formula for equidistant ordinates before given; and how, in the next place, from the areas thus found, may be derived the solidities of the laminæ themselves.

Let it be required therefore, in the first place, to determine the area of the first horizontal section, or that denoted in the table by 1°. Then, since the formula $(\Sigma + 4\,S + 2\,s)\frac{i}{3}$, requires the sum of the *extreme ordinates*, four times the sum of the *even ordinates*, and twice the sum of the *odd ordinates*, let the ordinates for the sections between 1′ and 5′ be in the first place selected, as follows:

Extreme Ordinates.	Even Ordinates.	Odd Ordinate.
0.8	5.1	10.9
17.4	14.8	2
18.2 = Σ	19.9	21.8 = 2 s
	4	
	79.6 = 4 S	

and since $\frac{i}{3} = \frac{3.4249}{3} = 1.1416$, we shall have

$(\Sigma + S + 2\,s)\frac{i}{3} = (18.2 + 79.6 + 21.8) \times 1.1416$

$= 136.54$, which, it will be observed, is the area entered in the first line of the vertical column, entitled *semi-horizontal areas between vertical sections 5′ and 1′.*

In the next place, let the ordinates for the sections between 1 and 27 be selected.

Extreme Ordinates.	Even Ordinates.	Odd Ordinates.
17.4	20.1	21.7
11.0	22.5	22.95
	23.25	23.55
28.4 = Σ	23.75	23.95
	24.1	24.25
	24.4	24.5
	24.55	24.55
	24.55	24.55
	24.5	24.4
	24.3	24.25
	23.95	23.4
	22.15	20.15
	16.9	
		282.2
	299.0	2
	4	
		564.4 = 2 s
	1196.0 = 4 S	

and since in the present series of sections,

$\frac{i}{3} = \frac{6}{3} = 2$ feet, we shall have

$(\Sigma + 4\,S + 2\,s)\frac{i}{3} = (28.4 + 1196.0 + 564.4) \times 2$

$= 3577.6$, which is the first area entered in the vertical column, entitled *semi-horizontal areas between vertical sections* 1 and 27.

In the third place, let the ordinates for the sections 1″ and 5″ be selected.

Extreme Ordinates.	Even Ordinates.	Odd Ordinate.
11.0	9.0	6.6
0.75	3.9	2
11.75 = Σ	12.9	13.2 = 2 s
	4	
	51.6 = 4 S	

and since in this case $\frac{i}{3} = \frac{1.5}{3}$ we shall have

$(\Sigma + 4\,S + 2\,s)\frac{i}{3} = (11.75 + 51.6 + 13.2) \times 0.5 =$

38.27, which is the first area entered in the vertical column named *semi-horizontal areas before section* 27. To this being added the small area 3.15 for the fore part of the stem, produces 41.42 for the total semi-horizontal area before section 27.

By referring to Fig. 1. Plate CCCCLXXXVIII, we shall perceive that the three sets of ordinates investigated above, comprised only the portion of the vessel included between the points 5′ and 5″; and that beyond those points two supplementary areas are to be found, one embracing a horizontal section of the rudder, and the other a horizontal section of the stem. These areas are, by proper measurement, found to be each 3.15, and are entered in the first lines of the columns entitled *semi-horizontal areas abaft vertical section 5*, and *supplementary semi-areas.*

Thus it appears that the area of the first horizontal section is made up of five portions, and which may be arranged as follows:

Semi-horizontal area abaft vertical section 5′	= 3.15
Semi-horizontal area between vertical sections 5′ and 1′	= 136.54
Semi-horizontal area between vertical sections 1 and 27	= 3577.6
Semi-horizontal areas before section 27	= 41.42
Total area of semi-horizontal section 1°	= 3758.71

By a similar mode of proceeding must the areas of all the horizontal sections, from 1° to 21° inclusive, be obtained, the results of which are recorded in the last vertical column of the table.

Let the next example selected for illustrating the application of the formula of equidistant ordinates, be the determination of the main or midship section denoted by 15. In this case we shall obtain the following investigation:

Extreme Ordinates.	Even Ordinates.	Odd Ordinates.
24.55	24.65	24.75
0.75	24.7	24.7
	24.5	24.2
25.30 = Σ	23.8	23.2
	22.55	21.8
	21.0	20.0
	19.0	17.9
	16.7	15.1
	13.2	10.3
	3.6	1.35
	0.75	
		183.3
	194.45	2
	4	
		366.6 = 2 *s*
	777.80 = 4 S	

and since $\frac{i}{3} = \frac{1}{3}$ we shall have

$$(\Sigma + 4\,S + 2\,s)\ \frac{i}{3} = (25.3 + 777.8 + 366.6) \times \frac{1}{3}$$

= 389.9, which, it will be remarked, is the area entered in the column devoted to the vertical section ⚲15, at the third horizontal line from the bottom.

In addition to this, there is the small area .03 to be added, and which produces for the total area of the vertical section ⚲15, the quantity 389.93, and which also is entered in the lowest line of the table.

Precisely after this manner are the areas of all the other vertical sections estimated, and their results recorded in the last mentioned line of the table.

But it may be necessary to allude more particularly to the minute areas constituting the last horizontal line but one of the table. By reference to Fig. 1. Plate CCCCLXXXVIII, we shall perceive that from the circumstance of the keel not being parallel to the fluid surface, the horizontal plane corresponding to the lowest section 23° will leave *abaft* the vertical section 16, (at which point the keel and the horizontal plane passing through 23° are coincident,) a portion of the keel *below* it; but *before* that section, a portion of the keel *above* it. Hence the areas recorded in the horizontal column in question, are *positive* abaft the 16th section, and *negative* on the other side of it.

Let us, in the next place, proceed to apply the formula in question to the determination of the *solidities* of the *horizontal* and *vertical* laminæ into which the ship has been divided. For this purpose, we have for the *horizontal sections* the areas recorded in the last vertical column of the table; and for the *vertical sections* the several areas recorded in the three principal departments of the lowest horizontal line of the table.

TO DETERMINE THE SOLIDITY BY HORIZONTAL SECTIONS.

Extreme Ordinates.	Even Ordinates.	Odd Ordinates.
3758.71	3719.32	3667.62
183.41	3602.27	3523.40
	3453.70	3308.58
3942.12 = Σ	3176.43	3030.13
	2879.89	2723.79
	2554.86	2380.11
	2197.81	2012.72
	1811.33	1573.24
	1295.79	937.11
	417.83	
		23156.70
	25109.28	2
	4	
		46313.40 = 2 *s*
	100437.12 = 4 S	

and since $\frac{i}{3} = \frac{1}{3}$, we shall have

$$(\Sigma + 4\,S + 2\,s)\ \frac{i}{3} = (3942.12 + 100437.12 + 46313.4) \times \frac{1}{3} = 50230.88,$$

which is the value of the solidity by horizontal sections. If to this last quantity be added the solidity of the part below section 21°, and which has been estimated separately on the ground of greater accuracy and convenience, we shall have 50230.88 + 260.15 = 50491.03 *for the absolute semidisplacement by horizontal sections.*

To determine the same by VERTICAL SECTIONS, we must perform the following calculations; and, first, for the semi-solidity between the sections 1′ and 5″.

Extreme Ordinates.	Even Ordinates.	Odd Ordinate.
15.72	33.76	61.74
126.98	95.10	2
142.70 = Σ	128.86	123.48 = 2 *s*
	4	
	515.44 = 4 S	

and since $\frac{i}{3} = \frac{3.4249}{3} = 1.1416$, we shall have

$$(\Sigma + 4\,S + 2\,s)\ \frac{i}{3} = (142.7 + 515.44 + 123.48) \times 1.1416 = 892.3$$

for the semi-solidity required.

In the next place, to obtain the semi-solidity of the sections between 1 and 27, we have

T 2

Extreme Ordinates.	Even Ordinates.	Odd Ordinates.
126.98	178.41	221.52
69.15	256.17	285.38
———	311.15	332.51
196.13 = Σ	349.16	361.96
	370.87	378.45
	383.73	387.22
	389.97	389.93
	389.90	387.34
	383.41	377.08
	366.93	351.95
	330.35	301.79
	262.95	212.49
	145.75	———
	———	3987.62
	4118.75	2
	4	———
	———	7975.24 = 2 *s*
	16475.00 = 4 S	

and since $\frac{i}{3} = 2$, we shall have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (196.13 + 16475.00 + 7975.24)$ $\times\ 2 = 49292.74$, for the semi-solidity required.

In the third place, to obtain the semi-solidity for the sections between 1″ and 5″, we have

Extreme Ordinates.	Even Ordinates.	Odd Ordinates.
69.15	49.72	31.21
5.60	15.05	2
———	———	———
74.75 = Σ	64.77	62.42 = 2 *s*
	4	
	———	
	259.08 = 4 S	

and since $\frac{i}{3} = \frac{1.5}{3} = 0.5$, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (74.75 + 259.08 + 62.42) \times 0.5$ $= 198.12$ for the solidity of the sections desired.

Hence, by taking the semi-solidity of the part abaft the vertical section 5′, and also the semi-solidity of the part before section 5″, and which results are recorded in the lowest horizontal line of the table, we shall have by arranging the results:

Semisolidity abaft vertical section 5′	=	90.04
Semisolidity between sections 1′ and 5′	=	892.30
Semisolidity between sections 1 and 27	=	49292.74
Semisolidity between sections 1″ and 5″	=	198.12
Semisolidity before section 5″	=	13.70
Semi-displacements by vertical sections		50486.90

The *sum* of the semisolidities determined by the *horizontal* and *vertical* sections will give the total mean displacement. Thus,

Semisolidity by horizontal sections	=	50491.03
Semisolidity by vertical sections	=	50486.90
Mean displacement in cubic feet	=	100977.93

To bring this quantity into tons, it must be divided by 35, the number of cubic feet of sea water in a ton, and which produces for the displacement required 2885.084 tons.

We shall now pass to the consideration of the centre of gravity of displacement.

ON THE CENTRE OF GRAVITY OF DISPLACEMENT.

To determine the centre of gravity of displacement, it may, in the first place, be remarked, that from the symmetrical form of the body, when it is divided by a vertical longitudinal plane passing through the middle of the keel, it must be necessarily situated in this plane, and that our object, in the first place, therefore, must be to determine the distance of the same point *below* the plane of the water section; and, secondly, to find its position with regard to the length.

To determine its distance below the plane of the water section, we must again have recourse to the last vertical column of the general table, and multiply the numbers contained in it successively by 0, 1, 2, 3, 4, 5 . . . . . 18, 19, 20, as in the following table, in order to apply them to the formula of equidistant ordinates.

Areas of semihorizontal sections.	Multipliers.	Resulting products.	Areas of semihorizontal sections.	Multipliers.	Resulting products.
3758.71	0	0000.00	2554.86	11	28103.46
3719.32	1	3719.32	2380.11	12	28561.32
3667.62	2	7335.24	2197.81	13	28571.53
3602.27	3	10806.81	2012.72	14	28178.08
3523.40	4	14093.60	1811.33	15	27169.95
3453.70	5	17268.50	1573.24	16	25171.84
3308.58	6	19851.48	1295.79	17	22028.43
3176.43	7	22235.01	937.11	18	16867.98
3030.13	8	24241.04	417.88	19	7939.72
2879.89	9	25919.01	183.41	20	3668.20
2723.79	10	27237.90			

To apply the column entitled resulting products, to the formula for equidistant ordinates, we shall therefore, have

Extreme Products.	Even Products.	Odd Products.
0000.00	3719.32	7335.24
3668.20	10806.81	14093.60
———	17268.50	19851.48
3668.20 = Σ	22235.01	24241.04
	25919.01	27237.90
	28103.46	28561.32
	28571.53	28178.08
	27169.95	25171.84
	22028.43	16867.98
	7939.72	———
	———	191538.48
	193761.74	2
	4	———
	———	383076.96 = 2 *s*
	775046.96 = 4 S	

and since the common interval of the horizontal sections is one foot, we have $\frac{i}{3} = \frac{1}{3}$; and therefore

$(\Sigma + 4\ S + 2\ s)\ \frac{1}{3} = (3668.20 + 775046.96 +$ $383076.96) \times \frac{1}{3} = 387264.04$ is the moment of the displacement between the horizontal sections 1° and 21°. To this, however, must be added the moment of the part below section 21°, amounting to 5489.05, giving for the moment of the entire semi-displacement, the number 392753.09.

But by a well-known principle of mechanics, if the moment of the semi-displacement be divided by that semi-displacement, the result will be the required depth of the centre of gravity of displacement below the water section. This depth therefore is $\frac{392753.09}{50188.96}$ = 7.78 feet. The semi-displacement here employed is the mean of the displacement determined by the horizontal and vertical sections.

To determine, in the next place, the position of the centre of gravity of displacement with respect to the length of the vessel, we must have recourse to the lowest horizontal column of the general table before referred to, and refer all the calculations to the primitive vertical plane marked 1.

In the first place, the moment of the rudder will be found by multiplying the semi-solidity abaft the vertical section 5′, by the distance of its centre of gravity from the primitive plane 1, and which is

$$90.04 \times 16.4 = 1476.66 \quad . \; . \; . \quad (M)$$

Secondly, to find the moment of the part between the vertical sections 5′ and 1′, we have

Semivertical areas between sections 5′ & 1′	Multipliers.	Resulting products.
126.98	0.00	000.00
95.10	3.425	325.72
61.74	6.850	422.92
33.76	10.275	346.88
15.72	13.700	215.36

and applying the column of resulting products to the formula for equidistant ordinates, we shall have

Extreme Products.	Even Products	Odd Product.
000.00	325.72	422.92
215.36	346.88	2
215.36 = Σ	672.60	845.84 = 2 s
	4	
	2690.40 = 4 S	

and since $\frac{i}{3}$ = 1·1416, the formula will produce

$$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (215{\cdot}36 + 2690{\cdot}40 + 845{\cdot}84) \times 1{\cdot}1416 = 4282{\cdot}83 \; . \; . \; . \; . \; . \; . \; (M')$$

Thirdly, to find the moment of the portion of the vessel comprised between the vertical sections 1 and 27, we have the following table:

Semivertical areas between sects 1 & 27.	Multipliers	Resulting products.	Semivertical areas between sects 1 & 27.	Multipliers.	Resulting products.
126.98	0	0000.00	389.93	84	32754.12
178.41	6	1070.46	389.90	90	35091.00
221.52	12	2658.24	387.34	96	37184.64
256.17	18	4611.06	383.41	102	39107.82
285.38	24	6849.12	377.08	108	40724.64
311.15	30	9334.50	366.93	114	41830.02
332.51	36	11970.36	351.95	120	42234.00
349.16	42	14664.72	330.35	126	41624.10
361.96	48	17374.08	301.79	132	39836.28
370.87	54	20026.98	262.95	138	36287.10
378·45	60	22707.00	212.49	144	30598.56
383.73	66	25326.18	145.75	150	21862.50
387·22	72	27879.84	69.15	156	10787.40
389·97	78	30417.66			

and applying the column of resulting products to the formula, we shall have

Extreme Products.	Even Products.	Odd Products
00000.00	1070.46	2658.24
10787.40	4611.06	6849.12
	9334.50	11970.36
10787.40 = Σ	14664.72	17374.08
	20026.98	22707.00
	25326.18	27879.84
	30417.66	32754.12
	35091.00	37184.64
	39107.82	40724.64
	41830.02	42234.00
	41624.10	39836.28
	36287.10	30598.56
	21862.50	
		312770.88
	321254.10	2
	4	
		625541.76 = 2 s
	1285016.40 = 4 S	

and since $\frac{i}{3}$ = 2, we further have

$$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (10787.4 + 1285016.4 + 625541.76) \times 2 = 3842691.12 \; . \; . \; . \; . \; (M'')$$

Fourthly, to determine the moment of the part comprised between the sections 1″ and 5″

Semivertical areas between sections 1″ & 5″.	Multipliers.	Resulting products.
69.15	156.0	10787.40
49.72	157.5	7830.90
31.21	159.0	4962.39
15.05	160.5	2415.52
5.60	162.0	907.20

and applying the column of resulting products to the before quoted formula, we have

Extreme Products.	Even Products.	Odd Product.
10787.40	7830.90	4962.39
907.20	2415.52	2
11694.60 = Σ	10246.42	9924.78 = 2 s
	4	
	40985.68 = 4 S	

And, since one-third of the common interval = 0.5, we shall have

$$(\Sigma + 4\,S + 2\,s)\frac{i}{3} = (11694.6 + 40985.68 + 9924.78) \times 0.5 = 31302.53 \; .\;.\;.\;. \; (M''').$$

Lastly, to determine the moment before section 53, we have,

$$13.7 \times 163.5 = 2239.95 \; .\;.\;.\;. \; (M'''').$$

If now we refer to the position of the primitive vertical plane to which all the preceding moments have been referred, we shall perceive that M and M′ are on one side of it, and M″, M‴, and M⁗, on the other: and that if we denote the mean semidisplacement by D, we shall have for the distance of the centre of gravity of displacement from the primitive plane 1, the expression

$$\frac{M'' + M''' + M'''' - M' - M}{D} = \frac{3842691.12 + 31302.53 + 2239.95 - 4282.83 - 1476.66}{50488.96}$$

= 76.66 feet, which is the distance of the centre of gravity from the primitive vertical plane 1.

The preceding investigations respecting the displacement have been conducted on either of the suppositions that the ship and the water are at *rest*, or of a ship and the water moving in *the same direction with the same velocity*, in which case the ship is still relatively at rest. But when the ship and water are relatively *in motion, either by the ship being at rest and the water in motion*, or by the *ship's moving* and the *water's being at rest*, or by *the ship and water moving with unequal velocities*, or in *different directions*, the depth to which the ship sinks must be determined in connexion with other considerations. As a proof of a difference in the two conditions of a vessel alluded to, we may adduce the observations of M. Romme, that a frigate which was lashed to a sheer hulk in the river Charente, sunk two inches more when the velocity of the stream was great than when the motion of the stream was only just sensible.

In an ingenious disquisition on this subject, Mr. Morgan, one of the foremen of Portsmouth Dockyard, adduces another remark of Romme on the same subject, in which that learned foreigner describes some experiments he made to determine the vertical pressure of water when in motion compared with its pressure when at rest. He had two tin tubes constructed, the one, Fig. 4. Plate CCCCLXXXVIII, straight as *a b*, and the other curved as *c d e*, each open at its ends, and capable of receiving a float *g f*, the lower part of which, *f*, was of cork, and the upper part a rod marked with inches and lines. These tubes, containing their floats, were first plunged into still water, and the division of the rods observed, corresponding with the upper orifices of the tubes. The tubes were then placed in running water, the current being in the direction *h i*, and the bent tube *c d e*, with its lower end turned in the same direction: the floats in both tubes were then observed to have sunk an inch below the position they had when the tubes were in still water. The bent tube was then turned so as to present its orifice to the current, when the float rose an inch above the position which it had in still water. The bent tube was then placed with the lower end perpendicularly to the direction of the current, when the float sunk an inch below its position in still water. He measured the velocity of the current, and found that the water ran 70 feet in 30″, or that its velocity was that due to a height of an inch and a line nearly; which corresponded with the distance the floats in the tubes rose or fell in the experiments. Other experiments in currents of different velocities produced similar results. In some instances the depression and elevation of the floats were as much as five or six inches, being always the height due to the velocity of the current. He ascertained also that the results were the same, to whatever depth the tubes were plunged into the water.

Suppose the depth to which the tubes are plunged into the water to be represented by k; then the vertical pressure of the water at the orifice b of the straight tube, when the water is at rest, is in proportion to this depth, and causes the water in the tube to rise to the level of the surrounding water; but when the water moves with a velocity due to the height z, the particles no longer press equally in all directions, but have a greater tendency to motion in the direction of the current than in any other; so that the vertical pressure of the particles at the orifice b is less than before, and by the experiment is found to be proportional to $k - z$.

In the application of the result of this experiment to a floating parallelopiped, whose sides are perpendicular, and whose upper and lower surfaces are parallel to the water's surface, the pressure of the water on the sides being horizontal, has no effect in supporting its weight; and the vertical pressure of the particles of the water on the lower surface, being less when in motion than when at rest, in the proportion of k to $k - z$, k being in this case the perpendicular distance of the lower side of the body from the water's surface, and z as before, the height due to the velocity of the current, the parallelopiped will sink deeper in the running water, than in the still water, in the same proportion: that is, the perpendicular depth of the immersed part of the body will be $k+z$, having sunk deeper the distance z.

When the bent tube *c d e* is placed with its lower end in the direction of the stream *h i*, the effect is the same as with the straight tube; the particles of water at the orifice *e*, pressing less on the particles in the tube when the water is in motion than when at rest, the water in the tube is not equally supported; so that it sinks below the level of the surrounding water, a distance found by the experiment to be equal to z, the height of the water in the tube being $k - z$. The effect is the same also when the lower end of the bent tube is placed perpendicularly to the current; but when placed with its orifice presented to the direction of the current, the particles of the water in motion exert a pressure at the orifice *e*, greater than they would when at rest, in consequence of the velocity in the direction of their motion, which causes the confined water in the tube to rise above the level of the surrounding water, a height found by the experiment to be equal to z, the altitude of the water in the tube being $k+z$.

Now as the water rose a distance z above the level of the surrounding water, when the lower end of the bent tube was placed exactly in the direction opposed to the current, and fell the same distance z below the level of the surrounding water, when the lower end of the tube was placed perpendicularly to the direction of the current, there must be an angle at which the tube might be placed with respect to the direction of the current, at which the water in the tube would be at the same height as the surrounding water. Taking any line v in the direction of the current to represent its velocity, which is wholly effective in raising the water in the tube, when placed in the opposite direction to the current the distance z, and which has the effect of depressing the water in the tube the same distance z; when placed perpendicularly to the direction of the current, the angle at which the tube must be placed, in order that such a part of this velocity may be effective in causing the water in the tube to rise exactly to the level of the surrounding water, may be found by supposing that at this angle the effective part may be equal to $\frac{1}{2} v$, which, by the resolution of the directions of the pressures, makes the angle at which the tube must be placed 60° with the direction of the current.

In the application of this reasoning to the determination of the vertical pressure of the water in motion on a ship's body, the pressure on the fore and after parts of the body must be considered separately; the greatest transverse section called the midship section, being the division between these parts.

The expression representing the pressure of the water on the fore part will be composed of two terms, the one expressing the pressure on the part of the body where it is greater than it would be if the body were at rest, and the other the pressure on the part of the fore body, where it is less than it would be if the body were at rest. The line of division, which we will call the neutral line, being the line on the fore part of the ship's body, at which the pressure of the water is neither increased nor diminished by the velocity of the water, will be a curved line, depending on the form of the ship's body, but always before the greatest transverse section. In regular figures, its position and form may be determined either geometrically or analytically; but in ships, can be found only by trial and calculation. In the expression for the pressure of the water on the part of the body contained between the neutral line and the midship, the pressure represented by the proportional depth k will be increased by a function of z; in the expression for the part of the fore body contained between the neutral line and the midship section, the pressure represented by the proportional depth k will be diminished by a function of z: and in the after body, $k-z$ will be the element representing the pressure.

Let $a\,b$, Fig. 5. Plate CCCCLXXXVIII, represent an element of the ship's body, and $c\,b$ the direction of the motion and the height due to the velocity of a particle of water, which meets this element. By resolving $c\,b$ into $c\,d$ and $d\,b$, $c\,d$, which is perpendicular to $a\,b$, is supposed to be destroyed, and the particle of water glides along the surface of the ship's body with a velocity $d\,b$. Let $c\,b$ be equal to z, and the depth of the particle below the surface of the water be equal to k, and the angle $a\,b\,c$ equal to i: then $d\,b = z . \cos . i$. The pressure of the particle of water on the part of the fore body before the neutral line will then be proportional to $k + z . \cos . i$; the pressure of the particle of water on the part of the fore body between the neutral line and the midship section, will be proportional to $k - z . \cos . i$: and the pressure of the particle of water on the after body will be proportional, according to the experiment on the bent tube, to $k-z$.

Suppose the ship to be placed with its fore part opposed to a current, the direction of which is that of the ship's keel, and the velocity that which is due to the height z. Suppose the surface of the ship's body below the surface of the water to be divided into an infinite number of small surfaces; let x be the horizontal distance of one of these small surfaces from the midship section, and y its transverse distance from the longitudinal vertical plane, dividing the ship into two equal and similar parts, and k its distance from the plane of floatation. The projection of this small surface on the plane of floatation is $d\,x . d\,y$: and representing the specific gravity of the water by P, the pressure of the water on this small surface, in a vertical direction, in the after body, $P\,d\,x . d\,y . (k-z)$; and the vertical pressure of the water on a small surface, in the part contained between the midship section and the neutral section in the fore body, is $P\,d\,x . d\,y\,(k-z . \cos . i)$: and the vertical pressure of the water on a small surface in the part of the fore body before the neutral section, by taking x for the distance of this small surface from the neutral section, is $P\,d\,x . d\,y . (k+z . \cos . i)$. The vertical pressure of the water on the whole of the fore part of the ship's body (taking both sides of the ship), is therefore

$$2\,P \int d\,x \int d\,y . (k + z . \cos . i)$$
$$+ 2\,P \int d\,x \int d\,y . (k - z . \cos . i):$$

and the vertical pressure of the water on the whole of the after part of the ship's body, is

$$2\,P \int d\,x \int d\,y . (k-z).$$

The sum of these terms,

$$2\,P \int d\,x . d\,y . (k+z . \cos . i) + 2\,P \int d\,x \int d\,y . (k-z . \cos . i)$$
$$+ 2\,P \int d\,x . d\,y . (k-z),$$

is the total vertical pressure of the water on the ship's body, lying opposed to a current, whose velocity is that due to the height z.

If the water were at rest, the total vertical pressure of the fluid on the ship's body, supposed to be sunk to the same depth below the surface of the water, taking z for the whole length of the ship, would be $2\,P \int d\,x \int d\,y\,k$. In this expression x is equal to the sum of the three lengths expressed by x in the former expression. This quantity representing the vertical pressure of the water on the ship's body when at rest, is evidently greater than the quantity representing the vertical pressure of the water on the ship's body when in motion, in consequence of the first term of the expression $2\,P \int d\,x \int d\,y . (k+z . \cos . i) + 2\,P \int d\,x \int$

$$d\,y . (k-z . \cos . i) + 2\,P \int d\,x \int d\,y . (k-z),$$

which is less than the sum of the two other terms, being increased in a less proportion by the addition of

z . cos. i to k, than the sum of the last two terms is diminished by z . cos. i being subtracted from k in the first, which is the smaller of the last two terms, and by z being subtracted from k in the last term. The vertical pressure of the water, therefore, being less on the ship's body when placed in a current than in still water, estimated to the same draught of water in both cases, the ship must sink deeper in the current than in still water. The distance it sinks depends on the value of z, the height due to the velocity of the current, and i, representing the different angles at which the particles of water strike the ship's body, which depend on the form of the body. Supposing the values of all the terms known, and subtracting the expression for the vertical pressure of the water in motion on the ship's body, from the expression for the vertical pressure of the water at rest, estimated at the same draught of water in both cases, the remainder will be the quantity to be taken from the expression for the vertical pressure of the water at rest, measuring from the line of floatation downwards, which determines the distance which the ship will sink deeper in the water in motion than at rest.

This expression represents the vertical pressure of the water, under the consideration that each particle of the fluid in motion impinges on the surface of the ship's body; neglecting the circumstance of those particles which meet the body at the middle of the fore part, escaping along the surface of the body, and preventing many of the particles farther removed from the middle from impinging on the surface, and communicating their action to the body only, through the medium of those particles in contact with it; the particles still farther removed from the middle, communicating in the same manner their action to the body through the medium of a greater number of intervening particles. The investigation is conducted with immediate reference to the results of the experiments with the tubes, instead of forming an independent theory on the hypothetical action of fluids on floating bodies. The division of the fore part of the ship's body into two parts, by the section at the lines on the surface of the body, at which the effect of the pressure of the water in motion is the same as that of the pressure of the water at rest, is introduced by the writer of these remarks, as being directed by the results of the experiments with the bent tube; considering that the whole pressure of the water on the fore part is not increased by the motion of the fluid, but only the part before the neutral section, the pressure on the remainder being diminished.

The vertical pressure of the water on the ship's body may be determined on the same principles, but with more difficulty, when the direction of the ship's length makes any angle with the direction of the current of the water.

It may be observed, that the alteration occasioned in the vertical pressure of the water in consequence of the relative motion of the ship and water, affects the determination of the stability of the ship, which is measured by the vertical pressure of the water multiplied into the distance it acts from the longitudinal axis passing through the centre of gravity. The connexion of the common theory of the stability of ships, however, with this principle, although requisite for the direct determination of the absolute stability of a ship under sail, is by no means necessary for the determination of the comparative stability of ships, which is generally required to be known.

ON STABILITY.

The general question of stability involves considerations of the highest importance, both to the theory and practice of naval architecture. We owe our first general conceptions of its nature and properties to Archimedes,* who, in his celebrated inquiries respecting Hydrostatics, first pointed out the nature of the force which a fluid exerts to restore a floating body, when deflected from its quiescent position to its original condition. The same inquiry in the hands of Bouguer,† of Euler,‡ of Chapman,§ and of Atwood,‖ has been very much extended; and by the labours of the last mentioned philosopher in particular, it has been placed in the clearest and most satisfactory point of view.

Without entering into the general circumstances of floating bodies, (for a masterly investigation of which we refer our readers to the papers of Mr. Atwood just quoted,) we may remark, that when a vessel is floating on the surface of the water, it is impelled *downwards* in a vertical line passing through its centre of gravity, the fluid at the same time exerting an equal and contrary force *upwards*, in the direction of a vertical line passing through the centre of gravity of the portion of the vessel immersed. Unless, therefore, the vertical lines representing these forces coincide; or, in other words, unless the centres of gravity of the entire vessel, and of the part immersed, are situated in the *same* vertical line, a tendency will be created in the vessel to revolve about an axis, until it finds a position in which it can float in a state of permanent equilibrium.

Supposing, therefore, a vessel to float in a state of permanent equilibrium, and an external force to be applied, to cause it to incline from this position, a certain degree of resistance, dependent on the general circumstances of the vessel, will be created, and which resistance is commonly denominated the stability of floating.

We know also from our ordinary experience, that some bodies are more easily inclined from their positions of equilibrium than others; and that varieties equally remarkable exist in their returns to their original situations. This, indeed, is a circumstance most remarkably exemplified in the practice of naval architecture. In some ships, a given impulse of the wind will produce an inclination much more considerable than in others; and hence correct notions respect-

* Archimedes de Insidentibus Humido.

† Bouguer, Traité du Navire, Liv. i. sect. 3, chap. iv.

‡ Euler, Theorie Complete de la Construction et Manœuvre des Vaisseaux, chapters iv. and v. or the English translation of the same by Watson.

§ Traité de la Construction des Vaisseaux par Chapman, chap. ii. or the English translation of the same by Dr. Inman, together with the notes of the translator.

‖ Atwood on the Stability of Ships, contained in the Philosophical Transactions for 1796 and 1798.

ing the general properties of stability, must be regarded as one of the most important elements of shipbuilding.

The first and most essential point to be obtained, is an expression or measure for the force of stability at any angle of inclination. This was first attempted by Bouguer, on the supposition that the vessel was inclined at an infinitely small angle: but his investigation, although applicable to bodies of all magnitudes and forms, when their deviations from a state of permanent equilibrium are limited to evanescent inclinations, is for that reason inapplicable to the rigid purposes of naval architecture, on account of the angles to which ships are inclined by the force of the wind and the sea, amounting to quantities very considerably removed from an evanescent state. Suppose, for example, the angle of inclination to amount to ten or twenty degrees, or as it sometimes does to thirty degrees; then will conditions be involved in the investigation, which will invalidate entirely any theorem founded on infinitesimal relations. This will be evident, by referring to the conditions of the immerged and emerged volumes, produced by the inclination of the vessel. Those volumes in the formula in question, are to be regarded as similar and equal; whereas the form of a ship, both above and below the water line which corresponds to the position of permanent equilibrium, presents no such equality. Nor is this a mere hypothetical objection, but one of the highest practical importance; since it is known that the quantity of sail which a ship is enabled with safety to carry, as well as the use of her lower deck guns in rough weather have a most material connexion with the form of the sides, above and below the plane of the water section corresponding to the position of permanent equilibrium.

To put the subject, however, in a clear and satisfactory point of view, let there be two vessels of the same weight, and let the planes of their water sections be also similar and equal: but let the sides of one of them have an inclination *outwards*, both above and below the water section, as in Fig. 4, Plate CCCCLXXXIX; and the sides of the other a similar inclination *inwards*, as in Fig. 5. Now, it is manifest, without the aid of any calculation, that, notwithstanding the assumed coincidences of the weights and of the forms and areas of the water sections, the stability of the first body must be much more considerable than that of the second; and that a quantity of sail which might be productive of no material inconvenience to the former, would to the latter be hazardous and destructive. Hence, as Mr. Atwood very properly observes in the first of his papers before quoted, "admitting that the theory of statics can be applied with any effect to the practice of naval architecture, it seems necessary that the rules to be investigated for determining the stability of vessels, should be extended to those cases in which the angles of inclination are of any magnitude likely to occur in the practice of navigation."

To determine the necessary formula, therefore, when the angle of inclination is of some definite magnitude, let ABC, Fig. 13. represent a transverse vertical section of a vessel, passing through its centre of gravity G, and therefore at right angles to the axis of motion. Let I A B L denote also the plane of the water section, dividing the solid into two portions, one *above* the water's surface, but not represented in the figure, and the other ACB *below* it. Let O also be the centre of gravity of the immersed volume, and join OG, and produce it to K, and which, from the conditions of hydrostatic equilibrium, must be at right angles to the plane of the water section.

Suppose, in the next place, a force to be externally applied to the solid, so as to cause it to move through any finite angle KGS, round the axis of motion before referred to; and let the line KC, which in the state of equilibrium was vertical, now assume the position of SGL. Let also IXN denote the new situation assumed by AXB, and WRMNP, the new position of the immersed volume, in consequence of the inclination. In the line SL take GE equal to GO; then it is evident that O, the centre of gravity of the immersed volume ADHB, will be transferred to E, the centre of gravity of the equal space IRMN; and the action of the fluid on the immersed volume, would be in the direction of a vertical line passing through E, if IRMN represented the volume immersed in the fluid. But from the inclined position of the solid, the volume NXP, which in the original position of the solid was *above* the fluid surface, is now immersed in it; and, on the contrary, the volume IWX, which in the position of equilibrium was surrounded by the water, in the new position, is elevated above it. Hence it follows, that the new condition of the solid will cause the centre of gravity of the immersed volume to approach towards that part of it which is most immersed in the fluid.

Suppose, therefore, the centre of gravity of the immersed volume WRMP to be situated at the point Q, and through Q draw FS parallel to GO, or which is the same thing, perpendicular to the plane of flotation. Through E and G, draw EY and GZ parallel to the last mentioned plane. Then since Q is the centre of gravity of the volume immersed, the pressure of the fluid will act in the direction of the vertical line QS, passing through that centre, with a force equivalent to the body's weight: and by the principles of mechanics, will have precisely the same effect to turn the solid round its axis, as if the same force was applied immediately at the point Z, and acting in the same direction QS. Since, therefore, the effect of the fluid's pressure acting in the direction of a vertical line passing through the centre of gravity Q, no way depends on the absolute position of that point, but on the horizontal distance between the vertical lines GO and SF, which pass through the primitive centre of displacement and the new position of that centre created by the circumstances of inclination, it follows, that in any attempt to determine the stability of a floating body, our object must be to determine the magnitude of the line GZ.

The volume immersed under the conditions of inclination being WBMP, is manifestly equal to the volume immersed under the original circumstances of hydrostatic equilibrium, diminished by the trilateral space IWX, and augmented by the trilateral figure NXP. But since the volume immersed must always preserve the same constant magnitude as long as the whole weight of the body subjected to examination remains unaltered, and which, in every inquiry of the kind, is a necessary and essential condition, it follows, that whatever may be the position of the point of intersection X, the trilateral areas before alluded to must be equal. Having made these few general observations, we proceed to the following construction for the purpose of determining the magnitude of GZ.

CONSTRUCTION.

Find a and d the centres of gravity of the spaces IWX and NXP; and from those centres, let perpendiculars $a\,b$, $c\,d$ be drawn to the fluid surface; and in the line EY, take ET a fourth proportional to the whole volume immersed WRMP, the trilateral area IWX or NXP, and the distance $b\,c$ between the perpendiculars demitted from the centres of gravity a and d. Through the point T thus found, draw FTS parallel to GO, intersecting GZ in Z. Then will GZ represent the measure of stability.

METHOD OF CALCULATION.

Let the total volume immersed be represented by V, and the volume NXP immersed in consequence of the inclination by v. Let also the distance GO = GE, between the centres of gravity of the entire body, and of the volume immersed, be denoted by α, and the sine of the angle of inclination KGS to radius unity, by φ. Let also the distance $b\,c$ between the perpendicular $a\,b$ and $d\,c$ be represented by β. Then by the construction

$$V : v :: \beta : \frac{\beta\, v}{V} = ET:$$

and since EG : ER :: 1 : φ,

or α : ER :: 1 : φ,

we have ER = $\alpha\,\varphi$;

$$\text{whence } RT = ET - ER = \frac{\beta\, v}{V} - \alpha\,\varphi.$$

$$\text{or } GZ = \frac{\beta\, v}{V} - \alpha\,\varphi \text{ - - (A)}$$

which is a general formula for the stability of a floating body of any magnitude and form, at any finite angle of inclination.

DEMONSTRATION.

It is demonstrated by the writers on mechanics, (Wood's *Mechanics*, art. 178, third edition,) that in any system of bodies given in position, if the situation of one of them be changed, the corresponding motion of the common centre of gravity estimated in any given direction, will be to the motion of the centre of gravity of the part of the system moved, estimated in the same direction, as the weight of the body moved is to the weight of the whole system. In the present instance, the volume IRMN may be regarded as a system of bodies, whose common centre of gravity is E. The centre of gravity a of one of the bodies IWX composing this system, is transferred, in consequence of the inclination of the entire body, to the point d, the centre of gravity of the equal volume NXP. Then since the translation of the volume IWX has occasioned a motion in its centre of gravity from a to d, and which estimated horizontally on the plane of flotation, is $b\,c$; by the mechanical theorem quoted, the entire volume WRMP, is to the volume IWX or NXP, as $b\,c$ to ET; which is the measure of the space the centre of gravity of the entire volume has passed through, when estimated in the same horizontal direction. If therefore a vertical line FTS be drawn through the point T, it must also pass through the centre of gravity of the immersed volume; and since the line ER is known in terms of the radius GE or GO, and the sine of the angle of inclination EGO, it follows that by subtracting its value from ET, there will remain RT, or its equal GZ, the measure of the stability required.

We shall now proceed to apply the formula just determined to the case of a vessel whose sides are parallel to the plane of the masts, both above and below the plane of flotation.

Let QBOAH, (Fig. 14.) represent a vertical section of the vessel, when it floats in an upright or quiescent position, BA denoting the plane of flotation. Let also G be the centre of gravity of the entire body, and E that of the portion immersed in the fluid. Let V as before represent the magnitude of the volume immersed.

Bisect the line BA passing through the plane of flotation in S; and through S draw CSH, forming with BA an angle equal to the vessel's inclination. Then since BSC is the triangular area raised *above* the fluid surface, in consequence of the inclination, and ASH the similar and equal surface depressed *below* it from the same cause; bisect BC and AH in the points F and N. Join FS and NS, and take SI to SF, and likewise SM to SN in the ratio of 2 to 3; then will I and M be the centres of gravity of the triangular spaces. From these centres, let fall IK and ML perpendicular to CH. Through E, draw EV parallel to CH, and take ET to KL, in the ratio of the volume ASH to the whole volume displaced. Through G draw GU parallel to CH, and through T the line TZ perpendicular to GU, and GR parallel to TZ. Then will RT or GZ be the measure of the vessel's stability.

To determine the value of GZ analytically, and thence numerically, let BA, the breadth of the water section be denoted by $4\,b$, and GE the interval between the centres of gravity of the entire body, and of the volume immersed by α; also the angle of inclination ASH by φ. Then $1 : 2\,b :: \tan.\varphi : 2\,b\tan.\varphi =$ AH, whence $AN = b\tan.\varphi$, and $SN = b\,(4 + \tan.^2\varphi)^{\frac{1}{2}}$. Also, as SN : HN :: sin. NHS : sin. NSH; or as $b\,(4+\tan.^2\varphi)^{\frac{1}{2}} : b\tan.\varphi :: \cos.\varphi : \dfrac{\sin.\varphi}{(4+\tan.^2\varphi)^{\frac{1}{2}}}$. Hence $\cos.\,NSH = \dfrac{\cos.\varphi + \sec.\varphi}{(1+\tan.^2\varphi)^{\frac{1}{2}}}$. Now $SM = \dfrac{2}{3}SN = \dfrac{2\,b}{3}(4+\tan.^2\varphi)^{\frac{1}{2}}$; and therefore $SL = \dfrac{2\,b}{3}(\cos.\varphi + \sec.\varphi)$. And since the triangles SLM, SKI are equal and similar, $KL = 2\,SL = \dfrac{4\,b}{3}(\cos.\varphi + \sec.\varphi)$. Also the area of the triangle $ASH = 2\,b^2\tan.\varphi$. Therefore by the mechanical theorem referred to in the demonstration,

$$V : v :: KL : ET,$$

$$\text{or } V : 2\,b^2\tan.\varphi :: \frac{4\,b}{3}(\cos.\varphi + \sec.\varphi) : ET,$$

$$\text{and hence } ET = \frac{8\,b^3\tan.\varphi\,(\cos.\varphi + \sec.\varphi)}{3\,V}.$$

Also because $GE : ER :: 1 : \sin.\ \varphi$,

therefore $ER = a \sin.\ \varphi$;

whence $RT = GZ = \frac{8\,b^2}{3\,V} \tan.\ \varphi\ (\cos.\ \varphi + \sec.\ \varphi) -$ $a \sin.\ \varphi$, is the analytical value of the proposed vessel's stability.

To determine the value of G Z numerically, let the breadth of the vessel at the water's surface, or AB be 100, and the interval GE between the centres of gravity of the entire body, and of the volume immersed be 13; that is, let $b = 25$, and $a = 13$. Suppose also the angle of inclination $\varphi = 15°$; and let V the area of the section of the volume displaced be represented by 3600. Then we shall have

$$\cos.\ \varphi + \sec.\ \varphi = \cos.\ 15° + \sec.\ 15° = 2{\cdot}0012020$$

$$\frac{8\,b^3 \tan.\ \varphi}{3\ V} = \frac{125000 \tan.\ 15°}{3 \times 3600} = 3{\cdot}1012639$$

$$\text{Hence } ET = 2{\cdot}0012 \times 3{\cdot}1012 = 6{\cdot}2062555$$

$$\text{and } a \sin.\ \varphi = 13 \sin.\ 15° = 3{\cdot}3646470$$

which gives the measure of stability $GZ = 2{\cdot}8416085$

From this result therefore it appears, that when the proposed vessel has been inclined from its position of permanent equilibrium through an angle of 15°, the action of the fluid to restore it to its quiescent position, will pass at the distance of 2·84, estimated horizontally, when the breadth of the water section is denoted by 100. And this result will be the same whatever be the length of the axis.

The absolute pressure of the fluid, is in reality the total volume displaced by the body. Suppose this quantity to be 1000 tons. Then since by this hypothesis, the stability of the vessel, when inclined at an angle of 15°, is equivalent to the force of 1000 tons, acting at the distance of $\frac{2{\cdot}84}{10000}$ parts of the breadth of the water section from the axis, to restore the vessel to its primitive state of equilibrium; the effect will be the same as if a force $\frac{1000 \times 2{\cdot}84}{50} = 56{\cdot}8$ tons were applied to turn the vessel at the distance of 50 from the axis.* If therefore the wind should act on the sails of the vessel with a force of 56·8 tons, at the mean distance of 50 from the axis, the force of stability would just balance it, so as to preserve an equilibrium, the vessel still preserving its inclination of 15°.

Such is nearly the method pursued by Mr. Atwood, to illustrate the general question of stability: and we have introduced the example to the attention of our readers, to enable them to form some idea of the mode pursued by that celebrated man in this very interesting inquiry. It would very far exceed the limits of the Encyclopædia, to follow him through all the cases and forms of bodies he has chosen to illustrate his subject; but we will endeavour, by tabulating some of his leading results, to afford our readers every assistance we are able on so important a question. We recommend, however, most earnestly to every one interested in the inquiry the two papers of Mr. Atwood contained in the *Philosophical Transactions* for 1796 and 1798.

TABLE *of Mr. Atwood's Results.*

Form of the Body.	Figure illustrative of its form.	Value of AB, or breadth of the water section, denoted by 2b in the general formula.	Distance of the centres of gravity of the entire body, and of the volume immersed, denoted by a in the general formula.	Area of the section of the volume displaced, denoted by V in the general formula	Magnitude of the angle of inclination, denoted by φ in the general formula.	Value of GZ, or the measure of the body's stability.	Equivalent effect of the wind acting on the sails of the body at the mean distance of 50 from the axis.
The sides of the vessel parallel to the plane of the masts, both above and below the water section.	Fig. 1. Plate II.	100	13	3600	15	2.84	Tons. 56.8
The sides of the vessel above the water section, projecting outwards 15°, but parallel to the masts below the same section.	Fig. 2.	100	13	3600	15	3.21	64.2
The sides of the vessel above the water section, inclining inwards 15°, but parallel to the masts below the same section.	Fig. 3.	100	13	3600	15	2.53	50.6
The side of the vessel above and below the water section inclining outwards 15°.	Fig. 4.	100	13	3600	15°	3.59	71.7
The sides of the vessel above and below the water section inclining inwards 15°.	Fig. 5.	100	13	3600	15°	2.21	44.2
The sides of the vessel forming an isosceles wedge inclined to each other 30°, the vertex being immersed in the water.	Fig. 6.	100	13	3600	15	2.86	57.0
The sides of the vessel forming an isosceles wedge inclined to each other 60°, the vertex being immersed in the water.	Fig. 7.	100	13	3600	15°	2.92	58.4
The sides of the vessel forming an isosceles wedge inclined to each other 30°, the vertex being above the water.	Fig. 8.	100	13	3600	15	2.86	57.0

* This distance is supposed to be estimated horizontally.

TABLE *of Mr. Atwood's Results.*

Form of the Body.	Figure illustrative of its form.	Value of AB, or breadth of the water section, denoted by $4b$ in the general formula.	Distance of the centres of gravity of the entire body, and of the volume immersed, denoted by a in the general formula.	Area of the section of the volume displaced, denoted by V in the general formula.	Magnitude of the angle of inclination, denoted by φ in the general formula.	Value of GZ, or the measure of the body's stability.	Equivalent effect of the wind acting on the sails of the body at the mean distance of 50 from the axis.
							Tons.
The sides of the vessel above the water section parallel to the masts, but below the water section inclining outwards 15°.	Fig. 9.	100	13	3600	15°	3.21	64.2
The sides of the vessel above the water section parallel to the masts, but inclining inwards 15°, below the same section.	Fig.10	100	13	3600	15	2.53	50.6
The sides of the vessel coinciding with the surface of a cylinder, the vertical sections being equal circles.	Fig.11.	100	13	3600	15°	2.63	52.5
The vertical sides of the vessel terminated by the arcs of a conic parabola.*	Fig 12	100	13	3600	15°	2.84	52.8

The object of Mr. Atwood in the investigation, of which the results are recorded in the preceding table, was to estimate the effects produced on different bodies, by assuming different forms for their sides; and for this purpose he preserved all their other elements constant. Thus, as the table illustrates, the breadth of the water section was in all cases denoted by 100: the distance of the centre of gravity of the entire body, and of the volumes displaced by 13: the area of the section of the volume displaced by 3600, and the angle of inclination of the constant magnitude of 15°. In the two last columns will be found the measure of stability for the different forms.

The table furnishes several remarkable conclusions. For example, by comparing the results of No. 6. with No. 8. the singular fact is disclosed, that if two isosceles wedges having their surfaces inclined at the same angle, have also the same breadth at the water's surface, and the distances between their centres of gravity, and of the volumes displaced equal, as also the weights of the bodies themselves, then will the stabilities of the two bodies, when inclined to the same angle from the upright, be always the same. The same principle may also be remarked by comparing the form No. 2. with No. 9. and likewise No. 3. with No. 10.

But the circumstance here adverted to possesses a much more general character, it being equally true, whatever be the nature of the figure assumed for the sides, provided the surfaces *below* the water line in one vessel, are *similar equal*, and *similarly disposed* with respect to the water section, to the sides of another vessel *above* the same section. This remarkable property may be demonstrated as follows:

Let QCHO, Fig. 15, represent a vessel, the sides of which *above* the plane of the water section project *outwards*, and the sides *below* the same plane *inwards*, the vessel in this position being in a state of permanent equilibrium. Suppose the vessel to be deranged from that position by the action of any force, and let CH be the position of the water's surface, in consequence of the inclination. Let also ASH

* The results contained in the preceding table are those obtained by Mr. Atwood from theory, by means of his general formula, $GZ = \frac{g\,n}{V} - a\,\varphi$; but as some of our readers may feel gratified by an experimental illustration of the truth of the same formula, we throw into this note an abstract of a paper published by Colonel Beaufoy, in the *Annals of Philosophy* for February 1824.

The apparatus employed by the Colonel was described originally in the *Annals* for March 1816, and as it may be useful to others engaged in the same interesting branch of experimental inquiry, we add a description of it.

In Plate CCCLXXXIX. Fig. 20, A, A represents a cistern filled with water, and mounted to a convenient height upon framed legs; B a model on which the experiment was tried, by attaching a fine line *a a* to the top of the mast D, and conducting it over a pulley, E. A scale F is suspended to the end of the line for the reception of the weights. These cause the model to incline, as the figure shows; and the degree of inclination of the mast from the perpendicular is shown by the plumb line *b*, upon a divided arch *d*. To prevent the body from being drawn away towards the pulley E by the draft of the line *a*, it is retained by two small lines (shown dotted at *g*, *g*,) which are made fast to sliders, *s*, *s*, at the side of the cistern, and have hooks at the opposite ends, which take hold of pins projecting from the stem and stern of the model B; and these are previously adjusted so that the centre of gravity of the model will be found in a line between them. The manner of making this adjustment is shown in Fig. 21. which represents a frame of wood, H, supporting two small uprights *h*, *h*. These have pieces of brass plate at the upper ends, with notches to receive the pins or pivots of the model B. These pivots are fitted into grooves, in two pieces of brass plate attached to the ends of the model. One of these slips of brass is shown separately at Fig. 22. where *k* is the pivot, and *l* a screw tapped into the brass slide to which the pivot is fixed, and passing through the same groove by means of this screw, the pivot *k* can be fastened at any part of the groove, and raised or lowered. The ballast is then raised or lowered till the model will barely rest on the pivots without overturning, as shown in Fig. 21. It is necessary, in order to know exactly what weight is applied to the top of the mast D, that the line *a* draw in a direction at right angles thereto. To ascertain this, a ruler, *m*, is fixed upon the top of the mast, and the pulley E is attached to a cross rail H, which applies against the uprights, and is suspended by a line *n*, which passes over a pulley, and is made fast to a cleat *o*. By this means the pulley E can at pleasure be raised or lowered until the direction of the line *a* corresponds with the ruler *m*. The manner of conducting the experiment is as follows: The cistern is filled with water up to a certain mark; and the model being put in, loaded with ballast, the water is added or decreased till the edge of the gunwale is exactly on a level with the edge of the cistern, as ascertained by applying a straight ruler, or looking across it. The plumb line *d*, cutting the zero of the divided arch, shows the vessel to be upright. In this state the model is ready for making the experiand SBC be the equal areas produced, the former being immersed in the fluid, and the latter elevated above it; and let M and I be their respective centres of gravity.

Suppose now the entire body to revolve round the line AB as an axis, and to perform half a revolution or 180°; then will the positions of its sides be entirely reversed; those parts of them which in the original

ment. The hooks of the two strings *g*, *g*, attached to the pivots and the two sliders *s*, *s*, are raised or lowered to make the strings *g*, *g* horizontal in the water. Weights being now put into the scale F, will show what weight is requisite to incline the model. The pulley E being raised or lowered by the line *n*, as is found necessary to make the line *n* draw parallel to the ruler *m*, or perpendicular to the mast. The inclination of the mast is shewn by the plumb line *b*, cutting the divisions of the arch *d*; but to counteract the weight of the plummet *b*, which tends to incline the mast, another counterbalancing plummet and line *r*, is applied to the opposite side of the model. For this purpose holes are made on the arch *d*, at every division, and a peg is put in at the division opposite to that which is cut by the plumb line. The experiment is tried with different weights, to produce the several inclinations at every five degrees, until 30 degrees from the perpendicular; and to verify the experiment, the model is changed end for end, the strings *g*, *g* being hooked on the pivots at the opposite ends. In this way the series of trials are made on the opposite side, by which means, if there is any difference in the two sides, or in the ballast, it will be detected, and allowed for by taking the mean of the different trials.

The bodies employed by Colonel Beaufoy were of different forms, measuring in breadth ten inches, and in length fourteen inches, or within a few hundredths of an inch of fourteen. The immersion in water was four inches, or two-fifths of the width. The total depths were various, those bodies whose sides projected outwards requiring greater depth than those with sides inclining inwards. The bodies to be referred to are, Figs. 1, 2, 3, &c. Plate CCCCLXXXIX.

As in the account of Atwood's investigation in the text, so in the experimental inquiry of Colonel Beaufoy, AB represents the breadth of the water section, and CH the surface of the water when the vessel is inclined. In the first set of experiments, the centres of gravity of the entire body, and of the volume immersed, were supposed to coincide in the point E, in which case ET represents the measure of stability. But in the second series of experiments the former centre was elevated above the latter 1.3 inches, or $\frac{13}{100}$ of the breadth of the water section, making GZ, as in Atwood's inquiry, the representative of stability. By producing TZ to meet EG produced, the point of intersection M becomes the metacentre of the body.

If from the total depth of each model the distance of the centre of gravity of each from its bottom be subtracted, the remainder will be the distance of the centre of gravity from the upper surface. If therefore to this distance be added the constant length of the mast, the sum will be the length of lever to which the different weights were applied to produce the desired inclination of the model. And since the momentum of the water acting on the inclining vessel must be equivalent to the momentum of the inclining power, it follows that, by calling w the inclining weight, L the length of the lever at which it acts, and W the weight of the displaced volume of water, in the first series of experiments we shall have $ET \times W = L \times w$, whence $ET = \frac{L \times w}{W}$; and in the second series $GZ \times W = L \times w$, whence $GZ = \frac{L \times w}{W}$, the values of the lines ET and GZ, being, as before remarked, the respective measures of the stability in the two sets of experiments.

To illustrate these formulæ, let the first experiment with the first model be selected from the following Tables, and let the angle of inclination be 5°. Then the total depth of the model being 7.1 inches, the distance of its centre of gravity from its bottom two inches, and the constant length of the mast 20.96 inches, it follows that $L = 7.1 - 2 + 20.96 = 26.06$ inches. And to produce an inclination of 5°, it appears, by the first horizontal column of the table, that a weight of 2.2239 ounces applied at the extremity of the above length of lever is necessary; hence $w = 2.2239$; also $W = 324.52$ ounces, and we derive from the formulæ $ET = \frac{L \times w}{W} = \frac{26.06 \times 2.2239}{324.52} = .18$, for the length of lever at which the displaced volume of water acts, to restore the body to its vertical position.

In the following tables, the results of the two series of experiments are recorded. In the first horizontal column is entered the weight of water displaced by the model; in the second, the length of lever at which the inclining power acts, and in the third, the distance of the centre of gravity of the model from its bottom. In the first vertical column is recorded the several angles at which the model is inclined; in the second, the weights necessary to produce those inclinations; in the third, the values of ET and GZ, the distances at which the displaced volume of water acts, to restore the body to its vertical position; in the fourth column, the values of the same lines calculated by the formula of Atwood; and in the last column, the elevation GM of the metacentre, above G the centre of gravity of the body, calculated by the trigonometrical proportion,

Sin ∠EMT : ET or GZ : : radius : EM or GM.

It may be proper to remark again, that in performing the experiments after the vessel had been inclined on one side, it was turned and then inclined the other, by which means any error in the distribution of the ballast, or in the position of the mast could be corrected, by taking the mean of the results deduced from the opposite positions. The difference, however, Colonel Beaufoy remarks, seldom amounted to two drachms, and, in general, was much less.

COLONEL BEAUFOY'S EXPERIMENTAL RESULTS.—MODEL I.—FIGURE I. PLATE CCCCLXXXIX.

Weight of Water displaced, 324.5 ounces, or the value of W.

Experiment I.					Experiment II.				
Total length of the Lever estimated from the Centre of Gravity, 26.06 inches, or the value of L.					Total length of the Lever estimated from the Centre of Gravity, 24.76 inches, or the value of L.				
Height of the Centre of Gravity above the bottom of the Model, 2 inches.					Height of the Centre of Gravity above the bottom of the Model, [illegible] inches.				
Angle of Inclination.	Inclining weight or value of w in ounces.	Experimental value of ET.	Theoretical value of ET, deduced from Atwood's formula.	Height of the metacentre above the centre of gravity of the body.	Angle of Inclination.	Inclining weight or value of w in ounces.	Experimental value of GZ.	Theoretical value of GZ, deduced from Atwood's formula.	Height of the metacentre above the centre of gravity of the body.
5°	2.2239	0.18	0.18	2.05	5	0.8633	0.06	0.07	[illegible]
10	4.4635	0.36	0.37	2.06	10	1.7509	0.13	0.14	[illegible]
15	6.8137	0.55	0.56	2.12	15	2.7777	0.21	[illegible]	2.12
20	9.2942	0.75	0.76	2.18	20	3.9581	0.30	[illegible]	2.13
25	12.0890	0.97	0.97	2.30	25	5.4202	0.41	[illegible]	2.28
30	15.1560	1.22	1.22	2.43	30	7.2464	0.55	0.56	2.41

position of the body projected *outwards*, *above* the water's surface, in the new position, inclining *inwards*, *below* the same surface; and the other parts of them which in the position of permanent equilibrium inclined *inwards* being now found inclining *outwards*. Let Fig. 16. denote this new condition of the body, and *c h* the position of the fluid surface, when the solid is inclined to the same angle as denoted by Fig. 15. Now since AB=*a b*, it follows that ABCO being applied to *a b c o*, so that the point A may coincide with *a*, AB with *a b*, and consequently the point B with the point *b*, the two sections will be identical and equal in all respects. Also since the lines CH, *c h*, are equally inclined to the lines AB, *a b*, and cut off the areas ASH, *a s h*, respectively equal to the areas BSC, *b s c*, it follows when the line AB coincides with *a b*, the points S and *s* must coincide also, and likewise the areas just mentioned. As a necessary consequence, the centres of gravity M and I will coincide with the corresponding points *m* and *i*; the line ML with *m l*, IK with *ik*, and consequently KL with *k l*. And since the area ASH is equal to the area

Model II.—Figure II.

Weight of Water displaced, 324.52 ounces, or the value of W.

Total length of the Lever estimated from the Centre of Gravity, 26.66 inches, or the value of L.					Total length of the Lever estimated from the Centre of Gravity, 25.36 inches, or the value of L.				
Height of the Centre of Gravity above the bottom of the Model, 2 inches.					Height of the Centre of Gravity above the bottom of the Model, 3.3 inches.				
5	2.2155	0.18	0.18	2.09	5°	0.8437	0.06	0.07	2.06
10	4.5000	0.37	0.41	2.12	10	1.8437	0.18	0.18	2.13
15	7.0208	0.58	0.59	2.23	15	3.0156	0·23	0.25	2.21
20	9.7187	0.80	0.82	2.33	20	4.5156	0·35	0.37	2·33
25	12.9320	1.06	1.08	2.51	25	6.4219	0·50	0.53	2·49
30	16.6610	1.37	1.38	2.74	30	9.0625	0·71	0.73	2·72

Model III.—Figure III.

Weight of Water displaced, 324.52 ounces, or the value of W.

Total length of the Lever estimated from the Centre of Gravity, 26.1 inches, or the value of L.					Total length of the Lever estimated from the Centre of Gravity, 24.8 inches, or the value of L.				
Height of the Centre of Gravity above the bottom of the Model, 2 inches.					Height of the Centre of Gravity above the bottom of the Model, 3.3 inches.				
5°	2.1929	0.18	0.18	2.02	5°	0.8177	0.06	0.06	2.02
10	4.3073	0.35	0.35	1.99	10	1.5677	0.12	0·13	1·99
15	6.4062	0.52	0.53	1.99	15	2.3335	0.18	0.20	1·99
20	8.5312	0.67	0.71	2.01	20	3.1667	0.24	0.26	2·01
25	10.7970	0.87	0.89	2.05	25	4.1198	0.31	0.34	2·04
30	13.2030	1.06	1.08	2.12	30	5·2604	0.40	0.43	2·10

Model IV.—Figure IV.

Weight of Water displaced, 359.14 ounces, or the value of W.

Total length of the Lever estimated from the Centre of Gravity, 26.71 inches, or the value of L.					Total length of the Lever estimated from the Centre of Gravity, 25.41 inches, or the value of L.				
Height of the Centre of Gravity above the bottom of the Model, 1.95 inches.					Height of the Centre of Gravity above the bottom of the Model, 3.23 inches.				
5	2.1937	0.16	0.17	3.80	5°	0.6094	0.04	0.06	3.73
10	4.5625	0.34	0.35	3.88	10	1.5260	0.11	0.12	3.85
15	7.5229	0.51	0.56	4.03	15	2.8177	0.20	0.23	4.00
20	10.4589	0.78	0.77	4.29	20	4.5469	0.32	0.33	4.17
25	11.4270	1.07	1.09	4.47	25	7·0104	0.50	0.54	4.40
30	19.2000	1.43	1.43	4.79	30	10.4170	0.74	0.78	4.70

Model V.—Figure V.

Weight of Water displaced, 289.96 ounces, or the value of W.

Total length of the Lever estimated from the Centre of Gravity, 26.03 inches, or the value of L.					Total length of the Lever estimated from the Centre of Gravity, 24.73 inches, or the value of L.				
Height of the Centre of Gravity above the bottom of the Model, 2.06 inches.					Height of the Centre of Gravity above the bottom of the Model, 3.36 inches.				
5	2.1302	0.19	0.20	2.19	5	0.9375	0.08	0.08	2.22
10	4.1823	0.37	0.37	2.16	10	1.7448	0.15	0.14	2.16
15	6.0937	0.55	0.57	2.11	15	2.4896	0.21	0.23	2.12
20	8.0104	0.72	0.74	2.10	20	3.2083	0.27	0.29	2.10
25	9.9583	0.89	0.91	2.11	25	3.9896	0.34	0.36	2.10
30	11.8750	1.07	1.09	2.13	30	4.7812	0.41	0.44	2.12

BSC, and *a s h* to *b s c*, it follows that the four areas are equal to each other. Hence since the volume immersed, is by the supposition in each case the same, it follows that $ET = \frac{\beta v}{V}$, and $e\,t = \frac{\beta v}{V}$, and therefore $ET = e\,t$.

Now this equality between the lines ET and *e t* being independent of the positions of the centres of gravity of the entire bodies, and also of the positions of the centres of gravity of the immersed volumes, it follows that if the distances of those centres be the same, that ER will be equal to *e r*, because by the hypothesis, the angles at which the bodies are inclined are the same. If therefore from ET we subtract ER, and from *e t* take *e r*, there will remain RT or GZ equal to *r t* or *g z*; and from which we infer that the stabilities of the two bodies are the same.

Another property demonstrated by Mr. Atwood is, that when the vertical sections of one vessel are terminated by the arcs of a conic parabola, and the sides of another vessel are parallel to the plane of the masts above and below the plane of the water section, the stabilities of the vessels will be equal at all equal inclinations from the upright, when the breadths of the water sections, and all the other conditions are the same in both cases—a coincidence which could scarcely be supposed to exist in bodies so dissimilar in form.

In another case he has also proved, that if the sides of one vessel coincide with the curve of a conic parabola, and the sides of another vessel with a conic parabola of any other form, but having a different parameter, the breadths of the water sections, the weights of the vessels, and the other conditions being the same, the stabilities of the two vessels at all equal angles of inclination will be equal. This he infers from the principle, that in proportion as the dimensions of the parabolic curve are augmented, the figure more closely approximates to a sectangular parallelogram; and that when they are increased *sine limite*, the form ultimately coincides with a body of that kind. And that as we have before seen that the stability of the conic parabola is the same with that of the rectangular parallelogram, so must the stability of a body whose form is that of a parabolic curve of the highest possible dimensions, approach to the same identity. As a matter of useful reference, illustrating the remarkable property alluded to, and because the forms of vessels approximate in many cases to the parabolic figure, we insert Fig. 17, in which the curve

*c*B*C*o is a conical or appollonian parabola.
*d*BD*o* a cubic parabola.
*e*BE*o* a biquadratic parabola.
*f*BF*o* a parabola of 8 dimensions.
and *g*BG*o* a parabola of 50 dimensions.

Having made these general observations on the subject of stability, we shall in the next place proceed to the application of the principles that have been developed, to the computation of the stability of the ship whose displacement we before computed.

For this purpose let BDQA, Fig. 18, represent that portion of the principal vertical section of the vessel proposed, which is situated below the water line BA, when the plane of the masts is at right angles to the fluid surface; and let DC represent the line which coincides with the surface of the water, when the vessel is inclined at an angle of 10°, at which angle we propose to compute the stability. This plane DC, from the conditions of stability, must be so situated as to cause the *volumes immersed and emerged* in consequence of the inclination, to be equal in solidity; and it will follow, from the varieties of form which the

Model VI.—Figure XI.

Weight of Water displaced, 240.710 *ounces, or the value of W.*

Total length of the Lever estimated from the Centre of Gravity, 25.73 inches, or the value of L. Height of the Centre of Gravity above the bottom of the Model, 2.33 inches.					Total length of the Lever estimated from the Centre of Gravity, 24 33 inches, or the value of L. Height of the Centre of Gravity above the bottom of the Model, 3 6[illegible] inches.				
5°	2.1719	0.23	0.24	2.66	5°	1.1667	0 12	0.13	2.65
10	4.3177	0.46	0.48	2.66	10	2.3229	0.23	0 26	2.65
15	6.4271	0.69	0.72	2.65	15	3.4114	0 34	0 37	2 66
20	8.4687	0.90	0.96	2.65	20	4.4896	0 45	0 51	2 63
25	10.5470	1.12	1.18	2.66	25	5 5208	0 56	0 63	2 62
30	12.5830	1 34	1.40	2.69	30	6 5417	0 66	0.75	2.62

Model VII.—Figure XII.

Weight of Water displaced, 215.97 *ounces, or the value of W.*

Total length of the Lever estimated from the Centre of Gravity, 27.08 inches, or the value of L. Height of the Centre of Gravity above the bottom of the Model, 2.4 inches.					Total length of the Lever estimated from the Centre of Gravity, 25.78 inches, or the value of L. Height of the Centre of Gravity above the bottom of the Model, 3.7 inches.				
5°	2.1021	0.26	0.27	3.02	5°	1.2708	0.21	0.16	3 04
10	4.2375	0 53	0.55	3.06	10	2 5835	0 31	0 32	3.07
15	6.4666	0.81	0.84	3.13	15	3 9687	0.47	0.50	3.13
20	8.8646	1.11	1.14	3.25	20	5 5469	0 66	0.69	3 24
25	11.5880	1.45	1.46	3.44	25	7.4427	0 89	0.91	3.40
30	14.5680	1.82	1.83	3.65	30	9.7864	1.17	1.17	3.63

By a reference to the third and fourth columns of each experiment, it will appear how closely the experimental values of ET and GZ, at the different angles of inclination, approximate to the theoretical values of the same lines, deduced from Atwood's formula.

different transverse sections of a vessel present, that the areas of the figures SAbC, SBeD can in no case be equal; although, in the previous investigations, from the perfect equality and similarity supposed to exist among the transverse sections, the areas of immersion and emersion were properly regarded as equal. And it is farther evident, that at whatever distance the point S is situated from the middle point X of the water's surface, in any one section, the same distance XS will be preserved in every other section; for by the supposition the vessel is inclined round the longer axis, and therefore the intersection of the planes which pass through the lines BA and DC will be parallel to the longer axis, and consequently parallel to a line drawn through all the points X, from one extremity of the vessel to the other.

To show, in the next place, by what means the magnitude of XS is to be determined, through X draw the line XXW inclined to the water's surface at the given angle; and let a plane be supposed to pass through it, so as to cut all the sections in like manner. Then by means of the ordinary rules of mensuration, let the area of the figure AXWb be computed for each section; and from these equidistant areas, let the solidity of the volume comprised between the two planes XW and XA be calculated by means of the formula $(\Sigma + 4\,S + 2s)\frac{i}{3}$, and let the same operation be performed for the solid contained between the planes BX and XX. Let the former of these solidities be denoted by A'. Then will the difference of these solidities be equal to the solid comprised between the two planes XW and DC. And if we represent the area of the section XW by W, this difference will be equivalent to W × SO; that is A—A' = W × SO.

But by trigonometry XS : SO : : 1 : sin. SXO.
and therefore SO=XS × sin. SXO.

This value of SO being substituted in the preceding equation, gives A—A'=W×XS×sin. SXO, and from which we obtain

$$XS = \frac{A - A'}{W \times \sin. SXO}.$$

Our limits will not admit of our exhibiting the actual computations for this formula, but the result for the value of XS=.25 of a foot.

Having determined the value of this necessary and essential element, we shall proceed at once to compute the stability. In the first place, to calculate the succession of mixtilineal areas produced by the transverse sections by which the vessel has been divided, and of which series ASCb represents one of immersion, and BSDe another of emersion, we must divide each of them into a triangular area as SAC in that of immersion, and into a parabolic area as CAb, to which curve the small segment CAb closely approximates.

To compute the succession of rectilineal areas, we must obtain all the values of SA and SB, and also all those of the succession of perpendiculars, one set of which is denoted by Cc and Dd. To obtain those of SA and SB, we must, in the first place, observe, that the point S not being situated, as we have before demonstrated, in the middle of the water line, but is distant from it by the quantity XS = .25 above determined, it follows that this quantity must be subtracted from XA in one case, and added to its equal XB in the other. Now the values of XA or XB will be found in the first horizontal column of the general table in the article on the displacement, and from the numbers representing them are derived the results recorded in the second and fifth columns of the following table.

Number of the section.	Values connected with the Immersion.			Values connected with the Emersion.		
	Values of SA.	Values of the perpendicular Cc.	Values of the triangle SCA.	Values of SB.	Values of the perpendicular Dd.	Values of the triangle SBD.
5'	0.55	0.10	0.0275	1.05	0.20	0.1050
4'	4.85	1.12	2.7160	5.35	0.76	2.0330
3'	10.65	2.72	14.4840	11.15	1.45	8.1395
2'	14.55	3.16	22.9890	15.05	2.04	15.3510
1'	17.15	3.40	29.1550	17.65	2.44	21.5330
1'	17.15	3.40	29.1550	17.65	2.44	21.5330
2	19.85	3.70	36.7225	20.35	3.00	30.5250
3	21.45	3.82	40.9695	21.95	3.40	37.3150
4	22.25	3.88	43.1650	22.75	3.62	41.1775
5	22.70	3.94	44.7190	23.20	3.82	44.3120
6	23.00	4.00	46.0000	23.50	4.00	47.0000
7	23.30	4.04	47.0660	23.80	4.08	48.5520
8	23.50	4.08	47.9400	24.00	4.16	49.9200
9	23.70	4.12	48.8220	24.20	4.20	50.8200
10	23.85	4.16	49.6080	24.35	4.22	51.3785
11	24.00	4.20	50.4000	24.50	4.26	52.1850
12	24.15	4.20	50.7150	24.65	4.32	53.2440
13	24.25	4.20	50.9250	24.75	4.36	53.9550
14	24.30	4.20	51.0300	24.80	4.36	54.0640
15	24.30	4.20	51.0300	24.80	4.36	54.0640
16	24.30	4.20	51.0300	24.80	4.36	54.0640
17	24.30	4.20	51.0300	24.80	4.32	53.5680
18	24.25	4.20	50.9250	24.75	4.28	52.9650
19	24.15	4.20	50.7150	24.65	4.20	51.7650
20	24.05	4.20	50.5050	24.55	4.16	51.0640
21	24.00	4.16	49.9200	24.50	4.12	50.4700
22	23.70	4.12	48.8220	24.20	4.04	53.8840
23	23.15	4.08	47.2260	23.65	3.84	45.4080
24	21.90	4.00	43.8000	22.40	3.60	40.3200
25	19.90	3.64	46.2180	20.40	3.20	32.6400
26	16.65	3.20	26.6400	17.15	2.40	20.5800
27	10.75	2.24	12.0400	11.25	1.64	9.2250
1''	10.75	2.24	12.0400	11.25	1.64	9.2250
2''	8.75	1.80	7.8750	9.25	1.36	6.2900
3''	6.35	1.28	4.0640	6.85	1.04	3.5620
4''	3.65	0.72	1.3140	4.15	0.60	1.2450
5''	0.50	0.10	0.0250	1.00	0.20	0.1000

Number of the section.	Values connected with the Immersion.			Values connected with the Emersion.		
	Values of the double ordinate CA.	Values of the abscissa Hh.	Areas of the parabolic segment ACh	Values of the double ordinate BD.	Values of the abscissa Fe.	Areas of the parabolic segment BDe.
5'	0.1	0.0	0.000	0.2	0.0	0.000
4'	1.7	0.0	0.000	1.1	0.0	0.000
3'	4.0	0.1	0.267	3.1	0.0	0.000
2'	4.6	0.3	0.920	4.0	0.0	0.000
1'	4.1	0.3	0.820	4.2	0.1	0.280
1	4.1	0.3	0.820	4.2	0.1	0.280
2	3.8	0.3	0.760	4.2	0.15	0.420
3	3.8	0.2	0.507	4.3	0.25	0.717
4	3.9	0.15	0.390	4.2	0.25	0.700
5	4.0	0.1	0.267	4.1	0.25	0.683
6	4.1	0.0	0.000	4.1	0.22	0.601
7	4.2	0.0	0.000	4.15	0.20	0.555
8	4.2	0.0	0.000	4.2	0.20	0.560
9	4.2	0.0	0.000	4.25	0.20	0.567
10	4.2	0.0	0.000	4.3	0.20	0.573
11	4.2	0.0	0.060	4.35	0.15	0.435
12	4.2	0.0	0.000	4.4	0.15	0.440

Number of the section.	Values connected with the Immersion.			Values connected with the Emersion.		
	Values of the double ordinate CA.	Values of the abscissa Hb.	Areas of the parabolic segment ACb	Values of the double ordinate BD.	Values of the abscissa Fe.	Areas of the parabolic segment BDe.
13	4.2	0.0	0.000	4.4	0.15	0.440
14	4.2	0.0	0.000	4.4	0.15	0.440
15	4.2	0.0	0.000	4.4	0.15	0.440
16	4.2	0.0	0.000	4.4	0.15	0.440
17	4.2	0.0	0.000	4.4	0.15	0.440
18	4.2	0.0	0.000	4.4	0.15	0.440
19	4.2	0.0	0.000	4.35	0.17	0.493
20	4.2	0.0	0.000	4.3	0.20	0.573
21	4.2	0.0	0.000	4.25	0.25	0.708
22	4.1	0.05	0.137	4.25	0.25	0.708
23	4.0	0.15	0.409	4.2	0.20	0.560
24	4.0	0.20	0.533	4.1	0.17	0.465
25	3.8	0.25	0.712	3.9	0.12	0.312
26	3.5	0.20	0.467	3.5	0.05	0.117
27	3.0	0.05	0.100			0.000
1	3.0	0.05	0.100		0.0	0.000
2″	2.5	0.0	0.000	1.95	0.0	0.000
3″	1.8	0.0	0.000	1.45	0.0	0.000
4″	0.9	0.0	0.000	0.8	0.0	0.000
5″	0.1	0.0	0.000	0.2	0.0	0.000

To compute the areas of the parabolic segments ACb, BDe, we must bisect the double ordinates CA, BD in H and F, and draw Hb, Fe, perpendicular to them. The different values of these double ordinates, and of their corresponding abscissæ, will be found in the preceding Table.

Hence, by adding together the corresponding triangular and parabolic areas recorded in the two preceding Tables, we shall obtain the values of the entire mixtilineal areas ASCb, BSDe, as entered in the next Table:

Number of the section.	Values connected with the Immersion. Values of the mixtilineal area ASCb.	Values connected with the Emersion. Values of the mixtilineal area BSDe.	Number of the section.	Values connected with the Immersion. Value of the mixtilineal area ASCb.	Values connected with the Emersion. Values of the mixtilineal area BSDe.
5′	0.0275	0.1050	15	51.0300	54.5040
4′	2.7160	2.0330	16	51.0300	54.5040
3′	14.7510	8.1395	17	51.0300	54.0080
2′	23.9090	15.3510	18	50.9250	53.4050
1	29.9750	21.8130	19	50.7150	52.2580
1	29.9750	21.8130	20	50.5050	51.6570
2	37.4895	30.9450	21	49.9200	51.1780
3	41.4765	38.0320	22	48.9590	54.5920
4	43.5550	41.8775	23	47.6200	45.9680
5	44.9860	44.9950	24	44.3330	40.7850
6	46.0000	47.6610	25	36.9300	32.9520
7	47.0660	49.1070	26	27.1070	20.6970
8	47.9400	50.4800	27	12.1400	9.2250
9	48.8220	51.3870	1″	12.1400	9.2250
10	49.6080	51.9515	2	7.8750	6.2900
11	50.4000	52.6200	3	4.0640	3.5620
12	50.7150	53.6840	4	1.3140	1.2450
13	50.9250	54.3950	5	0.0250	0.1000
14	51.0300	54.5040			

Having therefore obtained the values of all the mixtilineal areas recorded in the columns of the last table, we must proceed in the next place to compute from them, the solidities of the volumes immersed and emerged. These solidities are each made up of the five following portions:

First, the solidities of immersion and emersion abaft the vertical section 5′.

Secondly, the solidities of immersion and emersion between the vertical sections 5 and 1′.

Thirdly, the solidities of immersion and emersion between the vertical sections 1 and 27.

Fourthly, the solidities of immersion and emersion between the vertical sections 1″ and 5″.

Fifthly, the solidities of immersion and emersion before the vertical section 5″.

To compute the solidity abaft the vertical section 5′, let Fig. 19. be referred to, in which ABCD represents a transverse section of the stern post and rudder, EF being a vertical line passing through the middle of the same.

Then since by the first number of the horizontal column 5″ of the general table, the semi-thickness M p of the stern post is equal to 0.75, and that O the distance of the point of intersection produced by the inclination of the vessel, is distant from M the quantity 0.25, it follows that O p = 0.75 — 0.25 = 0.5, and O q = 0.75 + 0.25 = 1.00, and from which numbers the given angle of inclination 10°; and the breadth of the stern post and rudder 5 feet, the following calculations for the solidity are derived:

Solidity of immersion abaft vertical section 5′.	Solidity of emersion abaft vertical section 5′.
O p = 0.5	O q = 1.0
p s = 0.0881	q t = 0.1763
Area s O p = 0.022	Area q O t = 0.0881
Solidity of which s O p is a section } = 0.11	Solidity of which q O t is a section } = 0.4407

In a similar way, and by a reference to the same figure, may the solidities of immersion and emersion before the vertical section 5″ be computed, M p the semi-thickness of the stern post, being, according to the first number in the column 5′ of the general table, equivalent to 0.8, the breadth of the portion of the stern being 4.5 feet.

Solidity of immersion before the vertical section 5″.	Solidity of emersion before the vertical section 5″.
O p = 0.55	O q = 1.05
p s = 0.096	q t = 0.185
Area s O p = 0.0264	Area q O t = 0.0971
Solidity of which s O p is a section } = 0.1188	Solidity of which q O t is a section } = 0.4369

To obtain the solidities of the remaining portions, recourse must be had to the general formula $(\Sigma + 4\,S + 2\,s)\frac{i}{3}$: and first, for the portions comprised between the vertical sections 5′ and 1′, the necessary elements being obtained from the last table.

SOLIDITY OF IMMERSION.

Extreme Areas.	Even Areas.	Odd Area.
0.0275	2.7160	14.7510
29.9750	23.9090	2
30.0025 = Σ	26.6250	29.5020 = 2 s
	4	
	106.5000 = 4 S	

and since $\frac{i}{3} = 1.1416$, we shall have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (30.0025 + 106.5 + 29.502) \times 1.1416 = 189.5107$, which is the solidity of immersion comprised between the vertical sections 5′ and 1′.

SOLIDITY OF EMERSION.

Extreme Areas.	Even Areas.	Odd Area.
0.105	2.033	8.1395
21.813	15.351	2
21.918 = Σ	17.384	16.2790 = 2 s
	4	
	69.536 = 4 S	

and the common interval being as before, makes for the formula $(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (21.918 + 69.536 + 16.279) \times 1.1416 + 122.988$, which is the solidity of immersion, comprised between the vertical sections 5′ and 1′.

The next set of calculations must be for the solidities of immersion and emersion comprised between the sections 1 and 27.

SOLIDITY OF IMMERSION.

Extreme Areas.	Even Areas.	Odd Areas.
29.975	37.4825	41.4765
12.140	43.5550	44.9860
	46.0000	47.0660
42.115 = Σ	47.9400	48.8220
	49.6080	50.4000
	50.7150	50.9250
	51.0300	51.0300
	51.0300	51.0300
	50.9250	50.7150
	50.5050	49.9200
	48.9590	47.6260
	44.3330	36.9300
	27.1070	
		570.9265
	599.1895	2
	4	
		1141.8530 = 2 s
	2396.7580 = 4 S	

And since in the present series of sections one-third the common interval is 2 feet, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (42.115 + 2396.758 + 1141.853) \times 2 = 7161.452$, which is the solidity of immersion comprised between the vertical sections 1 and 27.

SOLIDITY OF EMERSION.

Extreme Areas.	Even Areas.	Odd Areas.
21.813	30.9450	38.0320
9.225	41.8775	44.9950
	47.6010	49.1070
31.038 = Σ	50.4800	51.3870
	51.9515	52.6200
	53.6840	54.3950
	54.5040	54.5040
	54.5040	54.0080
	53.4050	52.2580
	51.6370	51.1780
	54.5920	45.9680
	40.7850	32.9520
	20.6970	
		581.4040
	606.6630	2
	4	
		1162.8080 = 2 s
	2426.6520 = 4 S	

And since one-third the common interval is 2 feet as before, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (31.038 + 2426.652 + 1162.808) \times 2 = 7240.996$, which is the solidity of emersion contained between the vertical sections 1 and 27.

Lastly, to compute the solidities between the vertical sections 1″ and 5″, we derive the following numbers from the same table:

SOLIDITY OF IMMERSION.

Extreme Areas.	Even Areas.	Odd Area.
12.140	7.875	4.064
0.025	1.314	2
12.165 = Σ	9.189	8.128 = 2 s
	1	
	35.756 = 4 S	

And since the common interval in these latter sections is 1.5 feet, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (12.165 + 36.756 + 8.128) \times 0.5 = 28.524$, which is the solidity of immersion between the vertical sections 1″ and 5″.

SOLIDITY OF EMERSION.

Extreme Areas	Even Areas.	Odd Area.
9.225	6.290	3.562
0.100	1.245	2
9.325 = Σ	7.535	7.124 = 2 s
	4	
	30.140 = 4 S	

and since the common interval is the same quantity as before, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = 23.294$, which is the solidity of emersion comprised between the vertical sections 1″ and 5″.

Collecting the results therefore of the parts just determined of the solidities of immersion and emersion into separate sums, we shall obtain

	Immersion.	Emersion.
Solidities abaft vertical section 5′	0.1100	0.4407
Solidities between vertical sects. 5′ and 1′	189.5107	122.9880
Solidities between vertical sects. 1 and 27	7161.4520	7240.9960
Solidities between vertical sects. 1″ and 5″	28.5240	23.2940
Solidities before vertical section 5″	0.1188	0.4569
	7379.7155	7388.1556

These solidities differing only from the mean of the solidities of immersion and emersion, by the quantity 4.22, may be regarded as a proof that the distance 0.25 determined for XS, is not very widely distant from the truth.

Our next object must be to estimate the moments of the solids of immersion and emersion. To accomplish this, we must obtain the centres of gravity of each of the triangular and parabolic areas before determined. For this purpose in Fig. 18, bisect AC and BD in H and F: join SH and SF, and take S*r* and S*p* each equal to two-thirds of SH and SF. In like manner, in the abscissæ H*h* and F*e* of the parabolic segments, take *hf* equal to three-fifths of H*h*, and *eg* equal to three-fifths of F*e*. Then will the points *r* and *p* be the centres of gravity of the triangular areas, and *f*, *g*, those of the parabolic segments.

Since also the effect of the moment is to be estimated with reference to the surface, of which DSC is a section, from the centres of gravity just determined, let fall the perpendiculars *rt*, *fh*, *pn*, and *gi*, on it, either by calculation or the more expeditious means of actual measurement from the working drawings, obtain the values of S*t*, S*h*, and S*n*, S*i*. These values are entered in the third, sixth, tenth, and thirteenth columns of the next table, and when multiplied respectively into the values recorded in the second, fourth, ninth and twelfth columns, will produce the moments given in the fourth, seventh, eleventh, and fourteenth columns of the same table. This, however, we will more particularly illustrate after the table is entered.

Values connected with the Immersion.

Number of the Section.	Values of the Triangle SCA.	Values of S *t*.	Resulting Moments.	Values of the Parabolic Segments AC *h*.	Values of S *h*.	Resulting Moments.	Moments of the Mixtilineal Area ASC *h*.
5′	0.0275	0.33	0.0091	0.000	0.00	0.0000	0.0091
4′	2·7160	3 66	9.9406	0.000	0.00	0.0000	9.9406
3′	14·4840	8·66	125.4314	0.267	13.00	3 4710	128 9024
2′	22·9890	19·86	219.6605	0.920	16.40	15 0880	264.7485
1′	29·1550	12.16	354.5248	0·820	18.30	15·0060	369.5308
1	29.1550	12.16	354.5248	0.820	15.30	15 0060	369.5308
2	36·7225	13 6[illegible]	499.4266	0.760	20.50	15.5800	515 0069
3	40.9695	14 40	589.9608	0.507	21.70	11 0019	600.96[illegible]7
4	43.1650	14.80	638.[illegible]420	0.390	22.30	8.6970	647 5[illegible]
5	44 7196	15 00	670.7850	0.267	22.5[illegible]	6 0075	676 7925
6	46.0000	15.26	701.9600	0.000	22.95	0.0000	701·9600
7	47.0660	15 43	726.2284	0.000	23.15	0 0000	726·2284
8	47·9400	15 50	743.0700	0.000	23.30	0.0000	743 0700
9	48.8250	15 63	763.0879	0.000	23.45	0 0000	763 0879
10	49,6080	15.70	778.8156	0.000	23.60	0 0000	778 8156
11	50.4000	15.84	798.3360	0.000	23.77	0.0000	798.3360
12	50.7150	15.91	806.8756	0.000	23.88	0.0000	806 8756
13	50.9250	15.94	811.7445	0.000	23.92	0.0000	811.7445
14	51.0300	16 00	816.4800	0.000	24.00	0 0000	816.4800
15	51.0300	16.00	816.4800	0.000	24.00	0.0000	816.4800
16	51.0300	16.00	816.4800	0.000	24.00	0.0000	816·4800
17	51 0300	16.00	816.4800	0.000	24.00	0.0000	816 4800
18	50.9250	16 00	814.8000	0.000	24.00	0.0000	814.0000
19	50.7150	16 00	811.4400	0.000	24·00	0,0000	811·4100
20	50,5050	16.00	808.0800	0.000	24.00	0 0000	808·0800
21	49.9200	15.90	793.7280	0.000	23.90	0.0000	793·7280
22	48.8225	15.87	774.8051	0.137	23.80	3.2606	778·0657
23	47·2260	15·70	741.4482	0.400	23.60	9.4400	750·8882
24	43·8000	14 70	643.8600	0.533	22.15	11.8059	655·6659
25	36.2180	13 60	492.5648	0.712	20.50	14 5960	507·1608
26	26·6400	11·60	309.0240	0.467	17.45	8 1491	317.1731
27	12·0400	8·48	102.0992	0.100	11.72	1 1720	102·2712
1″	12.0400	8 48	102.0992	0.100	11.72	1.1720	103.2712
2″	7 8750	6.40	50.4000	0.000	0.00	0 0000	50.4000
3″	4·0640	4·66	18.9382	0.000	0.00	0.0000	18·9382
4″	1·3140	2 23	2.9302	0.000	0.00	0.0000	2·9302
5″	0·0250	0·30	0.0075	0.000	0.00	0.0000	0·0075

Values connected with the Emersion.

Values of the triangle SBD.	Values of S *n*.	Resulting moments.	Values of the parabolic segment BD *e*.	Values of S *i*.	Resulting moments.	Moments of the mixtilineal area BSD *e*.
0.1[illegible]5[illegible]	0.60	0 0[illegible]	0.000	0.00	0.0[illegible]	0.0695
2.0330	3.30	6.70[illegible]9	0.000	0 00	0.0[illegible]	6.7089
8.1[illegible]5	6 46	52.5[illegible]1[illegible]	0.0[illegible]	0 00	0.00[illegible]	52.5812
15.[illegible]510	8.86	136.0[illegible]	0.000	0 00	0.00[illegible]	136.[illegible]9
21.5330	10 5[illegible]	[illegible].7[illegible]25	0.2[illegible]	15.80	4.4[illegible]	[illegible]1.1[illegible]5
21.53[illegible]0	10.5[illegible]	[illegible]7[illegible]25	0.280	15.[illegible]0	4.[illegible]	[illegible]1.1[illegible]5
[illegible]5[illegible]	12.45	[illegible]	0.4[illegible]0	1[illegible].75	7.[illegible]75	[illegible]8[illegible].2165
37·515[illegible]	1[illegible].75	51[illegible]1	0.717	20.70	14.[illegible]19	[illegible]
41·1775	1[illegible]	[illegible]98 [illegible]1	0.700	21.50	15.[illegible]	61[illegible]
44·51[illegible]	1[illegible]00	[illegible]	0.[illegible]	22 70	15.[illegible]11	[illegible]
47·00[illegible]	15 [illegible]	[illegible]	[illegible]	[illegible]50	1[illegible]	74[illegible]
48 55[illegible]0	15 7[illegible]	[illegible]	0.53[illegible]	[illegible]70	15.1[illegible]	776.8765
49·9[illegible]	15 93	[illegible]	[illegible]	24·00	1[illegible]	8[illegible].0656
50·8[illegible]	16 15	[illegible]	[illegible]567	[illegible]	1[illegible]	[illegible].4765
51·5785	16 [illegible]	[illegible]1111	0.57[illegible]	24 45	11.[illegible]	[illegible]
52·1[illegible]	16·[illegible]	[illegible]10	0.[illegible]	[illegible]	[illegible]	[illegible]
52·4[illegible]	16.[illegible]	[illegible]	0.4[illegible]	[illegible]	10.[illegible]	[illegible]
[illegible]	1[illegible]	[illegible]761	[illegible]	[illegible]	1[illegible]	[illegible]1
51·0610	16 [illegible]	[illegible]779	0,410	[illegible]	10.[illegible]	[illegible].6119
54·0[illegible]10	16.[illegible]	[illegible]	0,410	24 [illegible]	10[illegible]	[illegible]119
51 0610	16.5[illegible]	[illegible]	0.[illegible]	24 85	10.9[illegible]	[illegible]11[illegible]
53.50[illegible]	1[illegible]	[illegible]	0.[illegible]	[illegible]85	10.9[illegible]	8[illegible]
52.9[illegible]	16 5[illegible]	[illegible]5111	0.4[illegible]	[illegible]	10.[illegible]	[illegible].4454
51.7650	16 [illegible]	[illegible]519	0.4[illegible]	[illegible]75	12.[illegible]17	[illegible]536
51 6626	16.[illegible]	[illegible]1	0.[illegible]	[illegible]	14.1[illegible]	[illegible]
50.[illegible]	16. [illegible]0	[illegible]140	0.70[illegible]	[illegible]	17.[illegible]	[illegible]
[illegible]	1.[illegible]	[illegible]	0.7[illegible]	[illegible]	16.[illegible]	[illegible]
45 10[illegible]	15 [illegible]	[illegible]9	0.50[illegible]	[illegible]	12.[illegible]	[illegible]
40·3[illegible]	14 [illegible]0	53[illegible]	0.405	[illegible]	1[illegible]	[illegible]
32·6400	13 06	426·[illegible]1	0.512	19.5[illegible]	[illegible]	[illegible]6
20·5800	10 70	220 2[illegible]0	0.117	[illegible]	1.[illegible]	[illegible]97
9·2250	7.00	61.5750	0.000	10.[illegible]0	0.0	6[illegible]750
9 2250	7.00	61.5750	0.000	10.[illegible]	0.00[illegible]	64.5750
6·2900	5.73	36 0417	0.000	0.0[illegible]	0.00[illegible]	36.0417
5·5620	4 26	15 1741	0.000	0.[illegible]	0.00[illegible]	15.1741
1·2450	2.60	13·2370	0.000	0.00	0.000[illegible]	3 2370
0.1000	0.60	0 0050	0.000	0·0	0.0000	0.0050

If now the moments corresponding to the mixtilineal areas ASC b, BSD c in the preceding table be applied to the formula $(\Sigma + 4\,S + 2\,s)\,\frac{i}{a}$, we shall obtain the total moments of immersion and emersion.

MOMENT OF IMMERSION.

Extreme Areas.	Even Areas.	Odd Area.
0.0091	9.9406	128.9024
369.5308	264.7485	2
369.5399 = Σ	274.6891	257.8048 = 2 s
	4	
	1098.7564 = 4 S	

and since one-third the common interval of the sections = 1.1416, we shall have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (369.5399 + 1098.7564 + 257.8048) \times 1.1416 = 1970.517$, which is the moment of the solid of immersion comprised between the vertical sections 5′ and 1′.

MOMENT OF EMERSION.

Extreme Areas.	Even Areas.	Odd Area.
0.0693	6.7089	52.5812
231.1665	136.0099	2
231.2358 = Σ	142.7188	105.1624 = 2 s
	4	
	570.8752 = 4 s	

and the common interval being as before, we have

$(\Sigma + 4\,S + 2\,s)\,\frac{i}{3} = (231.2358 + 570.8752 + 105.1624) \times 1.1416 = 1035.7433$, which is the moment of the solid of emersion comprised between the vertical sections 5′ and 1′.

To these results must be added the moments of the solidities of immersion and emersion *abaft* the vertical section 5′, and also of the solids *before* the vertical section 5″. The solidities of the portions referred to have been already determined, and from which their moments are very readily derived. The results are recorded in what follows, together with the moments of the other parts.

	Immersion.	Emersion.
Moments of solidities abaft vertical section 5′ - - - - -	0.0366	0.2935
Moments of solidities between vertical sections 5′ and 1′ - -	1970.5170	1035.7433
Moments of solidities between vertical sections 1 and 27 - -	110039.2472	113625.2814
Moments of solidities between vertical sections 1′ and 5″ - -	177.2579	126.0220
Moments of solidities before vertical section 5″ - - -	0.0442	0.3105
	112187.0329	114787.6507

The general formula for stability before deduced being $GZ = \frac{\beta v}{V} - \alpha \phi$, gives also by clearing from fractions, $V \times GZ = \beta v - \alpha V \phi$, and under which form we shall apply it to the example now under consideration.

For this purpose, we may remark, that the first member V × GZ represents the true measure of the stability, and that by the calculations immediately preceding, and those connected with the displacement, the centre of gravity of displacement, and the centre of gravity of the entire vessel, the values of all the elements of the second member become known.

In the *first* place, the quantity βv is equivalent to the sum of the moments of immersion and emersion, or equal to 112187.0829 + 114787.6507 = 226974.7336 = 6484.9924 tons.

Secondly, The element α denoting the distance between the centres of gravity of the entire body, and of the volume immersed, is equal to the sum of the distances of those centres from the plane of the water section. The distances of the former point *above* the plane here alluded to, has already been determined to be 0.9409; and the distance of the latter point *below* the same point, has also been found to be 7.78. Hence we shall have

$$\alpha = 0.9409 + 7.78 = 8.7209.$$

Thirdly, The element V, or the displacement, has been likewise found in the article devoted to that subject to be 2885.084.

Fourthly, The value of ϕ, the natural sine of the assumed angle of inclination = 0.1736482. Consequently the expression for the stability, or V . GZ = $\beta v - \alpha V \phi$ = 6484.9924 — 8.7209 × 2885.084 × 0.1736482 = 2115.9118 tons, which is the stability of the proposed vessel, at an angle of ten degrees.

The preceding calculations for the stability will, no doubt, be regarded by our readers as long and laborious, but we were anxious to lay before them the most approved and perfect methods. It will also be perceived, that it is the rigid determination of the value of βv by the formula for equidistant areas, which is the cause of the extension of the investigation. But the computation of the stability may be much modified and shortened by adopting the metacentric method of Bouguer, and will be sufficiently accurate when only an approximate value is required.

For this purpose, let the equation of stability V . GZ = $\beta v - \alpha V \phi$ be resumed, and let our object be to determine a more convenient form of computation for the function βv.

Let ADB, Fig. 23, represent a transverse vertical section of a vessel passing through the centre of gravity of displacement, the points A and B being in the plane of the water section. Suppose now a force to be so applied to the vessel as to cause it to incline through the angle aCA, and, at the same time, to preserve a constant volume of displacement, and also a constant breadth of the water section, and let ab be the water section produced by the inclination.

Suppose, in the next place, the semi-breadth of the vessel AC or CB to be denoted by x, and the length of the water line by y. Let also the volume of displacement be denoted, as before, by V.

Then, since by the hypothesis there is no alteration of volume in the displacement, the prism immersed, and of which a section is represented by the triangle AC a, must be equal to the prism emerged, and of which the equal and similar triangle BC b is a section. From a, let ao be drawn at right angles to AC; then will the area of either of the triangles CA a, CB b, be represented by $\frac{CA \times a\,o}{2} = \frac{CA \times C\,a \times \sin. \angle\, AC\,a}{2}$ (since CA and C a are supposed equal) $= \frac{CA^2 \times \sin.\ AC\,a}{2} = \frac{x^2 \sin. \phi}{2}$, the function ϕ representing the sine of the angle of inclination as before. Hence the differential of the volume immersed or emerged in consequence of the inclination, will be $\frac{x^2 \sin. \phi\, d\,y}{2}$.

Moreover, the distances of the centres of gravity of the same volumes, estimated from the common point C, will be $\frac{2\,x}{3}$. And by a law of mechanics, the emerged prism may be supposed to be transferred and concentrated with the prism immersed; and the moment produced by the transfer will be the volume of the prism, multiplied by the distance of translation of its centre of gravity, or $\frac{x^2 \sin. \phi\, d\,y}{2} \times \frac{4x}{3} = \frac{2x^3 \sin. \phi\; d\,y}{3}$.

Hence, the general equation of stability V . GZ $= \beta\, v - \alpha\, V\, \phi$ will present the approximate form V . GZ $= \frac{2 \sin. \phi}{3} \int x^3\; d\; y - \alpha\, V\, \phi$, and by which the following computation is performed.

To determine the value of $\int x^3\; d\, y$, we must again have recourse to the first horizontal line of the general Table of Ordinates, and after taking the cubes of the elements contained in it, apply the results to the formula $(\Sigma + 4\ S + 2\, s)\, \frac{i}{3}$.

Calculation for the Semi-Ordinates comprised between the vertical sections 5′ and 1′.

Extreme Semi-Ordinates.		*Even Semi-Ordinates.*	
Semi-Ordinates.	Cubes of Semi-Ordinates.	Semi-Ordinates.	Cubes of Semi-Ordinates.
0.8	0.512	5.1	132.651
17.4	5268.024	14.8	3241.792
	5268.536 = Σ		3374.443
			4
			13497.772=4 S

Odd Semi-Ordinates.

Semi-Ordinates.	Cubes of Semi-Ordinates.
10.9	1295.029
	2
	2590.058 = 2 s

and since one-third, the common interval of these sections, is 1.1416, we shall have

$(\Sigma + 4\ S + 2\ s)\ \frac{i}{3} = (5268.536 + 13497.772 + 2590.058) \times 1.1416 = 24380.4274$, which is the result for the sections composed between the vertical sections 5′ and 1′.

Calculation for the Semi-Ordinates comprised between the vertical sections 1 and 27.

Extreme Semi-Ordinates.		*Even Semi-Ordinates.*	
Semi-Ordinates.	Cubes of Semi-Ordinates.	Semi-Ordinates.	Cubes of Semi-Ordinates.
17.4	5268.024	20.1	8120.601
11.0	1331.000	22.5	11390.625
		23.25	12568.078
	6599.024=Σ	23.75	13396.484
		24.10	13997.521
		24.40	14526.784
		24.55	14796.346
		24.55	14796.346
		24.50	14706.125
		24.30	14348.907
		23.95	13737.780
		22.15	10867.288
		16.90	4826.809
			162079.694
			4
			648318.776 = 4 S

Odd Semi-Ordinates.

Semi-Ordinates.	Cubes of Semi-Ordinates.
21.70	10218.313
22.95	12087.822
23.55	13060.889
23.95	13737.780
24.25	14260.516
24.50	14706.125
24.55	14796.346
24.55	14796.346
24.40	14526.784
24.25	14260.516
23.40	12812.904
20.15	8181.350
	157445.691
	2
	314891.382 = 2 s

and since one-third, the common interval, is 2 feet, we have

$(\Sigma + 4\ S + 2\ s)\,\frac{i}{3} = (6599.024 + 648318.776 + 314891.382) \times 2 = 1939618.364$, which is the result for the sections comprised between the vertical sections 1 and 27.

Calculation for the Semi-Ordinates comprised between the vertical sections 1″ and 5″.

Extreme Semi-Ordinates.		*Even Semi-Ordinates.*	
Semi-Ordinates.	Cubes of Semi-Ordinates.	Semi-Ordinates.	Cubes of Semi-Ordinates.
11.00	1331.000	9.0	729.000
0.75	0.422	3.9	59.319
	1331.422 = Σ		788.319
			4
			3153.276 = 4 S

Odd Semi-Ordinates.

Semi-Ordinates.	Cubes of Semi-Ordinates.
6.6	287.496
	2
	574.992 = 4 S

and since one-third, the common interval, is 0.5, we shall have

$(\Sigma + 4\ S + 2\ s)\ \frac{i}{3} = (1331.422 + 3153.276 + 574.992) \times 0.5 = 2529.845$, which is the result for the sections comprised between the vertical sections 1″ and 5″.

Collecting these values, and adding to them the results belonging to the stem and stern post, we shall have

Result between vertical sections 5′ and 1′ -	24380.427
Result between vertical sections 1′ and 27′ -	1939618.364
Result between vertical sections 1″ and 5″ -	2529.845
Result of stem and stern post - - -	4.800
	1966533.436

This value, reduced into tons, becomes 56186.67, and which is therefore the value of $\int x^3\ d\ y$ in this measure. But the expression in our approximative formula is $\frac{2 \text{ sin. } \phi}{3} \int x^2\ d\ y$; and which becomes, by taking the function ϕ as 10°, equivalent to 6504,4761 tons. And the value of $\alpha\ V\ \phi$ being, as before determined, 4369.0806 tons, we shall obtain for the expression

$$V\ .\ GZ = \frac{2 \text{ sin. } \phi}{3} \int x^3\ d\ y - \alpha\ V\ \phi$$
$$= 6504.4761 - 4369.0806$$
$$= 2135.3955$$

tons, the stability of the vessel according to the approximative method proposed.

Hence it appears, that the metacentric stability differs from the true stability only by 19.48 tons, or by $\frac{1}{108}$ of the whole quantity; and as the calculation by the approximative method is so much shorter and more convenient than the method of Atwood, there can be no reason why it should not be adopted, when absolute precision is not required.

It is proper, however, to remark, that there are considerable chances of error in the employment of the metacentric method, when the constructer is not well acquainted with the method of Atwood. For a knowledge of the true method of computing the stability makes us acquainted with the necessity of examining particularly the figures of the solids of immersion and emersion, which the metacentric method does not; and if the sides of a ship should be found to incline considerably inwards in those parts, the latter method would without question be inapplicable.

It is remarkable that the stability of all ships, by the metacentric method, would be the same, *cæteris paribus*, as if the sides between the immersion and emersion were circular arcs, and the stability correctly measured by Atwood's method.

The practical errors, in the cases of the Endymion and Icarus, are as follows:

	Stability by Atwood's method.	Stability by the metacentric method.	Difference. Error.
Endymion of 50 guns	1729	1736	$7 = \frac{1}{247}$
Icarus of 10 guns	208	205	$3 = \frac{1}{69\text{n'ly.}}$

Atwood adduces, as a proof of the imperfection of the French method of measuring the stability, the case of Le Scipion, built at Rochefort in 1776, and L'Hercule and Le Pluton, which were built from the same design, and were found, when launched, very deficient in this important quality. The first *ingénieur constructeur* was sent from Paris to remedy the defect, and after trying an alteration in the ballast, which was found totally inadequate to correct it, he directed a doubling of timber to be brought round the sides of the ship, from four inches to one foot in thickness, extending the whole of the ship's length, and reconciling with the curve of the body ten feet below the water's surface. This completely remedied the defect. That the stability would be increased by it, would have been equally evident, by whichever method it might have been calculated. It could not have been suggested by Atwood's method, since it was not used in France,—indeed was not known. The fault of these ships was, in a great degree, if not altogether, too sudden an inclination inward abaft the main breadth. Atwood appears to have supposed it to arise altogether from falling away too suddenly below the plane of flotation. On this rests the whole of his argument in adducing these ships as an example of the incorrectness of the French, and the correctness of his method of determining the stability of ships. Their defect might have been clearly ascertained by subjecting the design to the determination of the height of the metacentre, which would have been found much too low.

Bouguer, however, carries the theory of the metacentre much further: he says that his theory being duly investigated under the consideration of the angle of inclination being infinitely small, it is necessary to extend the consideration of it, to render it applicable to finite angles. He traces the metacentric curve as the ship gradually inclines from its upright position, and determines its nature; he says that if this curve rises as the ship inclines, the ship will be secure; but if the curve descends, that the ship will be insecure.

Atwood shows, most clearly, the error of this doctrine: he says, that "the construction and properties of the metacentric curve, being a subject of geometrical reasoning, considered purely as such, are liable neither to ambiguity nor error; but on what grounds these properties are applied to measure the stability of vessels, or to estimate their security from upsetting, when much inclined from the upright, is not explained by M. Bouguer, M. Clairbois, or any other author I have had an opportunity of consulting."

Atwood proves that the stabilities of two vessels, one of which Bouguer considers to be secure in inclining, and the other insecure, are exactly equal. His reasoning on this part of the subject appears most conclusive, and we again earnestly recommend his two papers to the particular attention of the reader.

On the Centre of Gravity of a Ship.

Like all other material systems, a ship must possess a centre of gravity, whose essential properties are the same as commonly attributed to it by the elementary writers on mechanics. The determination, however, of its exact position in a ship, is a matter of considerable difficulty, and at the present moment is to be numbered among the many desiderata of naval architecture.

Frequently important calculations are made to depend on very rude and mechanical approximations towards its true situation; and connected as this very essential element is, with so many properties of a ship, we trust that our naval engineers will not rest until they have placed it on a basis more definite and exact than it reposes at present.

The first difficulty in the way of determining the centre of gravity of a vessel in a complete state of equipment for sea, (for the determination of this point under any other circumstances, as for example when the vessel is in a state of ordinary, would not produce all that is to be desired) arises from the peculiar circumstances of *form*, and the varied and uncertain influences of the masts, yards, rigging, and other necessary parts of a ship's equipment; and secondly, from the ever-changing circumstances of lading, and the different modes of stowage, which different conditions of a vessel require.

If we direct our attention to the hull, we shall find its external figure presenting a surface of a very uncertain kind; and although mathematicians might reach, by an approximate process, the position of the centre of gravity, under the most general circumstances of form, yet from the uncertainty which hangs over the general principles of construction, but little advantage would be likely to result from it. In the British navy at the present moment, we have almost *every possible variety of form*; and as every alteration of figure necessarily involves new considerations respecting the masts and their accompaniments, and also new considerations respecting the stowage, it follows, that we cannot, without making allowances, and for which we have no precise and definite rules, apply with certainty any results that may be obtained, even to ships of that class for which the primitive calculation was made.

If we consider for a moment the peculiar figure of a ship, we may remark, that wherever the point now under consideration is situated, three rectangular coordinate planes may be supposed to pass through it; and that to one only of the three can we assign any definite position. This certainty of position with respect to one of the co-ordinate planes, arises from the symmetry existing (or which at least ought to exist) between the two parts of a ship, when it is divided by a vertical longitudinal plane, passing through the centre of the keel; and in which plane, therefore, this point must be somewhere situated. This symmetry of form, therefore, with respect to the longitudinal plane, fixes the position of the centre of gravity of a vessel with regard to its *breadth*.

But in no other direction can we suppose a plane to pass, so that the moleculæ on opposite sides of it shall be *precisely similar and equal*; a condition indispensably necessary, for determining *a priori* from the *form* of the vessel, the position of either of the other co-ordinate planes. But we may, however, fix with some tolerable approach to certainty, the position of the centre of gravity with respect to *length*, by attending to a condition which the laws of Hydrostatics furnish, that the centres of gravity of the entire ship, and of the volume of fluid displaced by its immersion, are in the *same vertical line*; and that as every vessel when equipped, possesses a *given* displacement, it follows that the determination of the centre of gravity of displacement, fixes the position of the centre of gravity of the entire ship with regard to the *length*.

But the determination of the situation of the centre of gravity with respect to the third and last dimension *depth*, is that which involves the greatest share of difficulty; and for the attainment of which, many methods have been proposed; some grounded on theoretical considerations, and others founded on experiment. One very correct but laborious method is, by calculating the momentum of every molecule constituting the ship, from some assumed horizontal plane, and dividing the integral of these moments, by the total weight of the ship. This method is founded on the well-known mechanical theorem, that if p, p', p'', &c. be particles lying on *one* side of a plane given in position, and π, π', π'', &c. particles lying on the *other* side, at the perpendicular distances x, x', x'', &c. X, X', X'', &c. respectively, then the distance of the common centre of gravity of the particles p, p', p'', &c. π, π', π'', &c. from the plane, will be

$$\frac{p\,x+p'\,x'+p''\,x''+,\&c.-(\pi\,x+\pi'\,x'+\pi''\,x'',\ \&c.)}{p+p'+p''+,\&c.+\pi+\pi'+\pi''+,\&c.}$$

where the centre of gravity will lie on the *same* or *contrary* side of the plane with p, p' p'', &c. according as $p\,x+p'\,x'+p''\,x''+$,&c. is *greater* or *less* than $\pi\,x+\pi'\,x'+\pi''\,x''+$,&c.

In the present case, the plane to be assumed is that of the water surface, and to it must be referred all the moleculæ constituting the ship; and not only must the weight of *every individual timber, yard, gun, anchor, &c. &c. &c. be obtained*, but also the *corresponding distances of their centres of gravity from the plane assumed*. This operation is of course tedious and laborious*, but must of necessity be accomplished, if we are desirous of ascertaining with the greatest possible precision the situation of this very important point.

* What Mr. Reynold said of painters, may with equal truth be said of shipbuilders. "Those who are determined to excel must go to their work whether willing or unwilling, morning, noon, and night, and will find it to be no play, but very hard labour." Perhaps the mechanical arts do not in general inspire that ardour and enthusiasm which the cultivation of the fine arts so beautifully encourage; but there is unquestionably a wider field open for honour and renown in naval architecture, than in any other branch of mechanics. We want a man of original mind, who will pursue the subject for its *own sake*, and enter on its cultivation with that energy and enthusiasm, which distinguished Brindley for canals, or Watt for the steam engine; a mind ready to seize all the good that its predecessors have achieved, and courage to attempt those plans of its own, which an enlarged and philosophical mind has so much at command. It is not too much to expect, that such a man may yet arise, to throw a new light on naval architecture, and to impart to it that improvement which so many other arts have derived from highly gifted minds.

The limits of the Encyclopædia unfortunately, will not permit us to exhibit in perfect detail the individual weights necessary for this important calculation, but we shall endeavour, by a brief, and we hope luminous sketch, to give the results, and the methods by which they are obtained.

In the first place, the different weights constituting the ship, must be divided into two classes, throwing such as have their centres of gravity *above* the plane of flotation into one class, and those *below* the same plane, into another. The former are exhibited in the first of the following tables, and the latter in table the second.

Names of the different weights *above* the water's surface.	Values of p, p', p'', &c. in Tons.	Values of x, x', x'', &c. in Feet.	Values of the moments $p\,x, p'\,x'', p''\,x'$, &c.
Masts, yards, and bowsprit	77.61	54.64	4240.6104
Rigging and blocks -	58.56	56.53	3310.3968
Cables, hawsers, and spare rigging - - -	40.66	0.21	8.1520
Sails - - - -	9.04	45.80	414.0320
Long guns and carronades	241.22	11.69	2819.8618
Anchors - - -	15.50	19.19	296.0500
Boats - - - -	20.00	22 20	444.0000
Fire hearth - - -	7.00	14.00	98.0000
Officers' furniture and stores	6.00	1.03	6.1800
Men's bedding - -	5.62	22.68	127.4616
Men - - - -	37.50	6.06	227.2500
Sum of the moments *above* the water's surface			11991.9746

Names of the different weights *below* the water's surface.	Values of π, π', π'', &c. in Tons.	Values of x, x', x, &c. in Tons.	Values of the moments $\pi\,x, \pi', x', \pi'\,x''$, &c.
Hull - - - -	1608.13	0.842	1354.0455
Water - - - -	170.45	9 03	1539.1635
Tare of casks and tanks -	43.18	9.00	388.6200
Wood - - - -	60.00	9.03	541.8000
Coals - - - -	32.50	13.20	429.0000
Dry provisions - -	46.56	9.02	419.9712
Bread - - - -	36.90	3.36	123.9840
Wine, spirits, and beer -	25.02	8.40	210.1680
Purser's slops - -	1.75	0.20	0·3500
Men's chests - - -	12.77	6.50	83.0050
Shot - - - -	53.29	3.87	206.2323
Powder and cartridges -	18.23	6.85	124.8755
Boatswain's, gunner's, and carpenter's stores -	24.00	0.08	1.9200
Ballast - - - -	233.59	16 50	3854.2350
Sum of the moments *below* the water's surface			9277.3700

To explain the methods by which the numbers in the first and second numerical columns of the preceding tables were obtained, we must, in the first place, remark, that the plane to which the centre of gravity is to be here referred, is that of the water's surface; and that all the numbers recorded in the second numerical column, are to be regarded as the distances of the centres of gravity of the several weights entered in the first column, from the plane of flotation. Thus to obtain the first number, in the first table, the weights of the lower masts, the top masts, the top gallant masts, and their necessary appendages, together with the weights of all the yards, as likewise the weight of the bowsprit, were all carefully ascertained and also the distances of the centres of gravity of the same parts, from the plane of flotation. The former result gave 77·61 tons, which is the value of p in the general formula, and the latter 54·64 feet, which is the value of x. The moment of the masts, yards, &c. must therefore be $77{\cdot}61 \times 54{\cdot}64 = 4240{\cdot}6104$, which is the value of $p\,x$ in the third column of the same table. In like manner, must the weight of all the standing rigging be obtained, and also the weight of all the running rigging, divided into such portions as the judgment of the calculator may direct. This will give for the value of p', 58·56 tons; and when the distance of the common centre of gravity of the same portions is obtained, it will furnish the value of x' or 56·53 feet. The product of these, amounting to 3310·3968 or $p'\,x'$, is the value of the moment of the same. To obtain the moments of the cables, hawsers, &c. particular attention must be given to the place of stowage, in order to obtain the distance of their common centre of gravity from the plane of flotation. The weight of these articles, amounting to 40·66 tons, is the value of p'', and the distance of their common centre of gravity, from the assumed plane, amounting to 0·21 feet, is the value of x''. Their product, or 8·132 is the moment, or the value of $p''\,x''$, as recorded in the third column. The sails are estimated, when furled on their respective yards, and the spare sails as they are compactly stowed in the sailbins. The guns, a very important element in the computation, from the magnitude of their moment, must have their entire weights estimated with all their appendages, and also with equal care the distances of their centres of gravity from the assumed plane, making due allowance for the curvature of the decks. The moments also of the anchors must be estimated in their respective places of stowage, and so also must the boats, the fire hearth, the officer's furniture, the men's bedding, as stowed in the nettings, and lastly, the entire moment of the men, estimated at their quarters.

If we now pass to the consideration of the moments *below* the water's surface, as entered in the second table, our attention is first directed to the hull, the computations connected with which are very laborious and intricate. To perform the calculations with precision, the weight of each individual timber must be estimated, and also the position of its centre of gravity, whether above or below the fluid surface. Thus if we refer to the disposition of the eighty-four gun ship, plate IV. for the purpose of illustrating the operation, and take the bend of timbers at 8; marked *d, e, f, g, h, i, k, l,* and *m,* we must, in the first place, find the weight of the cross piece *d,* and then the distance of its centre of gravity below the load water plane. Afterwards the weight of the half floor *e,* on each side of the ship, and the distance of its centre of gravity; and so on for the first futtock *f* on each side the ship; the second futtock *g,* the third, fourth, and fifth futtocks *h, i, k,* the top timber *l,* and lengthening piece *m,* estimating the moments as positive, *above* the water's surface, and negative *below;* and at the same time making an allowance for the bolts and other fastenings belonging to the bend of timbers selected for illustration. Performing this operation for all the timbers, the keel, the planking, riders, beams, decks, knees, both of iron and wood, shelf-pieces, water-ways, breast-hooks—in a word, for every component part of the structure, we shall obtain the total moment of the entire hull. In the first number of the second table, the weight of the hull appears to be

1608.13 tons, which is the value of π in the general formula; and the distance of the common centre of gravity of all the individual parts amounts to 0.842 feet *below* the water line, and which is the value of x; giving for the moment of the hull 1354.0455, or the value of πx in the general formula. The water, the second particular contained in the table, must be estimated with the same minute attention to accuracy, whether contained in tanks or casks, and also the tare of the tanks or casks themselves. So also must the wood and coals, as stowed in bulk. The specific gravity of each species of provision must likewise be found, and which, by knowing the bulk of the same, and the position of the centre of gravity, will furnish the moment desired. In the same manner must the mechanical effects of the bread, as stowed in bulk in the bread room be estimated; the wine and spirits as stowed in the spirit room, the beer, the purser's slops, and the men's chests. The shot also, whether stowed in the shot lockers, or placed in the racks on the different decks; the powder and cartridges as stowed in the magazines, and the boatswain's, gunner's, and carpenter stores, as deposited in their respective store rooms.

There remains but one particular more, and that is the ballast; and to obtain the mechanical effect of which, the absolute *weights* of all the preceding articles must be selected from the tables, and their sum subtracted from the total displacement. The difference of the two will be the quantity of ballast necessary for the ship, and which amounts, in the present case, to 233.59 tons. To compute the position of the centre of gravity of the same, a plan illustrative of the mode of stowage must be carefully prepared, and the position of the point in question computed from thence. Its distance below the plane of flotation in the present case is 16.5 feet, producing, in conjunction with the weight of the ballast itself, the moment 3854.235, and which, it will be observed, with the exception of the moment of the masts, yards, and bowsprit, is the largest moment in the whole calculation.

Hence, it appears, that the sum of all the moments *above* the water's surface, or the value of $p x + p' x' + p'' x'' +$ &c. in the general formula, is 11991.9746; and the sum of all the moments *below* the water's surface, or $\pi x + \pi' x' + \pi'' x'' +$ amounts to 9277.37. Also the value of $p + p' + p'' +$ &c. . . . . . . $+ \pi + \pi' + \pi''$ &c. is the total displacement, or 2885·084 tons. Hence the general formula,

$$\frac{p x + p'x' + p'' x'' + \text{\&c.} - (\pi x + \pi' x' + \pi'' x'' + \text{\&c.})}{p + p' + p'' + \text{\&c.} + \pi + \pi' + \pi'' + \text{\&c.}}$$

becomes $\frac{11991.9746 - 9277.37}{2885.084} = .9409$ feet;

which is the altitude of the centre of gravity of the entire vessel, when completely equipped, *above* the plane of flotation. The centre is known to be *above* the plane of the water's surface, because the value of $p x + p' x' + p'' x'' +$, &c. exceeds $\pi x + \pi' x' + \pi'' x'' +$ &c. in the general calculation.

Such then is a general view of the process of obtaining the centre of gravity of a vessel, by estimating the moments of all its parts; an operation that was performed with the greatest industry and zeal by several students of the School of Naval Architecture, and from whose interesting results the preceding computations, with some alterations, have been derived.

It is obvious, however, that the method which has been just explained for determining the centre of gravity of a vessel, cannot on every occasion be adopted with convenience, although its accuracy and value renders it desirable, that it should be employed whenever circumstances will permit. Accordingly, different experimental plans have been proposed for determining this important point, one of which we shall now explain to our readers.

1°. "Let the ship's company be separated and placed on the decks, quarter-deck, and forecastle, either on the middle, or divided on both sides of the ship, so that it does not incline. Let all the guns be run out above and below; place the quadrant, by which the inclination of the ship is to be measured, and observe the ship's draught fore and aft."

2°. "Mark the situation of the gun carriages on the deck."

3°. "Haul in the guns either on one or both decks as far as the hatches and other hindrances will allow, some more and others less, till the ship has acquired an inclination of about six or eight degrees. Nail cleats against the trucks of the carriages, that they may stand fast. Let the men take their former stations and observe exactly how many degrees and minutes the ship inclines."

4°. "Number the guns, and measure the distance that each of them has been moved."

5°. "Take the weight of each gun, carriage, breeching, and coins, &c. that follow the gun when moved, and reduce this weight to cubic feet of sea-water."

6°. "Multiply the weight of each gun, &c. by the distance moved, which is the momentum of that gun."

If then we refer to the general formula of stability,

$$V \times GZ = \beta v - \alpha V \varsigma,$$

we shall find that the element we are desirous of determining is α, and whose value is represented by the equation.

$$\alpha = \frac{\beta v - V \times GZ}{V \varsigma}.$$

all the members of which being necessarily known by the conditions of the investigation, gives the distance of the centre of gravity of the ship, from the centre of gravity of displacement; and the position of the latter point being known from other investigations, will determine the situation of the centre of gravity of the ship.

The experimental method here described was originally proposed by Don Juan in 1771, although it has been commonly attributed to Chapman. Another method, however, has been proposed by Mr. Major in the Annals of Philosophy for June, 1826, which is so very neat and ingenious, that we insert it for the information of our readers.

Let the ship be heeled to the same angle by two separate horizontal forces, applied at different heights in the plane of the masts. Then it is evident that the momenta of the forces which result from the separate applications of the inclining forces must be equal, since the same constant force of stability represents them both. Let P represent one of these forces, and p the other; and let a and b be their respective distances of action from the centre of gravity of displacement; let also Δ be the angle of inclination of the ship from the perpendicular, and x the distance of the centre of gravity sought, from the centre of gravity of displacement. We shall then have the following equation of condition for the forces employed:

$$P(a-x)\cos.\ \Delta = p(b-x)\cos.\ \Delta,$$

$$\text{or } Pa - Px = pb - px,$$

$$\text{whence } x = \frac{Pa-pb}{P-p},$$

and from which we derive the following simple practical rule:

"Divide the difference of the momenta of the inclining forces from the centre of gravity of displacement, by the difference of the same paces, and the result will be the distance of the centre of gravity of the displacement.

Having now illustrated the method of determining the position of the centre of gravity, we shall consider what effect the total force acting at this point produces on the pitching and rolling of a ship, two considerations of great moment in the structure of a vessel.

To estimate in some degree, these effects, suppose ADB, Fig. 24, to represent the transverse section of a ship, AB being the section of the same plane with the water's surface, E the centre of gravity of the entire ship, and G the metacentre. Suppose, moreover, a force to be so applied at B, in the direction BH, as to produce an inclination denoted by the line *a b*. Then, by the principles of mechanics, the moment of the effort producing the inclination will be in proportion to EH, the distance between the centre of gravity and the point where the direction of the inclining force meets the axis DH; and the moment of the effort which tends to restore the ship to its upright position, is in proportion to EG, the interval between the centre of gravity and the metacentre. Now, since these efforts act in opposite directions, there results a motion, termed *rolling*; and the total effect of the forces producing it, is as the sum of EH and EG. And since the ship, during the act of rolling, ought to revolve round *a common longitudinal axis*, and not at different inclinations about *different axes*, a property, however, by no means easily to be obtained, but which we shall advert to again hereafter: and that its weight or displacement is supposed to be the same at all inclinations as when the vessel is situated in its upright position, a condition, however, which cannot happen, unless the ship, and consequently its centre of gravity E, be elevated a quantity, the value of which we shall now endeavour to exhibit.

Chapman in his naval architecture, supposes the quantity here alluded to, to be the versed sine of the angle GE *g* to the radius EG; but Dr. Inman, in a judicious note on the subject, properly remarks that this cannot be the case, and illustrates his position as follows: By inspecting, says he, Fig. 25, it will be seen that, supposing G to be fixed, the immersion must *exceed* the emersion. Through Y, therefore, the middle point between A and B, draw RYV parallel to *a b*; then, if RV were the water's surface, the immersion RYA would be equal to the emersion VYB. If, therefore, the surface of the water descends through XZ, the versed sine of the angle at G to the radius GX; or, which is the same thing, if the point G rise through the same line XZ, the displacement will remain unaltered. This, Dr. Inman observes, must be true at any inclination whatever, if the sides between wind and water be shaped as represented in this figure; but if the sides be not parallel to the plane of the masts, the above reasoning will be true only when the inclination is evanescent, or, in a practical sense very small.

Hence it appears that the versed sine of the angle alluded to, must be in proportion to the radius EX, Fig. 24. supposing X to be the point where EG cuts the surface of the water, and then it is limited to the condition of evanescent inclinations.

When the effort whose influence has produced the inclination has ceased, the ship will *fall* by the action of gravity through the height E *e* alluded to; and which fall is moreover accelerated by the action of the fluid on the metacentre G. As the rolling may sometimes extend as far as thirty degrees on each side, the magnitude of E *e* must be considerable, and it becomes a very important point, therefore, in the construction of a ship to guard against it. And to do this, Dr. Inman recommends the position of the centre of gravity to be found by computation, and then to alter the body, *till the immersion and emersion caused by heeling round a quiescent longitudinal axis passing through that point are the same.*

For this purpose, let G, Fig. 26. be the centre of gravity of a body whose transverse section is AOB. Draw GX at right angles to the load water line, and also GY, making with XG an angle, XGY, equal to any proposed inclination. Take GY equal to GX, and through Y draw *a* Y *b* at right angles to GY; then will *a b* be the load water line when the ship is inclined, and BS *b*, AS *a*, the prismatic solids, which are denominated those of immersion and emersion. If the contents of these are found to be unequal, the body must be altered and the solids recomputed, till they are found to be as nearly equal as possible.

The easy rolling of a ship round the longitudinal axis alluded to, depends, in the first place, on the position of the centre of gravity of the ship; and secondly, on the form of the sides of the vessel between wind and water. This will be apparent by referring to Figs. 25, 27, and 28, each of which represents the body of a ship whose sides are parallel to the plane of the masts, A *b* the surface of the water, A B the load water line in its upright position, and G the centre of gravity of the ship supposed equally distant from A B and *a b*. In the first of these figures, G, the centre of gravity, is supposed to be *below* the plane of the water's surface; in Fig. 27, the same point is supposed to be *coincident* with the same plane; and in Fig. 28 it is above it. At an angle of inclination of ten degrees, AS *a* is to be regarded as the *immersion*, and BS *b* the *emersion*, the axis of rotation passing quiescently through the point G.

Now, by an inspection of these Figures we may remark, that in Fig. 27, the ship, in the act of rolling, *will neither rise nor fall*, because the solids of immersion and emersion are the same; but in Fig. 25, the immersion being greater than the emersion, the ship will *rise* in heeling; whereas, in Fig. 28, the ship will *fall* when rolling, because the immersion is less than the emersion.

If, in Fig. 27, the sides were made to fall out above the load water line, it is manifest, supposing the axis of rotation quiescent, that the immersion would exceed the emersion. In such a case, therefore, the ship would rise. In Fig. 25, also, if the sides above the load water line fell out, the immersion would exceed the emersion in a greater degree than before, and produce a proportionate elevation of the ship. And if the same thing were to take place in Fig. 28, the immersion being greater than before, the falling of the vessel would be diminished. In all these cases, the longitudinal axis is supposed quiescent.

If, again, the sides of a ship fell out below the water, preserving their parallelism to the plane of the masts above it, the ship represented by Fig. 27 would fall in heeling, the rising of that represented by Fig. 25 would be corrected, and the falling of that denoted by Fig. 28 increased.

We may hence perceive how much the form of a vessel between wind and water influences her rolling; and, as a general principle, it may be observed, that the motion of rolling is more uniform, and more free from sudden shocks, when the centre of gravity of a ship is in or near the plane of the load water section. And as this position of the centre of gravity exercises the same influence in regard to pitching, which is rolling lengthways, it follows that the position of the centre of gravity alluded to, is that which is proper in both cases. If, however, other circumstances do not admit of the centre of gravity being situated in the plane referred to, every endeavour should be made to bring it as near to it as possible. It may also be further added, that as the keel, and the lower parts forward and aft, which are the cleanest, contribute greatly to the diminution of the rolling by the direct opposition of their surface to the water, the farther these parts are situated from the axis of rotation, the greater will be the effect they produce in diminishing the rolling. For the same reason, likewise, when the centre of gravity is in the plane of the load water section, the ship should roll less.

There is a curious and interesting view of the subject of rolling sometimes taken, of regarding the successive changes of position of a ship, as analogous to the oscillations of a heavy body influenced by the constant action of a gravitating force operating at its centre of gravity.

The writers on mechanics have shown, that the distance of the centres of oscillation and suspension, of a body vibrating by its own weight, may be found, by dividing the angular inertia of all its particles, that is, the sum of the products of each particle into the square of its distance from the axis of rotation, by the whole body multiplied into the distance between the said axis and the centre of gravity. Thus, if p, p', p'', &c. denote the particles of a ship, and d, d', d'', &c. their respective distances from the axis of rotation which passes through the centre of gravity, and M the entire mass of the ship, the length of such an isochronal pendulum will be

$$\frac{p\,d^2 \times p'\,d'^2 \times p''\,d''^2 \times \text{\&c.}}{\text{M.EG}}$$

where EG measures the interval between the centre of suspension and the metacentre, the whole buoyancy of the fluid, or its equivalent, the entire weight of the ship, acting upwards on the latter point G.

If we suppose all the terms $p\,d^2$, $p'\,d'^2$, &c. of the numerator given, as well as the mass M of the denominator, it is evident that the length of the isochronal pendulum will vary inversely as EG; and from which it follows, that the greater the distance of the metacentre from the centre of gravity of the ship, the shorter must be the representative pendulum, and the quicker will be the vibrations of the ship. The less, moreover, that distance is, the slower will the rolling become.

If we suppose again, the length of EG to be given, as also the mass of the ship, the times of vibration will vary as the quantities d, d', d'', &c. which represent the distances of the particles of the ship from the axis of rotation. The less also these distances are, the shorter will be the pendulum, and the quicker the rolling. The greater these distances are, the slower will be the periods of rolling.

The above reasoning, however, as Dr. Inman properly remarks, is only strictly true when the vibrations are evanescent; but may be regarded as nearly true when they are in a practical sense very small. When a ship rolls through finite angles, the vibrations differ considerably from those of a pendulum of an invariable length. For the point G, where the vertical axis passing through the centre of gravity, may be supposed to be acted on by the mean buoyancy of the fluid on righting the vessel, is not then a fixed point. Nor can any precise or general conclusions be drawn from the expression for the length of the isochronal pendulum, respecting the degree of quickness or slowness of the vibrations, as depending on the length of EG. What, however, is thence concluded respecting the position of the weights, is true for any angles of rolling. The farther they are situated from the longitudinal axis passing through the ship, the greater will be their inertia, and the greater also the resistance the ship opposes to an inclining power. It may be proper, therefore, in cases where the stability is too little, to have recourse to such an arrangement of the weights, care being taken, however, to keep them at the same distance below the surface of the water.

Nothing is more difficult, as Chapman observes, than to construct a ship, so as to unite the qualities of sufficient stability and easiness of rolling; since any increase of the distance between the centre of gravity of the vessel and its metacentre, increases the stability, and adds at the same time to the rolling of the vessel. If the stability be diminished, a greater inclination will be produced by a given force. The inclination and righting of the ship, however, will be slower and more easy, because the force producing the motion will be overcome more gradually, and the parts of the ship will, as a consequence, be in a less degree strained. At the same time it is manifest, as Dr. Inman remarks, that the stability cannot be too much diminished, without compromising the service of the ship, and even endangering its safety.

Again, Dr. Inman remarks, that an increase of stability has the effect of rendering the angle of inclination less; and so far it is useful: but carried to excess, the inclining force would be destroyed so suddenly, that the shock might be dangerous. The effect also of the stroke of a wave on the side, the breadth being supposed to be increased, for the purpose of giving additional stability, would become greater; so that a ship thus constructed, would in the least sea be subject to incessantly quick vibrations. And in this important particular, Chapman seems to have erred, when he considers the height of the metacentre *alone*, as a sufficient criterion of the properties of a vessel with respect to its easiness or vivacity of rolling. This, indeed, cannot be the case, unless the angles of rolling are regarded as absolutely evanescent. It is possible, as Dr. Inman farther remarks, that the height of the metacentre may be sometimes diminished, and yet by an attention to the form of the sides, the stability may be made sufficiently great. It is possible, on the other hand, that the height of the metacentre may be increased beyond the quantity usually assigned to it, and yet by injudicious alterations in the sides, the stability be found too little.

To form a proper estimate of a ship's properties in this respect, it is necessary, during the formation of her plan, to make accurate calculations of her stability at different angles of inclination, and to compare the result in each case with the stability of approved ships of the same class. So that to enable the constructer to plan ships, which might be expected to answer fully in point of stability, he must be furnished not only with various calculations on all kinds of ships which have been previously built, but also with a minute detail of their performance at sea.*

The difficulty also of establishing a proper relation between the stability and the property of rolling, is still farther increased in ships like our merchantmen, in which it is desirable to unite economy of construction with the capability of stowing the greatest possible cargo. Ships of this kind, as Chapman remarks, should be very full below, and have but little height above the water in proportion to their breadth. A ship of this kind also, should have its centre of gravity of displacement very low, and which would also have the property of bringing the metacentre low likewise. On this account it is necessary to bring the centre of gravity of the cargo as low as possible, in order that the ship may have sufficient stability. The consequence, however, of such a construction will be, that the ship will be subject to quick rolling, and violent shocks, which, however, may be partly diminished by *winging* the weights as much as possible. The rolling of ships of burthen is however favoured by another circumstance, namely, that for economy it is necessary to navigate them with as few men as possible, a circumstance that renders a less quantity of sail necessary, and diminishes the interval between the centre of gravity and the metacentre.

In ships of war the centre of gravity may be higher, and the position of the metacentre should be such as to bring the common centre of gravity of the ship and weights, as nearly as possible into the plane of flotation. In the British navy, the height of the metacentre above the surface of the water is generally less than 6 feet. In eighteen gun brigs, it is 5.5 feet. In thirty-six gun frigates, it is nearly 6 feet. In the Leopard, a fourth rate, it is 4.2 feet. In third rates it varies from 4 to 5.5 feet; and in the Howe, a first-rate of 120 guns, it is 3.7 feet. Its altitude is, therefore, the greatest in the smallest ships, and *vice versa*.

Having now seen that the centre of gravity of a ship, in regard to *height*, should be as nearly as possible coincident with the plane of flotation, it will be our next object to consider its position with regard to the length. On this head we shall follow the steps of Chapman.

As the length of a ship is very great in proportion to its breadth, the metacentre, with regard to the former dimension, will be considerably elevated, particularly in ships which have a full load water line, and are very lean under the water fore and aft. The length of the isochronous pendulum will in consequence be exceedingly great, especially, if by placing the weights near the extremities, the point of suspension is situated very low.

The rolling of the ship according to its length is such, that its extremities rise and fall; a motion produced by the raising of the fore part of the ship by a wave, and which is immediately succeeded by a depression of the same part the moment the wave has passed. This motion would cease immediately, if wave did not succeed wave with rapidity, and thus continue the effect. When a ship is close to the wind and meets the waves, and after a sea has passed the forepart falls suddenly, and raises itself with difficulty upon the following wave, the ship is said to *pitch*. When the after part falls heavily, the ship is said to *scend*. Both these effects very much impede the sailing, and prodigiously affect the masts. The whole frame, moreover, labours and works exceedingly.

The cause of the pitching and scending arises from the waves passing with rapidity the forepart of the ship, and when arrived at the middle part, leave the forepart unsupported. The ship necessarily precipitates itself into the void, with a momentum proportional to the rectangle of the weights in the forepart, and their distance from the point where the ship is sufficiently supported.

This kind of motion is greater in ships which are very full near the load water line fore and aft, and very lean below. If the weights in the fore part are carried nearer the middle, the momentum with which the ship plunges itself in this part will be less; and not only will this motion become less quick, but the succeeding waves which meet the fore part of the ship, will have less difficulty in raising it again. And a similar observation applies to the after part.

Hence it follows that all the weights should be brought as near as possible to the middle of the ship; and, therefore, that the centre of gravity with respect to the length, ought to be also at the middle point. This, however, though theoretically correct, cannot be practically exemplified on account of the weight of the foremast and its rigging, the bowsprit, the anchors, and the stores necessarily placed forward. And hence Chapman concludes that *the centre of gravity should be placed before the middle of the length, but not more than between a hundredth and a fiftieth of the length.*†

In every investigation of this kind, however, we should remember that the centre of gravity of the load water line and the centre of gravity of the ship should be in *the same vertical line;* for when the ship sails close to the wind, and is inclined on one side, if the load water line is fuller aft than forward, since the displacement must remain constant, it will have an inclination also forward. On this important point, Dr. Inman remarks, that when a ship floats upright,

* What an extensive and important field of inquiry, therefore, would be opened by a digest of the properties of the most approved ships of the British navy; and how earnestly is it to be desired that the same may be speedily undertaken, under the liberal auspices of our public boards.

† The length in Swedish construction is taken between two perpendiculars to the keel. That at the stern is drawn from a point on the after side of the stern post at the height of the wing transom at the middle line. That forward is drawn from a point on the foreside of the stern at the same height above the water line with the wing transom.

the centres of gravity of the ship and the displacement are at the same distance from the stern. When the ship is inclined, the latter point is carried to leeward, and in consequence the buoyancy of the water, supposed to act upwards through it, tends to turn the ship back. The axis round which the ship will then revolve, depends on the position of the centre of gravity of the displacement after the inclination. If it be in the transverse section passing through the centre of gravity of the ship, (which is supposed in all disquisitions on this subject) the vessel will be made to roll round an axis parallel to its length; since, in that case, there cannot be any tendency to roll round a transverse axis passing through the centre of gravity.

But if the centre of gravity of the inclined displacement be behind or before the said transverse section, in that case the buoyancy will cause the ship to revolve round a transverse axis as well as round a longitudinal one; in other words, it will cause the ship to revolve round a diagonal axis,—a motion that must tend to disunite the parts of the ship, to derange its adjustments, and operate considerably in retarding its progress.

It seems desirable, therefore, Dr. Inman continues, to keep the centre of gravity of the displacement, as the ship inclines, in the transverse section in which it is placed, when the ship floats upright. This may be effected by taking care in the construction, that the line joining the centres of gravity of the immersion and emersion, at least at common angles of heeling, be parallel to that section. For the motion of the centre of gravity of the displacement takes place in consequence of the removal of the emersion, and the addition of the immersion, which is equal in bulk to the emersion; it may be considered, therefore, as produced by transferring the emersion collected in its centre of gravity to the centre of gravity of the immersion. And by a well-known principle of mechanics, if this transfer be made along a line *parallel* to the transverse section, the centre of gravity of the whole system, or of the whole displacement being once in the plane of that section, must always remain so.

When a ship sails by the wind, that is, when the wind is on the side of the ship, or more ahead, then almost all vessels have such a form, that they will of themselves, without the aid of a rudder, turn the stem more towards the wind, because the mean direction of the water's resistance passes usually a little before the centre of gravity of the ship.

If this resultant passed too far ahead, it would be an inconveniency which might be remedied, by giving a greater draught of water aft. The greater the velocity of the ship, the more sensibly this effect is felt, and the vessel can then be kept to her course only by the constant action of the rudder.

ON THE RESISTANCE WHICH A SHIP IN MOTION MEETS WITH FROM THE WATER.

We come now to the consideration of a subject, embarrassed with difficulties of no ordinary kind, and which will continue to retard the advancement of naval architecture, so long as its primary laws remain imperfectly developed. The resistance of fluids has engaged the attention of some of the profoundest philosophers; and when we mention that the labours of Newton, of Huygens, of Euler, of Daniel Bernoulli, of D'Alembert, of Don Juan, of Bouguer, of Condorcet, of Borda, of Bossut, of Chapman, of Clairbois, and of many others, have furnished us with little more than theories distinguished for ingenious speculation, and examples of the beauty and power of analysis, with few, if any practical maxims to guide the constructer in the choice of the primary elements of his ship, our readers will only join us in regretting, that a subject so intimately connected with the progress of naval architecture, should yet be so entirely in its infancy, and so far removed from any thing like practical perfection.

In the Annals of Philosophy for December 1824, Mr. Harvey has remarked, in a paper on this interesting subject, that had the subject been one which "*individual* industry and sagacity could have successfully prosecuted, there can be no doubt but its complete solution would have been long ago achieved, or at least some large and important steps made towards its completion. But, unfortunately for the sake of science, and for the naval service of the country also, this is not the case. "The problem," says he, "is one which involves too many difficulties for any individual to contend with, unless that individual possessed talents of the very highest order, uninterrupted leisure, and the necessary command of money"—"three elements," says Mr. H., "not often united in the same person; and as the past has not afforded a fortunate example of the kind, we may almost fear the future will not be more propitious."

It is perhaps true, as the author of the foregoing quotation has remarked, that the completion of the problem of resistances will scarcely be accomplished by individual talent and industry; but it is more than probable that the germ of a correct theory, whenever it appears, will be the result of individual sagacity and thought. It certainly opens a curious and interesting field of inquiry, why so much *apparently* well-directed labour should have produced so little that is of practical importance and value; and why, at a period, when so many other departments of physical science have attained to such high comparative perfection, the science of Hydrodynamics should yet be involved in so much uncertainty and error.

A careful analysis of all the theories that have been offered on this important subject, and of the experiments on which they are founded, the circumstances also under which these experiments were performed, together with the peculiar views of their authors, bringing all to the test of the known and established principles of Mechanics and Hydrostatics, might perhaps unfold to us some of the causes that have retarded its advancement. Such a review would, at all events, as Mr. Morgan has remarked in one of his papers on Naval Architecture,* be "most likely to lead to some practical results, by ascertaining what is fairly and certainly established: and by showing the merits and defects of the different theories, be the means of determining the propriety of adopting parts of some theories, which, as wholes, may be inadmissible." Such a review, if attended with no higher

* Papers on Naval Architecture, No. I. p. 29.

benefits, "would at least have the advantage, by an acquaintance with what has been written on the subject, of preventing the unnecessary labour of retracing the steps of others; either leading to the further investigation of a theory, from a point to which it is arrived, or suggesting researches in other directions."*

But a remark† has been lately thrown out respecting this subject, by the Academy of Sciences of Paris, —a body which has done more to encourage theoretical and experimental inquiries on this question, than any other learned society in Europe,—that "almost all the attempts which have hitherto been made for discovering the laws of the resistance of fluids, are contrary to the first rule of experiments, by which we ought to endeavour *to decompose the phenomena into their most simple elements.* It has been most common indeed, to observe *the time employed by different bodies, in describing a given space in a fluid at rest, or the weight which keeps in equilibrium a body exposed to the impulse of a fluid in motion.* But this can only make us acquainted with the *total result* of the *different actions* which this fluid exerts *upon each of the points of the bodies, actions which are very varied, and often opposite to each other.* In this state of things, *compensations* take place, *which mask the primitive laws of the phenomenon,* and which render the results of experiment *inapplicable to any other case but that which has furnished them.* M. Dubuat, author of the *Principes d'Hydraulique*, appears to have been the first who perceived this defect; and, in order to avoid it, he endeavoured to measure the *local pressures* on the *different parts* of the surfaces of bodies exposed to the impulse of a fluid in motion. His experiments, though small in number, and not much varied *in so far as the form of the body is concerned*, present, nevertheless, many curious results. Under these circumstances, the academy thought it would be useful to resume these experiments, with more perfect instruments, to multiply them, and to vary the circumstances still more. And in following up these important views, the academy has proposed for the subject of a prize,‡ the following programme:

"To examine in its details the phenomena of the resistance of water, by determining with care, by exact experiments, the pressures *separately* sustained by a great number of points, properly chosen in the anterior, lateral, and posterior surfaces of a body, when it is exposed to the impulse of a fluid in motion, and when it moves in the same fluid at rest; to measure the velocity of the water in different points of the current near the body: to construct from the results and observations, the curves which these currents form;§ to determine the point where their direction commences before the body; and finally, to establish, if possible, from the experimental results, empirical formulæ, which might be afterwards compared with the experiments formerly made on the same subject." Let us hope that these new experiments may be attended with all the advantages desired to naval architecture.

Having made these general observations, in order to put our readers in possession of the real state of our information respecting the resistance of fluids, and its applications to the science of naval architecture, we shall offer a few remarks from Chapman, in order that our readers may become acquainted with the views of a man, who, if he did not possess the highest philosophical qualifications, nevertheless, from the great attention he devoted to naval architecture, and the efforts he made to blend science as much as possible with its practical details, is entitled to considerable attention.

When a ship is at rest, observes Chapman, the pressure of the water upon each of its extremities is the same; but as soon as it is impelled by any force, the pressure is increased at the end opposite to the impulse, and is diminished at that end where it acts.

Again, if a plane be moved in the water, the resistance is the most forcible when the direction of the motion is perpendicular to the plane, and becomes less as the plane assumes a position more oblique to the line of motion. Hence bodies of different forms and convexities, with equal bases, experience different resistances.

It is by no means difficult to estimate the resistance which one body meets with from another, when impinging on it: but the difficulty becomes prodigiously increased when the object is to determine the effect which any medium produces on bodies moved therein. The effect of the impact of bodies on each other is subject to known mechanical laws; but that of media upon solid bodies, is, as we have before remarked, almost unknown.

When a body is at rest in water, every part of it immersed in the water, is subject to a pressure perpendicular to its surface, and the degree of pressure produced is some function of the depth of the part subject to the action of the fluid. This is a fact verified by daily experience.

When a ship, Fig. 29, Plate CCCCLXXXIX, is put in motion in still water, with any velocity, it always happens that the water upon the extremity A before the greatest breadth C, rises against this part, above the surface at F. This elevation is perceptible at some distance before the ship in the direction of its course. It also extends laterally towards PQ: but beyond the greatest breadth C, the water *falls* again,

* Some steps towards a review of this kind have been made by Morgan and Creuze, in the useful work before quoted. In the first number is given an abridged translation of the theory of Don Juan, an author who united in his ingenious and useful work on the Theory of Seamanship, a rare combination of much that is useful both in theory and practice. In the second number is given a translation of the Abbé Bossut's Report on the Experiments made on the resistance of Fluids by D'Alembert, Condorcet, and the Abbe Bossut. We hope to see this excellent plan followed out in the succeeding numbers, and concluded by a general review of the whole subject.

† See Dr Brewster's Journal of Science, No X. p. 368.

‡ The prize will be a gold medal of the value of three thousand francs, and will be adjudged on the first Monday of June 1828. The memoirs must be sent to the secretaries of the Institute before the 1st of January 1828.

§ The late Admiral Sir Charles Knowles made many beautiful experiments for determining the paths of the filaments of water. At a certain distance from the body subjected to the action of the fluid, he allowed small jets of a coloured fluid which had no tendency to *mix* with water, to enter the fluid. The experiments were performed in a vessel having a glass bottom and sides. A luminous taper was placed several feet above, in order to throw the shadows of the coloured filaments on a white plane held below the bottom of the vessel, and on which the projected shadows of the various curves were accurately traced by a pencil.

so that between C and B it is below its proper level, until it meets in D the part of the fluid which constantly follows the ship with the same velocity as itself, in order to fill up the void space which it would otherwise leave behind. But as the water which glides along the side of the ship has already filled this space, there is a collision in the fluid in EE, which produces what is called *eddy water*. This is a thing most observable in small vessels, which draw little water; but in large ships the elevation of the water before is not perceptible till they have attained a velocity of 4 or 5 feet in a second. This water, which is before the greatest breadth, is driven forward with the ship, and so moves in the same direction; and as it is higher before the greatest breadth than abaft, it flows down a declivity, so as to acquire a velocity in a direction contrary to that of the ship: and moreover, the greater the velocity of the ship, the greater is this declivity.

All this may be readily observed when a ship is navigated in a sea but little agitated; but when a vessel sails in a channel where there is not more than three or four times the breadth of the ship between it and the sides of the channel, the effect is much more perceptible, however small may be the velocity.

Hence it follows that the resistance a ship sailing with a given velocity meets with, is increased on account of the water's rising before the greatest breadth, and because the ship has to propel a more elevated body of water before it, than at the commencement of its motion; although this column thus elevated and driven a-head, by acting on the water in the direction of its motion, before the body of the ship gets to the same point, in some degree diminishes the resistance.* *Secondly*, that the resistance is farther increased, because the water is lower behind the greatest breadth, and because this water has, moreover, lost in regard to its pressure against the after part of the ship, a force which depends on the velocity of the ship, and also on that with which the fluid flows along the after part of the ship, in running from the greatest breadth of the ship to the stern post.

We shall now proceed to illustrate the method employed for estimating the resistance of ships, by supposing ACBQ, Fig. 30. to be a body formed of two wedges, joined together at their base CQ, the pressure of the water on which, perpendicular to the surface, is denoted by FG, FG.

Suppose, in the next place, the body to move with the velocity FH, in a direction parallel to the middle line AB, from B to A. Complete the parallelogram of forces FGHI, and draw its diagonal IF. Produce the line IH if necessary, to meet AC or CB in K, and draw KL perpendicular to GI. Then will IL, which forms a part of the first parallelogram of force, represent the resistance which the body receives in the direction BA; and LI, forming a part of the other parallelogram of force, denote the effort of the fluid on the hinder part of the body, and which contributes to help it forward in the direction in which it moves.

Let the form of the entire body be limited to the condition that CM is perpendicular to AB, and that the latter diagonal is bisected by the former. Assume FG $= m$, and FH $= n$; and let the areas of the planes CE, CP, and CN be respectively denoted by A, B, and C.

By similar triangles we have,

$$KH = n \cdot \frac{DC}{AC},$$

$$\text{whence } IK = n \cdot \frac{DC}{AC} + m,$$

and $IL = \frac{DC}{AC}\left(n \cdot \frac{DC}{AC} + m\right)$ which is the measure of the resistance at the point F, produced by the forces FG and FH.

But the number of pressures represented by FG, is to the number represented by FH as the areas A and C. Consequently the effect of the water on the fore part of the body will be

$$A \cdot m \frac{DC}{AC} + C \cdot n \cdot \frac{DC^2}{AC^2}.$$

And, by a similar mode of reasoning, we obtain for the effect of the water on the after part of the body, the function

$$B \cdot m \cdot \frac{DC}{BC} - C \cdot n \cdot \frac{DC^2}{BC^2}.$$

If now we subtract the latter of these expressions from the former, we shall obtain for the resistance of the body, in the direction AB, the function

$$A \cdot m \cdot \frac{DC}{AC} + C \cdot n \cdot \frac{DC^2}{AC^2} - B \cdot m \cdot \frac{DC}{BC} + C \cdot n \cdot \frac{DC^2}{BC^2}.$$

But since A : AC :: B : BC, therefore $\frac{A}{AC} = \frac{B}{BC}$; or by multiplying each side of the equation by m . DC, we shall farther have $A \cdot m \cdot \frac{DC}{AC} = B \cdot m \cdot \frac{DC}{BC}$; and hence the preceding expression for the resistance is reduced to

$$C \cdot n \cdot \frac{DC^2}{AC^2} + C \cdot n \cdot \frac{DC^2}{BC^2}.$$

And from which we deduce, that so long as the velocity is not sufficient to produce an elevation of the water before, and a depression abaft the greatest breadth, so as to increase the fore resistance and diminish the aft, the body will experience the same resistance, whether the sharp or obtuse extremity moves forward; and yet that the resistance will be the least when the two extremities are equal, or when the greatest breadth is in the middle.

But, if we suppose that the water runs ahead of the ship before its greatest breadth, with a velocity represented by v, and that it has acquired a velocity w in a direction opposite to that of the body abaft this greatest breadth, then the velocity forward will be denoted by $n - v$, and the velocity aft, by $n + w$.

Since, moreover, the resistance is in proportion to the squares of the velocities,† the general expression for the resistance will be changed to

$$C \cdot (n - v)^2 \frac{DC^2}{AC^2} + C (n + w)^2 \frac{DC^2}{BC^2},$$

* Clairbois, in alluding to this observation of Chapman, remarks, that "this elevation of the water before the ship forms a kind of prow of water, whose figure is not so well adapted for dividing the fluid as that of the ship: and the ship being preceded by this prow of water, cannot overcome so easily the resistance of the fluid, as if it divided it immediately, which it does very nearly when the velocity is small."

† This hypothesis was afterwards modified by Chapman.

where we suppose C' to be greater than C, inasmuch as the water before the greatest breadth is more elevated than behind it.

Hence it is evident, that whatever relation exists between the elements n, v, and w, the body meets with less resistance when the obtuse end is forward, than when the acute end is so placed; and that the position of the main breadth with respect to the middle point of the body, depends on the quantities $n-v$ and $n+w$, in order that the resistance may be less than if its situation were anywhere else.

It is manifest also, that the greater v and w are with respect to n, the more the greatest breadth should be carried before the middle, in order to render the resistance the least.

No supposition can be imagined in which the elements n and v become identical; because in such a case, the water would flow forward with an equal velocity to the ship, a condition by no means admissible. It is also to be remarked, that v becomes very small with respect to n, when the velocity is small, and may even be supposed to vanish when n becomes very minute. The same thing also takes place with respect to the water abaft the greatest breadth, when the velocity is small, and the body has its maximum breadth very far aft, the water following the body to fill up the void space which it leaves. From this cause a part of the water follows the same direction as the body, the velocity of the body in relation to the water being $n-w$, and which therefore gives to the preceding expression for the resistance, the still more general form of

$$C'(n-v)^2 \frac{DC^2}{AC^2} + C(n+w)^2 \frac{DC^2}{BC^2}.$$

Such is the general expression for the resistance as given by Chapman,—an expression which it is proper to apprise our readers cannot be entirely depended on, inasmuch as he admits in it two suppositions, which have been repeatedly proved by experiment to be false. The first of these suppositions is, that the resistance to a plane surface varies as the square of the sine of the angle, which the surface makes with the line of motion; and secondly, when the angle is given that the resistance varies as the square of the velocity.

This general expression for the resistance is subject to different varieties of value, according to the relative dimensions of AC and BC; and there is moreover involved in its consideration, the position of the greatest breadth, when the resistance itself is a *minimum*, —a principle of great importance in the practice of shipbuilding. Dr. Inman, by reducing the expression for the resistance to a differential equation, has found, when the length is four times the breadth, that the greatest transverse section of a ship ought to be about $\frac{1}{72}$d of the length before the middle; or when the length is to the breadth as 3 to 1, about $\frac{1}{67}$th of the length before the same point.

Chapman deduces the conclusion, that to render the resistance always a minimum, the place of the greatest breadth ought to vary,—a condition obviously impossible.

In order, however, to put our readers in possession of the method employed by Chapman for estimating the resistance on a ship, we shall adopt his co-efficients of resistance, that for the forepart of the vessel being 6, and for the afterpart 7.* The expression for the resistance on the forepart of the vessel will therefore be

$6\,C \times \frac{DC^2}{AC^2}$, and on the after-part $7\,C \times \frac{DC^2}{BC^2}$. These expressions we shall now endeavour to apply.

Let ACDB, Fig. 1, Plate CCCCXCI. be a plane inclined at any angle to the horizon, and let the fluid impinge on it with a force represented by EF, in a horizontal direction from E to F.

From F, let FI be drawn parallel to the horizon, and from E, the line EG perpendicular to the assumed plane. Then will EG represent the measure of the force which acts at right angles to the plane. From G draw GH perpendicular to EF. Then will EH denote the relative action of the *direct force*. From E also, draw EI perpendicular to FI, and join the points G and I; then will the plane EGI be perpendicular to the horizon. Moreover, from G let a perpendicular be drawn to EI, or, which is the same thing, to the horizon, and then will GK represent the relative *vertical force*. Join the points K and H, and which being perpendicular to EF, will represent the relative *lateral force*. Hence the *relative direct*, *vertical*, and *lateral forces*, acting at the point F, are represented in value by the lines EH, GK, and KH.

To apply these principles to the fore-part *a c d* of a ship, Fig. 2, let *a a*, *b b*, *c c*, &c. represent some of its water lines, at equal distances from each other; and AK, BL, MN, &c. vertical sections, also at equal distances from each other. The intersections of these water lines and vertical sections, will form a series of trapeziums, each of which must be divided into triangles, by having its diagonal drawn. Draw, for example, the diagonal AD of the trapezium ABCD; and from D and A the extremities of the same diagonal, draw the lines DF and AE perpendicular to AC and DB; and from E and F, in like manner, let fall the perpendiculars EH and FG to the water lines *a a* and *b b*.

In the next place, in Fig. 3, draw the parallel lines RS and PQ at the same distance from each other, as the vertical sections, and to these lines draw the perpendicular RP. Transfer the distance DF in Fig. 2, from P to T in Fig. 3. Draw TR, and from T draw TU perpendicular to TR, to meet RP produced in U.

If, now, UR be supposed to express the absolute force of the fluid, UP will represent its relative *direct* action; FG, Fig. 2, its *vertical* action, and GD, in the same figure, its *lateral* action, those lines representing the fluid's action on the triangle ACD. Now, as the absolute force is constant, we may adopt for its representative the interval between the sections: and, for this purpose, draw PW at right angles to RT, and WX perpendicular to RP. Then will PX denote the relative *direct* force.

From Fig. 2, transfer the distance FG, which is the vertical force, when the absolute force is denoted by RU, from Z to Y in Fig. 3. And as the force RU has been reduced to RP, so the force, whose measure is ZY, should be reduced in the same ratio. Draw,

* It is proper to apprize our readers that these co-efficients of resistance are deduced from a particular supposition, one of the conditions of which is, that the velocity of the floating body is always the same.

therefore, the line TX; and since YZ : Qβ : : RP : RX :: RU : RP, it follows that Yβ will represent the relative *vertical* force on the triangle ACD.

Again, transfer DG from P to γ in Fig. 3, and draw γR. Then, in the same manner, will δX be the measure of the lateral force on the same triangle; and it will moreover appear, that RP being the measure of the absolute force, Px, βY, and δX will be the measures of the relative *direct*, the relative *vertical*, and the relative *lateral* forces; and we shall obtain the entire effect of these forces by multiplying each of them respectively by the triangular area ACD. In a similar manner may the effect of the fluid be ascertained on the triangle ADB, and on every other triangular area which may be found on the surface of the vessel.

If, therefore, the effect of the resistance on the forepart of the vessel be represented by M, and that on the afterpart by N, it follows that by applying the co-efficients of resistance, the whole resistance will be proportional to 6M + 7N. But as we have taken for the representative of the absolute force, the distance between the sections, and which may be greater in one place than in another, the relative force on one ship cannot be compared with that of another. It hence becomes necessary to find a plane figure, which, being moved in the water with the same velocity as the ship, shall meet with the same resistance. Such surface is called the *plane of resistance.* To determine the value of this plane of resistance, let x represent it, and let m be the absolute force of a particle. Then will mx be the resistance on the forepart of the vessel, and the same quantity mx be also the measure of the negative resistance, or the diminution of the pressure forward, in consequence of the motion. Hence, multiplying by the coefficients of resistance, we shall have $6mx + 7mx = 13mx$, for the measure of the whole resistance on the plane represented by x; that is $13mx = 6M + 7N$, and $x = \frac{6M + 7N}{13m}$. If we suppose M = 18, N = 16, and $m = 5$, we shall have $x = 3.38$, that is, the ship will meet with the same resistance as a plane whose area is 3.38 feet, when moved with the same velocity as the ship.

To apply this investigation to the actual circumstances of a ship, let Fig. 4 be referred to, and which is supposed to represent the vertical plane of the body.

The equally distant sections are represented by π, β, Z, X, u, &c. afore the section ϕ, and by 32, 30, 28, &c. abaft the same plane. The line 1, 1, also, denotes the load water section, and below which are drawn the parallel and equally distant planes, 2, 2; 3, 3; 4, 4, &c. By this construction, the whole surface of the body becomes divided into trapeziums, like B$\pi\beta$E, each of which, by means of one of its diagonals as πE, may again be divided into triangles.

From A, in the same figure, draw AC perpendicular to Bπ; and from π and E, the lines πI and EF, perpendicular to Eβ and Bπ. Again from C, draw CD perpendicular to the water line; and from F and I, the lines FH and IG also perpendicular to the same line; and in this manner proceed for all the triangular spaces.

This being accomplished, draw, as in Fig. 1, Plate CCCCXCII, two parallel lines IK, LM, at the same distance from each other, as the sections, and draw NO at right angles to them. Set off AC, Fig. 4, Plate CCCCXCI, from N to P in Fig. 1, Plate CCCCXCII, and make NQ equal to the distance of the section π from the stem, and draw PQ. But as the interval between the first section π and the stem is less than that between the sections, and as this latter distance is taken for the perpendicular effect on the forces on every space, draw from the point O, the line OR parallel to PQ.

Set off also DC, Fig. 4, from U to W in Fig. 1, Plate CCCCXCII, perpendicular to NR; and from N, draw through the point W, the line NX. Also from N, let fall the perpendicular NS on OR, and from S, the perpendicular ST upon NO. Then it will follow from the preceding investigation, that NT will be the relative *direct* force acting on the surface of the triangle ABπ.

Again, draw RT, and from X, the right line XY perpendicular to LM. Then will XY be the *vertical* force which acts against the same triangle; and in this manner are found the *direct* and *vertical* forces acting on the triangle 25, Fig. 4.

To find the direct and vertical forces which act on the triangle 24, we make ab, Fig. 1, Plate CCCCXCII, perpendicular to LM, and set off the distances EF, Fig. 4, Plate CCCCXCI, from a to c, Fig. 1, Plate CCCCXCII. From a draw also ad perpendicular to bc, and from d, the line de perpendicular to ab. Then will ae be the *direct* force. Draw again ce, and set off the distance FH, Fig. 4, Plate CCCCXCI, from the line bc, Fig. 1, Plate CCCCXCII, to the line LM perpendicular to the latter. Then will fg represent the vertical force acting on the triangle 24, Fig. 4, Plate CCCCXCI.

These various forces, multiplyed by the areas of the respective triangles, will produce the effect of the fluid on each of them.

In the same manner may the forces on the afterpart of the vessel be found, the construction for which is represented in Fig. 2, Plate CCCCXCII.

The distance between the sections is 4.95 feet; and between the water lines 2.25 feet. The computations for the direct forces, are entered in the following Tables:

Direct Resistance to the Vessel before the Middle Section.

Between the 1st and 2d Water-lines.								Between the 2d and 3d Water-lines.							
Triangles. No.	Triangles. Base.	Direct resistance.	This force X by the base.	Triangles. No.	Triangles. Base.	Direct resistance	This force X by the base.	Triangles. No.	Triangles. Base.	Direct resistance.	This force X by the base.	Triangles. No.	Triangles. Base.	Direct resistance.	This force X by the base.
25	2.02	2.11	4.16	26	1.07	1.83	1.95	25	1.07	1.67	1.78	26			
23	4.25	1.53	4.70	24	3.4	1.42	4.82	23	3.4	1.17	3.97	24	2.64	1.02	2.69
21	3.74	1.15	4.30	22	3.37	1.12	3.77	21	3.37	0.93	3.13	22	2.72	0.89	2.42
19	2.83	0.75	2.12	20	2.79	0.72	2.00	19	2.79	0.63	1.75	20	2.47	0.57	1.40
17	2.12	0.53	1.12	18	2.39	0.53	1.26	17	2.39	0.51	1.21	18	2.47	0.49	1.21
15	1.62	0.36	0.58	16	1.9	0.38	0.72	15	1.9	0.36	0.68	16	2.12	0.37	0.78
13	1.07	0.21	0.22	14	1.39	0.25	0.34	13	1.39	0.23	0.32	14	1.73	0.26	0.44
11	0.72	0.10	0.07	12	1.06	0.15	0.16	11	1.06	0.19	0.20	12	1.34	0.19	0.25
9	0.53	0.07	0.03	10	0.72	0.11	0.07	9	0.72	0.10	0.07	10	1.0	0.14	0.14
7	0.33	0.03	0.01	8	0.48	0.06	0.02	7	0.48	0.05	0.02	8	0.67	0.08	0.05
5	0.25	0.02	0.00	6	0.31	0.03	0.01	5	0.31	0.03	0.01	6	0.47	0.04	0.01
3	0.14	0.01	0.00	4	0.20	0.02	0.00	3	0.20	0.02	0.00	4	0.30	0.02	0.00
1	0.10	0.00	0.00	2	0.15	0.01	0.00	1	0.15	0.01	0.00	2	0.22	0.01	0.00
			17.31				15.12				13.14				9.39
X by ½ height of trian.			1.125				1.125				1.125				1.125
Effects			19.47				17.01				14.78				10.56

Direct Resistance to the Vessel before the Middle Section.

Between the 3d and 4th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
23	2.61	0.86	2.27	24	1.73	0.57	0.98
21	2.72	0.74	2.01	22	2.07	0.65	1.34
19	2.47	0.50	1.23	20	1.92	0.44	0.84
17	2.47	0.45	1.11	18	2.12	0.40	0.84
15	2.12	0.37	0.78	16	2.01	0.33	0.66
13	1.73	0.28	0.48	14	1.81	0.27	0.49
11	1.34	0.19	0.25	12	1.61	0.19	0.30
9	1.02	0.14	0.14	10	1.29	0.14	0.18
7	0.67	0.08	0.05	8	0.96	0.10	0.09
5	0.47	0.04	0.01	6	0.72	0.07	0.05
3	0.30	0.03	0.01	4	0.46	0.04	0.01
1	0.22	0.02	0.00	2	0.34	0.03	0.01
			8.34				5.79
× by ½ height of trian.			1.125				1.125
			9.38				6.51

Between the 4th and 5th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
23	1.73	0.61	1.05	24	0.81	0.44	0.35
21	2.07	0.51	1.05	22	1.50	0.40	0.60
19	1.92	0.38	0.72	20	1.46	0.32	0.46
17	2.12	0.37	0.78	18	1.50	0.30	0.45
15	2.01	0.31	0.62	16	1.58	0.23	0.36
13	1.84	0.23	0.42	14	1.58	0.18	0.27
11	1.61	0.19	0.30	12	1.64	0.18	0.29
9	1.29	0.15	0.19	10	1.40	0.13	0.18
7	0.96	0.09	0.08	8	1.13	0.11	0.12
5	0.72	0.06	0.04	6	0.93	0.07	0.06
3	0.46	0.04	0.01	4	0.73	0.01	0.02
1	0.34	0.02	0.00	2	0.55	0.03	0.01
			5.26				3.17
			1.125				1.125
			5.91				3.56

Between the 5th and 6th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
23	0.81	0.35	0.28				
21	1.50	0.34	0.51	22	1.00	0.20	0.20
19	1.46	0.28	0.40	20	0.97	0.17	0.16
17	1.50	0.23	0.34	18	0.90	0.14	0.12
15	1.58	0.18	0.28	16	0.93	0.11	0.10
13	1.58	0.16	0.25	14	0.97	0.09	0.08
11	1.64	0.14	0.22	12	1.10	0.07	0.07
9	1.40	0.11	0.15	10	1.13	0.06	0.06
7	1.13	0.08	0.09	8	1.08	0.05	0.05
5	0.93	0.06	0.05	6	0.90	0.04	0.03
3	0.73	0.04	0.02	4	0.82	0.03	0.02
1	0.55	0.02	0.01	2	0.79	0.02	0.01
			2.69				0.90
× by ½ height of trian.			1.125				1.125
			2.92				1.01

Between the 6th and 7th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
21	1.00	0.17	0.19	22	0.30	0.05	0.01
19	0.97	0.16	0.15	20	0.50	0.07	0.03
17	0.90	0.11	0.09	18	0.40	0.06	0.02
15	0.93	0.08	0.07	16	0.35	0.05	0.01
13	0.97	0.07	0.06	14	0.40	0.04	0.01
11	1.10	0.06	0.06	12	0.40	0.03	0.01
9	1.13	0.05	0.05	10	0.40	0.02	0.01
7	1.08	0.04	0.04	8	0.40	0.02	0.01
5	0.99	0.02	0.02	6	0.39	0.01	0.00
3	0.82	0.02	0.01	4	0.35	0.01	0.00
1	0.79	0.01	0.00	2	0.28	0.06	0.00
			0.71				0.11
			1.125				1.125
			0.83				0.12

Direct Resistance to the Vessel abaft the Middle Section.

Between the 1st and 2d Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	6.22	1.11	7.[illegible]	32	3.13	1.52	4.75
29	3.56	0.58	2.[illegible]	30	3.00	0.85	2.55
27	2.1[illegible]	0.37	0.83	28	2.62	0.42	1.10
25	1.72	0.2[illegible]	0.49	26	2.31	0.31	0.71
23	1.20	0.13	0.[illegible]1	24	1.7[illegible]	0.24	0.41
21	1.0[illegible]	0.19	0.20	22	1.7[illegible]	0.21	[illegible]
19	0.75	[illegible]	0.06	20	1.3[illegible]	0.1[illegible]	0.1[illegible]
17	0.62	0.07	0.04	18	[illegible]	0.11	0.1[illegible]
15	0.51	0.07	0.03	16	0.76	0.09	0.06
13	0.39	[illegible]	0.02	14	0.50	0.06	0.03
11	0.35	0.01	0.01	12	0.30	0.06	0.03
9	[illegible]	[illegible]	0.01	10	0.13	0.01	0.01
7	0.20	[illegible]	0.00	8	[illegible]	0.01	0.01
5	0.17	[illegible]	0.00	6	[illegible]	0.02	0.00
3	0.15	0.01	0.0[illegible]	4	[illegible]	[illegible]	0.00
1	0.11	0.00	0.00	2	0.11	0.01	0.00
			11.[illegible]				10.20
× by ½ height of trian.			1.125				1.125
			12.[illegible]				11.47

Between the 2d and 3d Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	3.04	0.95	2.88	32	1.73	0.61	1.05
29	3.00	0.64	1.92	30	2.01	0.60	1.20
27	2.6	0.45	1.17	28	2.[illegible]5	0.5[illegible]	1.02
25	2.31	0.35	0.57	26	2.07	0.35	0.72
23	1.72	0.25	0.43	24	2.02	0.28	0.56
21	1.47	0.21	[illegible]	22	1.65	0.22	0.36
19	1.12	0.15	0.16	20	1.61	0.27	0.33
17	0.91	0.13	0.11	18	1.21	0.15	0.18
15	0.76	0.11	0.08	16	1.00	0.12	0.12
13	0.56	0.07	0.03	14	0.81	0.10	0.08
11	0.50	0.05	0.02	12	0.68	0.07	0.04
9	[illegible]	[illegible]	0.01	10	0.56	0.05	0.02
7	[illegible]	[illegible]	0.01	8	0.15	0.01	0.01
5	[illegible]	[illegible]	0.00	6	[illegible]	[illegible]	0.01
3	[illegible]	0.01	0.00	4	0.23	0.02	0.00
1	0.11	0.00	0.00	2	0.16	0.01	0.00
			7.69				5.68
			1.125				1.125
			8.65				6.39

Direct Resistance to the Vessel abaft the Middle Section.

Between the 3d and 4th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	1.73	0.48	0.83	32	1.07	0.29	0.31
29	2.01	0.48	0.96	30	1.35	0.29	0.39
27	2.05	0.4[illegible]	0.82	28	1.4[illegible]	0.29	0.4[illegible]
25	2.07	0.31	0.64	26	1.49	0.27	0.41
23	2.02	0.26	0.52	24	1.69	0.26	0.43
21	1.65	0.21	0.34	22	1.61	0.21	0.33
19	1.61	0.20	0.32	20	1.70	0.19	0.32
17	1.21	0.12	0.14	18	1.5	0.16	0.24
15	1.00	0.11	0.11	16	1.34	0.14	0.18
13	0.81	0.08	0.06	14	0.98	0.09	0.08
11	0.68	0.07	0.04	12	0.88	0.08	0.07
9	0.56	0.04	0.02	10	0.74	0.06	0.04
7	0.45	0.03	0.01	8	0.63	0.05	0.03
5	0.31	0.02	0.0[illegible]	6	0.39	0.03	0.01
3	0.2	0.01	0.00	4	0.51	0.02	0.00
1	0.16	0.00	0.00	2	0.19	0.01	0.00
			4.81				3.24
× by ½ height of trian.			1.125				1.125
			5.41				3.64

Between the 4th and 5th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	1.67	0.27	0.28	32	0.70	0.16	0.11
29	1.35	0.28	0.[illegible]7	30	0.88	0.16	0.14
27	1.4	0.26	0.36	28	0.95	0.16	0.14
25	1.49	0.25	0.37	26	1.00	0.16	0.16
23	1.69	0.24	0.40	24	1.11	0.16	0.17
21	1.6[illegible]	0.19	0.30	22	1.23	0.16	0.19
19	1.70	0.18	0.30	20	1.24	0.15	0.18
17	1.5	0.1[illegible]	0.19	18	1.30	0.14	0.18
15	1.34	0.12	0.16	16	1.37	0.13	0.17
13	0.98	0.10	0.09	14	1.17	0.12	0.14
11	0.88	0.09	0.07	12	1.13	0.09	0.10
9	0.71	0.06	0.04	10	0.91	0.07	0.06
7	0.63	0.05	0.03	8	0.76	0.05	0.03
5	0.39	0.04	0.01	6	0.62	0.03	0.01
3	0.51	0.02	0.00	4	0.40	0.02	0.00
1	0.19	0.01	0.00	2	0.26	0.01	0.00
			2.97				1.78
			1.125				1.125
			3.34				2.00

Between the 5th and 6th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	0.7	0.15	0.10	32	0.41	0.08	0.03
29	0.88	0.15	0.13	30	0.56	0.08	0.04
27	0.95	0.15	0.13	28	0.61	0.08	0.04
25	1.00	0.15	0.15	26	0.62	0.08	0.04
23	1.11	0.15	0.16	24	0.64	0.08	0.05
21	1.23	0.15	0.18	22	0.75	0.08	0.06
19	1.24	0.14	0.17	20	0.78	0.08	0.06
17	1.30	0.13	0.16	18	0.83	0.08	0.06
15	1.37	0.12	0.16	16	0.83	0.05	0.04
13	1.17	0.10	0.11	14	0.88	0.05	0.04
11	1.13	0.07	0.07	12	0.95	0.05	0.04
9	0.91	0.05	0.04	10	0.76	0.04	0.03
7	0.76	0.04	0.03	8	0.76	0.04	0.03
5	0.62	0.03	0.01	6	0.76	0.03	0.02
3	0.4	0.02	0.00	4	0.54	0.02	0.01
1	0.26	0.01	0.00	2	0.38	0.01	0.00
			1.60				0.59
× by ½ height of trian.			1.125				1.125
			1.80				0.66

Between the 6th and 7th Water-lines.

Triangles. No.	Base.	Direct resistance.	This force × by the base.	Triangles. No.	Base.	Direct resistance.	This force × by the base.
31	0.41	0.07	0.02	32	0.22	0.05	0.01
29	0.56	0.07	0.03	30	0.29	0.04	0.01
27	0.61	0.07	0.04	28	0.32	0.04	0.01
25	0.62	0.07	0.04	26	0.31	0.03	0.01
23	0.64	0.07	0.04	24	0.31	0.03	0.01
21	0.75	0.07	0.05	22	0.31	0.02	0.00
19	0.78	0.07	0.05	20	0.31	0.02	0.00
17	0.83	0.06	0.04	18	0.31	0.02	0.00
15	0.83	0.05	0.04	16	0.31	0.01	0.00
13	0.88	0.04	0.03	14	0.31	0.01	0.00
11	0.95	0.04	0.03	12	0.28	0.01	0.00
9	0.76	0.03	0.02	10	0.26	0.01	0.00
7	0.76	0.03	0.02	8	0.25	0.00	0.00
5	0.76	0.02	0.01	6	0.24	0.00	0.00
3	0.54	0.02	0.01	4	0.23	0.00	0.00
1	0.38	0.01	0.00	2	0.21	0.00	0.00
			0.47				0.05
			1.125				1.125
			0.53				0.06

Recapitulation of the direct Resistances between the Lines of Flotation.

For the part afore ∅.		For the part abaft ∅.	
Between the 1st and 2d water-lines - - - - - - =	36.48	Between the 1st and 2d water-lines - - - - - - =	23.91
2d and 3d =	25.34	2d and 3d =	15.04
3d and 4th =	15.89	3d and 4th =	9.05
4th and 5th =	9.47	4th and 5th =	5.34
5th and 6th =	3.93	5th and 6th =	2.46
6th and 7th =	0.95	6th and 7th =	0.59
Against the Stem =	13.16	Against the Rudder =	20.00
Whole resistance afore ∅ =	105.22	Whole resistance abaft ∅ =	76.39

The formula representing the value of the plane of resistance, was before found to be $\frac{6M + 7N}{13m}$. And in the example before us, the value of $M = 105.22$; of $N = 76.39$, and of $m = 4.95$. Hence the numerical value of the half area of the plane of resistance.

$$= \frac{6 \times 105.22 + 7 \times 76.39}{13 \times 4.95} = 18.12.$$

Consequently, the vessel whose resistance we have endeavoured to estimate, will experience a resistance equivalent to that of a plane whose surface is 36.24 square feet; or, in other words, of a square whose linear edge is 6 feet, the velocity of the plane being the same as that of the vessel.

Such, however, are the difficulties attendant on this subject, that Dr. Inman, in a note to his *Translation* of Chapman's *Treatise on Shipbuilding*, observes that it is difficult to draw from the theory of resistances, "any particular conclusions applicable to shipbuilding," but that, "generally, the resistance to ships moving with the *same velocity*, seems to depend on the following circumstances:

First, on the area of the midship section, as causing a greater or less displacement of fluid by the motion of the ship.

Secondly, on the form of the fore body, as causing more or less additional resistance from the motion of the ship, considering only the inertia of the particles displaced;—that is, supposing the void space left astern in consequence of the displacement to be instantly filled by the fluid.

Thirdly, on the form of the after body, as causing a greater or less diminution of pressure forward, on account of the motion of the ship alone.

Fourthly, on the shape of the whole body, as affording a more or less easy and rapid transit of the displaced fluid to the stern; that is, to the void space, which otherwise would be left behind for an instant.

Fifthly, on the form of the whole body, with respect to direction and the quantity of superficies, as causing more or less friction, and more or less adhesion of the fluid."

In the construction of a ship, the displacement, Dr. Inman continues, is supposed to be a given quantity. The area of the midship section may be varied to a certain extent, and still the same displacement retained. The less this is, the less will be the resistance, since the quantity of fluid displaced in a given time will thereby be diminished; and this section will be the least possible (supposing the length given,) when the fore and after bodies are full, and every transverse section equal. But such a form, on many accounts, and even from the consideration of the resistance alone, could not be adopted. The impact of the fore body against the fluid would be too direct, the motion of the after body from the fluid would also be too direct, and the fluid displaced could not flow easily to the after parts of the ship.

Supposing the length of the ship to be undetermined, in that case, by increasing the length, the midship section might be diminished without limit. The body might at the same time be properly formed for cleaving the fluid, and also transmitting it to the stern. But then (without entering into any other consideration except the resistance,) the friction would be so far increased by the extension of the body, as to retard the ship more than if it were shorter, and the midship section greater. It appears, therefore, that the midship section cannot be too far diminished either by filling the fore and after bodies, or by extending the whole or either of these bodies without an increase of the resistance.

If the proper area of the midship section be supposed to be determined, it becomes a question in a general view, how the fore and after bodies must be formed so that the ship may meet with the least resistance.

The fore body, Dr. Inman continues, must be formed not only so as to cleave the fluid with the greatest facility, but also so as to disperse it to the right and left, and thereby facilitate its transit to the stern; at the same time it must diminish the resistance in one point of view, to form the after body, so that the two streams, which may be conceived to flow on the sides of the ship, may at the stern take as much as possible the same direction, namely, the one opposite to the direction in which the ship is moving. With these two views, therefore, the half of the ship before the middle must be filled a little more than the after part. Now this may be done two ways; either by carrying the greater transverse section before the middle, or by filling the whole fore body of the ship, and keeping the greatest section in the middle. But the superiority of the former method appears from the consideration, that by this means the proper effect is produced on the fore body, whilst at the same time a finer run may be given to the after body. Whence is seen the propriety of placing the greatest transverse section of a ship before the middle.

Upon the whole, therefore, in constructing a ship from a given displacement for fast sailing, we must give a proper area to the midship section, and also carry that section something before the middle. Care must be taken to shape the fore and after bodies,—the former, so that the fluid may be separated with facility, and at the same time the displaced fluid dispersed, and transmitted towards the centre; and the latter, so that the fluid displaced may flow with as great facility as possible to the stern. At the same time, the after body must not be elongated so as to increase the friction.

These general remarks have been made without any reference to the amount of the acting power, that is, the quantity of sail, which, however, it is very important to attend to in a construction. Supposing a ship to be formed with a given displacement, so as with a certain motive power (not producing inclination,) to sail the fastest, still it does not follow that its form is the best for moving through the water by means of sails, the power of which is exerted in inclining the ship, as well as in forcing it ahead. If this form were modified a little, so that a greater quantity of sail could be carried, without inclining the ship too far upon a wind, the increase of which sail would more than counterbalance the addition thereby caused in the resistance, the ship would be improved by this alteration in its quality of sailing. This consideration, therefore, must be added to those already adverted to, in constructing a ship for fast sailing.

We have anticipated in some measure a few observations, that would more properly have fallen under the head of Construction; but we were anxious to furnish our readers with the remarks of the distinguished Professor of the College of Naval Architecture, on Chapman's views relative to the resistance of fluids, in order to place every step of so difficult and mysterious a subject, in a candid and explicit point of view.

It may not be amiss, however, to allude more particularly to the experiments with which Mr. Chapman says his formula of resistance $C' \times \frac{DC^2}{AC^2}\left(n - v\right)^2 + C \times \frac{DC^2}{BC^2}\left(n + w\right)^2$ is found to agree.

In a large and deep pond, says he, were placed a hundred feet from each other, two poles A, B, and two piles C, D, Fig. 5, Plate CCCCXCI. to which were fitted two copper pullies, and through these were reeved ropes to support the weights, as represented in the figure. The lines E and G were attached to the body employed in the experiment. On the line E, a weight was placed, to give motion to the body in the water; and on the other line G, there was also a weight, but less than the first, to keep the body in the straight line from which it would have deviated without it. To the line E were tied two small pieces of red cloth I, K, at the distance of 74 feet from each other. To measure the time, a stop watch showing seconds was used. When the mark arrived at L, the stop watch was let go, and when the mark I was come to the same point, the watch was stopped. It then showed the number of seconds which the body F took up to pass over the space of 74 feet. The bodies with which the experiments were performed, were of wood, and 28 inches in length. The transverse sections under the water were circular. Their diameters at the greatest breadth were $\frac{2}{7}$ of the length, or 8 inches, and the water lines either straight or conic parabolas, and the vertex of the parabolic curve was at the greatest breadth. As the bodies were lighter than water, lead was run in, until their specific gravity was nearly equal to that of sea water, so that they only just floated, having their axes parallel to the surface of the water. The weight attached to the line E, to put the body in motion, was varied according as it was required to increase or diminish the velocity; but the retarding weight was always the same. The bodies employed were the following:

Fig. 6, Plate CCCCXCI. having its greatest breadth at the middle, and its extremities formed by parabolic lines.

Fig. 7, ——— having its greatest breadth at $\frac{2}{7}$ of its length from the point B. The extremities also were parabolas.

Fig. 8, ——— having its greatest breadth at $\frac{1}{7}$ of the length from the point D, the extremities still parabolic.

Fig. 9, ——— having its greatest breadth at the middle. The extremity F parabolic, and the other G conic.

Fig. 10, ——— having its greatest breadth at $\frac{2}{7}$ of the length from the point H. The extremity H parabolic, the other conic.

Fig. 11, ——— having its greatest breadth at $\frac{2}{7}$ of the length from the point O. The extremities conical.

Fig. 12, ——— wholly conic, having its greatest breadth equal to that of the other bodies, and its length twice and a half the breadth.

The results of the experiments performed with these bodies, are recorded in the following table:

		Fig. 6.	Fig. 7.		Fig. 8.		Fig. 9.		Fig. 10.		Fig. 11.		Fig. 12.	
Weight of the bodies.		27 lb.	27 lb.		27 lb.		22 lb.		$19\frac{3}{4}$ lb.		$16\frac{3}{4}$ lb.		12 lb.	
Moving weights.	Retarding weights.	Time of the bodies describing the space of 74 feet in seconds.												
		Seconds.	Seconds.		Seconds.		Seconds.		Seconds.		Seconds.		Seconds.	
		A	B	C	D	E	F	G	H	I	O	P	R	P
$\frac{3}{4}$ the weight of the body.	$\frac{1}{2}$ the weight of the body.	$25\frac{1}{2}$	$26\frac{1}{4}$	$24\frac{3}{4}$	$27\frac{3}{4}$	$26\frac{1}{2}$	$25\frac{1}{4}$	$25\frac{1}{2}$	$27\frac{1}{4}$	$24\frac{1}{4}$	30	$29\frac{3}{4}$	45	$29\frac{1}{2}$
The weight of the body.	$\frac{1}{2}$ the weight of the body.	14	14	$14\frac{1}{2}$	$14\frac{1}{2}$	$16\frac{1}{2}$	$13\frac{3}{4}$	$13\frac{3}{4}$	15	16	$24\frac{1}{2}$	$24\frac{1}{4}$	38	24
$\frac{3}{2}$ the weight of the body.	$\frac{1}{2}$ the weight of the body.	11	$10\frac{1}{2}$	$11\frac{1}{2}$	$10\frac{1}{2}$	$13\frac{1}{2}$	11	11	$10\frac{1}{4}$	$11\frac{1}{2}$	$12\frac{1}{2}$	$17\frac{1}{2}$	$30\frac{3}{4}$	$19\frac{1}{4}$
37 lb. in all	$12\frac{1}{3}$ lb. in all.	$12\frac{1}{2}$	lost.		11	14	$10\frac{3}{4}$	11	10	$11\frac{1}{4}$	12	16		

To understand the nature of these experiments, let the example of Fig. 7 be selected, in which the *moving* weight was equal to that of the entire body; and the *retarding* weight, half the same quantity. It may then be remarked, that with the extremity B forward, the body will pass over 74 feet in 14 seconds; but with the sharper end C in a similar situation, the body will pass over the same in $14\frac{1}{2}$ seconds. In like manner, with the body represented in Fig. 10, and the same conditions of the moving and retarding weights, when the parabolic extremity of the body was moved forward, the time of describing 74 feet was 15 seconds; but with the conical extremity under the same circumstances, the same space was described in 16 seconds.

Each of the experiments recorded in the table, Chapman informs us, was repeated six times, with considerable uniformity. The velocities, he remarks, do not present the proportionality we might be led to expect from a consideration of the weights,—a circumstance, however, which he attributes to a division of the fluid too near the surface. The number of pullies over which the line passed, rendered the experiments less exact, on account of friction. The friction, however, being the same for all the experiments, the variation in the velocity ought to be the same.

The inferences Mr. Chapman draws from his experiments are the following: First, *That when the motion is slow, the body has a greater velocity when the sharper end is forward, than the full.* Secondly, *That when the velocity is increased to a certain degree, the body passes over the same space in equal times with either extremity forward.* Thirdly, *That when the velocity becomes still greater, the body takes a less time to pass over the same distance when its obtuse end is forward. Thus, says he, it is the velocity of the body which should determine the place of the greatest breadth, to render the resistance* *the least*—a conclusion, however, we would add, that implies the inadmissible supposition of a variable position of the greatest breadth.

In the present state of our information respecting the important question of the resistance of fluids, we must receive almost every principle deduced from it, with the greatest circumspection and caution. We regret, as we have before remarked, our inability to furnish any satisfactory information on the subject; but we should only have misled our readers had we not honestly confessed the state of our knowledge on this great question. We might have enlarged very much, it is true, this part of our article, by some elaborate theoretical investigations, and perhaps have shown their coincidence with *certain particular experiments.* But no real and solid information would have been gained from trains of analytical investigation, which, at the moment of their *practical* application to naval architecture, seem almost, as Mr. Harvey expresses it, "to lose their identity," leaving nothing behind but the regret, that so much labour and earnest zeal should have produced so little that is useful to man, for the purposes of shipbuilding.

We regret, however, that our limits will only merely allow us to allude to the experiments performed at the Greenland dock, in the years 1793, 1794, 1795, 1796, 1797, and 1798, by a Society instituted expressly for the noble and patriotic purpose of improving naval architecture. These experiments amounted to nearly 10,000 in number, and were published under the auspices of the Society in a thin quarto volume, now become very rare. The labour must have been immense; and we gladly record our warm admiration of the industry and zeal that animated the members of this most useful Society. In the introduction to this article, we alluded to the advantages that would result from the establishment of a Society expressly devoted to the cultivation of naval architecture, both in theory and practice. We yet hope to see this accomplished; and we are sure that whenever that great object may be accomplished, its founders will not overlook the labours of the ingenious members of the Society above alluded to.

ON THE SAILS OF SHIPS.

The principal object in the formation of a ship, is its motion through the water, and the action of the wind on the sails is the great source from which that motion is derived. The degree in which this action is exerted, is dependent in a great measure on the size of the sails, and therefore the right determination of their forms and dimensions, is a subject of much importance to naval architecture.

To obtain as great a degree of velocity as possible, the dimensions of sails are sometimes carried beyond those limits which the safety and stability of a vessel sanction; but there must be some proportions and sizes for sails, which shall ensure to every class of ships, the *maximum* conditions of the very important elements of stability and velocity. This, however, is one of the many important elements yet to be determined by the future cultivators of naval architecture.

Let us in the first place attend to a few simple considerations connected with this very important subject. Suppose, in the first place, the line AB, Fig. 3, Plate CCCCXCII. to represent the water section of a vessel; and, in it, let DG be assumed as the measure of the fluid's horizontal action against the head of the ship; and since from the assumed theory of resistances it is known, that when a ship is in motion, the action of the water on the after part of the vessel is distinguished by a sign opposite to that which characterizes the fluid's action on the bow; let IE in the same horizontal line be assumed as the measure of its action, and in its proper numerical relation to DG. Let GH, also at right angles to the water section, denote the vertical force of the water upon the head, the direction of which is from G to H; and KI the direction of a similar force acting on the after part, the direction of which is from K to I. Join DH, which will be the resultant of the first pair of forces acting in the direction DH. Join also KE, which will be the resultant of the second pair of forces, and the action of which will be exerted from K to E.

Produce these resultant forces to meet in F, and make FN and FO respectively equal to them; and let these forces, in their new condition, be supposed to change their character from resultant to component forces, and complete the parallelogram FNPO, and draw its diagonal PF, and let it also be produced to Q. From the centre of gravity C of the ship, let fall CL, CM, and CQ perpendicular respectively to DH, EK, and PF. Then by a well-known theorem in mechanics, we have the following equation:

$$FN.\ CL + FO.\ CM = FP.\ CQ;$$

and if, therefore, PF denote the force and direction of wind, and the centre of gravity of the sails be in the line PF, the surface of the sails being perpendicular to the same line, the ship, as a necessary consequence, will be impelled through the water by the action of the wind, without having either of her extremities elevated or depressed.

Now this line PF which represents the direction of the wind's action, is *inclined* to the water's surface; whereas its direct action may be supposed more generally to operate in a *horizontal* direction; and therefore from the points C and N let CW and NS be drawn perpendicular to the horizon, and from the point F, the line FR parallel to the same plane. Through P also, draw TR parallel to NS.

This construction furnishes the similar and equal triangles DGH, FSN, and EIK, NTP; and from which we have DG = FS, and EI = NT or SR. Hence FS + NT = DG + IE = FR, the measure of the entire direct resistances.

The triangles CQW and FRP being similar, we have also the proportion

$$CQ : CW :: FR : FP$$

and from which we obtain

$$CQ \cdot FP = CW \cdot FR$$

Hence the equation derived from the well-known theorem in mechanics before given, becomes

$$FN.\ CL + FO.\ CM = CW.\ FR;$$

so that the horizontal effort of the wind on the sails, being necessarily equal to the horizontal effort of the water on the hull of the vessel, the point W will be the proper height of the centre of gravity of the sails, now that the direction XY of the wind has been assumed parallel to the horizon.

These conditions, if it were possible rigidly to maintain them, would preserve both extremities of the vessel from being either elevated or depressed. But there are circumstances continually operating, to destroy this uniformity of condition; sometimes tending in their consequences to elevate the centre of gravity of the sails above the point W, and at other times to depress it. If the former condition take place, and the centre of gravity of the sails be supposed at α, the effect will be to depress the bow of the vessel; but if, on the contrary, the centre of gravity be situated at β, below the centre of gravity W, before determined, the effect of the wind will be to depress the stern. In order, therefore, that the sails may have no tendency to produce either an elevation or depression of the stem or the stern, the centre of effort of the wind on them, should be situated somewhere in the line XY.

Hence we may perceive of what importance it is to have a right determination of this centre. For if we suppose it situated at either α or β, an increase of sail would not increase the velocity of sailing in proportion to the surface, since one or other of the extremities must, under such circumstances, be depressed, and consequently, the resistance increased.

Mr. Chapman truly observes, that in a ship full at the load water line forward, and lean below, the resultant of the effort of the water rises very much; and therefore, in order for it to sail well, it ought to have high sails. But in a vessel whose forepart is full under the water, the resultant will not rise so considerably; and, consequently, to possess proper qualities of sailing, it ought to have its sails of a less elevation. The after part of a vessel is equally to be considered with its fore part in determining the centre of effort of the sails. The latter condition, however, is too often lost sight of in inquiries of this kind.

Hence also it may be observed, that two ships of the same length, breadth, and tonnage, may possess equal stability, and yet require different heights of tho sails to move equally well with the wind aft.

To determine, says Mr. Chapman, the necessary surface for sails, it would be necessary to enter into many long and laborious calculations, and which, in the end, would produce no result of great practical importance. A better plan is to compare plans of different ships whose properties are known, and to draw from the comparison, such results as will enable us to ascertain the proper and necessary relations of the centre of effort of the wind on the sails, and the stability.

Let, for example, ABC, Fig. 4, be a vessel inclined by the effort of the wind HG, and let AB be the load water line, D the centre of gravity of the ship, E the centre of gravity of the displacement, and G the centre of effort of the wind on the sails. If now, from E, we draw a vertical line EF, the point F will be the metacentre. Moreover, from D, draw DK perpendicular to EF, and let the force of the wind, which acts perpendicularly to the line GD, be represented by U, and that which acts in the vertical line EF, and which is equivalent to the displacement, by D.

Now, as the motion of rotation is performed round the centre of gravity, the moment of the sails to incline the ship will be equivalent to GD . U; and the moment of the ship at the same time, to resist the inclination DK . D. But since, whatever be the magnitude of the interval between the metacentre and the centre of gravity of the vessel, it preserves a constant relation to KD at equal inclinations, the moment of the ship to resist inclination may always be expressed by FD . D, and which moment ought to bear a certain relation to the moment of the sails DG . U, in order that the degree of inclination may be the same.

The wind acting, moreover, in the direction HG, the ship will be impelled from B towards A, the resistance of the water acting in the line IL, which therefore passes either above or below the centre D. If this line passes above the centre of gravity D, the stability will be increased, and if below it, the stability will be diminished.

Very great labour is necessary, in order to calculate for any ship, the line in which the resistance of the water operates on the side; and Mr. Chapman remarks, that it is sufficient to know that the mean direction of this resistance rises less is ships, the hulls of which are very lean towards their extremities and keels, than in those ships which possess a fulness throughout. The effect on the stability, Mr. Chapman observes, cannot be considerable, if we suppose this mean direction to pass through the centre of gravity of the ship; and hence the moment of the sails relatively to this last mentioned point, should always bear a certain relation to the whole weight of the ship, multiplied by the distance of its centre of gravity D from its metacentre F; that is to say, the moment of the sails in all the ships is equivalent to m . D . DF, in which the co-efficient m must be determined by experiment.

Mr. Chapman remarks, that by calculating the moment of the sails for several ships, he has found the value of $m = \frac{35.5}{x^{\frac{1}{3}}}$, where x denotes the length of the ship from the stem to the stern post; and hence the preceding formula for the moment of the sails is $\frac{35.5}{x^{\frac{1}{3}}}$. DF . D.*

But the most remarkable anomalies are presented by merchant ships in this particular department of naval architecture; anomalies which owe their origin to the different specific gravities of their cargoes; and producing different elevations or depressions of the centre of gravity, with the same constant draught of water. And hence also it follows, that ships in different voyages, having cargoes of different specific gravities, must present different varieties of values for their moments of stability, and consequently equally varied results in the efforts of their sails.

To determine the position of the centre of gravity of the sails, both as regards its elevation above the plane of the load water section, and its position with respect to the length of the vessel, recourse must be had to the method of moments, before applied in determining the centre of gravity of the ship. This method we illustrated by the general formula

$$\frac{p\,x + p'\,x' + p''\,x'' + \&c. - (x\,\pi + \pi'\,x' + \pi''\,x'' + \&c.)}{p + p' + p'' + \&c. + \pi + \pi' + \pi'' + \&c.};$$

and in applying it to the determination of the altitude of the centre of gravity above the load water section, it is manifest that the elements denoted by the consecutive values of π and x will vanish, because all the moments are situated on the *same* side of the plane to which their effects are to be referred; but in applying it to the determination of the position of the same point with respect to the length of the vessel, one term $\pi\,x$ will preserve its negative character, in consequence of the centre of gravity of the spanker sail being situated abaft the assumed vertical line $x\,y$, Plate CCCCXCIII. which passes through the section (1),

* Dr. Inman has remarked that F is not truly the position of the metacentre when the inclination of the vessel is finite, and that the expression of the moment of the sails, given in the text, should be used with caution, especially in determining the proper quantity of sails for ships whose forms differ much from those adopted by Chapman as the basis of his investigation.

Plate CCCCLXXXVIII. Fig. 1. The formula, in the first case, will therefore be reduced to the form of

$$\frac{p\,x + p'\,x' + p''\,x'' + \&c.}{p + p' + p'' + \&c.}$$

and, in the latter, to

$$\frac{p\,x + p'\,x' + p''\,x'' + \&c. - \pi\,x}{p + p' + p'' + \&c. + \pi}.$$

To apply these formulæ to the purpose intended, recourse must be again had to Plate CCCCXCIII. which represents a draught of the masts, sails, &c. in their proper proportions. The first process of calculation is to determine the area of each sail by the ordinary rules of mensuration, and the position of the centre of gravity of each sail, by such graphical rules as the familiar writers on mechanics teach; and then estimating the distance of each centre from the planes to which their effects are intended to be referred. Thus, the area of the main-top-sail ABCD, and the position of its centre of gravity E, are found by applying the methods referred to, to the dotted lines contained in it; and then determining, first the distance EG of this centre from the load water line, and afterwards the distance of the same point EF from the assumed vertical plane $x\,y$. The results of the calculations of the areas of the several sails are recorded in the second column of the following table; the distances of their centres of gravity from the plane of the load water section in the third column, and the distances of the same points from the assumed vertical plane $x\,y$, are moreover entered in the fourth column. The multiplication of these areas by the proper distances of their centres from the assumed planes, will give the moments recorded in the fifth and last columns.

Hence the value of the last formula but one, will become, under the present conditions,

$$\frac{p\,x + p'\,x' + p''\,x'' + \&c.}{p + p' + p'' + \&c.} = \frac{1960570.49}{24511.83} = 79.98 \text{ feet},$$

which is the elevation (+)P of the common centre of gravity of all the sails, above the plane of the load water section.

And for a similar reason, the other formula produces

$$\frac{p\,x + p'\,x' + p''\,x'' + \&c. - \pi\,x}{p + p' + p'' + \&c. + \pi} =$$

$$\frac{2215546.163 - 20669.79}{24511.83} = 89.54 \text{ feet},$$

which is the distance (+) Q of the centre of gravity of the sails, before the assumed section $x\,y$.

Table of Results of the Centre of Gravity of the Sails.

Names of the sails.	Areas of the sails in square feet.	Distances of the centres of gravity of the sails above the plane of the load section.	Distances of the centres of gravity of the sails before the assumed section (1.	Moments of the sails estimated from the plane of the load water section.	Moments of the sails estimated from the assumed section (1.)
Jib - - - - -	1548.00	70.9	+198.0	109753.20	+306504.00
Foretop-mast stay-sail -	1044.75	58.6	+184.1	61222.35	+192338.47
Fore course - - - -	3109 80	48.6	+142.2	151136.28	+442213.56
Foretop sail - - - -	3228.30	94.4	+142.7	304751.52	+460678.41
Foretop-gallant sail - -	1024.10	136.2	+143.1	139482.42	+146548.71
Main course - - - -	4140.70	47.3	+ 64.2	195855.11	+265832.94
Maintop sail - - - -	4286.74	100.0	+ 63.2	428674.00	+270921.97
Maintop-gallant sail - -	1420.65	145.5	+ 62.4	206704 57	+ 88648.56
Spanker - - - - -	2026.45	51.3	— 10.2	103956.88	— 20669 79*
Mizentop sail - - -	1977.14	87.5	+ 16.0	172999.75	+ 31634.24
Mizentop-gallant sail - -	705.20	122.0	+ 14 5	86034.40	+ 10225.30
Total area of the surface of the sails	24511.83			1960570.49	2194876.37

Such is the method by which the position of the centre of gravity of the sails is determined.

In order, however, to determine whether the quantum of sail thus assumed, be that which the circumstances of the vessel require, a condition of equality must exist, between the aggregate of the moments thus determined, and the numerical product arising from the multiplication of the whole weight of the ship, by the distance of its centre of gravity from the metacentre.

If such an equality should not exist, the draught must be altered, until the desired relation be obtained; but here a wide latitude is open to the constructer, to correct the error that may exist. If, for example, the sails, according to their first disposition, should all bear a proper relation to each other, as far as *magnitude* is concerned, the alteration that the anomaly to be corrected may require, should affect them *all proportionally*. If, on the contrary, a partial alteration in the canvass will produce the correction desired, such an alteration should be applied, as will correct the defect. It is manifest, also, that any alteration in the surfaces of the sails will not only affect their areas, but also sensibly influence the positions of their centres of gravity, and thereby the general moment of the sails. Sometimes we fear alterations are made in sails, without a due attention to this important particular. But it should ever be remembered, that any new arrangement in the parts of a system, will in all cases affect the position of the centre of gravity of that system, and sometimes produce important effects on the general system with which those parts may be connected.

Suppose again it should be found that the elevation of the centre of gravity of the sails, above the plane of the load water line, is either too great or too small, but that its position with respect to the vertical section is correct, considerable judgment will be necessary, in any alteration of the sails, to preserve the centre in the same vertical line, and to give to it the elevation desired. On the other hand, the altitude of the same centre above the plane of the load water section, may be just that which a sound experience sanctions, but, that from some circumstances connected with the sailing quality of the

* This moment is distinguiseed by a negative sign, as already remarked, because the sail whose effect it is designed to indicate, is not on the *same* side of the assumed section (1), as the other sails.

vessel, it is desirable to remove it nearer towards the stern, or to cause it to advance towards the bow; in such a case equal judgment will be necessary in effecting any change. Sometimes, no doubt, in correcting errors of this kind, the attempt to remove one bad quality, is followed by the introduction of another; but in this, as in all human pursuits, the point to be obtained, is that which shall give the aggregate of the errors, of the least possible degree. Frequently, we believe, that canvass is added to sails, and their surfaces diminished with few considerations respecting their centres of gravity, or the laws of their momentum. Blind experience, unaided by the light of science, has too often been the guide of the mariner.

Chapman has given an admirable example to illustrate whether the common centre of gravity of the sails is well placed in regard to the mean direction of the resistance of the water, in a case wherein that centre is placed 67.22 feet above the load water line, and nearly $\frac{1}{10}$th of the length of the stem to the sternpost before the centre of gravity of the ship, but to which we can do no more than refer the reader, to Dr. Inman's translation of that important work.

The subject of the sails of ships is yet in its infancy, and well merits the attention of the man of science. Is it not remarkable, it may be asked, how few of our British mathematicians have directed their attention to matters connected with naval pursuits? The great problem of the longitude, and many other branches of nautical astronomy, have undoubtedly been wonderfully improved by their exertions; but the subject of shipbuilding has never in any considerable degree engaged their attention. The great end and object of science, is to turn its chief course towards objects of public utility; and now that we see the paths of discovery opening before us, in this most noble and interesting pursuit; "we must follow boldly wherever they lead us; confident that, sooner or later, theoretical knowledge must eventually contribute to the benefit of society, with regard to the more practical purposes of life."

ON THE DIMENSIONS AND DIFFERENT FORMS OF SHIPS.

One of the first and most important considerations which a naval constructer has to attend to, is the relation which the co-ordinate dimensions of a ship bear to each other;—how the length should be related to the breadth, and how both these elements are connected with the depth. *Duhamel*, in his *Architecture Navale*, has made it the subject of a particular examination, but we shall prefer following *Chapman* in his important remarks on this subject.

This able writer enters on the investigation, by supposing two bodies of different forms, one being that of a rhomboid, of which the uppermost surface is taken for the load water line, as Fig. 5, Plate CCCCXCII. and the other that of a body formed by the junction of two wedges ABGE, CGED, as Fig. 6, and whose upper surface, the rectangle ABCD, is, in like manner, taken for the load water section.

Suppose these bodies to be impelled through the water by a quantity of sail proportional to their stability; and let their half lengths moreover be represented by L, their half baeadths by B, and their draught of water by D. The moment of stability for the first of these bodies will be $\frac{B^3 \times L}{4}$, and the plane of resistance $\frac{B^3 \times D}{L^2 + B^2}$. A body of such a figure, however, could not acquire a great velocity by means of sails, and would sail badly close to the wind.

The moment of stability of the second body will be $B^3 L$, and the plane of resistance $\frac{D^3 B}{L^2 + D^2}$. And since the moment of stability increases in a triplicate ratio of the breadth, whilst the plane of resistance increases only in the simple proportion of the same dimension, this form is the best adapted for sailing close to the wind. This body also being impelled through the water, the square of its velocity will be in the direct ratio of the area of the sails, and in the inverse ratio of the plane of resistance. But the moment of stability is as that of the sails; and the moment of the sails, as the area of the sails multiplied by the height of a certain point, and which altitude is also proportional to the height of the sails; consequently, the area of the sails is, as the moment of stability, raised to the power of $\frac{2}{3}$, that is to say, as $(B^3 L)^{\frac{2}{3}}$. The area of the sails, therefore, divided by the plane of resistance $= \frac{(B^3 L)^{\frac{2}{3}}}{B \times D^3} (L^2 + D^2) = B \left(\frac{L^{\frac{8}{3}}}{D^3} + \frac{L^{\frac{2}{3}}}{D}\right)$; and hence the velocity will be as $B^{\frac{1}{2}} \left(\frac{L^{\frac{4}{3}}}{D^{\frac{3}{2}}} + \frac{L^{\frac{1}{3}}}{D^{\frac{1}{2}}}\right)$. But since $L^{\frac{1}{3}}$ is very small when compared with $L^{\frac{4}{3}}$, we may neglect the last term of the expression, and regard the velocity as proportional to $\frac{B^{\frac{1}{2}} \times L^{\frac{4}{3}}}{D^{\frac{3}{2}}}$*

From this expression for the velocity, Chapman draws some useful practical inferences. In the first place, that when the area of the load water surface is given, a ship to sail well by the wind should have great length according to its breadth, and the draught of water the smallest possible. If, however, the area of the load water section be not given, but only the length of the vessel, it will be necessary to give very great breadth, because the velocity increases as the square root of that dimension. But if the breadth be given, the length should be considerable, because this dimension is raised to the $\frac{4}{3}$rd power, when the draught of water is given. If, on the other hand, from a certain determined length or breadth, we have the choice of augmenting one of these dimensions, it is most advantageous, if the object be to increase the velocity, to augment the length rather than the breadth. And from all these considerations, Chapman infers that there cannot be any constant proportion assigned between the length, the breadth, and the draught of water.

* Let F = force of the wind on the sails, S = surface of the sails, A = area of the plane of resistance, R = resistance, and V = velocity. Then $R \propto AV^2$; but $R = F$, and $F \propto S$. Consequently $S \propto AV^2$, and $V^2 \propto \frac{S}{A}$.

Let H also be the height of the point of the sail, then the area of the sails, $\times H \propto$ stability; or since $H \propto S^{\frac{1}{2}}$; therefore $S \times S \propto^{\frac{1}{2}}$ stability. Consequently $S \propto (\text{stability})^{\frac{2}{3}}$.

From these circumstances also we may derive some information why a small ship, built on what is technically called the model of a large ship, known to possess very desirable qualities, should be found to have no properties analogous to the vessel from which she was deduced. This will be apparent, by attending for a moment to the elements of the expression for the velocity, all of which by the supposition are variable, but as they are constituted in the formula, vary by different laws. Suppose velocity to be the standard of comparison, and that its value in some determinate case be denoted by 10; that is,

$$\text{suppose } \frac{B^{\frac{1}{2}} \times L^{\frac{4}{3}}}{D^{\frac{3}{2}}} = 10;$$

the question is, what ought to be the other dimensions of a vessel, whose length is previously fixed at l, to possess an equal degree of velocity with that which is given? To this interesting and important question, no satisfactory answer, we fear, can be afforded in the present state of our knowledge. There is no doubt *some* relation existing between these primary dimensions in ships of different classes; so that having the length, the breadth, and draught of water of a ship of one class given, with a certain numerical velocity, the same velocity might be obtained, with dimensions suited to a ship of another class. Such a relation, and even we fear the feeblest beginnings towards it, can hardly be made the subject of calculation; but it is, however, a condition, to the attainment of which all our efforts will, we hope, continually tend. Had Euler, for example, been as well acquainted with the Philosophy of Naval Architecture, as with those beautiful systems of analysis, which it was ever the object of his sublime and original genius to create and improve, some approximations towards these relations would, no doubt, have been attained. Let us hope that the future cultivators of Naval Architecture will unceasingly endeavour to attain these things.*

The qualities of similar ships varies, Mr. Chapman imagines, in a different proportion from what a consideration of their size would give.

To illustrate this, he remarks that if the breadth of a vessel be regarded as variable, the burthen of the ship will vary as the cube of that dimension, and the velocity of sailing as the cube root of the same. The number of the crew also, which is proportional to the area of the sails $B^2 L^{\frac{2}{3}}$, will vary as $B^{\frac{8}{3}}$. Hence, by supposing two ships, whose capacities for burthen are in the ratio of eight to one, and their relative velocities as ten to eight; if the larger vessel sail with a crew of twenty-four men, the smaller will require four. According to the capacities of the two ships, the latter ought to be navigable by three men. Hence also we perceive, that in making small ships similar to large ones, the former will possess the worst sailing qualities, and will require a more numerous crew in proportion to their capacities than large ones.

Mr. Chapman also remarks it is possible to render a small ship navigable by a crew proportionate to its capacity; but that it cannot be done without diminishing the quantity of canvass, and then the sailing qualities of the vessel will be impaired. This fault may be remedied to a certain degree, by giving it less breadth; but this would be attended with inconvenience. Hence we prefer in small ships the property of sailing well, to having it in our power to diminish the crew.

The velocity also being in proportion to the quantity $\frac{B^{\frac{1}{2}} L^{\frac{4}{3}}}{D^{\frac{3}{2}}}$, increases as the depth decreases, supposing at the same time the length and breadth to increase. This object may be attained more easily by adding to the length, but for the greater safety of the navigation it is more convenient to increase the breadth. This will elevate the metacentre. The sails also may, in such a case, have an increased surface; but the ship would require a more numerous crew.

Great and small ships moreover cannot, with the same form, sail with the same security; nor can we avoid the inconvenience of being obliged to have a more numerous crew in small ships than in large. Small ships, therefore, cannot have the same advantages as large ones, when they are employed in the same trade.

As small ships lose in the quality of sailing, by being assimilated in form to large ones, so large vessels will improve this valuable property by being moulded similar to small ones. Mr. Chapman hence concludes, that it is proper to give to large ships forms similar to small ones, because they would thereby gain in the quality of sailing. But for merchant ships, where it is so much the more necessary to give great capacities in the water, as they are larger, they seldom want a superior quality of sailing, provided they are sufficiently stiff upon a wind not to be embayed on a lee shore. Added to this, in such a case, these ships would lose the advantage of sailing with a small crew, and as they cost more in construction in proportion than small ones, it is necessary in their formation to endeavour to combine qualities most advantageous to the interests of their owners.

In the following table is recorded the values of certain essential elements in shipbuilding, derived from one primitive element, the burthen, and which, owing its origin to Chapman, and deduced by him from a long course of experience, will be considered as very valuable.

* It was the object of Euler, in the valuable treatise he has bequeathed to us, to consider, from particular principles, certain conditions connected with the construction and properties of vessels. Had that great man been supplied with data to have entered on the *comparative properties* of vessels in general, what might we not have expected from his fertile and original mind? At the present moment this appears to us the great object to be attended to. Materials drawn from *comparative observation* should be collected, and every effort made by drawing together *comparative experimental results*, to prepare the way for some "master spirit," who, without doubt, will at some future time appear, to do that for naval architecture, which has been done for so many other branches of physical science.

Elements of different Ships.

Species of ship.	Burthen in lasts reduced into cubic feet, reckoning 91 cubic feet for each last.	Displacement in cubic feet to the outside of the timbers.	Length from the perpendicular at the stem to that at the stern post.	Greatest breadth to the outside of the timbers.	Distances of the load water line from the upper edge of the rabbet of the keel, at the frame ϕ.	Area of the midship section.	Depth of the keel measured from the upper edge of the rabbet.	Difference or draught of water.	Area of the load water line.	Quantity by which the centre of gravity of displacement is below the load water line.	$\frac{2}{3}\int\frac{y^3dx}{D}$.	Fraction of the distance between the centre of gravity of displacement and the load water line, when the centre of gravity of the ship and lading is below the water.	Distance of the metacentre from the centre of gravity of the ship and lading.	Moment of stability.
	P	D	x	z	h	ϕ	k	d	W	V	S		L	M
Frigates.	$D^{\frac{17}{18}}$	$P^{\frac{18}{17}}$	$(56D)^{\frac{1}{3}}$	$\frac{x^{\frac{4}{5}}}{1.383}$	$\frac{x}{8.1}$	$\frac{1.705D}{x^{1+\frac{1}{14}}}$	$\frac{x^{\frac{2}{5}}}{4.64}$	$\frac{x^{\frac{3}{4}}}{23.3}$	$=\frac{x^{1+\frac{1}{36}}}{1.49}$	$\frac{x^{\frac{7}{6}}}{48}$	$\frac{x^{\frac{1}{2}}}{1.289}$	$\frac{1}{4}$	$\frac{49.65x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}$	$\frac{x^3}{56}\left(\frac{49.65x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}\right)$
Heck Boats or Pinks.	$D^{\frac{19}{20}}$	$P^{\frac{20}{19}}$	$(54D)^{\frac{1}{3}}$	$\frac{x^{\frac{4}{5}}}{1.429}$	$\frac{x^{1-\frac{1}{60}}}{7.547}$	$\frac{1.729D}{x^{1+\frac{1}{27}}}$	$\frac{x^{\frac{3}{7}}}{5.66}$	$\frac{x^{\frac{2}{3}}}{17.5}$	$=\frac{x^{1+\frac{1}{24}}}{1.5}$	$\frac{x^{\frac{139}{120}}}{45.54}$	$\frac{x^{\frac{21}{40}}}{1.651}$	$\frac{2}{7}$	$\frac{38.8x^{\frac{21}{40}}-x^{\frac{139}{120}}}{64}$	$\frac{x^3}{54}\left(\frac{38.8x^{\frac{21}{40}}-x^{\frac{139}{120}}}{65}\right)$
Cats or Barks.	$D^{\frac{21}{22}}$	$P^{\frac{22}{21}}$	$(52D)^{\frac{1}{3}}$	$\frac{x^{\frac{4}{5}}}{1.476}$	$\frac{x^{1-\frac{1}{30}}}{7.032}$	$\frac{1.76D}{x^{1+\frac{1}{20}}}$	$\frac{x^{\frac{1}{2}}}{8.4}$	$\frac{x^{\frac{2}{3}}}{18.8}$	$=\frac{x^{1+\frac{1}{20}}}{1.5}$	$\frac{x^{\frac{23}{20}}}{43.2}$	$\frac{x^{\frac{11}{20}}}{2.147}$	$\frac{1}{3}$	$\frac{30x^{\frac{11}{20}}-x^{\frac{23}{20}}}{64}$	$\frac{x^3}{52}\left(\frac{30x^{\frac{11}{20}}-x^{\frac{23}{20}}}{64}\right)$
Flat bottomed vessels, or vessels with a small draught of water.	$1.07D^{\frac{21}{22}}$	$\frac{P^{\frac{22}{21}}}{1.07}$	$(63D)^{\frac{1}{3}}$	$\frac{x^{\frac{4}{5}}}{1.6}$	$\frac{x^{1-\frac{1}{10}}}{6.436}$	$\frac{2.1D}{x^{1+\frac{1}{10}}}$	$\frac{x^{\frac{1}{2}}}{9.8}$	$\frac{x^{\frac{2}{3}}}{24}$	$=\frac{x^{1+\frac{1}{30}}}{1.4}$	$\frac{x}{26}$	$\frac{x^{\frac{1}{2}}}{1.341}$	$\frac{1}{8}$	$\frac{24.23x^{\frac{1}{2}}-x}{32.5}$	$\frac{x^3}{63}\left(\frac{24.23x^{\frac{1}{2}}-x}{32.5}\right)$

It is worthy of observation in reference to this table, how particularly the element x which represents the length from the perpendicular at the stem to that at the stern post, is connected with most of the other elements, and how readily the whole may be derived, by a logarithmic process, from the element P representing the burthen. For the purpose of assisting the young naval engineer in computing the various elements, we shall take the case of a frigate in which the value of P is equivalent to 45,500 cubic feet. From this, or any other assumed value, we may deduce step by step, by a very easy logarithmic operation, all the other elements of the table.

Value of the burthen P assumed $=$ 45,500 cubic feet.

Hence, to obtain the displacement D, we have, by applying logarithms to the function $P^{\frac{18}{17}}$ which represents it, $l\,P^{\frac{18}{17}}=\frac{18}{17}\,l\,4.6580114=l\,4.9320121$. Therefore, by passing from logarithms to numbers, we obtain the displacement $D=P^{\frac{18}{17}}=85509$.

To obtain the value of x, we have the expression $(56\,D)^{\frac{1}{3}}$, which, by logarithms, presents

$$l\,(56\,D)^{\frac{1}{3}}=\tfrac{1}{3}\,l\,(56\,D)=\tfrac{1}{3}\,(l\,56+l\,D)$$

$=l\,2.2267334$; and by passing from logarithms to numbers, we have $x=(56\,D)^{\frac{1}{3}}=168.55$.

To find the value of z, we have the function $\frac{x^{\frac{4}{5}}}{1.383}$, which, by logarithms, gives

$$l\frac{x^{\frac{4}{5}}}{1.383}=l\,x^{\frac{4}{5}}-l\,1.383=\tfrac{4}{5}\,l\,x-l\,1.383$$

$=l\,1.6405645$; and by passing from logarithms to numbers, we have $z=\frac{x^{\frac{4}{5}}}{1.383}=43.708$.

To obtain the value of h, we have the function $\frac{x}{8.1}$, which gives, by the application of logarithms,

$$l\,x-l\,8.1=l\,1.3182484;\text{ and hence}$$

$$h=\frac{x}{8.1}=20.809.$$

For the value of ϕ, we have the expression $\frac{1.705\,D}{x^{\frac{41}{40}}}$, and which presents the logarithmic form

$$l\frac{1.705\,D}{x^{\frac{41}{40}}}=l\,1.705\,D-l\,x^{\frac{41}{40}}$$

$$=l\,1.705+l\,D-\tfrac{41}{40}\,l\,x=l\,2.8813348.$$

Hence we have $\phi=\frac{1.705\,D}{x^{\frac{41}{40}}}=7.6091$.

For the value of k, we have the expression $\frac{x^{\frac{2}{5}}}{4.64}$.

Hence, by logarithms, we have $l\frac{x^{\frac{2}{5}}}{4.64}$

$$=l\,x^{\frac{2}{5}}-l\,4.64=\tfrac{2}{5}\,l\,x-l\,4.64=l\,0.2241754.$$

$$\text{Hence } k=\frac{x^{\frac{2}{5}}}{4.64}=1.6756.$$

To find d, the table furnishes the function $\frac{x^{\frac{3}{4}}}{23.3}$ which, by logarithms, gives

$$l\frac{x^{\frac{3}{4}}}{23.3}=l\,x^{\frac{3}{4}}-l\,23.3=\tfrac{3}{4}\,l\,x-l\,23.3=l\,0.3026943.$$

$$\text{Hence } d=\frac{x^{\frac{3}{4}}}{23.3}=2.0077.$$

To obtain W, we have the logarithmic expression

$$l\frac{z\,x^{\frac{31}{30}}}{1.49}=l\,z\,x^{\frac{31}{30}}-l\,1.49=$$
$$l\,z+l\,x^{\frac{31}{30}}-l\,1.49=l\,z+\tfrac{31}{30}\,l\,x-l\,1.49$$
$$=l\,3.7683360.$$

$$\text{Hence W}=\frac{z\,x^{\frac{31}{30}}}{1.49}=5865.9$$

For the value of V, we take the function $\frac{x^{\frac{7}{6}}}{48}$, and which, by logarithms, becomes

$$l\frac{x^{\frac{7}{6}}}{48}=l\,x^{\frac{7}{6}}-l\,48=\tfrac{7}{6}\,l\,x-l\,48=l\,0.9166144.$$

$$\text{Hence V}=\frac{x^{\frac{7}{6}}}{48}=8.253.$$

For S, we have the expression $\frac{x^{\frac{1}{2}}}{1.289}$. Hence $l\frac{x^{\frac{1}{2}}}{1.289}$

$$=l\,x^{\frac{1}{2}}-l\,1.289=\tfrac{1}{2}\,l\,x-l\,1.289=l\,1.0031138.$$

$$\text{Consequently S}=\frac{x^{\frac{1}{2}}}{1.289}=10.072.$$

We have now to find the value of L by means of the formula $\frac{49.65\,x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}$, which may be changed into $\frac{49.65\,x^{\frac{1}{2}}}{64}-\frac{x^{\frac{7}{6}}}{64}$.

Applying logarithms to the first of these quantities, we have

$$l\frac{49.65\,x^{\frac{1}{2}}}{64}=l\,49.65+l\,x^{\frac{1}{2}}-l\,64=l\,49.65+\tfrac{1}{2}\,l\,x-$$
$$l\,64=l\,1.0031060.$$

$$\text{Hence }\frac{49.65\,x^{\frac{1}{2}}}{64}=10.072.$$

Applying logarithms to the second quantity, we have

$$l\frac{x^{\frac{7}{6}}}{64}=l\,x^{\frac{7}{6}}-l\,64=\tfrac{7}{6}\,l\,x-l\,64=l\,0.7916756.$$

$$\text{Hence }\frac{x^{\frac{7}{6}}}{64}=6.1898.\quad\text{Consequently}$$

$$\text{L}=\frac{49.65\,x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}=10.072-6.1898=3.8822.$$

Finally, for the value of M we have the function

$$\frac{x^3}{56}\left(\frac{49.65\,x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}\right)=\frac{49.65\,x^{\frac{7}{2}}-x^{\frac{25}{6}}}{3584}$$
$$=\frac{49.65\,x^{\frac{7}{2}}}{3584}-\frac{x^{\frac{25}{6}}}{3584}.$$

Applying logarithms to the former of these quantities, we have

$$l\frac{4965\,x^{\frac{7}{2}}}{3584}=l\,49.65\,x^{\frac{7}{2}}-l\,3584=l\,49.65+l\,x^{\frac{7}{2}}-$$
$$l\,3584=l\,49.65+\tfrac{7}{2}\,l\,x-l\,3584=l\,5.9351182.$$

$$\text{Hence }\frac{49.65\,x^{\frac{7}{2}}}{3584}=861230$$

By a similar application to the latter quantity, we have

$$l\frac{x^{\frac{25}{6}}}{3584}=l\,x^{\frac{25}{6}}-l\,3584=\tfrac{25}{6}\,l\,x-l\,3584=$$
$$l\,5.7236878.$$

$$\text{Hence }\frac{x^{\frac{25}{6}}}{3584}=529280.\quad\text{Consequently}$$

$$\text{M}=\frac{x^3}{56}\left(\frac{49.65\,x^{\frac{1}{2}}-x^{\frac{7}{6}}}{64}\right)=861230-529280=331950.$$

Thus it appears that the vessel presented for examination, ought to have a displacement of 85509 cubic feet to the outside of the timbers; a length of 168.55 feet from the stem to the sternpost; a breadth of 43.708 feet to the outside of the timbers; a distance of 20.809 feet from the load water line to the upper edge of the rabbet of the keel; a superficial area of 760.91 feet for the midship section; a depth of keel from the upper edge of the rabbet 1.6756 feet; a difference of draught of water forward and aft of 2.0077 feet; a superficial area of 5865.9 feet for the load water section; a distance of 8.253 feet for the interval of the centre of gravity below the load water line; a distance of 10.072 feet for the interval between the centre of gravity and the metacentre; a distance also of 3.8822 feet between the metacentre and the common centre of gravity of the ship and lading; and finally, a moment of stability represented by 331950 feet.

In the first and second of the following tables, similar results of many ships of the same class, together with many others, are recorded.

Chapman has furnished us also with some valuable formulæ relating to the construction of privateers, and in which he has deduced all their necessary elements, from the weight of the guns, and the distance of the centre of gravity of the guns from the load water line.

In these formulæ he assumes A, C, and *c* as the elements alluded to; B the weight of the part above the water, comprising the masts, yards, sails, rigging, &c.; *a* the distance of the common centre of gravity of these weights from the load water line; D the displacement of the vessel to the outside of the timbers; *z* the breadth of the ship measured from the same parts; *y* the half breadth; *x* the length from the fore part of the stem to the after part of the stern post; *d* the depth of the ship, taken at the main section ϕ, from the load water line to the rabbet of the keel; and *k* the number of months for provisions.

Then Chapman asserts that the number of the crew may be represented by . . . . $3.763\,\text{A}^{\frac{5}{9}}$;

The weight of the crew by . . . . $10.16\,\text{A}^{\frac{5}{9}}$;

And their mechanical effect by . . . . $15\,\text{A}^{\frac{5}{9}}$;

The provisions also for *k* months, and water for half the time, wood, &c. by . . . $18\,k\,\text{A}^{\frac{5}{9}}$.

The formula for the time he finds to be $k = \frac{A^{\frac{2}{7}}}{2.756}$ and from which he derives the equation . . . $18\,k\,A^{\frac{5}{9}} = 6.534\,A^{\frac{53}{63}}$.
He has also found that the displacement is well proportioned, when $15\,A^{\frac{5}{9}} + 6.534\,A^{\frac{53}{63}} + A = K$, the displacement D being equivalent to $6.14\,c^{\frac{1}{4}}\,K^{\frac{13}{15}}$.
$B = \frac{D^{\frac{21}{20}}}{6.281}$ and the distance $a = \frac{D^{\frac{1}{3}}}{3.48}$.

In the next place, he assumes $C + 10.16\,A^{\frac{5}{9}} = Q$, and supposes the centre of gravity of displacement to be below the load water line by the quantity m, whose value he afterwards determines. Then the moment of stability, supposing the inclination very small, will be $\frac{2}{3}\int y^3\,d\,x - (m + a)\,B - (m + c)\,Q$.* But since $\frac{2}{3}\int y^3\,d\,x = (m + 6)\,D$, he finds that $(m + 6)\,D - (m + a)\,B - (m + c)\,Q = 6\,D$; and from which he derives $m = \frac{a\,B + c\,Q}{D - (B + Q)}$.

The same distinguished engineer also found the value of the stability to be $(m + 6)\,D$ or $\frac{2}{3}\int y^3 d\,x = \frac{z^3\,x^{\frac{21}{20}}}{26}$ and $z = \frac{x^{\frac{9}{10}}}{2.36}$. Hence also he derives $(m + 6)\,D = \frac{x^{\frac{15}{4}}}{341.8}$; and thence $x = \left(341.8\ (m + 6)\,D\right)^{\frac{4}{15}}$.

The area of the load water section he also finds should be $\frac{z\,x^{\frac{24}{23}}}{1.621}$; and the area of the main section $\phi = \frac{2.366\,D}{x^{\frac{13}{12}}}$. The value of d, moreover, he finds to be $\frac{x}{10.5}$. The centre of gravity of the ballast he supposes to be below the plane of the load water section, by a quantity equivalent to $\frac{x^{\frac{7}{5}}}{95}$; and the weight of the ballast he represents by

$$95\left(\frac{1.11 \times \left((m + a)\,B + (m + c)\,Q\right) - m\,D}{x^{\frac{7}{5}} - 95\,m}\right).$$

The moment of the sails with relation to the centre of gravity of the ship, or the plane of the load water line, he designates by the function $\frac{35.56 \times 6\,D}{x^{\frac{1}{3}}}$.

Such are the formulæ which this very celebrated man has, with infinite labour and research, deduced for the class of ships in question; but as a numerical example, at all times throws light on a subject presented in an algebraical dress, we shall select the instance he has given to illustrate their application.

For this purpose he assumes the following values, viz.

$$A = 2588,\quad C = 1815,\quad \text{and } c = 7.47;$$

which are adapted to a privateer of twenty-four twelve pounders on the main deck, eight four-pounders on the quarter deck and forecastle, with the lowest sill of the middle gun port, six feet above the water.

The logarithmic computations necessary for the application of the different formulæ, are exhibited in the following process.

To find the value of K, or that of $15\,A^{\frac{5}{9}} + 6.534\,A^{\frac{53}{63}} + A$, we have the separate expressions $l\,15 + \frac{5}{9}\,l\,A$, $l\,6.534 + \frac{53}{63}\,l\,A$, and A.

Hence l 15	=		1.1760913
$\frac{5}{9}\,l\,A$	=		1.8960913
and $15\,A^{\frac{5}{9}}$	=	1180.8	3.0721826
Also l 6.534	=		0.8151791
$\frac{53}{63}\,l\,A$	=		2.8712239
and $6.534\,A^{\frac{53}{63}}$	=	4857.4	3.6864030

Consequently $15\,A^{\frac{5}{9}} + 6.534\,A^{\frac{53}{63}} + A = 1180.8 + 4857.4 + 2588 = 8626.2$.

To find the value of D, we obtain by the application of logarithms to the proper expression $l\,6.84 + l\,c^{\frac{1}{4}} + l\,K^{\frac{13}{15}} = l\,6.84 + \frac{1}{4}\,l\,c + \frac{13}{15}\,l\,K$.

Or l 6.84	=		0.8350561
$\frac{1}{4}\,l\,c$	=		0.2183301
$\frac{13}{15}\,l\,K$	=		3.4110436
Hence D	=	29136	4.4644298

To find B, we have the expression $\frac{D^{\frac{21}{20}}}{6.281}$, which by logarithms presents the form of

$$l\,\frac{D^{\frac{21}{20}}}{6.281} = l\,D^{\frac{21}{20}} - l\,6.281 = \tfrac{21}{20}\,l\,D - l\,6.281.$$

Hence we have

$\frac{21}{20}\,l\,D$	=		4.6876512
l 6.281	=		0.7980288
and B	=	7755.7	3.8896224

To discover a, we have the expression $\frac{D^{\frac{1}{3}}}{3.48}$ and which by logarithms presents the form of

$$l\,\frac{D^{\frac{1}{3}}}{3.48} = l\,D^{\frac{1}{3}} - l\,3.48 = \tfrac{1}{3}\,l\,D - l\,3.48.$$

Hence $\frac{1}{3}\,l\,D$	=		1.4881433
l 3.48	=		0.5415792
and a	=	8.8423	0.9465641

* This expression is in some degree open to objection when the inclination becomes finite, it being then necessary to take into account the alteration made in the sides of the ship between wind and water.

To find Q, we have the expression $10.16\,A^{\frac{5}{9}} + C$, the application of logarithms to the first part of which presents,

$l\ 10.16$	$=$	1.0068937
$\frac{5}{9}\ l\ A$	$=$	1.8960913
Hence $10.16\,A^{\frac{5}{9}} = 799.81$		2.9029850

Consequently $Q = 10.16\,A^{\frac{5}{9}} + C = 799.81 + 1815 = 2614.81$.

To develope the value of m, the function $\dfrac{a\,B + c\,Q}{D - (B + Q)}$ presents for the application of logarithms the following:

$l\ a$	$=$	0.9465641
$l\ B$	$=$	3.8896224
Hence $a\,B = 68578$		4.8361865
And $l\ c$	$=$	0.8733206
$l\ Q$	$=$	3.4174385
whence $c\,Q = 19533$		4.2907591

And therefore $a\,B + c\,Q = 68578 + 19533 = 88111$.

$$\text{Hence } m = \frac{a\,B + c\,Q}{D - (B + Q)} = \frac{88111}{18765.49} = 4.695.$$

To obtain the value of x, we have the function $(341.8\,(m + 6)\,D)^{\frac{4}{15}}$, which adapted to logarithms, becomes $\frac{4}{15}\,(l\ 341.8 + l\,(m + 6) + l\ D)$.

Hence we have

$l\ 341.8$	$=$	2.5337721
$l\,(m + 6)$	$=$	1.0291808
$l\ D$	$=$	4.4644298
		8.0273827
		4
		15)32.1095308
		$2.1406354 = 138.24 = x$.

The expression for the ballast may be computed as follows:

$l\,(m + a)$	$=$	1.1315224
$l\ B$	$=$	3.8896224
Hence we have $(m + a)\,B = 104989$		5.0211448
$l\,(m + c)$	$=$	1.0141121
$l\ Q$	$=$	3.4174385
And also $(m + c)\,Q = 31736$		4.5015506

Consequently $(m + a)\,B + (m + c)\,Q = 136725$

Moreover $l\ 1.11$	$=$	0.0453230
And $l\,\{(m + a)\,B + l\,(m + c)\,Q = \}$		5.1358479

Hence we have $1.11\,((m + a)\,B + (m + c)\,Q) = 151764$ . . 5.1811709

Again, $l\ m$	$=$	0.6716356
$l\ D$	$=$	4.4644298
Therefore $m\,D = 136793$		5.1360654

And $1.11\,((m + a)\,B + (m + c)\,Q) - m\,D = 14971$.

Also $l\ 95$	$=$	1.9777236
And $l\,\{1.11\,((m + a)\,B + (m + c)\,Q) - m\,D\} = 14971$	$=$	4.1752508
Whence $95\,\{1.11\,((m + a)\,B + (m + c)\,Q) - m\,D\} = 1422245$		6.1529744

Moreover, for the denominator, we have

$\frac{7}{5}\ l\ x$	$=$	2.9968896
Whence $x^{\frac{7}{5}} = 992.86$		
And $l\ 95$	$=$	1.9777236
$l\ m$	$=$	0.6716356
Which gives $95\,m = 446.02$		2.6493592

Therefore $x^{\frac{7}{5}} - 95\,m = 546.84$

$$\text{Consequently } 95\left\{\frac{1.11\,((m+a)\,B + (m+c)\,Q) - m\,D}{x^{\frac{7}{5}} - 95\,m}\right\} = \frac{1422245}{546.84} = 2600.8 \text{ the ballast.}$$

To obtain the value of the stability, we have

$$\tfrac{2}{3}\int y^3\,dx = (m + 6)\,D.$$

Hence $l\,(m + 6)$	$=$	1.0291808
And $l\ D$	$=$	4.4644298
Wherefore $\frac{2}{3}\int y^3\,dx = (m + 6)\,D = 311611$		5.4936106

For the value of z, we have the function,

$$\frac{x^{\frac{9}{10}}}{2.36}, \text{ whence } l\,\frac{x^{\frac{9}{10}}}{2.36} = \tfrac{9}{10}\,l\,x - l\,2.36.$$

Wherefore $\frac{9}{10}\,l\,x$	$=$	1.9265719
$l\ 2.36$	$=$	0.3729120
Whence $z = 35.784$		1.5536599

To obtain the area of the load water-line, we have

$$l\,\frac{z\,x^{\frac{24}{23}}}{1.626} = l\,z + l\,x^{\frac{24}{23}} - l\,1.626$$
$$= l\,z + \tfrac{24}{23}\,l\,x - l\,1.626.$$

Wherefore $l\,z$	$=$	1.5536599
$\frac{24}{23}\,l\,x$	$=$	2.2337065
		3.7873664
$l\,1.626$	$=$	0.2111205
Whence $\dfrac{z\,x^{\frac{24}{23}}}{1.626} = 3769.2$		3.5762459

To find the area of the main section ϕ, we have the logarithmic expression $l\,2.366 + l\,D - \frac{13}{12} l x$.

Wherefore $l\,2.366$	=	0.3740147
$l\,D$	=	4.4644298
		4.8384445
$\frac{13}{12}\, l x$	=	2.3190217
Whence $\frac{2.366\,D}{x^{\frac{13}{12}}} = 330.69$		2.5194228

To determine d, we have $lx - l\,10.5$.

$l x$	=	2.1406354
$l\,10.5$	=	1.0211893
Whence $\frac{x}{10.5} = 13.166$		1.1194461

For the number of the crew, we have the expression $3.763\,A^{\frac{5}{9}}$, which, by logarithms, becomes

$$l\,3.763 + \tfrac{5}{9}\, l\,A;$$

Wherefore $l\,3.763$	=	0.5755342
$\frac{5}{9}\, l\,A$	=	1.8960913
Whence the number of the crew = 296		2.4716255

For the provisions we have $\frac{A^{\frac{2}{7}}}{2.756}$, whence, by logarithms we have $l\frac{A^{\frac{2}{7}}}{2.756} = \frac{2}{7}\, l\,A - l\,2.756$.

Wherefore $\frac{2}{7}\, l\,A$	=	0.9751327
$l\,2.756$	=	0.4402792
And the provisions	= 3.4265	0.5348535

The distance of the centre of gravity of the ballast below the load water line is represented by $\frac{x^{\frac{7}{5}}}{95}$, whence we have the logarithmic expression,

$$\tfrac{7}{5} l x - l\,95$$

$\frac{7}{5} l x$	=	2.9968896
$- l\,95$	=	1.9777236
Whence $\frac{x^{\frac{7}{5}}}{95} = 10.451$		1.0191660

The difference of the draught of water fore and aft $= \frac{x^{\frac{5}{8}}}{14.46}$, which, by logarithms, becomes

$$\tfrac{5}{8} l x - l\,14.46.$$

Wherefore $\frac{5}{8} l x$	=	1.3378971
$l\,14.46$	=	1.1601683
And $\frac{x^{\frac{5}{8}}}{14.46} = 1.5057$		0.1777288

Finally, for the moment of the sails, we have

$$l\,35.56 + l\,6 + l\,D - \tfrac{1}{3}\, l x.$$

$l\,35.56$	=	1.5509618
$l\,6$	=	0.7781513
$l\,D$	=	4.4644298
		6.7935429
$\frac{1}{3} l x$	=	0.7135451
Whence $\frac{35.56 \times 6\,D}{x^{\frac{1}{3}}} = 1202258$		6.0799978

Hence we have obtained the following elements for the vessel in question, rejecting the superfluous decimals:

The stability - - - - - - - -	311611
The length from the stern to the stern-post - - - - - - - - -	138.24
The breadth to the outside of the timbers - - - - . - - - - -	35.78
Ballast in cubic feet of sea water -	2600.8
Displacement - - - - - - - -	29136
Area of the loadwater line - - -	3769.2
Depth of the frame ϕ from loadwater line to rabbet of the keel - - -	13.17
Area of the frame ϕ - - - - - -	330.69
Number of crew - - - - - - -	296
Months for which provisioned - -	3.43
Quantity by which the centre of gravity of the ballast should be below the loadwater line - - - - - - -	10.45
Difference of draught of water - -	1.51
Moment of sails from the centre of gravity of the ship, or the loadwater line - - - - - - - - - -	1202258

And by the same methods are obtained the proportions of the sixteen ships recorded in the sixth of the following tables:

Proportions of Merchant Ships, calculated by the Rules in the preceding Table. No. 1. Frigates.

No.	Weight in lasts.	Displacement.	Length from stem to stern.	Breadth.	Area of midship section.	Draught of water at ⊕ on the keel.	Draught of water. Aft.	Draught of water. Forward.	Depth of keel.	Area of plane of load water line.	Quantity by which the centre of gravity is before the middle	Quantity by which ⊕ is before the middle of the length from stem to stern.
		cu. ft.	feet.	feet.	sq. ft.	feet.	feet.	feet.	feet.	sq ft	feet.	feet.
1	500	85510	168 6	43.71	760.9	20.81	23.62	21.61	1.66	5853	2.37	12.04
2	480	81890	166.1	43.21	739·5	20.51	23.30	21.31	1.65	5700	2.33	11.86
3	460	78280	163.6	42.69	717.9	20.20	22.97	21·00	1.64	5545	2.30	11.69
4	440	74680	161.1	42.16	694.4	19.89	22.63	20.71	1.63	5388	2.26	11.51
5	420	71090	158.5	41.61	673.8	19.57	22.29	20.37	1.62	5229	2.23	11.32
6	400	67520	155.8	41.04	651.3	19.23	21.92	20.03	1.61	5066	2.18	11.13
7	380	63950	153.0	40.45	628.4	18·89	21.56	19.69	1.60	4900	2.15	10.93
8	360	60390	150.1	39.84	605.2	18.53	21.17	19.33	1 59	4732	2.10	10.72
9	340	56840	147.1	39.20	581.5	18.16	20.77	18.96	1.58	4560	2.07	10.51
10	320	53310	144.0	38.53	557.5	17.78	20.36	18.57	1.56	4384	2.03	10 29
11	300	49790	140.7	37.84	533.0	17.38	19.93	18.17	1.55	4205	1.98	10.05
12	280	46280	137.4	37.11	508.0	16.96	19.47	17.75	1.53	4022	1.93	9.81
13	260	42790	133.8	36.34	482.3	16.52	19.00	17.31	1.52	3833	1.88	9.56
14	240	39310	130.1	35.53	456.2	16.06	18.50	16.86	1.50	3640	1.82	9.29
15	220	35850	126.1	34.66	429.6	15.57	17.98	16.36	1.48	3442	1.77	9.01
16	200	32410	122.0	33.75	401.7	15.06	17.42	15.85	1.46	3234	1.72	8.71
17	180	28990	117.5	32.75	373.3	14.51	16.82	15.29	1.44	3022	1·65	8.39
18	160	25590	112.7	31.68	343.9	13.92	16.18	14.70	1.42	2799	1·58	8.05
19	140	22220	107.5	30.50	315.5	13.28	15.49	14.05	1.39	2568	1·51	7.68
20	120	18870	101.8	29.21	281.4	12.57	14.72	13.35	1.36	2324	1·43	7.27
21	100	15557	95.5	27.75	247.8	11.79	13.87	12.56	1.33	2066	1·34	6.82
22	90	13915	92.0	26.93	230.3	11.36	13.40	12.12	1.31	1929	1·30	6.57
23	80	12283	88.3	26.05	212.1	10.90	12 90	11.66	1.28	1790	1·24	6 31
24	70	10664	84.2	25.08	193.2	10.40	12.34	11.15	1·26	1640	1·17	6.01
25	60	9058	79.7	24.02	173.6	9.85	11.73	10.59	1·23	1484	1·11	5.69
26	50	7468	74.8	22.81	152.8	9.23	11.06	9.97	1·20	1318	1·05	5.34
27	40	5896	69.1	21.42	130.8	8.53	10.29	9.26	1·16	1141	0.97	4.94
28	30	4348	62.4	19.79	107.1	7.71	9.37	8.41	1·12	947	0.88	4.46
29	20	2830	54.1	17.61	80.7	6.68	8.23	7·37	1·06	729	0·70	3.86
30	10	1359	42.4	14.48	49.8	5.23	6.60	5.88	0 96	465	0·60	3.03

(No. 3.) *Proportions of Merchant Ships—Heckboats or Pinks.*

No.	Burthen in large lasts.	Displacement.	Length from stem to stern.	Breadth.	Area of the frame ⊕	Draught of water at ⊕ on the Keel.	Draught of water. Aft.	Draught of water. Forward.	Depth of keel.
		cu. ft.	feet.	feet.	sq. ft.	feet	feet.	feet.	feet.
4	440	69910	155.7	39.71	641.1	18.97	21.46	19.81	1.54
5	420	66600	153.2	39.20	623.8	18.67	21.14	19.60	1.53
6	400	63260	150.6	38.69	603.2	18.36	20.80	19.19	1.51
7	380	59940	147.9	38.10	580.9	18.05	20.46	18.86	1.50
8	360	56620	145.1	37.54	561.0	17.70	20.10	18.52	1.49
9	340	53310	142.3	36.94	539.5	17.35	19.75	18.17	1.48
10	320	50020	139.3	36.32	517·2	17.00	19.35	17.81	1·46
11	300	46740	136.1	35.66	494·7	16.62	18.91	17.43	1 45
12	280	43160	132.9	34.97	471.6	16.25	18.52	17.01	1·44
13	260	40200	129.5	34.26	448.3	15.82	18.08	16.62	1·42
14	210	36950	125.9	33.49	424.3	15.39	17.62	16.19	1·40
15	220	33720	122.1	32.69	399.6	14.93	17.13	15.72	1.38
16	200	30500	118.1	31.82	374.2	14.45	16.61	15.24	1.36
17	180	27300	113.8	30.90	348.0	13.94	16 05	14.71	1.34
18	160	24120	109.2	29.89	320.9	13.38	15.45	14.15	1.32
19	140	20950	101.2	28.79	292.7	12.78	14.80	13.54	1.29
20	120	17810	98.7	27.57	263.2	12.12	14.08	12.86	1.26
21	100	14703	92.6	26·20	232.1	11.38	13.28	12 11	1.23
22	90	13159	89.2	25.44	215.9	10.97	12.84	11·70	1.21
23	80	11625	85.6	24.60	199.1	10.53	12.36	11.25	1.19
24	70	10101	81.7	23.70	181.5	10.03	11.81	10.74	1.17
25	60	8588	77.4	22.69	163.3	9.54	11.28	10.24	1 14
26	50	7088	72.6	21.57	144 0	8·56	10.64	9.64	1.11
27	40	5605	67.1	20.25	123·5	8.29	9.91	8.96	1.07
28	30	4141	60.6	18.68	101·3	7.51	9.05	8.16	1.03
29	20	2702	52.6	16.67	76·6	6.53	7.96	7·15	0.97
30	10	1302	41.3	13.72	47.5	5.14	6.40	5 72	0.87

Proportions of Merchant Ships, &c. Sequel of the preceding Table. (No. 2.)

No.	Quantity by which the centre of gravity of displacement is below the water.	Distance of the metacentre from centre of gravity of displacement	Distance of the metacentre from centre of gravity of the ship with lading.	Moment of stability.	Height of the main-mast in proportion to stability. Above centre of gravity of the ship.	Below the centre of gravity.	Whole length	Weight of sheet anchor. sk	lp	Number of crew.	Number, which multiplied by displacement, and divided by length from end to end equal area of the frame ⊕.
	feet.	feet.	feet.		feet.	feet.	feet.	sk	lp		
1	8.253	10.072	3.883	332000	94.78	15.28	110.06	16	...	57	1.500
2	8.115	10.000	3·914	320500	93.68	15.06	108.74	15	14	55	
3	7·975	9.925	3·942	308600	92.52	14.85	107.37	15	8	52	
4	7 830	9.847	3·975	296850	91.31	14.62	105.93	15	1	50	
5	7.681	9 767	4·006	284820	90.04	14.36	104.40	14	13	47	
6	7.529	9·684	4·036	272520	88.74	14.15	102.89	14	5	45	1.504
7	7.371	9·596	4·067	260100	87.37	13.90	101.27	13	17	42	
8	7.209	9·505	4 099	247500	85.95	13.64	99.59	13	8	39	
9	7.041	9·409	4 128	234650	84.43	13.37	97.80	12	16	37	
10	6 868	9·309	4.157	221550	82.84	13.10	95.94	12	4	35	
11	6.688	9·204	4.187	208500	81.16	12.82	93.98	11	12	34	
12	6.500	9·092	4 217	195200	79.40	12.52	91.92	11	...	32	1.508
13	6.305	8·975	4.245	181640	77.51	12.19	89.70	10	8	30	
14	6.101	8.848	4·273	167990	75.53	11.87	87.40	9	16	28	
15	5.886	8 713	4·299	154100	73.38	11.51	84.89	9	3	27	
16	5.659	8.568	4·324	140120	71.10	11.14	82.24	8	10	25	
17	5.419	8.410	4 346	125960	68.62	10.74	79.36	7	17	23	
18	5.162	8 237	4.365	111710	65.92	10.31	76.23	7	4	21	1.510
19	4 886	8.045	4.381	97330	62.96	9.85	72.81	6	10	19	
20	4.586	7.830	4·391	82850	59.67	9.34	69.01	5	16	17	
21	4.254	7.582	4·391	68202	55.95	8.77	64.72	5	1	15	
22	4.075	7 425	4.388	61052	53.89	8.45	62.34	4	13	13	
23	3.881	7·289	4.380	53795	51.67	8.12	59.79	4	5	12	
24	3.673	7.119	4·366	46555	49.24	7.75	56.99	3	17	11	1.525
25	3 447	6.928	4·344	39340	46.55	7.35	53.90	3	9	10	
26	3·198	6 709	4·311	32190	43.55	6.90	50.45	3	...	9	
27	2.917	6 450	4·263	25140	40.09	6.38	46.47	2	11	7	
28	2.591	6.130	4·186	18200	36.00	5.79	41.79	2	1	6	
29	2.193	5.707	4·061	11494	30.89	5.03	35.92	1	10	4	
30	1.648	5·050	3 814	5182	23.69	3.95	27 64	—	18	3	1.553

Proportions for Merchant Ships—Heckboats or Pinks. Sequel of the preceding Table. (No. 3.)

No.	Area of the plane of load-water line.	Quantity by which the centre of gravity is before the middle.	Quantity by which ⊕ is before the middle of the length from stem to stern.	Quantity by which the centre of gravity of displacement is below the water.	Distance of the metacentre from the centre of gravity of displacement.	Distance of the metacentre from the centre of gravity of the ship with lading.	Absolute moment of stability.	Number, which multiplied by the displacement, and divided by length from end to end equal the area of the frame ⊕.
	sq ft	feet.	feet.	feet.	feet.	feet.		
4	5095	2 20	11.97	7.605	8.576	3 171	221720	1.434
5	4943	2 15	11·78	7.463	8.502	3·202	213220	
6	4790	2.11	11·58	7.316	8 426	3·228	201230	
7	4634	2.07	11·37	7.165	8 347	3·257	195260	
8	4474	2 03	11·16	7.009	8·264	3·284	185940	
9	4312	2 00	10 94	6.848	8·178	3·312	176610	
10	4146	1.95	10·71	6.682	8·087	3·339	167020	1.440
11	3976	1 91	10 47	6.509	7·991	3·367	157370	
12	3804	1.87	10·22	6.329	7·890	3 394	147560	
13	3625	1 82	9.96	6.132	7 783	3·428	137410	
14	3442	1.76	9·68	5.944	7 669	3·447	126780	
15	3255	1 71	9·39	5.738	7 547	3·472	117070	1 447
16	3059	1 66	9·08	5 552	7.416	3 495	106610	
17	2859	1.60	8 75	5 289	7·273	3·519	96650	
18	2649	1.53	8 40	5.041	7.118	3 536	85362	
19	2430	1.46	8.01	4.775	6 986	3 555	74180	
20	2199	1 39	7.59	4 485	6.750	3.564	79230	1 453
21	1955	1.30	7.12	4 168	6.527	3.567	52450	
22	1827	1.25	6 85	3.990	6 461	3.569	46960	
23	1692	1.20	6·58	3.804	6·264	3 564	41430	
24	1551	1.15	6·28	3·603	6·112	3·553	35890	
25	1405	1 08	5·95	3 384	5·941	3·539	28070	1.471
26	1249	1 02	5.58	3 135	5 745	3·514	24910	
27	1081	0 95	5.16	2·870	5 514	3 475	19475	
28	895	0·87	4 66	2.553	5 228	3·415	14141	
29	690	0 77	4·04	2·166	4.852	3·316	8958	
30	441	0 70	3.17	1.634	4·271	3.113	4054	1 505

No. 4. *Proportions of Merchant Ships—Cats and Barks.*

No.	Burthen in lasts.	Displacement.	Length from stem to stern.	Breadth.	Area of frame.	Draught of water at the frame Φ to the upper side of the keel.	Draught of water. Aft.	Draught of water. Forward.	Depth of the keel.	Area of the load-water line.	Quantity by which the centre of gravity is before the middle.
		cub. ft.	feet.	feet.	sq. ft.	feet.	feet.	feet.	feet.	sq. ft.	feet.
7	380	56880	143.5	36.02	544.1	17.30	19.58	18.12	1.43	4432	2.15
8	360	53750	140.9	35.48	524.4	16.99	19.24	17.80	1.41	4280	2.10
9	340	50620	138.1	34.91	504.4	16.66	18.89	17.47	1.40	4126	2.07
10	320	47510	135.2	34.33	484.0	16.32	18.53	17.12	1.38	3968	2.03
11	300	44400	132.2	33.70	463.2	15.97	18.15	16.77	1.37	3802	1.98
12	280	41300	129.0	33.37	441.9	15.60	17.75	16.39	1.35	3636	1.92
13	260	38230	125.7	32.09	420.2	15.22	17.33	16.00	1.33	3468	1.88
14	240	35140	122.3	31.68	397.2	14.71	16.89	15.58	1.32	3293	1.83
15	220	32080	118.6	30.92	375.0	14.38	16.42	15.14	1.30	3113	1.78
16	200	29350	115.1	30.19	353.9	13.98	16.00	14.73	1.28	2938	1.73
17	180	26000	110.6	29.23	327.1	13.44	15.41	14.18	1.25	2737	1.66
18	160	22980	106.1	28.28	301.9	12.92	14.84	13.65	1.23	2540	1.59
19	140	19983	101.3	27.25	275.6	12.35	14.22	13.07	1.20	2321	1.51
20	120	17002	96.0	26.10	248.1	11.72	13.54	12.42	1.17	2105	1.44
21	100	14046	90.1	24.81	219.2	11.02	12.78	11.71	1.13	1870	1.35
22	90	12579	86.8	24.09	204.0	10.64	12.35	11.31	1.11	1747	1.30
23	80	11155	83.4	23.33	188.7	10.23	11.91	10.90	1.09	1623	1.25
24	70	9667	79.5	22.45	171.9	9.77	11.49	10.42	1.06	1486	1.20
25	60	8225	75.3	21.51	154.8	9.28	10.86	9.91	1.03	1345	1.13
26	50	6795	70.7	20.44	136.7	8.72	10.25	9.35	1.00	1195	1.06
27	40	5378	65.4	19.20	117.4	8.09	9.56	8.69	0.96	1034	1.00
28	30	3979	59.1	17.72	96.5	7.34	8.73	7.92	0.92	859	0.90
29	20	2602	51.3	15.82	73.3	6.40	7.68	6.95	0.85	661	0.80
30	10	1258	40.5	13.04	45.7	5.07	6.19	5.56	0.76	424	0.70

(No. 5.) *Proportions of Merchant Ships of a small draught of water in form like Barks.*

No.	Burthen in lasts.	Displacement.	Length from stem to stern.	Breadth.	Area of the frame Φ.	Draught of water at the frame Φ to the upper side of the keel.	Draught of water. Aft.	Draught of water. Forward.	Depth of the keel.	Area of the plane of the load water line.
		cub. ft.	feet.	feet.	sq. ft.	feet.	feet.	feet.	feet.	sq. ft.
10	320	44400	140.9	32.74	403.4	13.35	15.21	14.08	1.21	3908
11	300	41500	137.8	32.15	386.6	13.08	14.92	13.81	1.20	3749
12	280	38080	134.5	31.54	369.3	12.80	14.61	13.52	1.18	3588
13	260	35720	131.0	30.89	351.5	12.50	14.29	13.22	1.17	3421
14	240	32840	127.4	30.21	333.4	12.19	13.96	12.99	1.15	3250
15	220	29990	123.6	29.48	314.7	11.86	13.60	12.57	1.13	3074
16	200	27140	119.6	28.70	295.4	11.51	13.22	12.21	1.12	2891
17	180	24300	115.2	27.88	275.4	11.14	12.81	11.82	1.09	2703
18	160	21480	110.6	26.97	254.7	10.73	12.36	11.40	1.07	2506
19	140	18670	105.6	25.99	233.1	10.29	11.88	10.95	1.05	2302
20	120	15900	100.1	24.90	210.6	9.81	11.35	10.45	1.02	2086
21	100	13130	93.9	23.65	186.5	9.26	10.75	9.89	0.99	1855
22	90	11756	90.5	22.97	173.9	8.96	10.41	9.57	0.97	1734
23	80	10391	86.8	22.23	160.8	8.63	10.05	9.23	0.95	1609
24	70	9034	82.9	21.41	147.1	8.28	9.66	8.88	0.93	1476
25	60	7687	78.5	20.51	132.8	7.89	9.23	8.46	0.90	1338
26	50	6350	73.7	19.48	117.7	7.45	8.75	8.01	0.87	1190
27	40	5027	68.2	18.31	101.5	6.94	8.18	7.49	0.84	1038
28	30	3719	61.6	16.90	83.9	6.34	7.52	6.88	0.80	850
29	20	2432	53.5	15.02	64.1	5.58	6.67	6.08	0.75	650
30	10	1176	42.0	12.43	40.4	4.49	5.44	4.94	0.66	424

No. 4. *Proportions of Merchant Ships—Cats and Barks—sequel of preceding Table.*

No.	Quantity by which the frame Φ is before the middle of the length from stem to stern.	Quantity by which the centre of gravity of displacement is below the water	Distance of the metacentre from the centre of gravity of displacement.	Distance of the metacentre from the centre of gravity of the ship with its lading.	Moment of stability.	Height of the main-mast in proportion to stability. Above the centre of gravity.	Below the centre of gravity.	Whole length.	Weight of the sheet anchor.		Number of crew.	Number, which, multiplied by displacement, and divided by length from end to end, equal area of the frame Φ.
	feet.	feet.	feet.	feet.		feet.	feet.	feet.	sk.	lp.		
7	11.96	6.999	7.153	2.474	140700	74.54	12.07	86.61	10	15	27	1.390
8	11.73	6.849	7.089	2.502	134400	73.41	11.88	85.29	10	6	26	
9	11.50	6.693	7.002	2.528	127980	72.21	11.65	83.86	9	17	25	
10	11.26	6.517	6.921	2.556	121440	70.95	11.43	82.38	9	8	24	
11	11.01	6.366	6.836	2.583	111690	69.61	11.19	80.80	8	19	23	
12	10.75	6.191	6.746	2.609	107780	68.20	10.94	79.14	8	10	22	
13	10.47	6.010	6.659	2.637	109810	66.69	10.69	77.38	8	1	20	
14	10.19	5.820	6.549	2.662	93570	65.05	10.41	75.46	7	12	19	
15	9.88	5.620	6.411	2.688	86230	63.30	10.12	73.42	7	3	18	
16	9.59	5.432	6.306	2.711	79590	61.63	9.87	71.50	6	14	17	
17	9.21	5.185	6.197	2.738	71180	59.38	9.48	68.86	6	5	16	
18	8.84	4.946	6.058	2.761	63460	57.15	9.12	66.27	5	14	14	1.400
19	8.41	4.687	5.905	2.77[illegible]	55520	54.66	8.75	63.39	5	3	13	
20	7.99	4.406	5.73[illegible]	2.797	47530	51.91	8.31	60.22	4	11	12	
21	7.5[illegible]	4.095	5.5[illegible]	2.808	39440	48.77	7.83	56.60	3	19	11	
22	7.23	3.925	5.412	2.8[illegible]9	35340	47.02	7.56	54.58	3	13	9	
23	6.95	3.748	5.307	2.[illegible]11	31360	45.18	7.28	52.16	3	7	8	
24	6.62	3.54[illegible]	5.1[illegible]	2.806	27150	43.05	6.96	50.01	3	1	8	1.413
25	6.2[illegible]	[illegible]	5.012	2.79[illegible]	23020	40.76	6.63	47.39	2	14	7	
26	5.89	[illegible]	[illegible]	2.784	[illegible]	38.2[illegible]	6.24	44.16	2	7	6	
27	5.4[illegible]	[illegible]	[illegible]	2.7[illegible]	[illegible]	[illegible]	5.80	41.01	2	—	6	
28	4.[illegible]	2.5[illegible]	[illegible]	2.715	[illegible]	31.6[illegible]	5.28	36.96	1	12	4	
29	[illegible]	[illegible]	[illegible]	[illegible]	6471	27.21	4.6[illegible]	31.86	1	4	3	
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.60	24.64	—	11	3	1.464

Proportions for Merchant Ships, &c. Sequel of the preceding Table, (No. 5.)

No.	Quantity by which the centre of gravity is before the middle.	Quantity by which the frame Φ is before the middle of the length.	Quantity by which the centre of gravity of displacement is below the water.	Distance of the metacentre from the centre of gravity of the displacement.	Distance of the metacentre from the centre of gravity of the ship, and its lading.	Moment of stability.	Height of the main-mast in proportion to stability. Above the centre of gravity.	Below the centre of gravity.	Whole length.	No. which, multiplied by displacement, and divided by length from end to end, equal area of the frame Φ.
	feet.	feet.	feet.	feet.	feet.		feet.	feet	feet.	
10	2.12	10.81	5.419	8.852	4.514	200400	83.64	9.55	93.19	1.280
11	2.07	10.59	5.298	8.752	4.511	187200	81.76	9.36	91.12	
12	2.05	10.34	5.172	8.648	4.505	173900	79.79	9.17	88.96	
13	1.96	10.08	5.040	8.537	4.501	160790	77.73	8.96	86.69	
14	1.91	9.80	4.901	8.418	4.495	147660	75.56	8.75	84.31	
15	1.85	9.51	4.755	8.291	4.486	134520	73.24	8.52	81.76	1.300
16	1.80	9.19	4.599	8.154	4.474	121400	70.76	8.36	79.12	
17	1.74	8.86	4.443	8.005	4.458	108340	68.13	8.01	76.14	
18	1.67	8.51	4.255	7.843	4.437	95300	65.29	7.73	73.02	
19	1.59	8.12	4.060	7.662	4.412	82400	62.20	7.42	69.62	
20	1.50	7.69	3.849	7.460	4.360	69360	58.81	7.09	65.90	1.325
21	1.41	7.22	3.610	7.225	4.336	56910	54.98	6.71	61.69	
22	1.36	6.97	3.480	7.093	4.308	50640	52.89	6.50	59.39	
23	1.31	6.68	3.339	6.949	4.277	44440	50.62	6.27	56.89	
24	1.24	6.37	3.187	6.788	4.237	38280	48.17	6.02	54.19	
25	1.18	6.04	3.020	6.608	4.190	32220	45.48	5.79	51.27	1.356
26	1.11	5.66	2.831	6.401	4.132	26210	42.49	5.44	47.93	
27	1.02	5.24	2.622	6.157	4.062	20420	39.05	5.07	44.12	
28	0.93	4.71	2.371	5.855	3.960	14727	35.02	4.65	39.67	
29	0.80	4.11	2.058	5.455	3.806	9256	30.01	4.11	34.12	
30	0.63	3.23	1.616	4.833	3.541	4170	23.00	3.33	26.33	1.442

(No. 6.) *Proportions for Privateers, according to the formula.*

No.	Artillery. Guns. In battery. Number.	Caliber.	On the quarter deck, &c. Number.	Caliber.	Bow chases. Number.	Caliber.	Swivels. Number.	Caliber.	Length from stem to stern from outside to outside.	Breadth to the outside of the frame at the load water line.	Displacement.	$\int \frac{2}{3} y^3 dx$.	Area of the load water line.	Area of the frame φ.
		lb.		lb.		lb.		lb.	feet.	feet.	cub. ft.		sq. ft.	sq. ft.
1	28	18	12	6	..	..	..	..	161.52	41.16	47170	558500	5086	452.3
2	26	18	10	6	..	..	..	..	155.65	39.82	42330	486200	4747	422.0
3	26	12	10	4	..	..	..	..	142.38	36.74	31910	348100	3995	350.8
4	24	12	8	4	..	..	..	..	138.24	35.78	29140	311600	3769	330.7
5	24	8	8	3	..	..	..	..	126.75	33.10	22080	225400	3184	275.3
6	22	8	..	..	..	..	..	..	119.78	31.45	18130	182060	2853	244.3
7	22	6	..	..	..	..	..	..	112.60	29.75	15064	143350	2530	213.5
8	20	6	..	..	..	..	..	..	109.84	29.09	13907	131545	2411	202.5
9	18	6	..	..	..	..	..	..	106.94	28.40	12749	118970	2288	191.1
10	16	6	..	..	..	..	..	..	103.82	27.65	11577	106470	2160	179.2
11	14	6	..	..	..	..	..	..	100.46	26.84	10395	94130	2027	166.7
12	12	6	..	..	..	..	..	..	96.76	25.96	9185	81780	1884	153.4
13	10	6	..	..	..	..	..	..	92.70	24.97	7967	69620	1734	139.4
14	8	6	..	..	..	..	..	..	88.01	23.83	6698	57300	1567	124.0
15	..	..	..	..	1	12	16	3	81.31	22.19	5175	42590	1343	104.38
16	..	..	..	..	1	8	16	2	74.60	20.54	3845	30825	1136	85.13

Proportions for Privateers, &c. Sequel of the preceding Table, (No. 6.)

φ.	Quantity by which the centre of gravity of the displacement is below the water.	Height of the metacentre above the water.	Quantity by which the centre of gravity is before the middle.	Quantity by which φ is before the middle of the length from stem to stern.	Differences of the draught of water.	Quantity of ballast in cubic feet of sea water.	Centre of gravity of the ballast below the water.	Number of crew.	Months for which provisioned.	Moment of the sails with regard to the centre of gravity or to the water-line.	Height of the battery above the water.	No. which multiplied by the displacement, and divided by length from end to end, equal the area of frame φ.
t.	feet.	ft.	feet.	feet.	feet	cub. ft.	feet.	No.			feet	
.40	5.840	6	1.61	8.10	1.66	4224	13.00	400	4.00	1935000	8.50	1.548
.80	5.485	6	1.56	7.86	1.62	3705	12.34	381	4.00	1679100	7.00	1.552
.50	4.907	6	1.42	7.21	1.53	2861	10.89	312	3.52	1303800	6.50	1.565
.16	4.695	6	1.38	7.03	1.51	2616	10.45	296	3.13	1202100	6.00	1.568
.10	4.205	6	1.27	6.50	1.42	2020	9.26	244	3.10	938000	5.75	1.580
.40	3.878	6	1.20	6.17	1.37	1676	8.55	217	2.92	797700	5.50	1.588
.70	3.582	6	1.13	5.86	1.34	1393	7.84	188	2.71	665600	5.25	1.595
.40	3.459	6	1.10	5.70	1.30	1286	7.57	178	2.64	619525	5.00	1.600
.10	3.331	6	1.07	5.56	1.28	1183	7.29	168	2.56	573100	4.75	1.603
.80	3.197	6	1.04	5.41	1.25	1070	7.00	157	2.47	525600	4.50	1.607
.50	3.055	6	1.00	5.23	1.23	959	6.68	146	2.38	477100	4.25	1.612
.20	2.903	6	0.97	5.08	1.20	856	6.34	134	2.28	426855	4.00	1.616
.80	2.738	6	0.93	4.89	1.17	742	5.97	121	2.16	375600	3.75	1.622
.40	2.555	6	0.88	4.65	1.13	626	5.55	107	2.03	321268	3.50	1.629
.70	2.230	6	0.81	4.32	1.08	503½	4.97	86	1.81	254900	4.00	1.640
.10	2.018	6	0.75	4.02	1.02	367	4.41	69	1.62	194850	3.75	1.651

(No. 7.) *Proportions of Masts and Yards for Merchant Ships with three Masts—Frigate built.*

Number.	Length from stem to stern.	Breadth.	Mainmast. Length.	Diameter.	Maintop mast. Length.	Diameter.	Maintop gallant mast. Length.	Diameter.	Diameter of foremast.	Foretop mast. Length.	Diameter.	Foretop gallant mast. Length.	Diameter.	Diameter of the mizen mast.	Mizen topmast. Length.	Diameter.
	feet.	feet.	feet.	in.	feet.	in.	feet.	in.	in.	feet.	in.	feet.	in.	in.	feet	in.
1	168.6	43.71	103.0	35.2	60.0	19.2	32.5	9.7	34.0	54.0	18.2	29.0	8.7	23.5	43.5	12.9
2	166.1	43.21	102.0	34.6	59.2	19.0	32.2	9.6	33.1	53.5	18.0	28.7	8.7	23.1	43.0	12.7
3	163.6	42.69	101.0	34.1	58.5	18.7	32.0	9.5	32.7	52.7	17.7	28.5	8.6	22.7	42.5	12.6
4	161.1	42.16	99.7	33.5	57.7	18.5	31.5	9.4	32.1	52.0	17.5	28.2	8.5	22.4	42.0	12.5
5	158.5	41.61	98.5	33.0	57.0	18.2	31.0	9.2	31.5	51.2	17.2	28.0	8.4	22.0	41.5	12.4
6	155.8	41.01	97.2	32.4	56.2	18.0	30.5	9.1	30.9	50.5	17.0	27.7	8.2	21.6	41.0	12.2
7	153.0	40.45	96.0	31.7	55.5	17.7	30.0	9.0	30.2	49.7	16.7	27.2	8.1	21.2	40.5	12.0
8	150.1	39.84	94.7	31.1	54.7	17.5	29.5	8.9	29.5	49.0	16.5	26.7	8.0	20.9	40.0	11.7
9	147.1	39.20	93.5	30.5	53.7	17.0	29.0	8.7	29.0	48.2	16.1	26.2	7.9	20.2	39.5	11.5
10	144.0	38.53	92.2	29.7	52.7	16.7	28.5	8.5	28.2	47.5	15.7	25.7	7.7	19.9	39.0	11.2
11	140.7	37.81	90.5	29.0	51.7	16.5	28.0	8.4	27.5	46.7	15.1	25.2	7.6	19.4	38.5	11.0
12	137.1	37.11	88.7	28.2	50.7	16.0	27.5	8.2	26.9	45.7	15.0	24.7	7.5	19.0	37.7	10.7
13	133.8	36.34	87.0	27.5	49.7	15.7	27.0	8.0	26.1	44.7	14.6	24.2	7.4	18.4	37.0	10.5
14	130.1	35.53	85.2	26.7	48.7	15.4	26.5	7.9	25.4	43.7	14.2	23.7	7.2	18.0	36.2	10.2
15	126.1	34.66	83.2	25.9	47.5	15.0	25.7	7.6	24.5	42.7	13.9	23.2	7.1	17.2	35.5	10.0
16	122.0	33.75	81.2	25.0	46.2	14.5	25.0	7.5	23.7	41.7	13.5	22.5	6.9	16.6	34.7	9.6
17	117.5	32.75	79.0	24.0	44.7	14.0	24.2	7.2	22.7	40.5	13.1	21.7	6.6	16.0	34.0	9.5
18	112.7	31.68	76.7	23.0	43.2	13.5	23.1	7.0	21.9	39.0	12.7	21.0	6.4	15.1	33.6	8.9
19	107.5	30.50	74.0	21.7	41.7	13.0	22.5	6.7	20.6	37.5	12.4	20.2	6.1	14.6	32.0	8.5
20	101.8	29.21	71.2	20.5	40.0	12.4	21.5	6.5	19.5	36.0	12.0	19.5	5.9	13.7	30.7	8.1
21	95.5	27.75	68.0	19.2	38.0	11.6	20.5	6.1	18.2	34.0	11.2	18.5	5.5	13.0	29.2	7.7
22	92.0	26.93	66.0	18.5	37.0	11.2	20.0	6.0	17.5	33.0	10.9	18.0	5.4	12.5	28.5	7.5
23	88.3	26.05	64.0	17.6	35.7	10.9	19.2	5.7	16.7	32.0	10.5	17.5	5.1	12.0	27.7	7.2
24	84.2	25.08	62.0	16.9	34.2	10.5	18.5	5.5	16.0	30.7	10.0	16.7	5.0	11.4	27.0	7.0
25	79.7	24.02	59.5	15.9	32.7	10.0	17.7	5.2	15.0	29.5	9.5	16.0	4.7	10.6	26.0	6.7
26	74.8	22.81	56.7	14.7	31.0	9.4	16.7	5.0	14.0	28.0	9.0	15.2	4.5	9.7	24.7	6.4
27	69.1	21.42	53.5	13.6	29.2	8.7	15.7	4.7	13.0	26.2	8.2	14.2	4.2	9.6	23.5	6.0
28	62.4	19.79	49.7	12.2	27.0	8.0	14.5	4.4	11.6	24.2	7.5	13.0	4.0	8.1	21.7	5.7

Proportions of Masts and Yards for Merchant Ships, &c. Continuation of the preceding table. (No. 7.)

Number.	Bowsprit. Length.	Diameter.	Jib boom.	Length of the head of the main-mast.		Length of the head of the fore mast.		Length of the head of the mizen-mast.		Quantity by which the fore-mast is lower than the main mast.		Main yard. Length.	Diameter.	Maintop sail yard. Length.	Diameter.	Maintop gallant yard. Length.	Diameter.	Fore yard. Length.	Diameter.
	feet	in.	in.	ft.	in.	ft	in.	ft	in.	ft.	in.	feet.	in.	feet.	in.	feet.	in.	feet	in.
1	48.5	34.6	14.4	14	4	12	10	10	9	5	5	87.5	21.9	69.2	16.0	48.5	8.0	79.0	19.7
2	48.0	34.1	14.2	14	2	12	9	10	8	5	5	86.2	21.6	68.2	15.7	47.7	8.0	77.7	19.5
3	47.5	33.5	14.1	14	—	12	7	10	6	5	4	85.0	21.4	67.2	15.1	47.0	7.9	76.5	19.2
4	47.0	32.9	14.0	13	10	12	6	10	5	5	4	83.7	21.1	66.2	15.1	46.2	7.7	75.2	19.0
5	46.5	32.2	13.9	13	8	12	4	10	3	5	4	82.5	20.7	65.2	14.9	45.5	7.6	74.0	18.7
6	46.0	31.6	13.6	13	6	12	2	10	2	5	3	81.0	20.4	64.2	14.6	44.7	7.5	72.7	18.4
7	45.2	31.0	13.4	13	4	12	—	10	—	5	3	79.5	20.0	63.0	14.4	44.0	7.4	71.5	18.0
8	44.5	30.4	13.1	13	2	11	10	9	11	5	3	78.0	19.6	61.7	14.1	43.2	7.2	70.2	17.6
9	43.7	29.7	12.9	13	—	11	8	9	9	5	3	76.5	19.2	60.5	13.9	42.5	7.1	68.7	17.2
10	43.0	29.0	12.6	12	9	11	6	9	7	5	2	74.7	18.7	59.2	13.6	41.5	7.0	67.2	16.9
11	42.2	28.2	12.4	12	7	11	3	9	5	5	2	73.0	18.4	58.0	13.4	40.5	6.7	65.7	16.5
12	41.5	27.5	12.1	12	4	11	1	9	3	5	2	71.2	17.9	56.5	13.[illegible]	39.5	6.5	64.2	16.1
13	40.7	26.7	11.9	12	1	10	10	9	—	5	1	69.5	17.4	55.0	12.6	38.5	6.5	62.5	15.6
14	39.7	26.0	11.6	11	10	10	8	8	10	5	1	67.5	16.9	53.5	12.2	37.5	6.2	60.7	15.1
15	38.7	25.1	11.2	11	7	10	5	8	8	5	—	65.5	16.4	51.7	11.9	36.2	6.0	59.2	14.7
16	37.7	24.2	10.9	11	4	10	2	8	6	5	—	63.5	15.9	50.0	11.5	35.0	5.9	57.2	14.2
17	36.5	23.4	10.5	11	—	9	11	8	3	4	11	61.0	15.4	48.2	11.1	33.7	5.6	55.2	13.8
18	35.2	22.5	10.1	10	8	9	7	8	—	4	11	58.5	14.9	46.2	10.6	32.5	5.4	52.7	13.4
19	34.0	21.3	9.7	10	4	9	3	7	9	4	10	56.0	14.1	44.0	10.1	31.0	5.1	[illegible]	[illegible]
20	32.5	20.6	9.4	9	11	[illegible]	11	7	5	4	[illegible]	53.0	13.2	41.7	9.6	[illegible]	4.[illegible]	47.7	11.[illegible]
21	31.0	18.7	8.9	9	5	8	5	7	1	4	8	49.7	12.4	39.2	9.0	27.5	4.5	44.7	11.1
22	30.0	18.0	8.7	9	2	8	3	6	[illegible]	4	[illegible]	48.0	12.0	37.7	8.6	26.5	4.5	42.[illegible]	[illegible]
23	29.0	17.2	8.1	8	11	8	—	6	7	4	[illegible]	47.[illegible]	11.5	36.2	8.2	25.[illegible]	4.4	41.[illegible]	10.[illegible]
24	28.0	16.5	7.9	8	7	7	9	6	[illegible]	4	7	45.7	11.0	34.5	7.9	24.2	4.1	[illegible]	[illegible]
25	26.7	15.5	7.5	8	3	7	5	6	2	4	[illegible]	43.5	10.4	32.7	7.5	23.0	4.[illegible]	[illegible]	[illegible]
26	25.5	14.5	7.[illegible]	7	11	7	1	5	11	4	[illegible]	39.0	9.7	30.7	7.1	21.5	[illegible]	[illegible]	[illegible]
27	23.7	13.4	6.5	7	5	6	8	5	7	4	[illegible]	36.0	9.6	28.2	6.5	19.[illegible]	[illegible]	[illegible]	[illegible]
28	22.0	12.0	6.0	6	11	6	3	5	2	4	[illegible]	32.5	8.1	25.7	5.9	18.[illegible]	[illegible]	[illegible]	[illegible]

Proportions for Masts and Yards of Merchant Ships, &c. Continuation of the preceding Table, (No. 7.)

Number.	Foretop sail yards. Length.	Diameter.	Foretop gallant yard. Length.	Diameter.	Cross jack yard. Length.	Diameter.	Mizentop sail yard. Length.	Diameter.	Sprit sail yard. Length.	Diameter.	Sprit sail top sail yard. Length.	Diameter.	Depth of the trestle trees. Of the top. Mainmast.	Fore.	Mizen.	Of the cross trees. Maintop-gallant.	Foretop-gallant.
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft	in.	ft.	in.	in.	in.	in.	in.	in.
1	62.2	14.2	43.7	7.2	61.0	12.7	50.0	11.5	62	13.0	43.5	8.0	14.5	13.7	8.7	6.2	5.9
2	61.5	14.1	43.2	7.1	60.2	12.6	49.5	11.4	61	12.9	43.0	8.0	14.2	13.6	8.5	6.1	5.7
3	60.5	13.9	42.5	7.0	59.5	12.5	49.0	11.1	60	12.6	42.2	7.9	14.1	13.5	8.4	6.0	5.6
4	59.5	13.6	41.7	6.9	58.7	12.4	48.5	11.0	59	12.4	41.5	7.7	14.0	13.2	8.2	6.0	5.6
5	58.5	13.4	41.0	6.9	58.0	12.1	47.5	10.9	58	12.1	40.7	7.6	13.7	13.1	8.2	5.9	5.5
6	57.5	13.1	40.2	6.7	57.2	12.0	46.7	10.7	57	12.0	40.0	7.5	13.5	13.0	8.1	5.7	5.5
7	56.5	12.9	39.5	6.6	56.2	11.7	46.0	10.5	56	11.7	39.2	7.4	13.5	12.7	8.0	5.7	5.4
8	55.5	12.6	38.7	6.5	55.2	11.6	45.2	10.4	55	11.5	38.5	7.2	13.2	12.5	8.0	5.7	5.2
9	54.5	12.4	38.0	6.4	54.2	11.4	44.5	10.1	54	11.2	37.7	7.1	13.0	12.2	7.9	5.5	5.1
10	53.2	12.1	37.2	6.1	53.2	11.1	43.7	10.0	53	11.1	37.0	7.0	12.7	12.1	7.7	5.5	5.0
11	52.0	11.9	36.5	6.0	52.2	11.0	42.7	9.7	52	11.0	36.2	6.7	12.5	11.9	7.5	5.2	5.0
12	50.7	11.6	35.7	5.9	51.2	10.7	41.7	9.5	51	10.7	35.5	6.6	12.2	11.6	7.4	5.2	4.9
13	49.5	11.4	34.7	5.7	50.0	10.5	40.7	9.4	50	10.5	34.7	6.5	12.0	11.4	7.2	5.0	4.9
14	48.0	11.1	33.7	5.6	48.7	10.2	39.7	9.1	49	10.2	34.0	6.2	11.7	11.1	7.0	5.0	4.7
15	46.5	10.7	32.7	5.4	47.5	10.0	38.7	8.9	47	9.9	33.0	6.0	11.5	10.9	6.9	4.7	4.5
16	45.0	10.4	31.7	5.2	46.0	9.7	37.7	8.5	45	9.5	31.7	5.9	11.2	10.5	6.7	4.6	4.4
17	43.5	10.0	30.5	5.0	44.5	9.4	36.5	8.2	43	9.0	30.5	5.6	11.0	10.2	6.5	4.5	4.2
18	42.0	9.6	29.2	4.9	42.7	9.0	35.2	8.0	41	8.6	28.7	5.4	10.7	9.9	6.2	4.5	4.1
19	40.0	9.2	27.7	4.6	41.0	8.6	33.7	7.6	39	8.1	27.5	5.1	10.2	9.5	6.0	4.2	3.9
20	37.7	8.7	26.2	4.4	39.0	8.1	32.0	7.2	37	7.7	26.0	4.9	9.5	9.0	5.7	4.0	3.7
21	35.2	8.1	24.7	4.1	37.0	7.7	30.2	7.0	35	7.4	24.5	4.6	9.0	8.5	5.5	3.7	3.6
22	34.0	7.9	23.7	4.0	35.7	7.5	29.2	6.7	33	7.0	23.5	4.5	8.7	8.2	5.2	3.6	3.5
23	32.7	7.5	22.7	3.9	34.5	7.2	28.2	6.5	32	6.7	22.5	4.4	8.5	8.0	5.0	3.5	3.4
24	31.2	7.1	21.7	3.6	33.0	7.0	27.0	6.1	31	6.5	21.5	4.1	8.2	7.7	4.7	3.5	3.1
25	29.5	6.7	20.7	3.4	31.5	6.6	25.7	5.9	29	6.0	20.2	4.0	7.7	7.2	4.5	3.2	3.0
26	27.7	6.2	19.2	3.2	29.7	6.2	24.5	5.5	27	5.6	19.0	3.7	7.2	6.9	4.2	3.2	2.9
27	25.5	5.7	17.7	3.0	27.7	5.7	22.7	5.1	25	5.2	17.5	3.5	6.7	6.4	4.0	3.0	2.6
28	[illegible]	5.2	16.0	3.0	25.2	5.2	20.7	4.6	23	4.9	16.0	3.1	6.2	6.1	3.7	2.7	2.5

(No. [illegible]) *Proportions of Masts and Yards for Merchant Ships with three Masts—Bark built.*

No.	Length from stem to stern	Breadth.	Mainmast. Length.	Diameter.	Maintop-mast. Length.	Diameter.	Maintop gallant mast. Length.	Diameter.	Diameter of foremast.	Foretop mast. Length.	Diameter.	Foretop-gallant mast. Length.	Diameter.	Diameter of the mizenmast.	Mizentop-mast. Length.	Diameter.
	ft.	ft.	ft.	in.	ft.	in.	ft.	in.	in.	ft.	in.	ft.	in.	in.	ft.	in.
7	[illegible]	36.02	86.2	25.2	47.5	15.0	25.5	7.6	24.0	42.7	14.2	23.0	7.1	16.9	36.0	10.0
8	140.9	35.48	85.0	24.7	46.7	14.7	25.2	7.5	23.5	42.0	14.0	22.7	7.0	16.5	35.5	9.9
9	138.1	34.91	83.7	24.2	46.0	14.5	25.0	7.4	23.0	41.2	13.7	22.5	6.9	16.1	35.0	9.7
10	135.2	34.55	82.5	23.7	45.2	14.2	24.5	7.2	22.5	40.5	13.5	22.2	6.7	15.9	34.5	9.5
11	132.2	33.70	81.2	23.2	44.5	14.0	24.0	7.1	22.0	39.7	13.2	21.7	6.6	15.5	34.0	9.4
12	129.0	33.07	79.7	22.6	43.7	13.4	23.5	7.0	21.5	39.0	12.9	21.2	6.5	15.1	33.5	9.1
13	125.7	32.39	78.2	22.0	42.7	13.1	23.0	6.9	21.0	38.2	12.6	20.7	6.4	14.7	33.0	8.9
14	122.3	31.68	76.7	21.4	41.7	13.0	22.5	6.7	20.6	37.5	12.2	20.2	6.2	14.2	32.2	8.6
15	[illegible]	30.92	75.2	20.7	40.7	12.6	22.0	6.6	19.6	36.7	12.0	19.7	6.1	13.9	31.5	8.5
16	115.1	30.19	[illegible]	20.0	39.7	12.4	21.5	6.5	19.0	35.7	11.7	19.2	6.0	13.4	30.7	8.2
17	110.6	[illegible]	71.2	19.2	38.5	11.9	20.7	6.2	18.2	34.7	11.4	18.7	5.9	12.9	30.0	7.9
18	106.1	28.28	69.0	18.7	37.2	11.4	20.0	6.0	17.4	33.5	10.9	18.0	5.6	12.2	29.2	7.6
19	[illegible]	27.25	66.7	17.5	35.7	10.9	19.2	5.7	16.6	32.5	10.4	17.2	5.4	11.7	28.2	7.2
20	[illegible]	26.10	61.2	16.5	34.2	10.4	18.5	5.5	15.4	30.7	9.9	16.5	5.1	11.0	27.2	6.9
21	96.1	[illegible]	61.2	15.5	32.5	9.7	17.5	5.2	14.7	29.2	9.4	15.7	4.9	10.4	26.0	6.6
22	[illegible]	[illegible]	59.7	14.9	31.5	9.5	17.0	5.1	14.1	28.5	9.1	15.2	4.7	10.0	25.5	6.4
23	[illegible]	[illegible]	[illegible]	14.2	30.5	9.2	16.5	5.0	13.5	27.5	8.9	14.7	4.6	9.5	24.7	6.2
24	[illegible]	[illegible]	56.0	13.6	29.5	8.9	16.0	4.7	13.0	26.5	8.5	14.2	4.5	9.1	24.0	6.0
25	[illegible]	[illegible]	53.7	12.9	28.2	8.4	15.2	4.5	12.2	25.2	8.0	13.7	4.2	8.6	23.0	5.6
26	[illegible]	[illegible]	[illegible]	12.1	26.7	7.9	14.5	4.2	11.6	24.0	7.4	13.0	4.0	8.1	22.0	5.2
27	[illegible]	[illegible]	48.5	11.1	25.0	7.4	13.5	4.0	10.6	22.7	7.1	12.5	3.7	7.5	21.0	5.0
28	[illegible]	[illegible]	45.0	10.0	23.2	6.7	12.5	3.7	9.4	20.7	6.5	11.2	3.5	6.7	19.5	4.5

Proportions of Masts and Yards of Merchant Ships, &c. Continuation of the preceding Table, (No. 8.)

No.	Bowsprit. Length.	Diameter.	Jib-boom thick.	Length of the head of the mainmast.		Length of the head of the foremast.		Length of the head of the mizenmast.		Quantity by which the foremast is lower than the mainmast.		Mainyard. Length.	Diameter.	Maintop-sail yard. Length.	Diameter.	Maintop-gallant-yard. Length.	Diameter.	Foreyard. Length.	Diameter.
	ft.	in.	in.	ft.	in	ft	in.	ft	in	ft	in	ft.	in.	ft.	in.	ft.	in.	ft.	in.
7	39.5	24.5	11.2	12	—	10	9	9	—	3	9	68.0	17.0	55.0	12.6	38.5	6.4	61.2	15.4
8	39.0	24.0	11.0	11	10	10	8	8	10	3	9	66.7	16.6	54.0	12.4	37.7	6.2	60.0	15.
9	38.5	23.5	10.9	11	8	10	5	8	9	3	9	65.5	16.4	53.0	12.1	37.0	6.1	59.0	14.
10	37.7	23.0	10.7	11	5	10	4	8	7	3	8	64.2	16.0	52.0	12.0	36.3	6.0	57.7	14.
11	37.0	22.5	10.5	11	3	10	2	8	5	3	8	62.7	15.6	51.0	11.7	35.7	5.9	56.5	14.
12	36.2	22.0	10.2	11	1	10	—	8	4	3	8	61.5	15.2	49.7	11.5	34.7	5.7	55.3	13.
13	35.5	21.5	10.0	10	10	9	9	8	2	3	7	60.0	15.0	48.5	11.1	34.0	5.6	54.0	13.
14	34.7	21.0	9.7	10	8	9	7	8	—	3	7	58.3	14.6	47.2	10.9	33.0	5.5	52.5	13.
15	34.0	20.0	9.5	10	5	9	5	7	10	3	7	56.5	14.1	46.0	10.5	32.2	5.4	50.7	12.
16	33.2	19.4	9.2	10	2	9	2	7	8	3	6	55.0	13.7	44.7	10.2	31.2	5.2	49.5	12.
17	32.0	18.9	8.9	9	11	8	11	7	5	3	6	53.0	13.2	43.0	9.9	30.0	5.0	47.7	12.
18	31.0	17.7	8.5	9	6	8	8	7	2	3	6	51.0	12.7	41.3	9.5	29.0	4.9	46.0	11.
19	30.0	17.0	8.2	9	3	8	4	7	—	3	5	48.7	12.2	39.5	9.0	27.7	4.6	43.7	11.
20	28.7	16.0	7.9	8	11	8	—	6	8	3	5	46.3	11.5	37.5	8.6	26.2	4.4	41.7	10.
21	27.2	15.0	7.4	8	6	7	8	6	4	3	5	43.5	10.9	35.3	8.1	24.7	4.1	39.2	9
22	26.5	14.4	7.1	8	3	7	5	6	3	3	4	42.0	10.5	34.0	7.7	23.7	3.9	37.7	9
23	25.7	13.7	6.9	8	—	7	3	6	—	3	4	40.5	10.1	32.7	7.5	23.0	3.7	36.5	9
24	24.7	13.2	6.6	7	9	7	—	5	10	3	4	38.7	9.6	31.3	7.1	22.0	3.6	35.0	8
25	23.7	12.5	6.2	7	6	6	9	5	7	3	3	36.7	9.1	29.7	6.7	20.7	3.4	33.0	8
26	22.5	11.9	5.9	7	2	6	5	5	4	3	3	34.7	8.6	28.0	6.4	19.7	3.1	31.2	7
27	21.0	10.9	5.5	6	9	6	1	5	—	3	2	32.2	8.0	26.0	6.0	18.2	3.0	29.0	7
28	19.0	9.9	5.1	6	3	5	8	4	8	3	2	29.2	7.2	23.7	5.4	16.5	2.7	26.3	6

Proportions of Masts and Yards for Merchant Ships, &c. Continuation of the preceding Table. (No. 8.)

No.	Foretop-sailyard. Length.	Diameter.	Foretop-gallant yard. Length.	Diameter.	Cross-jack yard. Length.	Diameter.	Mizentop-sailyard. Length	Diameter.	Spritsail-yard. Length.	Diameter.	Spritsail-topsail-yard. Length.	Diameter.	Depth of the trestle t[rees] Of the tops. Mainmast.	Fore.	Mizen.	Of cr[oss] tr[ees] Maintop-gallant.
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in	in.	in.	in.	in.
7	49.5	13.4	34.5	5.7	49.7	10.4	41.7	9.6	49.5	10.2	34.5	6.4	11.2	10.7	7.0	5.
8	48.5	11.1	34.0	5.6	48.7	10.2	41.0	9.4	48.5	10.1	34.0	6.2	11.0	10.6	6.9	4.
9	47.7	11.0	33.3	5.5	48.0	10.0	40.3	9.2	47.7	10.0	33.3	6.1	11.0	10.4	6.7	4.7
10	46.7	10.7	32.7	5.4	47.3	9.9	39.7	9.1	46.7	9.7	32.7	6.0	10.7	10.2	6.6	4.
11	45.7	10.5	32.2	5.2	46.3	9.7	39.0	9.0	45.7	9.6	32.2	5.9	10.7	10.0	6.5	4.
12	44.7	10.2	31.2	5.1	45.3	9.5	38.2	8.7	44.7	9.2	31.2	5.7	10.5	9.7	6.4	4.4
13	43.7	10.0	30.7	5.0	44.3	9.2	37.3	8.5	43.7	9.1	30.7	5.6	10.2	9.6	6.2	4.4
14	42.5	9.7	29.7	4.9	43.5	9.1	36.5	8.4	42.5	8.9	29.7	5.5	10.0	9.4	6.0	4.
15	41.5	9.5	29.0	4.7	42.5	8.9	35.7	8.2	41.5	8.7	29.0	5.4	9.7	9.1	5.9	4.1
16	40.2	9.2	28.0	4.6	41.2	8.6	34.7	8.1	40.2	8.4	28.0	5.2	9.5	8.9	5.7	4.
17	38.7	9.0	27.0	4.5	39.7	8.4	33.5	7.7	38.7	8.1	27.0	5.0	9.2	8.6	5.5	4.
18	37.0	8.5	26.0	4.4	38.7	8.1	32.5	7.4	37.0	7.7	26.0	4.9	9.0	8.4	5.2	3.
19	35.5	8.2	24.7	4.2	37.2	7.7	31.2	7.1	35.5	7.4	24.7	4.6	8.5	8.0	5.0	3.7
20	33.7	7.9	23.2	4.0	35.3	7.4	29.7	6.9	33.7	7.0	23.7	4.4	8.0	7.6	4.7	3.
21	31.7	7.4	22.2	3.7	33.7	7.0	28.2	6.6	31.7	6.6	22.2	4.1	7.7	7.2	4.6	3.
22	30.7	7.0	21.3	3.5	32.5	6.7	27.2	6.2	30.7	6.4	21.3	3.9	7.5	7.0	4.5	3.1
23	29.5	6.7	20.7	3.2	31.2	6.5	26.2	6.0	29.5	6.1	20.7	3.7	7.2	6.7	4.4	3.
24	28.2	6.4	19.7	3.1	30.2	6.2	25.3	5.7	28.2	5.9	19.7	3.6	7.0	6.5	4.2	3.
25	26.7	6.1	18.7	3.0	28.7	6.0	24.2	5.5	26.7	5.6	18.7	3.4	6.5	6.1	4.0	2.
26	25.2	5.9	17.7	2.9	27.3	5.7	23.0	5.2	25.2	5.4	17.7	3.1	6.2	5.9	3.7	2.
27	23.5	5.4	16.3	2.7	25.5	5.4	21.5	5.0	23.5	5.0	16.3	3.0	5.7	5.5	3.5	2.
28	21.2	4.9	15.0	2.5	23.5	4.9	19.7	4.5	21.2	4.5	15.0	2.7	5.5	5.0	3.2	2.

The following Table contains the algebraical elements and numerical results of five classes of ships of the line. It is likewise derived from Chapman.

Elements for the Construction of Ships of the Line, by F. H. Chapman.

Nature of the Elements.		Algebraical Elements.	Ships of 110 Guns.	Ships of 94 Guns.	Ships of 80 Guns.	Ships of 74 Guns.	Ships of 66 Guns.
			Swedish feet.*				
isplacement to the outside of the timbers	=	D	152875	123257	107400	96422	88722
ength on the construction water line	=	$l = 5{\cdot}18454\ D^{0.3088}$	206.81	195.9	185.48	179.40	174.8
ddition on the ends	=	$\frac{l}{83} = f$	2.49	2.36	2.23	2.16	2.1
f this is added before	=	$\frac{7}{10} f$	1.74	1.65	1.56	1.15	1.47
nd abaft	=	$\frac{3}{10} f$	0.75	0.708	0.669	0.648	0.63
Vhole length of the water line between the rabbets	=	L	209.3	198.3	187.7	181.5	176.9
lain breadth on water line for three deckers	=	$\frac{l^{0.9947}}{3.5734}$ } $= B$	56.2	53.3	50.92	49.5	48.46
lain breadth on water line for two deckers	=	$\frac{l^{0.8392}}{1.5728}$ }					
First derived element	=	$\frac{D}{lB} = t$	13.13	12.28	11.37	10.85	10.47
Second derived element	=	$1.6303 t^{0.935} = t\,r$	18.11	17.90	15.82	15.15	14.65
xponent of the parabolic curve, expressing the areas of the transverse sections—(the less this exponent is, the sharper is the ship fore and aft)	=	$\frac{t}{tr - t} = n$	2.638	2.597	2.551	2.524	2.503
Main sectional area to the outside of the timbers	=	$B\,t\,r = \phi$	1019.2	906.9	806	750.4	719
Construction depth	=	$2.37402\ t\,r^{0.7047} = d$	21.75	20.72	19.26	18.94	18.49
Depth to the upper edge of rabbet of the keel	=	$1.503\ d^{0.87} = q$	21.9	20.98	20.02	19.46	19.03
Frame exponent	=	$\frac{\phi}{B\,d - \phi} = m$	4.976	4.571	4.175	3.964	3.813
lotation ½ area moulded	=	$\frac{\frac{1}{2}(B.L)^{1.046}}{1.7186} = W$	5113.1	4567.2	4109.5	3854.1	3668.6
lotation exponent	=	$\frac{W}{\frac{1}{2}\,BL - W} = r$	6.5882	6.3477	6.1372	6.054	5.9257
Moment of stability for three deckers in cubic feet of water	=	$\frac{\frac{1}{2}(B^3 L)^{1.025}}{2.9902}$ }	2320500	1859900	1512300	133340	1210800
Moment of stability for two deckers in cubic feet of water	=	$\frac{\frac{1}{2}(B^3 L)^{1.0714}}{5.9551}$ }					
Distance from centre of displacement to metacentre	=	$\int \frac{2}{3}\left(\frac{y^3\,dx}{D}\right) = p$	15.18	14.59	14.08	13.83	13.65
Exponent of displacement from the water line to the keel	=	$\frac{\frac{1}{2} D}{d\,W - \frac{1}{2} D} = s$	2.198	2.1015	1.9942	1.9332	1.8879
Centre of gravity of displacement from water line	=	$\frac{(s+1)(2s+1) + s(2s+4)}{2(2s+1)(2s+4)} = g$	8.572	8.105	7.598	7.308	7.091
Metacentre above water line	=	$p - g = S$	6.608	6.395	6.48	6.52	6.559
Common centre of gravity of ship above water line	=	v	2.80	2.38	2.22	2.23	2.24
Distance of metacentre above centre of gravity	=	a	3.80	4.01	4.26	4.29	4.319
Expression for ships with same sails and same stability	=	$\ddot{a}$	3.809	3.975	4.131	4.291	4.348
Distance of the centre of gravity before the middle of the water line	=	$\frac{L}{76}$	2.75	2.61	2.47	2.39	2.33
Middle of the water line l abaft the middle of the water line L	=	$0.2f$	0.50	0.47	0.45	0.43	0.42
Distance of the centre of gravity before the middle of the water line l	=	a	3.25	3.08	2.92	2.82	2.75
Distance of ϕ before the centre of gravity	=	$a\,(n+1)$	11.83	11.08	10.37	9.94	9.63
Place of ϕ before the middle of the water line l	=	$a\,(n+2)$	15.08	14.16	13.29	12.76	12.38
Distance from the abaft end of the water line l to ϕ	=	P	118.5	112.1	106.0	102.4	99.8
Distance, for design, between the sections abaft ϕ	=	$\frac{P}{10}$	11.85	11.21	10.6	10.24	9.98
From the fore end of the water line l to ϕ	=	Q	88.34	83.81	79.45	79.94	75.04
Distance of sections before ϕ	=	$\frac{Q}{10}$	8.83	8.38	7.94	7.69	7.50
Height of lower port sill above the water	=		6.48	6.50	6.83	6.92	6.75
			Cubic feet of water, Swedish				
Weight of guns, balls, wads, powder, carriages			22863	18212	14685	12662	11536
Gunners' stores, $\frac{3}{100}$ of the above to add							
Ballast in cubic feet of water			18179	14193	11146	9627	8762
Number of men			1000	848	706	658	606
Hull, rigging, boats, anchors, &c. or the whole ship without guns, stores, ballast, and provisions			86255	73255	61910	55848	51588

* A Swedish lineal foot = .974 English lineal feet.
A Swedish square foot = .951 English square feet.
A Swedish cubic foot = .927 English cubic feet.

The foregoing tables suggest some important reflections. It is evident that Chapman entertained the idea of connecting together all the essential elements of naval architecture, by means of empirical formulæ, and of deriving all from some one primitive root or element. The bare conception of such an idea, marks the character of his mind in strong and original colours; and the steps he made towards its practical execution, stamp his name with double honour and renown.

The point to which naval architecture should continually approximate as a *limit*, ought to be the perfecting of the elements alluded to: obtaining for them more correct or appropriate co-efficients; establishing more completely their necessary relations, and throwing over the whole investigation a more accurate and philosophical character. No method of procedure, we would remark, can be more consistent with the legitimate and proper objects of philosophical inquiry. In the language of the modern analysis, it would be regarding every element of a ship, as a function of some one primitive element, and, by means of properly prepared co-efficients, deducing each one from it. There must, for example, be in every ship *some relation* between its length and displacement; so that by adopting one of them as its primitive term, the other by means of some multiplier or co-efficient, ought to be deduced from it. The breadth, too, must be a function of the length, and therefore some function of the displacement, if that element (and perhaps it is the best) be adopted as the primitive one. The area of the main section may also be so connected with the breadth, as to be resolvable at first into terms of the length, and ultimately into that of the displacement itself. In like manner, may the area of the plane of flotation, the moment of stability, the place of the metacentre, the position of the centre of gravity, and indeed the value of every other element of a ship, be ultimately traced to the displacement. If the whole length on the water line be denoted by l the entire length of the same line between the rabbets, must be some multiple of the same dimension; and as the former may be shown to be a function of the displacement, so may the latter. So that the displacement, or some other appropriate quantity, being assumed as a primitive element, every other element becomes connected with it; and no sooner is the *relation* of one part to another shown, than that relation becomes immediately connected with the element assumed. Hence adopting the language of functions we may say with Lagrange, that if the displacement be denoted by the primitive function $f\mathrm{D}$, in the series,

$$f\mathrm{D}, f'\mathrm{D}, f''\mathrm{D}. f'''\mathrm{D}, \text{ \&c.},$$

the derived functions of the same series,

$$f'\mathrm{D}, f''\mathrm{D}, f'''\mathrm{D}, \text{ \&c.},$$

may represent, successively, the other elements of a ship.

But it may be asked, in attempting to extend the investigation of these elements beyond the limits attained by Chapman, how are these *derived functions* to be obtained? We answer, by experiment and observation; by inquiring into the properties of the most approved models that have hitherto been produced; by *grouping* together facts, and drawing from their united testimony, legitimate results; pouring into the very heart of shipbuilding the genuine spirit of induction, and throwing over the whole of the inquiry the mantle of a pure philosophy; viewing facts, not as detached and insulated fragments, but as parts of a system which the progress of inquiry must eventually blend into one perfect and harmonious whole.

To those who may be disposed to deny the possibility of tracing, in the extended manner alluded to, the connexion of these different elements, we would observe, that some ships of war, and some vessels of our mercantile marine, possess confessedly better qualities than others. Some, indeed, possess a more than ordinary proportion of good qualities, and as such, become proper objects of *philosophical* examination. Suppose for example, that two or more ships of a particular class were selected, whose properties were generally recognised as good, might not many important conclusions be deduced from an analysis of their different elements? Each ship, for example, would have a given displacement, a length, a breadth a main sectional area, a certain stability, a particular position of the metacentre, a corresponding position of the centre of gravity, and indeed many other elements, each of which it would be highly proper to ascertain, and the relation of all of which to some primary element, it would be of the first importance to determine. These elements would, of course, at first possess a numerical character; but the generalizing eye of a philosopher would soon trace the existence of laws among the apparently unconnected arithmetical results; and order, and a system of definite relations, assume the place of irregularity, apparent accident, and chance.

To draw an example from the first of the tables before given, Chapman shows, in the case of a frigate, that the displacement is so related to the burthen estimated in cubic feet, as to present the conditional equation

$$\mathrm{D} = \mathrm{P}^{\frac{18}{17}};$$

or, in the second table, that the length is related to the displacement by an equation of the form

$$l = x\,\mathrm{D}^{y},$$

wherein l and D represent the elements referred to, and x, y, are unknown or indeterminate quantities, which it is the proper business of well-directed experiments to disclose.

In like manner we may draw from the investigations of the same able engineer, that the breadth is related to the length by the expression

$$\mathrm{B} = \frac{lx'}{y'}$$

where l the length may be obtained from the conditional equation before given, in terms of the displacement, and x', y' are empirical quantities, owing their origin entirely to experiment and observation.

Hence we may perceive how important it must be to the interests of naval architecture, to obtain from ships of approved character and value, every element that may be desired; not however by theoretical inquiry, but by well-digested courses of experiment, and long trains of observation; tabulating all the results that successful industry may obtain, in approved, and intelligible forms; entering every conclusion not as a detached and insulated quantity, but as an element which bears some relation to every other step of the inquiry.

Hitherto it has been the practice of those connected with naval inquiries, to view the various elements of shipbuilding, too much in the light of detached and insulated quantities, and not as parts of a system which possess the most perfect and intimate relations, and incapable of separation from each other. How often, from the imperfect condition of our knowledge, are we obliged to give to our most laborious disquisitions on stability, on displacement, on the metacentre, and indeed to most of the elements of naval architecture, a detached and insulated character; unable to trace the gradually inductive steps by which one branch of the inquiry is led on to another; how one individual element of a system is related to the elements that surround it, and how it stands connected with the great whole, of which it forms a part. And in no view of the subject before us, is this remarkable circumstance more apparent, than when we speak of the dimensions of ships, and endeavour to connect together the elements which compose them.

No one we will venture to say, who investigates the present condition of naval architecture, can for a moment allow, that it has been benefited in any material degree, by the example which the great reformer of philosophy exhibited to the experimental world. There has been little of what may be truly termed *inductive inquiry*, displayed in its history; and it stands now almost as a solitary monument of the folly which guided the predecessors of Bacon, in the paths of experimental investigation. Yet, in no subject is there greater room for the application of the most rigid principles of the inductive logic, than this. Millions of ships have been constructed, but only here and there a successful example has been offered for our contemplation, as if to mock the implicit obedience we pay in the practice of naval architecture, to uncertain and ill-defined rules.

There is one subject more, however, while referring to the tables of Chapman, to which we would briefly advert, and that is *notation*. A simple inspection of these tables will show, that that celebrated man did not avail himself of all the advantages that this powerful and important instrument is capable of affording. There is more in notation, to adopt a common phrase, than first meets the eye. Simplicity, uniformity, generality—a capability itself of suggesting new relations and inquiries—these, and many other particulars, are connected with the question of notation. And when we have seen the march of whole departments of science retarded for years, by the use of barbarous and improper symbols, it is not too much to insist, that in the formulæ and equations of condition that may hereafter be created for the use and extension of naval architecture, some little attention sould be paid to the lights that the modern analysis has thrown on the great question of notation. The remotest element of a ship must be connected with some primitive element, by a series of unquestionable laws,—laws dark and mysterious it is true at present, but which the spirit of a genuine and pure induction will eventually illuminate and make clear. This remote element may, however, be traced to its primitive element by a shorter route, by one process of ratiocination than another; but by no better method than by the pure light of a legitimate notation, can the "line of shortest descent" to this great point be obtained.

Shipbuilding began to be particularly attended to in England in the reign of Henry the Seventh, who commenced the Royal Navy of England by building the Great Harry, which is said to have been the first ship built with two decks in this country. In the succeeding reign the foundation was laid for an extensive royal navy; and the Admiralty and Navy boards were constituted for the direction of naval affairs. In the early part of this reign, the Regent, of 1000 tons burden, with the Mary Rose of 500 tons, and several other vessels, were constructed. The Regent being burnt in an engagement with the French fleet in 1512, Henry the Eighth ordered a ship to be built of equal tonnage, carrying 700 men, and named Henry grace de Dieu. The principal defect of ships at this period appears to have been too great height above the water in proportion to the extreme breadth, while at the same time the lower tier of guns, was much too near the water's surface. The loss of the Mary Rose is attributed to the defect of her ports being very near the water: Sir Walter Raleigh says they were within sixteen inches of the water. The loss of this vessel led to the raising the lower deck ports higher from the water.

At the end of the sixteenth and the beginning of the seventeenth centuries, ships of war were divided into seven classes, at the suggestion of Sir Robert Dudley. He gave the dimensions of the vessels according to the services for which they were intended, all of them being constructed to draw very little water. The length of the first class called the galleon, was four times the breadth; and the lengths of the other vessels gradually increased in proportion to their breadth. The seventh class, called the *passa-volante*, intended entirely for velocity, had its length in what has been truly characterised the extravagant proportion of ten times its breadth. At the period referred to, the ships of all nations displayed a remarkable similarity,—a circumstance arising from the Venetian vessels having been adopted by most of the constructers of that time, as models of imitation. In the reign of James the First, Mr. Phineas Pett built the Royal Prince, of the burden of 1400 tons, and 64 guns. The keel of this ship was 114 feet, and her cross beam 44 feet. In the reign of Charles the First, a much larger ship was constructed, called the Sovereign of the Seas. The length of her keel was 128 feet, and her main breadth 48 feet. Her length from the fore end of the beak head to the after end of the stern, *a prora ad puppim*, 232 feet; and in height, from the bottom of her keel to the top of the lanthorn, 76 feet. *She bore five lanthorns, the biggest of which would hold ten persons upright; had three flush decks, a forecastle, half deck, quarter deck, roundhouse, and also galleries*. A general increase of the ships of the Royal Navy took place in this reign; and in 1677 the dimensions of the different classes of ships were established by government. In the year 1684, Sir Richard Haddock, the comptroller of the navy, directed a scientific inquiry to be made into the solid content immersed in the water, of a ship of each class, when laden, from a fourth to a sixth rate, and by subtracting the weight of the ship's hull, when launched, from the total displacement, to determine the true burden in tons it will carry, and to compare this correct tonnage with the nominal tonnage calculated by the rules then in use This appears to have been the first attempt at the scientific investigation of the elements of ships in this country.

The following tables are taken from Derrick's *Memoirs of the Royal Navy*.

DIMENSIONS OF SHIPS.

An Account, showing the Dimensions established, or proposed to be established at different times, for Building Ships.

	Establishment of				Proposed in		Establishment of
	1677.	1691.	1706.	1719	1733.	1741.	1745.
100 Gun Ships.	ft. in	ft. in	ft in	ft. in.	ft. in.	ft. in.	ft. in.
Length on the gun deck	165 0	-	-	174 0	174 0	175 0	178 0
of the keel for ....tonnage -	137 8	-	-	140 7	140 7	142 4	144 6½
Breadth, extreme -	46 0	-	-	50 6	50 6	50 0	51 0
Depth in hold - -	19 2	-	-	20 0	20 6	21 0	21 6
Burthen in tons -	1550	-	-	1869	1869	1892	2000
90 Gun Ships.							
Length on the gun deck	153 0	-	162 0	164 0	166 0	168 0	170 0
of the keel for ....tonnage -	-	-	132 0	132 5	134 1	137 0	138 4
Breadth, extreme -	4 4	-	18 6	47 2	47 9	48 0	48 6
Depth in hold - -	18 2	-	18 6	18 10	19 6	20 2	20 6
Burthen in tons -	1307	-	1551	1566	1623	1679	1730
80 Gun ships with three decks							
Length on the gun deck	-	156 0	156 0	158 0	158 0	161 0	165 0
of the keel for ....tonnage -	-	-	127 0	128 2	127 8	130 10	134 10¾
Breadth, extreme -	-	41 0	43 6	44 6	45 5	46 0	47 0
Depth in hold - -	-	17 4	17 8	18 2	18 7	19 4	20 0
Burthen in tons -	-	1100	128 3	1350	1400	1472	1585
70 Gun Ships							
Length on the gun deck	150 0	-	150 0	151 0	151 0	154 0	160 0
of the keel for ....tonnage -	-	-	122 0	123 2	122 0	125 5	131 4
Breadth, extreme -	39 8	-	41 0	41 6	43 5	44 0	45 0
Depth in hold - -	17 0	-	17 4	17 4	17 9	18 11	19 4
Burthen in tons -	1013	-	1069	1128	1224	1291	1414
60 Gun Ships							
Length on the gun deck	-	144 0	144 0	144 0	144 0	147 0	150 0
of the keel for ....tonnage -	-	-	119 0	117 7	116 4	119 9	123 0½
Breadth, extreme -	-	37 6	38 0	39 0	41 5	42 0	42 8
Depth in hold - -	-	15 8	15 8	16 5	16 11	18 1	18 6
Burthen in tons -	-	900	914	951	1068	1123	1191
50 Gun Ships.							
Length on the gun deck	-	-	130 0	134 0	134 0	140 0	144 0
of the keel for ....tonnage -	-	-	108 9	109 8	108 [illegible]	113 9	117 8½
Breadth, extreme -	-	-	35 0	36 0	38 6	40 0	41 0
Depth in hold - -	-	-	14 0	15 2	15 9	17 2½	17 8
Burthen in tons -	-	-	704	755	853	968	1052
40 Gun Ships.							
Length on the gun deck	-	-	118 0	124 0	124 0	126 0	133 0
of the keel for ....tonnage -	-	-	97 6	101 8	100 3	102 6	108 10
Breadth, extreme -	-	-	32 0	33 2	35 8	36 0	37 6
Depth in hold - -	-	-	13 6	11 0	14 6	15 5½	16 0
Burthen in tons -	-	-	531	594	678	706	814
20 Gun Ships.							
Length on the gun deck	-	-	-	106 0	106 0	112 0	113 0
of the keel for ....tonnage -	-	-	-	87 9	85 8	91 6	93 4
Breadth, extreme -	-	-	-	28 4	30 6	32 0	32 0
Depth in hold - -	-	-	-	9 2	9 5	11 0	11 0
Burthen in tons -	-	-	-	374	429	498	508

Mr. Derrick informs us that the dimensions of the establishment of 1755, recorded in the above table, were determined from the proposals which the Lords Commissioners of the Admiralty directed the Flag Officers, the Surveyor of the Navy, and the Master Shipwrights of the dockyards, after consultation, to lay before them of a scheme of dimensions and scantlings, and a draught of a ship of each class, to remedy the defects which English ships were said to possess, of being weak from a deficiency in the scantlings, of not being able to carry so great a weight of metal as foreign ships, of their lower guns being too near the water, and of their being crank. The ships built according to these proposals, it is said, carried their guns well, and possessed sufficient stability, but were formed too full in their after bodies, a defect which was removed in the ships built at the commencement of the war in 1756, when a farther increase of dimensions was made. The improvement in the ships built according to the established dimensions of 1745, does not appear to have proceeded from any alteration in the *relative* proportion of the dimensions of the preceding establishments in 1719, 1733, and 1741. The length of the ships of the first class on the gun deck, in the order of these four dates, appears to have been 3.48, 3.48, 3.5, and 3.49 times the extreme breadth, where very little difference exists in the relative dimensions. The improvement in these ships arose from the general increase of the dimensions by which the guns were raised further above the water, (even supposing their height from the keel to remain the same,) in consequence of the load water line being lowered, the displacement being increased only by the additional weight of the hull, other weights remaining the same; the stability being also increased, the ships would incline less under the same press of canvass.

Spain was the first nation which increased the dimensions of the different classes of ships to considerable extent; and France followed her example with better success. The capture of the Princessa, soon after the commencement of hostilities with the former country in 1739, carrying 70 guns, and being upwards of 1700 tons burthen, pointed out the propriety of increasing the dimensions of our largest class of two decked ships, which may be seen by the following table to be so much inferior to her. The large two decked ships of the French were also proved to be very fine and powerful vessels, and in many points superior to the English eighty gun ships with three decks. In several instances, ships captured by the French were found, when retaken by the English, to have had their force reduced from what they carried in our service. The admiralty consequently directed the eighty gun ships then in use, with three decks, to be substituted by two decked ships of 74 guns, whose dimensions were particularly considered, and care taken that their lower tier of guns should be six feet above the water.

Comparative Dimensions of three ships of different nations about the middle of the eighteenth century.

	Length on the gun deck.	Extreme breadth.	Burden in tons.	Length in proportion to the breadth.
	ft. in.	ft. in.		
Shrewsbury, English ship of 74 guns, launched in 1750,	166 1	47 1	1594	3.52
Magnanime, of 84 guns, captured from the French in 1747,	173 7	49 7½	1832	3.49
Princessa, of 70 guns, captured from the Spaniards about 1740,	165 1	49 8	1709	3.32

The increase of dimensions in the English ships of 74 guns, proceeded very slowly. Their general dimensions appear to have been confined to 168 feet 3 inches in length, 47 feet 4 inches in breadth, and 1644 tons burden. England did not possess any two decked ships carrying 84 guns till after the middle of the eighteenth century. The French and Spanish navies were long inferior to the English in their want of three deckers, of which experience taught them the largest classes were much too powerful for their largest two deckers. It was not till after the peace of 1763 that either France or Spain possessed a single ship of three decks. The English three decker, the Royal George, carrying 100 guns, launched in 1756, of 2046 tons burden, was built of superior dimensions to our preceding first rates, and commenced that increase of size which has been so successfully carried forward in modern ships, and which has not yet attained by any means its limit.

The following table shows the magnitude and relative dimensions of the principal classes of modern ships of several European nations. The length and breadth would have been taken at the load water section, if they could have been obtained for all the ships. There will be, however, no considerable error in comparing them according to the dimensions given in the table.

Comparative dimensions of modern ships of different nations.

Names of ships.	Number of guns.	Length on the gun deck of the line of battle ships, and on the lower decks of the frigates.		Extreme breadth.		Burden in tons.	Proportion of the breadth to the length.
		ft.	in.	ft.	in.		
English.							
Caledonia,	120	205	0	53	6	2602	$\frac{100}{383}$
Ganges,	84	193	10	51	5¼	2255	$\frac{100}{376}$
Bulwark,	76	176	2½	48	9	1836	$\frac{100}{361}$
Portland, frigate,	60	172	0	43	8	1468	$\frac{100}{393}$
Latona, frigate,	46	150	1½	39	11	1063	$\frac{100}{376}$
Spanish.							
San Josef,	110	194	3	54	3	2457	$\frac{100}{358}$
San Nicolas,	82	179	9½	49	7¼	1942	$\frac{100}{362}$
San Antonio,	74	174	10	47	10	1700	$\frac{100}{365}$
Medea, frigate,	44	147	2	40	1	1046	$\frac{100}{367}$
French.							
Commerce de Marseilles,	120	208	4	54	9½	2747	$\frac{100}{380}$
Tonnant,	84	194	2	51	9¼	2281	$\frac{100}{375}$
Bahama,	74	175	7	48	0	1772	$\frac{100}{365}$
Niobe, frigate,	44	156	0	40	8½	1142	$\frac{100}{383}$
Unité, frigate,	42	148	6	39	7	1040	$\frac{100}{375}$
Swedish.							
From Chapman's large work on ships of war.	110	207	8	55	7⅜		$\frac{100}{372}$
	80	186	2¾	50	4¾		$\frac{100}{369}$
	74	179	3½	49	0⅜		$\frac{100}{365}$
	40	151	1½	39	10⅜		$\frac{100}{379}$
Danish.							
Christian VII.	84	187	0	50	10½	2131	$\frac{100}{367}$
Princess Carolina,	74	173	1½	46	3⅞	1637	$\frac{100}{370}$
Freya, frigate,	42	148	7	39	4	1022	$\frac{100}{377}$

"The advantage of giving large dimensions to ships carrying a certain force, arises," says Mr. Morgan in an ingenious disquisition on this subject, contained in the third number of his 'Papers on Naval Architecture,' from several causes. It enables them to possess great stability, and thereby to carry a great press of sail, with a comparatively small body immersed in the water; thus giving them a great moving force in proportion to the resistance they experience in moving through the water, which must increase their rate of sailing. Large dimensions in proportion to the number of guns, gives fine quarters to the men in action. It also enables a finer form to be given to ships below the water, so that they may have a good entrance forward, and a clean run aft to the rudder: and to have the form best calculated to present great lateral resistance to the water, which prevents the ship from making much leeway. This form below the water, in connexion with great stability, is very beneficial in enabling the ship to beat off a lee shore.

The greater expense arising from the increase of dimensions is, however, a disadvantage which renders it desirable not to carry this principle far beyond necessary limits. The number and weight of guns a ship is intended to carry, must be the foundation of the design. The total weight of a ship being found, a corresponding displacement must be given, and the height of the lower tier of guns, when the ship is fully stored and provisioned, fixed at not much less than six feet from the water's surface. The number of guns to be placed on a deck being determined, with such a distance between them as naval officers have found to be sufficient to work the guns conveniently in action, and the necessary length given before the foremost and abaft the aftermost port, the least length which can be given to the ship is found. The breadth in proportion to the length must then be determined, so that the stability may be sufficient to work the leeward guns in a strong wind. The draught of water being then determined, such as experience has found to be necessary to keep a ship of such a class up to the wind, the form of the body may be given according to the judgment of the constructer, the best calculated for producing the necessary qualities of velocity, lateral resistance, answering the rudder readily, &c. Should the total displacement be then found equal to the weight of the ship, the dimensions are determined according to the necessary limits. Whatever increase of dimensions beyond these limits may be given, to alter any particular property, must be at the disadvantage of additional expense.

From these tables also may be seen, the relative proportion between the length and breadth of the ships of different nations. The determination of the breadth to be given to any ship of which the length is fixed, is one of the most important considerations in the design. It is this dimension which principally affects the stability of ships,—a quality on which the efficiency of a man-of-war, as well as its safety, depend. Although in order to determine the true value of the moment of stability, it is necessary to find the correct volumes of the parts immersed and emerged by the inclination, yet the breadth being the principal element in the determination of the value of this property, a tolerably correct judgment of the relative stability of ships, if not very dissimilar in form, may be generally obtained by comparing their relative breadths. This property, *ceteris paribus*, continues Mr. Morgan, is proportional to the length and third power of the breadth; so that a very small addition to the breadth increases the stability as much as a very considerable addition to the length. The advocates for great length in proportion to the breadth of ships, assert that long and narrow ships are the fastest sailers. With the same moving power, that is, with the same quantity of sail, the long and narrow ship, under some circumstances, particularly with the wind aft or but little on the quarter, in light breezes and a smooth sea, may sail faster than a broader and shorter ship. But when a ship sails with the wind at any point between the limits of being close-hauled and on the quarter, the ship is necessarily inclined by the power of the wind on the sails, and requires sufficient stability to prevent the inclination becoming too great. A deficiency in stability is frequently of the most serious consequence: it may cause the loss of a ship on a lee-shore: it may prevent a ship in a stiff breeze, when engaged with an enemy, from using the leeward guns: in a chase it may render a ship incapable of carrying the necessary press of sail to come up with the enemy: by a ship heeling much, it brings the round part of the body into the water, and the keel and lower parts of the body, which oppose the greatest lateral resistance to the water, become more oblique to its direction, and the ship is consequently allowed to fall to leeward more than it would if less inclined; the effect of the force of the wind on the sails is also diminished by its direction being more oblique when the ship is inclined. The importance of a ship possessing great breadth in proportion to the length, to ensure sufficient stability, appears under these circumstances much more than to counterbalance the advantage, which, by having greater length in proportion to the breadth, might be obtained in velocity in light winds and a smooth sea. It may be observed, that too great stability is, on the other hand, dangerous by the great strain it brings on the ship, and the liability it gives of carrying away the masts. But this is an excess which is very rarely complained of: the more frequent defect appears to be a deficiency in this quality.

In the last column of this table is shown the breadths of the different ships in proportion to their lengths. In the ships of three decks, the relative breadths of the ships of the different nations is in the following proportion and order: of the Spanish ship $\frac{100}{358}$, of the Swedish $\frac{100}{372}$, of the French $\frac{100}{360}$, and of the English $\frac{100}{363}$; where the relative breadth of the Spanish ship is seen to be the greatest, and of the English ship the least. In the large class of ships of two decks, of 80 guns and upwards, the relative breadth is in the following proportion and order: of the Spanish ship $\frac{100}{362}$, of the Danish $\frac{100}{367}$, of the Swedish $\frac{100}{369}$, of the French $\frac{100}{375}$, and of the English $\frac{100}{376}$; where the relative breadth of the Spanish ship is seen to be the greatest, and of the English ship the least. The difference, however, in the relative breadth of the last two, the French and English ships, is very little, and if some other French eighty-fours had been taken instead of the Tonnant, the relative breadth of the French and English ships of this class would have been the same, the Ganges having been built after a French ship, the Canopus. In the smaller ships of two decks, the relative breadth is in the following proportion and order: of the English $\frac{100}{361}$, of the Spanish, Swedish and French $\frac{100}{365}$, and of the Danish $\frac{100}{373}$; where the relative breadth of the English ships is the greatest, and of the Danish the least. In the frigates, the relative breadth is in the following proportion and order: of the Spanish ship $\frac{100}{367}$, of the French Unité (while in the French service, the Imperieuse) $\frac{100}{375}$, of the English Latona (one of a numerous class in our service, built after the old Leda) $\frac{100}{376}$, of the Danish $\frac{100}{377}$, of the Swedish $\frac{100}{379}$, of the French Niobe $\frac{100}{383}$, and of the English Portland $\frac{100}{393}$; where the relative breadth of the Spanish frigate, is seen to be the greatest, and of the English 60 gun frigates the least. The relative breadth of the French frigates taken during the last war, is generally nearer that of the Niobe than of the Unité.

From this comparison, continues Mr. Morgan, it appears that the relative breadth of our 120-gun ships is less than that of the three-decked ships of the other nations; that the relative breadth of our large class of two-decked ships agrees nearly with that of the French, and is less than that of the ships of the other nations; and that the relative breadth of the 60-gun frigates is considerably less than that of the frigates of other nations, and of most of our own frigates. The relative breadth of the Latona stands high in the order of the ships of their respective classes.

It does not appear, from this table, that any regularity exists in the proportion between the length and breadth of ships according to their magnitude. Whether ships, as they increase in magnitude, should have greater or less relative breadth in proportion to their length, does not appear to have been attended to as a general principle in the designs of the ships of different nations. In the Spanish ships, the relative breadth of those of three decks is greater than that of the ships of two decks, and the relative breadth of the larger Spanish and Danish ships of two decks is greater than that of the smaller ships of two decks, and the relative breadth of the two-deckers is greater than that of the frigates. In the ships of the other nations, the contrary is more frequently adopted, although very irregularly.

The first consideration respecting the relation between the length and breadth of ships of different magnitude, is, whether large or small ships require the greater relative stability. Now suppose a larger and smaller ship to have their moments of sails in proportion to their stability, and the height of their lower tier of guns to be the same from the water's surface, when they are upright; while these two ships would then be inclined, by the force of the wind on the sails, to the same angle, this inclination might be dangerous to the larger ship, but quite safe to the smaller ship, the sides of the two ships above the water being immersed nearly in proportion to their breadth. Supposing the breadth of the larger ship to be 50 feet, and of the smaller 40 feet, and the height of the lower ports in both ships to be six feet from the water's surface, when the lower ports of the smaller ship are, in consequence of the inclination, two feet from the water, the lower ports of the larger ship are only one foot from the water.

Supposing that the moment of sails is given in a proper proportion in the smaller ship, a smaller moment of sails in proportion to their relative stability must either be given to the larger ship, or a greater moment of stability, retaining the same moment of sails. For the sake of velocity, it is desirable that the stability of the larger ship should be increased.

Suppose the two ships to be similar, the one carrying two tiers of guns, the other three. The stability being in the proportion of the fourth power of the simple dimensions, if the centres of gravity of the two ships were raised above the centres of gravity of the displacements only in proportion to the dimensions of the ships, the stability of the larger ship would be increased in a much greater proportion than in the smaller ship; but as the centre of gravity in the large ship is raised by the additional deck and tier of guns higher than in the proportion of the dimensions, the stability is increased in one way and diminished in another. The effect of these elements of the stability on the value of its moment should be correctly ascertained. Probably, on the whole, the stability of the larger ship may generally be rather increased than diminished by the alterations, but not sufficiently without a little increase of relative breadth. This, however, could be obtained by calculation and experiments on other different classes of ships, and would be valuable information for the determination of the relative dimensions of ships of different sizes.

By comparing the dimensions in this table with those of the three ships given in a former table, it appears that the breadth of ships in proportion to their length is less in this table than in those which were built about the middle of the last century. The relative breadth of the Spanish ship appears to have been then, as well as at later periods, the greatest in proportion to the length; the relative breadth of the English ship in proportion to the length appears to have been considerably less than that of the Spanish, and a little greater than that of the French ship. By the table also, it appears that the relative breadth of English ships in proportion to their length was increased in the establishment of 1706 from the dimensions of preceding establishments, and that this relative increase continued with very little alteration till 1745. Towards the end of the last century a decrease of their relative breadth was introduced, which has influenced most of the subsequent designs. The breadth of the largest ships, by the establishment of 1745, varied from $\frac{100}{349}$ to $\frac{100}{355}$ the length; at the present time, the breadth of most of our line of battle ships is within the limits of $\frac{100}{361}$ and $\frac{100}{382}$; by which it appears that the relative breadth of our line of battle ships is considerably less at present than it was at that period.

The proportional breadth which should be given to ships is very materially affected by the consideration of the number and weight of the guns which they are intended to carry; as the greater the number of guns, and the greater their weight, the more is the stability diminished by the greater elevation of the centre of gravity of the ship, which must be counteracted by a corresponding increase of breadth. The best disposition of force as to the calibre of the guns to be used on board different ships, is a very difficult subject, and particularly requires, Mr. Morgan observes, the opinion of experienced and scientific naval officers for its determination. It appears to be generally admitted, that the effect of large shot is much more destructive than that of a greater number of smaller shot, making together the same weight. The limit to which the size of the guns on board ship may be carried with advantage, is bounded by the consideration of the number of hands required to work them, the convenience of handling the shot in action, the strain brought on the beams and ship's sides by their weight, and the effect they produce on the stability of a ship. The height of the guns above the water influences very materially the stability; and while particular attention should be paid, that the lower tier should be at a sufficient height to use the leeward guns under all circumstances in which they may be required, the upper tiers should be kept as low as possible.

The establishment of guns in 1757 and 1762, directed in the first rates, 42-pounders on the lower deck, 24-pounders on the middle deck, and 12-pounders on the upper deck. The establishment of 1792, directed 32-pounders on the lower deck, 24-pounders on the middle deck, and 18-pounders on the upper deck. It appears that 42-pounders have been considered too heavy for use on board ship. The large line of battle ships of the Americans* carry long 32-pounders on the lower deck, short 32-pounders on the upper deck, and 32-pounder carronades on the quarter deck, waist, and forecastle. The advantage proposed by this disposition of force, is the great weight of metal of a broadside, and the prevention of mistakes in the size of the shot in action. The principal force of large ships being chiefly required in general action, and at short distances, the short 32-pounders and the carronades are adopted as giving a very efficient force. The total weight of metal of a broadside of an English 120 gun ship is 1520 lb.; the weight of metal of one of these American two decked ships, carrying guns in the waist, is 1600 lb. The English first rate has thus the appearance of a greater force than it possesses, from the smallness of the weight of metal of many of the guns. To concentrate the weight of metal appears desirable, not only as preventing incorrect comparison, but as giving the most efficient force, and as affording the means of keeping the weight of the guns low.

The most important consideration respecting any proposed disposition of guns, is to place the lower tier at such a height as to be at a sufficient distance from the load-water-line, and to give the ship such breadth as to ensure a proper moment of stability.

The advantage of dividing the ships of the royal navy into as few classes as the different services would admit, has been frequently recommended as very desirable, particularly as relates to the appropriation of stores and gear. Experience may eventually determine the classes, into which the royal navy might be advantageously divided. Such a division must, however, always be subject to alteration from previously unforeseen circumstances; such, for instance, as the adaptation of steam vessels to the purposes of war, &c. Ships of three decks might probably be confined to one class, having a little greater breadth, and a little more height from the lower deck to the load-water-line than our present first rates. Ships of two decks may also probably be confined to one class, carrying 84 guns, as our present ships Ganges and Asia, with a little increase of breadth. Frigates might, perhaps, be confined to two classes, the larger carrying 60 guns,

* "Mr Morgan was on board one of these ships, the Washington, at New York, a few years ago, which carried 100 32 pounder guns and carronades: 32 long 32-pounders on the lower deck, 34 short 32 pounders on the upper deck, and 34 32-pounder carronades on the quarter-deck, waist, and forecastle."

of about the same length as our present frigates of this class, and of a greater breadth; and the smaller class of 46 guns, of nearly the same length and breadth as our present frigates of this force built after the Leda. The present 28 gun frigates are generally considered a bad class, having too great a height above the water in proportion to the part of the body below; the same defect which the old 80 gun ships with three decks, and the 64 gun ships with two decks possessed. This cannot be fully corrected without their dimensions being so considerably increased, as to render it questionable whether their expense might not be too great for their relative utility. A large class of corvettes, similar to some built in America, carrying 24 or 26 guns, might in many services substitute these small frigates, and be a powerful and useful ship in the service. Our corvettes of 18 guns fully substitute the 18 gun brigs, found too large for their rig, and are useful vessels for general service. The present 10 gun brigs, which are found good sea boats, might be the last class. These seven classes, with cutters and other small craft, might probably constitute advantageously the royal navy.

There appear to be limits, beyond which the magnitude of the three great divisions of the navy into ships having one, two, or three decks, cannot be carried, without injuring their properties, and increasing the expense of construction, equipment, and wear and tear, to an extent incompatible with their respective force and general service. If a nation does not possess ships of each of these three divisions, of the greatest magnitude of the respective limits, which although not yet correctly defined, experience has advanced far towards approximating to, it may be surprised in wars with other nations, by having to oppose, with great inconvenience and additional expense, and perhaps ineffectually, the smaller ships with two decks to the largest ships of one deck, and ships with three decks to the largest ships with two decks. The large ships with two decks, of 84 guns, and the large frigates of 60 guns, may probably have arrived near the greatest limits of magnitude of these divisions, and therefore would prevent surprise by new classes of ships of other nations.

To illustrate the loci of certain remarkable points connected with the formation of a vessel, Chapman constructed an ingenious figure, and which we have given in Fig. 1, Plate CCCCXCIV, for the information of our readers. Its description is as follows:—

On the load water line AB, a series of intervals 20, 40, 60, 80, 100, &c. are assumed as representatives of different lengths from the stem to the stern post of a vessel. Chapman then found, that in the case of a bark, the locus of the centre of gravity of displacement would be denoted by the line CGB, the locus of the metacentre by DDB, and that of the centre of gravity of the ship and lading by EEB. In the case of a frigate, he found FFB to be the locus of the centre of gravity of displacement, GGB that of the metacentre, and HHB that of the ship with its lading. So that for a vessel of the form of a bark 80 feet long, the distance from the load water line to the centre of gravity of displacement, would be denoted by LC; the height of the metacentre above the load water line by LD, and the depression of the centre of gravity of the vessel with its lading, below the load water line, by the quantity LE. But for a frigate, the distance of the centre of gravity of displacement below the load water line would be LF, the height of the metacentre above the same line LG, and the distance of the centre of gravity of the ship and lading below the water, LH. The length of the mainmast, moreover, is determined by the distance of the line HB from the same plane BA, so as to be of a magnitude corresponding to the stability.

If there be given to large and small ships, a form similar to that which is 110 feet in length, the straight line MB in the figure will represent the locus of the metacentre, and the line K K B the curve which will determine the length of the mainmast, so as to be in its proper relation to the stability.

In the formation of these curves, Chapman has introduced one supposition not strictly proper, and that is a uniformity in the density of the lading, a condition which, it is manifest, cannot in all cases be fulfilled. The graphic representations, however, he has given will be found of very essential service in the practice of shipbuilding. It would be possible to construct a series of curves for ships of the same class, which should embrace the important condition of a variable density in the lading.

Experience has taught us that the place of the midship bend exercises a very sensible influence on the properties of a ship; its situation depending more or less on the form of the extremities.

This will be apparent, if we compare a body composed of two wedges joined at their bases, and the place of whose centre of gravity is given, with another body of the same length, but composed of two hemispheroids; then it will be found, that the lengths of these spheroids will not bear the same proportion to the whole length as those of the wedges; or, in other words, the greatest breadths of the two bodies will be at different distances from their extremities.

To approximate in some degree to the situation of the midship bend, let ADBI, Fig. 2, Plate CCCCXCIV, represent the body of a ship, in which DI is supposed to denote the position of the section desired, and ADF, AIF similar parabolas, and BDF, BIF other like curves of that kind. Let C moreover be the middle point of the length from the stem to the stern post; E the centre of gravity of the entire vessel;* G the centre of gravity of DAI *before* the greatest section, and H the centre of gravity of the other portion of the vessel, abaft the same plane.

Assume AB, the entire length of the vessel $= a$, FA the distance of the midship section from the extremity $A = x$, and CE the interval between the middle point of the length, and the centre of gravity of the vessel $= m$. Now, by the property of the parabola, the distance of its centre of gravity G from the point $A = \frac{5}{8}$ AF, and FH $= \frac{3}{8}$ FB. Moreover, the areas of the parabolic spaces ADI, BDI vary as x and $a-x$; and referring every thing to the point A, we obtain the equation $\frac{5}{8}x^2 + (x + \frac{3}{8}(a-x))(a-x) = a(\frac{1}{2}a - m)$, which furnishes, by the ordinary processes

* Assuming the position E of the centre of gravity of the vessel is not rigidly correct; but the error is of no great moment, and it simplifies the investigation.

of algebraic reduction, the value of $x = \frac{1}{4}a - 4m$; and from which it follows, that the distance between the middle of the length of the ship, and its greatest section, ought to be four times the distance between this middle point and the centre of gravity of the ship. In a ship fuller at its extremities, so that $AG = \frac{7}{12}AF$, the distance of the greatest section from the middle $= 6m$. Should it be still fuller, so that $AG = \frac{9}{16}AF$, the distance of the greatest section before the middle point will be $8m$.

Hence it is seen, says Chapman, that the greatest section should be before the middle of the length for sharp ships, as frigates, four times the distance of the middle point of the length from the centre of gravity of the ship; and for merchant ships, which are very full, eight times the same distance.

This is the place of the midship bend, when the distances are estimated on the load water line; but if they are taken on the upper part of the keel, to which the frames are commonly placed perpendicular,† the midship bend ought to be a little before the greatest section, by a quantity depending on the difference of the draught of water forward and aft, and on the curvature of the ship at the middle.

This distance may be considered, in general, as equal to the difference of the draught of water.

OF THE SCALE OF SOLIDITY.

By a scale of solidity, we are to understand a method employed by naval architects, for ascertaining the displacement of a ship, at different depths below the load water line, by means of a curve, whose abscissæ correspond to the respective draughts of water, and ordinates to the displacements at the same points.

To construct a scale of solidity for the vessel whose entire displacement was before calculated, we must have recourse to the last column of the general table of results, named "Total Areas of Semi-Horizontal Sections."

If we refer to the table of results here quoted, and to the second figure of Plate CCCCLXXXVIII, we shall, in the first place, perceive that the *total* displacement of the vessel, or, in other words, the displacement *below* the load water line 1°, amounts to 100977.93 cubic feet, or 2885.08 tons; and that to ascertain the displacement *below* the horizontal section 2°, we must deduct from the total displacement, the solidity of the part comprised between the sections 1° and 2°. In performing the subsequent calculations, the areas of the semi-horizontal sections contained in the column above referred to, must be doubled to obtain the *total* areas of the horizontal sections, and also the total displacements.

To obtain the contents of the solid between the horizontal sections 1° and 2°, it is manifest, since the interval between the sections is one foot, that the mean of the two, or $\frac{7517.42 + 7438.64}{2} = 7478.03$ cubic feet is the quantity desired; and that by subtracting this result from the total displacement, and dividing the result by 35, there will remain 2671.43 tons for the displacement of the vessel *below* the horizontal section 2°. Hence it appears, that by decreasing the draught of water one foot, the displacement will be diminished 213.65 tons.

To determine, in the next place, the displacement below the horizontal section 3°, the solidity between the sections 1° and 3° must be determined, and the result subtracted from the total displacement. This must be accomplished by means of the formula $(\Sigma + 4\,S + 2\,s)\frac{i}{3}$, and for which in the present case, we have the following elements:

Extreme Areas.	Even Area.	Odd Area.
7517.42	7438.64	
7335.24	4	
14852.66 = Σ	29754.56 = 4 S	Zero.

And since $\frac{i}{3} = \frac{1}{3}$, we shall have $(\Sigma + 4\,S + 2\,s)\frac{i}{3}$

$= (14852.66 + 29754.56 + 0.0) \times \frac{1}{3} = 14869.07$,

for the solidity of the part required. Hence, by taking this from the total displacement, and reducing the result into tons, we shall have 2460.25 tons for the displacement of the vessel *below* the section 3°. So that by decreasing the draught of water 2 feet, the displacement is diminished 424.83 tons.

Again, to determine the displacement *below* the horizontal section 4°, the solidity of the part contained between the planes 3° and 4° must be first determined, and to it added the solidity of the part between the sections 1° and 3° before determined, and the sum taken from the total displacement.

The solidity between the sections 3° and 4° is evidently $\frac{7335.24 + 7204.54}{2} = 7269.89$

Solidity between the sections 1° and 3° before determined $= 14869.07$

Solidity between the sections 1° and 4° $= 22138.96$

Hence $\frac{109977.93 - 22138.96}{35} = 2252.54$ tons,

which is the displacement *below* the horizontal section 4°. Thus, by decreasing the draught of water 3 feet, the displacement is diminished 632.54 tons.

To determine, in the next place, the displacement *below* the section 5°, recourse must be again had to the formula for equidistant ordinates, by which means we have

Extreme Areas.	Even Areas.	Odd Area.
7517.42	7438.64	7335.24
7046.80	7204.54	2
14564.22 = Σ	14643.18	14670.48 = 2 s
	4	
	58572.72 = 4 S	

† It has been usual for constructers to place the different bends of timbers, at right angles to the line of the keel; a position, particularly in small ships, of the most objectionable kind, from the unnecessary strains to which the fastenings are exposed. Dr. Inman, the Professor of the College of Naval Architecture at Portsmouth, has with his usual judgment, placed the timbers of the Sapphire, one of the new experimental ships, *at right angles to the intended load water section*, a position sanctioned by the soundest principles of science.

and since $\frac{i}{3} = \frac{1}{3}$ we shall farther have

$(\Sigma + 4\ S + 2\ s)\frac{i}{3} = (14564.22 + 58572.72 + 14670.48) \times \frac{1}{3} = 29269.14$. Hence, by subtracting this from the total displacement, and reducing the result into tons, we have 2048.82 tons for the displacement *below* section 5°. Therefore, by decreasing the draught of water 4 feet, the displacement is diminished 836.26 tons.

Again, to obtain the displacement *below* the horizontal section 6°, we have

the solidity between the sections 5° and 6°

$= \frac{7046.80 + 6907.40}{2} = 6977.10$

Solidity between the sections 1° and 5° before determined $= 29269.14$

Solidity between the sections 1° and 6° $= 36246.24$

Hence $\frac{100977.93 - 36246.24}{35} = 1849.48$ tons must be the displacement below the horizontal section 6°. Therefore, by diminishing the draught of water 5 feet, the displacement is decreased 1035.6 tons.

To determine the displacement below the horizontal section 7°, we have

Extreme Areas.	Even Areas.	Odd Areas.
	7438.64	
7517.42	7201.54	7335.24
6617.16	6907.40	7046.80
14134.58=Σ	21550.58	14382.04
	4	2
	86202.32=4S	28764.08=2s

And since $\frac{i}{3} = \frac{1}{3}$, we shall farther have

$(\Sigma + 4\ S + 2\ s)\frac{i}{3} = (14134.58 + 86202.32 + 28764.08) \times \frac{1}{3} = 43033.66$. And by subtracting this result from the total displacement, and dividing the difference by 35, we shall have 1655.55 tons for the displacement below the horizontal section 7°. Thus, by decreasing the draught of water 6 feet, the displacement will be diminished 1229.53 tons.

By obtaining in this manner the displacements below the successive horizontal sections (applying the formula for equidistant ordinates, when the number of areas is *odd*, and when they are *even*, adopting the method above employed for ascertaining the displacements below the sections 4° and 6°) we shall obtain the numbers recorded in the first numerical column of the following table: and if we farther subtract each of these results from the total displacement, (2885.08 tons) we shall find the numbers entered in the second numerical column, and which denote respectively the successive alterations of displacement, produced by an uniform diminution of the draught of water.

Displacement of the Horizontal sections.		Decrease in the displacement produced by diminishing the draught of water.	
	Tons.		
Section 1°.	2885.08	Zero.	0. 0
Section 2.	2671 43	1 foot.	213 65
Section 3.	2460.25	2 feet.	424.83
Section 4.	2252.54	3 feet	632.54
Section 5.	2048.82	4 feet.	836.26
Section 6.	1849.48	5 feet.	1035 60
Section 7.	1655.55	6 feet.	1229 53
Section 8.	1470.26	7 feet.	1414.82
Section 9.	1292.80	8 feet.	1592.28
Section 10.	1123.94	9 feet.	1761.14
Section 11.	963.78	10 feet.	1921.30
Section 12.	812.96	11 feet.	2072.12
Section 13.	671 91	12 feet.	2213 17
Section 14.	541 11	13 feet.	2343.97
Section 15.	420.78	14 feet.	2464.30
Section 16.	311.52	15 feet.	2573.56
Section 17.	214 47	16 feet.	2670 61
Section 18.	132 50	17 feet.	2752 58
Section 19.	67.93	18 feet.	2817.15
Section 20.	29.92	19 feet.	2855 16
Section 21.	14.75	20 feet.	2870.33

To construct the desired scale of solidity, let the vertical line 1° B. Fig. 3, Plate CCCCXCIV. be drawn equal to 22.35 feet, the mean draught of water, measured from the under side of the false keel; and let this line be divided at equal intervals of a foot, at the points 2°, 3°, 4°, 5°, 6°, &c. corresponding to the intervals at which the foregoing displacements were computed. At the point 1°, erect the perpendicular line 1°A equal to 2885.08 tons, the displacement below the horizontal section 1°: and at the point 2°, the perpendicular 2°C equal to 2671.43 tons, the displacement below the horizontal section 2°; at the point 3°, the perpendicular 3°D equal to 2460.25 tons: at the point 4°, the perpendicular 4°E equal to 2252.54 tons; and through the remaining points 5°, 6°, 7°, 8°, 9°, &c. perpendiculars corresponding respectively to the displacements at those points. Then, if through the extremities A, C, D, E, &c. a fair and uniform curve be drawn, the scale of solidity will be completed, and the uses of which we shall now proceed to exemplify.

Suppose in the first place, the vessel were floating at her load water line 1°A, and that it were necessary for some purpose to diminish her draught of water four feet. Then since the line 1°A represents the displacement at the load water line, and 5°F the displacement corresponding to the point 5, or when the draught of water is diminished four feet; through F draw F*a* parallel to 1°B, and A*a* will represent on the scale of equal parts from which 1°A was laid off, the quantity of lading or stores to be removed, in order to reduce the draught of water to the desired quantity. The value of A*a* in the example selected will be 836.26 tons.

Suppose, in the next place the converse case were to occur, to ascertain what alteration would take place in the draught of water, by diminishing the lading by any given quantity, say 419 tons, when the load water line was denoted by 2°C. If on this water line, C*b* be laid off equivalent to the 419 tons, and through *b*, the line *b*E be drawn to intersect the curve of solidity in E, and E4° be drawn parallel to A1°, intersecting $1^\circ B$ in 4°, then will $2^\circ\ 4^\circ$, measured on the scale of equal parts, be the diminution of the draught of water desired, and which in the present instance is two feet.

Again, suppose a vessel had received some unknown portion of her lading, and it were required to ascertain by means of the scale of solidity, the exact quantity thereof. Let the mean draught of water be in the first place ascertained, and laid off from B to H; and through H let HI be drawn parallel to $1^\circ A$, meeting the curve of solidity in I. From I let IK be drawn perpendicular to $1^\circ A$. Then will HI, measured on the scale of $1^\circ A$, represent the actual displacement produced by the vessel and her present lading; and AK the quantity necessary to bring her down to the load water line $1^\circ A$. Also $1^\circ H$ will denote the depth to which the vessel will sink, in order to receive the portion of the cargo denoted by AK.

Suppose, lastly, that a vessel had received a known portion of her cargo, and it were required to ascertain the draught of water produced thereby. On the load water line $1^\circ A$, lay off $1^\circ L$ equal to the given displacement, and through L draw LM perpendicular to $1^\circ A$, intersecting the curve of solidity in M. Through M draw MN parallel to $1^\circ A$, intersecting $1^\circ B$ in N. Then will NB denote the mean draught of water required.

The uses therefore of scales of solidity are very great, and in the mercantile navy in particular, are of the highest importance. Every ship ought to have a scale of solidity constructed for it; and the more numerous the horizontal sections for which it is calculated, the better. It is probable, also, that if the properties of the curves of solidity of several vessels of each class of our men-of-war were investigated, some analytical relations might be discovered, of great importance to naval architecture.

It may be proper to remark, that in consequence of the great *numerical* disproportion between the *displacements* and their corresponding *draughts of water*, it is convenient in practice, to adopt different scales for those elements. For example, if $1^\circ A$, which in the present case is represented numerically by 2885, be measured by the same scale as that employed for the draught of water, the figure will be of an inconvenient size, unless the scale for the latter be assumed very minute, which will be attended also with disadvantage. The best way, therefore, is to adopt one convenient scale for the draught of water, and another for the displacement, but taking care in the application of the figure, to measure each by its own proper scale.

ON CALCULATING THE TONNAGE OF SHIPS.

The method of constructing a scale of solidity, naturally leads to the consideration of the mode by which the tonnage of a ship should be calculated; an interesting disquisition on which, we add from the pen of Mr. Morgan.

The propriety of having some scale by which the magnitude or capacity of ships may be compared with one another under one point of view, is universally acknowledged. Different causes, according to the services to which ships are applied, conduce to the propriety of a true method of comparison. If the number of guns a ship of war carries be correctly stated, and subject to no variation, and the number of guns should bear a constant relation to the magnitude of the body, the designation of a ship according to the number of guns might be sufficient for general purposes; as ships of war require chiefly to be compared with respect to their force.

The tonnage is generally used as a measure, by which ships built by contract are paid for. In order that this method of estimating the value of a ship may be correct, the relative alteration of any dimension should alter the tonnage in the same proportion, as it would effect the expense of building the ship. By the present method of measuring the tonnage, the increase of the breadth of a ship increases the tonnage in a much greater proportion than the expense of building. Though other rules may be given for calculating the tonnage of ships, which may be less incorrect as a scale of payment of building than the one at present in use, yet, as no correct analogy can be established between the tonnage and the expense of building, it appears desirable that some other scale of payment should be adopted, founded on more correct principles. If any part of the displacement of a ship be taken as a measure of the expense of building, it appears more reasonable that the weight of the hull, which is determined by the light displacement, should be taken, than the part of the displacement which is brought into the water by the lading. A better scale of the expense of building ships even than this may probably be determined by attention to this particular object, there being certainly no necessity that the same scale of measurement should be used for the lading and expense of building.

The disadvantage of paying for ships in proportion to their tonnage, is, however, no doubt, in a great degree corrected by a full examination of the design, previously to the settlement of the contract. In merchant ships, however this mode of payment is in numerous instances found to be injurious, by being the means of too little breadth being given to them in order to reduce the tonnage, and thereby lessen the expense of building.

A correct method of calculating the tonnage, although desirable for all ships for the sake of uniformity, is particularly necessary for merchant ships, which should always be compared by the true quantity of lading they can carry, in correct proportion to which their dues should be paid. The tonnage should be the correct measure of the number of tons of the lading of a ship. This is the weight that will bring a ship down in the water from the light water line, at which it swims when properly equipped with every thing on board, except the lading, to the load water line, at which it swims when laden.

This may be correctly found by determining the solid content of the body between the light and load water lines, the weight of which, considered as sea water, is the true lading; this solid divided by 35, the number of cubic feet of sea water in a ton, gives the true tonnage or weight of the lading.

The rule commonly used in England does not even approximate, on correct principles, to the true tonnage; the elements of the calculation being erroneously taken, the half breadth of the ship being substituted for the mean depth from the load to the light draught of water, and the divisor 94 substituted for 35, as a correction, though a very inadequate one, to this error.

Among the methods that have been proposed for the determination of the tonnage of ships, that of Chapman, in the eleventh chapter of his *Traite de la Construction des Vaisseaux*, is founded on the true elements of the calculation; it has, however, this serious disadvantage—that different divisors are taken at the will of the person who makes the calculation, according to his judgment of the relative fulness of the body between the load and light draughts of water.

That there would be considerable trouble in obtaining the correct tonnage of all the ships of the merchant navy, must be admitted: of the ships of the Royal Navy the trouble would be much less, as it could be calculated from the drawings by which they were built, which are always preserved in the Navy Office. But the correct tonnage, even of all merchant ships, might be obtained in a few years: and when the tonnage of the ships now afloat should be known, the great difficulty would have been surmounted, as the tonnage of every new ship could be calculated with comparatively little trouble. A scale of tonnage should be calculated for every ship, previously to its being launched, either from the drawing (if built from one), or from the ship itself. The light water line might be determined when the ship is fully equipped, with every thing on board except the lading, and transferred to the scale of tonnage previously made; the tonnage betwen this and the load water line would be the true tonnage, or weight of lading of the ship. The lading on board, when the ship swam at any intermediate line between the light and load water lines, would be immediately known by reference to the computed scale.

If it be objected, that many persons who are now capable of measuring the tonnage of ships would be unable to make these additional calculations, it may be answered, that as the number required to perform this service would be but small, sufficient persons might be found from those at present employed in this work, fully competent to undertake it: and indeed, that the calculations are so simple, that all might soon be perfectly acquainted with them.

Atwood gives in his paper on the stability of ships, in the *Philosophical Transactions of the Royal Society of London*, for 1798, p. 301, the tonnage of the *Cuffnells*, an East Indiaman, between the load water section and six successive horizontal sections below it, at two feet apart. The total displacement of this ship he determines to be 3410 tons.

The water-section, No. 12, is the load-water-section.

From the Water-Section.	Difference of Tonnage.	From the Water-Section.	Difference of Tonnage.
12 to 11	377 tons.	12 to 11	377 tons.
11 to 10	374	12 to 10	751
10 to 9	367	12 to 9	1118
9 to 8	357	12 to 8	1475
8 to 7	348	12 to 7	1823
7 to 6	333	12 to 6	2156

From these calculations a scale of tonnage may be formed, by which the weight of lading which would bring down this ship any distance between the load and light draughts of water may be immediately found.

The following method of calculating the tonnage of ships, although by no means superseding the propriety of scales of tonnage, may be considered superior to the rule at present in use, being founded on the true elements of the tonnage, the length and breadth of the ship, and the depth between the load and light draughts of water, and approximating very nearly to the true tonnage.

Let $a\,b$, Fig. 7, Plate CCCCXCII. represent the load-water-line, and $c\,d$ the light water-line; take the arithmetical mean of $a\,c$ and $b\,d$, which call e; let the length of the load water line, $a\,b$, be taken from the fore part of the rabbet of the stem to the after part of the rabbet of the stern-post, which call f; and let the greatest breadth at the load water line be represented by g. Multiply these three quantities together; then $\frac{x}{y} \cdot e\,f\,g$ will be the tonnage, in cubic feet, of sea-water, $\frac{x}{y}$ representing the fraction expressing the proportional part of the whole solid.

By obtaining the correct tonnage of different ships, by rules for calculating the contents of solids, it is found that $\frac{3}{4}$ may be substituted for $\frac{x}{y}$ subject to certain corrections, determined by reference to the ships whose tonnage is required. This correction may be most easily applied when reduced to a per centage, according to the different degrees of fulness of the part of the body contained between the load and light-water-lines, which may be determined by the following method:—

Draw $e\,f$ parallel to $a\,b$, and at a distance below it equal to half the mean of $a\,c$ and $b\,d$, and let $g\,t\,h$, Fig. 8, represent the horizontal view of this section; divide the whole length $g\,h$ into eight equal parts, and at the points of division draw $i\,q$, $k\,r$, $l\,s$, $m\,t$, $n\,u$, $o\,v$, and $p\,w$, perpendicular to the middle line $g\,h$. Take the sum of the lengths of these seven ordinates, and add to the part of the tonnage already found $1\frac{1}{2}$ per cent. for every one per cent. that this sum exceeds six times the length of the longest of these ordinates. This will give an approximate value of the tonnage to a great degree of accuracy.

Rule.

Take the length of the ship from the fore part of the rabbet of the stem to the after part of the rabbet of the stern-post at the height of the load water line, the greatest breadth of the ship at this height, and the mean depth between the light and load water lines; multiply these three dimensions together, and take $\frac{3}{4}$ the product, and divide by 35.

Then divide the length of the ship at half the mean depth between the light and load water-lines into eight equal parts, take the sum of the lengths of the seven half-breadths to the outside of the ship, and add to the above quantity $1\frac{1}{2}$ per cent. for every one per cent. this sum exceeds six times the length of the greatest of these half-breadths.

The result is the tonnage, or the weight in tons, that will be required to bring the ship down in the water from the light to the load-water line.

Example.

	Feet.
Length of a ship of 80 guns, from the fore part of the rabbet of the stem to the after part of the rabbet of the stern-post, at the height of the load-water-line . . .	181.75
Greatest breadth at this height to the outside of the plank of the bottom . .	50.25
Mean depth between the light and load-water-lines	7.83

Then $\frac{3}{4} \cdot \frac{181.75 \times 50.25 \times 7.83}{35} = 1532.4$ tons.

The sum of the seven half-breadths to the outside of the ship . .	161.5
The length of the greatest of these half-breadths	24.8

$24.8 \times 6 = 148.8$; then $161.5 - 148.8 = 12.7$.

12.7 is 8.5 per cent. of 148.8; and $1.5 \times 8.5 = 12.75$; then 12.75 per cent. of $1532.4 = 195.4$ tons.

Adding 195.4 tons to the first quantity, 1532.4 tons, the result, $1532.4 + 195.4 = 1727.8$, the required tonnage.

The light water line in His Majesty's ships can always be obtained by observation, and in merchant-ships it can be accurately taken when every necessary store is on board, including every thing but the lading, and entered on the register. There would be also frequent opportunities of proving the truth of it. Should this measurement be taken in any case when some of the stores (as anchors, cables, &c.) are not on board, proper deduction must be made for it in the calculation of the tonnage.

The principal trouble in this operation is the measurement of the half-breadths; but it requires only such a degree of attention as every one may be expected to pay who may be directed to perform the operation. The arithmetical operation is very simple, and may be as easily remembered as the present rule.

This rule admits of several modifications: a method less correct, but on the same principle, might be adopted by the measurement of the half-breadths on the lower deck, instead of the half-breadths at the horizontal section at the mean depth between the light and load water lines, or the measurement of fewer half-breadths might be taken; but the rule as above stated appears sufficiently easy for practice, particularly as greater correctness is always a sufficient reward for a little more trouble.

ON THE ARCHING OF SHIPS.

By the arching of a ship, we mean that alteration of form which every vessel undergoes from the moment it is launched. In every point of view in which the general problem of arching can be contemplated, it will be found to involve considerations of the highest importance to naval architecture. Owing its origin to those peculiarities of form, which the complicated conditions of stowage, stability, velocity, and general sailing qualities render necessary, it has been a great and principal object with the naval engineer, to preserve to the *floating* vessel unimpaired, those essential properties of form, which he endeavoured to impart to her in the process of *building*. Constructed, as ships in general are, of timbers of the most varied dimensions and forms,—disposed in directions of so many different kinds, and subjected to strains so changeable in direction and quantity, it may be fairly said, that next to the original determination of the best form, the skill and intelligence of the ship builder may be measured, by the degree in which the tendency to arching may be diminished. We shall hereafter have reason to admire the masterly combinations of Sir Robert Seppings, to prevent this derangement of the frames of our ships of war.*

We shall proceed to trace, by an inductive process, the operation of those forces that contribute to arching.

If, in the first place, an elastic body of any magnitude, specifically heavier than water, be wholly immersed in that fluid, no tendency to derange the figure or position of any of its axes will be produced, from the equal and uniform action of the water on its different surfaces. But if the solid be specifically lighter than water, and have consequently only a portion of its volume immersed, either of its axes,—whether it be longitudinal, lateral, or vertical, will be subjected to peculiar alterations of position and figure,—partly from the pressure of the fluid operating only on portions of its sides, and partly, if the form of the body be irregular, from the upward pressure of the water on its different vertical sections, not being equivalent to the weights of the sections themselves.

Let us, however, first take the case of a body, whose superior and inferior surfaces are equal, similar and parallel, and any vertical section of which is represented by ABCD, Fig. 1, Plate CCCCXCV. and let the line EF represent the surface of the water section, and therefore indicating the depth of the portion immersed.

Then since the upper and lower surfaces of the body are, by the hypothesis, equal, similar, and parallel, it follows that its sides are, in every part, perpendicular to the fluid surface. Suppose also the body to be composed of vertical laminæ of equal thickness, at right angles to the section ABCD, and let GH denote one of them. Then since the gravitating force of this lamina is exerted in the direction GH passing through its centre of gravity, and that this same line likewise passes through the centre of gravity of the column of fluid IH, displaced by the lamina: it follows from the laws of hydrostatics, that there will be an equlibrium between the gravitating force of the lamina, and the upward pressure of the fluid displaced by it: and that hence no derangement will take place in the particles constituting the lamina, from the influence of the pressure here alluded to. And since all the laminæ constituting the body are, by the hypothesis, similarly acted on by the fluid, it follows that no effort will be produced by the upward pressure of the fluid, to derange the form of the solid.

But suppose, in the next place, that some of the vertical laminæ, which make up the solid, should cease to preserve a perfect equality between the gravitating force and the upward pressure of the fluid; a case that would arise if a vertical section of the body were

* We cannot but regret that the important improvements connected with the trussed frame have not found their way more generally into our merchants' yards. It must be as beneficial to preserve a merchant ship from arching as a ship of war. We shall hereafter allude to some important considerations relating to the building of merchant ships.

of the form ABCD, Fig. 2, Plate CCCCXCV; some of the laminæ, as KL, receiving no upward support from the fluid, while their own gravitating powers remain undiminished: and others, as MN, deriving from the water only a partial support: it follows, that even if the sections between B and C could preserve their forms unchanged, those beyond the same points would by no means do so; and that, therefore, from the necessary adhesion existing among all the laminæ constituting the body, there would be a general tendency in the whole body to alter its form.

To investigate this new condition, let G denote the centre of gravity of the entire solid, and O that of its immersed volume; and let the line connecting those points be produced, so as to divide the entire solid into the two portions APQB, and DPQC. Now although, from the laws of hydrostatic equilibrium, the points G, O are situated in the same vertical plane, it by no means follows that the portion of the entire solid, APQB, and its immersed volume RSQB, in the present condition of the whole body, can have their centres of gravity in the same vertical plane. Hence we may imagine the centre of gravity of the former to be situated as at α, and of the latter as at β; the centre α, being, from the form of the body, necessarily farther from the vertical line PQ, than the centre β. In like manner, may we suppose the point γ to be more distant from the same vertical line PQ, than the point δ.

Now, the gravitating force of the solid APQB operating at α, and the upward pressure of the fluid at β, and that these forces act in opposite and not coincident directions; from those centres, let lines be drawn perpendicular to the fluid surface; and let W represent the gravitating effort of the body APQB, and w that of the fluid acting through β. Let also a similar construction be made with respect to the centres γ, δ, the weights W′, w' representing the mechanical efforts operating at those points.

If we now contemplate the effect of the forces acting at the points α, γ, it is apparent that their tendency is to *depress* the extremities of the body; whereas the action of the forces operating at the points β, δ, have a tendency to *elevate* its middle parts; and we know, from the theory of the neutral axis, that the ultimate effect of these forces must be, to make the entire body turn about a line of that nature, situated somewhere within the area of fracture, if the forces applied are capable of breaking the body; and which line, for the sake of illustration, we may suppose to be situated in the plane of the fluid surface at S; thereby causing all the fibres *above* that surface to be in a state of *extension*, and all *below* in a state of *compression;* while those fibres which pass through the neutral point S, undergo neither extension nor compression, but are in a state perfectly neutral with regard to both.

But if, in addition to the want of support afforded by the fluid to the inclined surfaces AB, CD, we imagine the vertical sections between B and C so constituted, as not in every case to be exactly in equilibrium with the columns of fluid displaced respectively by them; it is obvious that an additional tendency to arching will be created, and which we shall now more particularly investigate, by contemplating the actual conditions of a ship.

To discover the law which influences a ship, whether laden or unladen, when floating quiescently in water, we shall, in the first place, consider it with respect to its length, and afterwards in relation to its breadth.

To accomplish this, let us suppose a vessel to be divided into vertical sections of an indefinitely small constant thickness, perpendicular to the vertical longitudinal plane. If we commence our consideration at the stern, and advance gradually forward, it is evident that the sections comprising the counter and its connecting parts, being free from the water, will be subject to no reaction from it: and when at last any reaction of the fluid does take place, it must at first, from the peculiar form of the body, be infinitely less than the weight of the section whose displacement occasions it. As we approach, however, nearer the midship section of the vessel, the upward section of the fluid will approach more and more to an equality with the weight of its corresponding section, and ultimately become equal to it; and if we pass beyond this section, and which may be denominated the Section of Hydrostatic Equilibrium, we shall find the weight of the water displaced, become greater than the weight of the section above it. In like manner, if we commence at the bow of the vessel, we shall find a similar section of hydrostatic equilibrium, and afterwards a like increase of the weight of the water displaced above the weight of the section reposing on it.

Let us, therefore, in this very interesting inquiry adopt the investigation of Dupin, contained in his paper "*Sur la Structure des Vaisseaux Anglais,*" in the Philosophical Transactions for 1817.

For this purpose, let x represent the distance of any part of a vessel, from a vertical plane assumed as a standard of reference for the different moments, and let $d\,x$ be the thickness of the infinitely small sections parallel thereto. Let also $\varphi\,(x)\,d\,x$ denote the weights of those sections, and $\psi\,(x)\,d\,x$ that of the water which they displace. Then will the total moment of these forces be

$$x\,.\,\varphi\,(x)\,.\,d\,x - x\,.\,\psi\,(x)\,.\,d\,x,$$

and, consequently, the integral of the same system of moments

$$\int \Big\{ x\,.\,\varphi\,(x)\,.\,d\,x - x\,.\,\psi\,(x)\,.\,d\,x \Big\}.$$

Now, in order that this function may be either a maximum or a minimum, it is necessary that its variation should be zero, and which, therefore, produces the equation

$$\delta\int \Big\{ x\,.\,\varphi\,(x)\,.\,d\,x - x\,.\,\psi\,(x)\,.\,d\,x \Big\} = o.$$

But in this latter expression, neither of the original sections alters its weight; and the functions (x) and $\psi\,(x)$ remain constant, as well as the thickness $d\,x$ of the sections, only by removing the plane, with respect to which the moments are taken, to the distance $\delta\,x$ the section of which $\varphi\,(\delta\,x)$ represents the weight, and $\psi\,(\delta\,x)$ its displacement is added.

Hence we have

$$o = \delta\int \Big\{ \varphi\,(x) - \psi\,(x) \Big\}\, x\,d\,x = \int \Big\{ \tfrac{1}{2}\,\big[\varphi\,(\delta\,x) - \psi\,(d\,x)\big] + \big[\varphi(x) - \psi\,(x)\big] \Big\}\, d\,x\,.\,\delta\,x.$$

But since the functions $\varphi\,(x)$ and $\psi\,(x)$ become zero when we cause x to vanish,—these expressions represent the weight and displacement of a vanishing section; and hence we may perceive that $\phi(\delta x) - \psi(\delta x)$ becomes infinitely small when compared with $\phi(x) - \psi(x)$.

If, therefore, the expression $\phi(\delta x) - \psi(\delta x)$ may be neglected, much more may the function $\frac{1}{2}\left[\phi(\delta x) - \psi(\delta x)\right] d\,x \,.\, \delta x$; and hence the general expression representing the condition of either the maximum or minimum of the moments, which tend to produce arching, will be

$$o = \int \left\{\phi(x) - \psi(x)\right\} d\,x \,.\, \delta x,$$

or

$$o = \delta x \int \left\{\phi(x) - \psi(x)\right\} .\, d\,x,$$

in which $\int \phi(x)\, d\,x$ is the total weight of the sections under consideration, and $\int \psi(x)\, d\,x$ the total weight of the displacement of the same sections.

From this last equation of condition, we learn that the sum of the moments which tend to produce arching is either a maximum or a minimum, when the weight of the part of the vessel, either before or behind the plane of the moments, is equal to the weight of the water displaced by the same part of the ship.

It may be necessary, however, to distinguish the condition of the maximum from that of the minimum, and which may be discovered by the circumstance, that according as the term of the formula neglected has the *same* or a *contrary* sign from the expression for the total moment

$$\int \left\{\phi(x) - \psi(x)\right\} x \,.\, d\,x,$$

the sum of the moments, with relation to the plane determined, will be a *minimum* or a *maximum*.

But since $\phi(\delta x)\,\delta x$ is the weight of the section having δx for its thickness, and $\psi(\delta x)\,\delta x$ the weight of the water displaced by the same section, it follows that the quantity

$$\tfrac{1}{2}\left[\phi(\delta x) - \psi(\delta x)\right] .\, \delta x \,.\, d\,x$$

will be positive or negative, according as the weight of the infinitely small section, which commences at the plane of the moments, is greater or less than the weight of the water displaced by the section itself. From these principles we deduce the following theorems:

I. *That when a vertical plane divides a vessel into two parts, so that the weight of each part is equal to the weight of water displaced by it, the moments of those parts estimated in relation to the same plane, to produce what we have denominated arching, will be either a maximum or a minimum.*

II. *That this effect will be a maximum, when the infinitely small section contiguous to the plane of the moments, has its own moment in a contrary direction to that of the total moment.*

III. *That the effect will be a minimum when this section has its own moment acting in the same direction as the total moment.*

We shall proceed to the farther illustration of these theorems by their application to a seventy-four gun ship, the elements of which are derived from Dr. Young's paper on the employment of Oblique Riders, contained in the Philosophical Transactions for 1814.

Distribution of the forces operating on the hull of a seventy-four gun ship, when fitted for sea, its length being 176 feet, and breadth 47.5 feet.*

Length estimated on the plane of flotation, in feet.	Weights of the sections corresponding to those lengths in tons.	Displacements of the same sections in tons.	Differences between the weights of the sections and their displacements in tons.
49	+ 699	— 627	+ 72
20	+ 297	— 405	—108
50	+1216	—1098	+118
20	+ 290	— 409	—119
37	+ 498	— 461	+ 37
176	+3000	—3000	=000

* As many of our readers may be desirous of having the whole of the analytical investigation relating to this important subject, from the pen of Dr. Young, we add it in the following note.

The laws of equilibrium will not allow us to suppose the above forces concentrated in the middle of the respective portions, or equally distributed through them; and it becomes necessary, that one of the weights should be situated further forwards, which must be that of the foremost portion, containing the bowsprit and its rigging. It is also natural to suppose the excesses of weight and pressure distributed with as few abrupt changes as possible, so as to neutralise each other at the common termination of the adjoining portions, and to become more unequal in parts more remote from these neutral points. Thus the excess of weight in the first 49 feet being 72 tons, it may be supposed to begin at the rate of $\frac{144}{49}$ tons per foot, and to diminish gradually and equably, so that its centre of action will be at the distance $\frac{49}{3}$ from the end; the excess of pressure must increase in the next place, until, at the distance of 59 feet from the stern, it becomes $\frac{108}{10}$ per foot, and must then diminish until it vanishes at 69, where the excess of weight must begin to prevail, becoming at 94, $\frac{118}{25}$ per foot, and vanishing at 119. The excess of pressure might then be supposed to increase gradually through the next portion, in order to avoid an abrupt change at its extremity; but this supposition would still be insufficient, and it becomes necessary to imagine that for 6.6 feet the forces remain neutralised, and the pressure then prevails, so that its excess becomes at last $\frac{119}{6.7} = 17.7$ per foot; it must then decrease for 17.5 feet, and the excess of weight at the extremity must become 19.7 per foot, the neutral point being at 156.5. The equilibrium of the forces will then be expressed by the equation $72 \times 16.3 - 108 \times 59 + 118 \times 94 - 119 \times 134.5 - 155 \times 144.8 + 192 \times 169.5 = 0$

From this distribution of the forces, we obtain a determination of the strain from each point of the respective portions, which is in the joint ratio of the magnitudes and distances of all the forces concerned, on either side of the point, reduced into a com-

In order to distribute with some uniformity, the positive and negative differences recorded in the last column of the preceding table, M. Dupin has had recourse to a geometrical figure, and by an hypothesis, originally adopted by Dr. Young, in the paper before quoted, has assumed in the line AO, Fig. 3, Plate CCCCXCV. supposed coincident with the plane of the water's surface, certain segments AC, CE, EG, GH, HK, KM, and MO, having values equivalent to the quantities recorded in the first column of the succeeding table; and on those segments has supposed certain triangular areas to be formed, equivalent to the positive and negative quantities recorded in the last column of the former table. For example, on the segment AC is formed the right angled triangle ABC $=+72$; on CE, the isosceles triangle CDE $=-108$; on EG, the isosceles triangle EFG $=+118$; on HK the right angled HIK $=-119$; and on KM, MO the right angled triangles IKM, MON, the area of the former being -155, and of the latter $+192$; the difference of these areas being equivalent to $+37$, the last member of the column last refered to. The pomon result. For the first portion it is $\frac{144}{49}x \times \frac{1}{2}x - \frac{1}{2}\cdot\frac{144}{49}\cdot\frac{x}{49}x\,\frac{1}{3}x = \frac{72}{49}x^2 - \frac{1}{6}\cdot\frac{144}{49}\cdot\frac{x^3}{49}$, x being the distance from the stern; for the 2d, $72\,(x-16\tfrac{1}{3}) - \frac{1}{6}\cdot\frac{108}{10}\cdot\frac{(x-49)^3}{10}$; 3d, $72\,(x-16\tfrac{1}{3}) - 54\,(x-55\tfrac{2}{3}) - \frac{108}{20}\,(x-59)^2 + \frac{1}{6}\cdot\frac{108}{100}\cdot(x-59)^3$; 4th, $72\,(x-16\tfrac{1}{3}) - 108\,(x-59) + \frac{1}{6}\cdot\frac{118}{25}\cdot\frac{(x-69)^3}{25}$; 5th, $72\,(x-16\tfrac{1}{3}) - 108\,(x-59) + 59\,(x-94) + \frac{118}{50}\,(x-94)^2 - \frac{1}{6}\cdot\frac{118}{25}\,\frac{(x-94)^3}{25}$; 6th, from 119 to 125.6, $72\,(x-16\tfrac{1}{3}) - 108\,(x-59) + 118\,(x-94)$; for the 7th, we must add to this expression $-\frac{1}{6}\cdot\frac{119}{13.4}\cdot\frac{(x-125.6)^3}{13.4}$; and, in the last 37 feet, the strain will be expressed by $(176-x)\,19.7 \times \frac{1}{2}\,(176-x) - \frac{1}{6}\cdot 19.7\,\frac{(176-x)^3}{19.5}$. Hence we find the strain, at seven points, 22 feet distant from each other, and from the ends 605, 1993, 2815, 2244, 2655, 4610, and 1875; and by taking the fluxion of x in the seventh portion, we determine the maximum at $141\tfrac{1}{3}$ feet, amounting to 5261 tons, supposed to act at the distance of one foot. In order to form an idea of the curve which would be produced by such a strain acting on a uniformly flexible substance, we may consider the curvature as represented by the second fluxion of the ordinate y, and by finding and correcting the fluent separately for each portion, we may obtain the ordinate or fall at any given point corresponding to a given extent of arching of the whole fabric. It will, however, be sufficiently accurate for this purpose, to consider the forces as concentrated in a limited number of points, dividing those which act in the extreme portions into two parts, in order that the curvature may be continued to the ends; so that the whole of the forces may be thus distributed: at 0.36; at 32 2-3, 36; at 59, -108; at 94, 118; at 134·5, -119; at 144.8, -155; at 163, 96; and at 176, 96. The strain for each portion may then be represented by $a - b\,x$ whence $\ddot{y} = a\,\dot{x}\,\dot{x} - b\,x\,\dot{x}\,\dot{x}$, $\dot{y} = a\,x\,\dot{x} - \frac{1}{2}\,b\,x^2\,\dot{x} + c\,\dot{x}$, and $y = \frac{1}{2}\,a\,x^2 - \frac{1}{6}\,b\,x^3 + c\,x + d$. It will be most convenient, in calculation, to make x begin anew with each portion, setting out from the middle, and to divide the numbers by 100, in order to shorten the operations: thus, for the middle portion from 88 to 59, the strain will be $.2028 + .36\,x$, a being .2028, and $b = -.36$; and when x becomes .22, y is .00552, and when $x = .29$, $\frac{\dot{y}}{\dot{x}} = .0740$, and $y = .0011$; which values being substituted in the equations for the next portion, we have $c = .074$, and $d = .0011$; and by going through the whole length in this manner, we find the fall at the extremes and at seven equidistant intermediate points, .08697, .05325, .02514, .00552, 0, .00507, .02531, .06705, and .12325. If we wish to find the point at which the curve is parallel to the chord of the whole, we must enquire where $c = (.12325 - .08697) : 1.76$. which will be at 98 feet or 10 feet before the midships.

We must next determine the magnitude of the strain arising from the longitudinal pressure acting on the lower part of the ship only. The resistance being supposed to be proportional, in the first instance, to the degree of compression or extension, according to the common and almost necessary law of the constitution of elastic bodies, and varying also in the direct ratio of the strength of the fabric, which may be assumed to be either equable, or in the case of a ship, proportional to the distance from a point more or less remote, we must form an equation of equilibrium for the absolute equality of the forces in opposite directions, and another for their powers of acting with respect to any given point as the fulcrum of a lever. Thus the fluxion of the absolute resistance at the distance x from the upper surface, supposing the strength to be as $a + x$, and the neutral point, at which the compression and extension cease to be at the distance b, will be $(b - x)\,c\,(a + x)\,\dot{x} = c\,(a\,b - a\,x + b\,x - x\,x)\,\dot{x}$, which, when x is equal to the depth d, must become equal to the force f producing the strain, or $f = c\left(a\,b\,x - \frac{1}{2}\,a\,x^2 + \frac{1}{2}\,b\,x^2 - \frac{1}{3}\,x^3\right)$; and for the second equation, referring the forces to the upper surface as a fulcrum, the fluent of $c\,(b - x)\,(a + x)\,x\dot{x}$, must be equal to $e\,f$, e being the distance at which the force e is applied; whence $e\,f = c\left(\frac{1}{2}\,a\,b\,d2 - \frac{1}{3}\,a\,d^3 + \frac{1}{3}\,b\,d^3 - \frac{1}{4}\,d^4\right)$. Now if we make $a = d = x$, the equations become $c\left(\frac{3}{2}\,b\,d^2 - \frac{5}{6}\,d^3\right) = f$, and $c\left(\frac{5}{6}\,b\,d^3 - \frac{7}{12}\,a^4\right) = e\,f$, and from the former we have $c\left(\frac{5}{6}\,b\,d^3 - \frac{25}{54}\,d^4\right) = \frac{5}{9}\,d\,f$; and, by subtraction, $\frac{13}{108}\,c\,d^4 = \left(\frac{5}{9}\,d - e\right)f$; consequently the force f may be considered as acting on a lever of the length $e - \frac{5}{9}\,d$; and if we take any other value for a, the fractional multiplier of d, instead of $\frac{5}{9}$ will be $\frac{3\,a + 2\,d}{6\,a + 3\,d}$, thus if $a = \frac{1}{2}$, we have $e - \frac{7}{12}\,d$ for the length of the lever. In order to find the mean distance e at which the pressure of the water acts, we may suppose the form of the mean transverse section of the ship to be parabolic, and the area such as to correspond to the bulk of 3000 tons of water, each containing 35 cubic feet, the length being 176 feet, and the breadth $47\tfrac{1}{2}$, whence the depth must be 18.84 feet; then the centre of gravity of a parabola being at the sitive areas, it will be perceived, are formed below the plane of flotations, and the negative areas above it. These particulars are recorded in the next table.

Values of the segments making up the total length AO of the ship.	Areas equivalent to the differences between the weights of the sections and their displacements.
AC = 49	Surface ABC = + 72
CE = 20	Surface CDE = − 108
EG = 50	Surface EFG = + 118
GH = 6.6	Surface HHK = − 119
HK = 13.4	Surface IKM = − 155
KM = 17.5	Surface MNO = + 192
MO = 19.5	
Total AO = 176	Total = 000

In the next place, let the centres of gravity of the several triangular areas referred to, be determined, and from them let perpendiculars be demitted on the primitive line AO, meeting it in the points b, d, f, r, s, and n. The determination of these centres will furnish the elements of the following table; the comparison of the first and last columns of which, gives the respective distances of the common origin of the horizontal ordinates from the centres of gravity of the triangles.

$$\begin{aligned}
A\,b &= \tfrac{1}{3}\,AC &&= \tfrac{1}{3}\,49 &&= 16{\cdot}3\\
A\,d &= AC + \tfrac{1}{2}\,CE &&= 49 + 10 &&= 59\\
A\,f &= AE + \tfrac{1}{2}\,EG &&= 69 + 25 &&= 94\\
A\,r &= AH + \tfrac{2}{3}\,HK &&= 125{\cdot}6 + 8{\cdot}9 &&= 134{\cdot}5\\
A\,s &= AK + \tfrac{1}{3}\,KM &&= 139 + 5{\cdot}8 &&= 144{\cdot}8\\
A\,n &= AM + \tfrac{2}{3}\,MO &&= 156{\cdot}5 + 13 &&= 169{\cdot}5
\end{aligned}$$

This construction, therefore, furnishes for the equilibrium of the forces operating on the vessel, the equation

$$0 = 72 \times 16{\cdot}3 - 108 \times 59 + 118 \times 94 - 119 \times 134{\cdot}5 - 155 \times 144{\cdot}8 + 192 \times 169{\cdot}5,$$

being identical with that given by Dr. Young, at page 306 of the paper before referred to.

On this equation of equilibrium, M. Dupin makes many judicious observations. In the first place, he remarks, that the triangle EFG ought not to be regarded as isosceles, since its vertex is the point in which the difference between the weight of the section and its displacement is the greatest in this part of the vessel, and which point ought to correspond with the position of the main mast. But the main mast is situated abaft the middle point ϕ of the vessel, and is therefore nearer to the common point of origin, A by 19 feet $\left(=\frac{176}{2} - 69\right)$ than the central part of the ship. According to Dupin, the vertex of the triangle CDE is too far forward by at least 12 feet. In order also to make the sum of the moments vanish, Dr. Young was obliged to transfer a weight of 37 tons from the fore part of the ship to its displacement. These discrepancies arose from the imperfect nature of the data furnished to Dr. Young.

Let us, however, follow the steps of Dupin, and, retaining still the hypothesis of Dr. Young, apply the theorems before investigated, to the determination of the sections, which indicate either a maximum or a minimum. For this purpose, since the area of the triangle ABC was designated by + 72, and that of the triangle CDE by − 108, we must endeavour to draw within the latter triangle a line such as P p, which shall cut off from it the negative area CDP p, equal numerically to the area of the triangle ABC. Since, therefore, the area of the trapezium CDP p is, by this supposition, equal to −72, it follows that the area of P p E = −36; and since similar triangles are to each other in the duplicate ratio of their homologous sides, we have

$$\triangle\,D\,d\,E : \triangle\,P\,p\,E :: d\,E^2 : p\,E^2,$$

or numerically $-\frac{108}{2} : -36 :: 10^2 : \frac{-36 \times 10^2}{-54} = p\,E^2$.

Hence $p\,E = 20\sqrt{\frac{1}{6}} = 8{\cdot}15$; and consequently

$$A\,p = AE - p\,E = 69 - 8{\cdot}15 = 60{\cdot}85.$$

Let us now take the moments of the triangle ABC, and the trapezium CDP p = △ CDE − △ P p E, with respect to the line P p, in which case we shall, in the first place, have for the portions of the centres of gravity

$$\begin{aligned}
p\,b &= A\,p - A\,b = 60{\cdot}85 - 16{\cdot}3 = 44{\cdot}55\\
p\,d &= d\,E - p\,E = 10 - 8{\cdot}15 = 1{\cdot}85\\
\tfrac{1}{3}\,p\,E &= \tfrac{8{\cdot}15}{3} = 2{\cdot}72;
\end{aligned}$$

and secondly, for the moments required, the following results:

distance of $\frac{3}{5}$ of the depth from the vertex, (Vince's *Fluxions*, p. 101,) and the centre of oscillation at $\frac{5}{7}$, when the point of suspension is at the vertex (p. 111,) the distance of these points $\frac{4}{35}$ will be increased to $\frac{6}{35}$, when the point of suspension is removed to the terminaton of the absciss, and the distance of the centre of pressure from the vertex will be $\frac{3}{5} - \frac{6}{35} = \frac{3}{7}$, and $\frac{3}{7} \times 18.84 = 8.074$ which, subtracted from $\frac{4}{9} \times 40 = 17.777$, leaves 9.703 for the length of the lever. Now the magnitude of the pressure on this section must be to 3000 tons, as the depth of the centre of gravity, 7.536 to 176, that is 128.45 tons, which, acting at the distance 9.703, will produce a strain of 1247 tons, or, in the terms of the preceding calculation .1247, which is the multiple of $\frac{1}{2}\,x^2$ indicating the fall. These different causes of arching being independent of each other in their operation, their effects will be simply united into a common result; and the whole curvature of the ship, supposing its strength equable throughout its length, may be thus represented:—

Distance from the stern -	0	22	44	66	88	110	132	154	176
Strain - - - -	1247 + 0	605	1993	2815	2224	2655	4610	1875	0
Fall - - - -	.04828	.02716	.01207	.00302	.00000	.00302	.01207	.02716	.04828
	.08697	.05325	.02514	.00552	.00000	.00507	.02531	.06705	.12325
	.13525	.08041	.03721	.00854	.00000	.00809	.03738	.09421	.17153
For twelve inches of arching	10.58	6.29	2.91	.67	.00	.63	2.93	.737	13.42

$$44.55 \times +\ 72 = +\ 3207.6$$
$$1.85 \times -\ 108 = \quad -\ 199.8$$
$$2.72 \times -\ 36 = \quad -\ 97.8$$

and since the value of the positive moment is $+3207.6$, and the aggregate of the negative moments -297.6, the definitive moment will be $+3207.6 - 297.6 = 2910$: a positive quantity, whose tendency is to make the stern of the vessel fall.

If, however, in conformity to the second theorem, we find that the moment of the infinitely small section contiguous to the plane of the moments here referred to, be of a contrary character to that of the definitive moment just deduced, we shall be justified in concluding, that the moment of 2910 is absolutely the greatest that can be discovered; and that the moment of the infinitely small section alluded to, is *negative*, is apparent on account of its partaking of the general condition of the triangle CDE, which has all its sections of a *less* weight than the volumes of water they respectively displace, whereas the total moment by the preceding calculation is clearly *positive*.

If, in the next place, we proceed to the consideration of the sections comprised between the points E and G, and remark, that by the primitive hypothesis, the area of the triangle $EFG = +118$, which is a quantity greater than the area of the triangle $E\,p\,P$; let us suppose a line $Q\,g$ to be so drawn, perpendicular to the water's surface, as to cut off the triangle $Q\,g\,E$ equal to the triangle $E\,p\,P$. To determine the position of this line, we have, by the similar triangles $F\,f\,E$, $Q\,g\,E$, the proportion,

$$\text{as } \triangle F\,f\,E : \triangle Q\,g\,E :: E\,f^2 : E\,g^2,$$

$$\text{or numerically } \frac{118}{2} : 36 :: 25^2 : \frac{36 \times 25^2}{59} = E\,g^2$$

Hence $E\,g = 150\sqrt{\frac{1}{59}} = 19{\cdot}5$, and consequently

$$A\,g = AE + E\,g = 69 + 19{\cdot}5 = 88{\cdot}5.$$

Taking therefore, the moments of the triangles ABC, CDE, and $Q\,g\,E$, with respect to the line $Q\,g$, in which case we shall, in the first place, have for the positions of the centres of gravity

$$g\,b = A\,g - A\,b = 88{\cdot}5 - 16{\cdot}3 = 72{\cdot}2$$
$$d\,g = A\,g - A\,d = 88{\cdot}5 - 59 \quad = 29.5$$
$$\frac{1}{3}E\,g \qquad = \frac{19{\cdot}5}{3} \qquad = 6{\cdot}5$$

and secondly, for the moments required,

$$72{\cdot}2 \times +\ 72 = +\ 5196$$
$$29{\cdot}5 \times -\ 108 = \quad -\ 3186$$
$$6{\cdot}5 \times +\ 36 = +\ 234$$

and, since the values of the positive moments amount to $+5430$, and the negative moment is -3186, the definitive moment will be $5430 - 3186 = 2244$, a positive quantity.

If now we consider the nature of the sections which are infinitely near to $Q\,g$, we shall perceive that their weights exceed their displacements, and that their tendency is to produce a curve in the ship analogous to the moment just determined; and that therefore the moments which tend to arch the ship longitudinally in $Q\,g$, at the distance of 88·5 feet aft, must, by Theorem III. be a *minimum*.

Let us now proceed to the consideration of the sections which are situated between the points H and M. The displacements of these sections, as we have before remarked, exceed their absolute weights, by a quantity equivalent to $-119 + 155$; and which quantity is greater than the total result $+72 - 108 + 118$, on account of the other differences before referred to. It is evident, therefore, that we may cut off from the triangle HIM, by means of the vertical line $B\,r$, such a triangle $HR\,r$ as to make

$$ABC + EFG - GDE - HR\,r = o.$$

and which condition furnishes for the value of the area of the triangle sought,

$$HR\,r = ABC + EFG - CDE$$
$$= 72 + 118 - 108$$
$$= 82.$$

Hence we shall have by proportion, as

$$\triangle HIK : \triangle HR\,r :: HK^2 : H\,r^2,$$

$$\text{or numerically } 119 : 82 :: 13.4^2 : \frac{82 \times 13.4^2}{119} = H\,r^2;$$

$$\text{whence } H\,r = 13.4\sqrt{\frac{82}{119}} = 11.21,$$

and consequently $A\,r = AH + H\,r = 125.6 + 11.21 = 136.81$.

Taking now the moments of the triangles ABC, CDE, EFG, and $H\,r$ R in relation to the line R r, we shall, in the first place, have for the positions of the centres of gravity,

$$r\,b = r\,A - A\,b = 136.81 - 16.3 = 120.51$$
$$r\,d = r\,A - A\,d = 136.81 - \ 59 \ = \ 77.81$$
$$r\,f = r\,A - A\,f = 136.81 - \ 94 \ = \ 42.81$$
$$\tfrac{1}{3}\,r\,H \qquad = \frac{11.21}{3} \qquad = \ 3.74$$

and, secondly, for the moments required

$$120.51 \times +\ 72 = +\ 8676.72$$
$$77.81 \times -\ 108 = \quad -8403.48$$
$$42.81 \times +\ 118 = +\ 5051.58$$
$$3.74 \times -\ 82 = \quad -306.68$$

and since the values of the positive moments amount to 13728.30, and of the negative moments 8710.16, it follows that the definitive moment will be the positive quantity 5018.14

Here, therefore, as in the vertical plane passing through $P\,p$, the sections which are infinitely near to R r, will have their weights less than the resistance of the water they displace; and the moments of the same sections act in a contrary direction to that of the total moment. Hence, by the second theorem, the positive moment 5018.14, above deduced, is a *maximum*.

At the extremities A and O of the vessel, the sum of the moments being zero, must furnish likewise two *minimum* values; and if we therefore collect together the series of *maximum* and *minimum* values of the moments having a tendency to arch the vessel, they may be represented as in the following table:

At zero or the point A.	At A p = 60·85 feet from A.	At A q = 88·53 feet from A.	At A r = 136·81 feet from A.	At A o = 176 feet from A.
Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
Value of the moment = 0.	Value of the moment = 2910.	Value of the moment = 2244.	Value of the moment = 5018·14.	Value of the moment = 0.

According to Dr. Young, (see the preceding note,) the moments estimated at every 22 feet from the stern to the stem, may be represented as in the following table:

At zero.	*At 22 ft.*	*At 44 ft.*	*At 66 ft.*	*At 88 ft.*	*At 110 ft.*	*At 132 ft*	*At 154 ft.*	*At 176 ft*
Value of the moment = 0	Value of the moment = [illegible]05	Value of the moment = 1943	Value of the moment = [illegible]515	Value of the moment = [illegible]	Value of the moment = [illegible]	Value of the moment = [illegible]	Value of the moment = [illegible]	Value of the moment = 0*

If we now refer to the maximum and minimum sections which pass through A p and A q, in the investigation of Dupin, we shall perceive, that from the former to the latter, there must be a continual declension in the value of each moment; and that consequently, at the distance of 88 feet from the origin at A, the magnitude of the moment must be greater, than at the distance of 82.53 feet from the same point where the maximum section obtains; a conclusion which agrees with the theory of Dr. Young. In like manner, by referring to the maximum sections deduced by Dupin, we shall find that they are greater than the sections nearest to them in the investigation of Dr. Young.

But the same correspondence in the results does not take place, if we compare the position of the maximum section of Dr. Young with the deductions of Dupin; since the former makes that section to exist at the distance of 111.3 feet from the after part of the water line, and producing a strain equivalent to 5234 tons, acting at the distance of one foot; whereas the last mentioned philosopher estimates the strain at a similar point to be 4020.3 tons. This subject therefore, like most others connected with naval architecture, requires a more rigorous and extended investigation; and we regret that our limits prevent us from entering farther into so interesting an inquiry at the present time.

The preceding investigation has been conducted on the supposition, that the causes of arching are due entirely to the unequal distribution of the weight and pressure; but there is, in fact another cause for this important derangement of a ship's figure, arising from the longitudinal and horizontal pressure of the water. According to Dr. Young, the partial pressure of the water in a longitudinal direction, affects the *lower* part of the ship only, compressing and shortening the keel, while it has no immediate action on the upper decks.† The pressure, thus applied, must obviously occasion a curvature, if the angles made with the decks by the timbers, are supposed to remain unaltered, while the keel is shortened, in the same manner as any soft and thick substance, pressed at one edge between the fingers, will become concave at the part compressed; and this strain, upon the most probable supposition respecting the comparative strength of the upper and lower parts of the ship, must amount, Dr. Young thinks, to more than one third as much as the mean value of the former, being equivalent to the effect of a weight of about 1700 tons, acting on a lever of one foot in length, while the strain, arising from the unequal distribution of the weight and the displacement, amounts, where it is greatest, that is, about 87 feet from the head, to 5234, in a seventy-four gun ship of the usual dimensions; and although the strain is considerably less than this exactly in the middle, and throughout the aftermost half of the length, it is nowhere converted into a tendency to "sag," or to become concave. It must, however, be remembered, says Dr. Young, that when arching actually takes place from the operation of these forces, it depends upon the comparative strength of the different parts of the ship and their fastenings, whether the curvature shall vary more or less from the form, which results from the supposition of a uniform resistance throughout the length. An apparent deviation may also arise from the unequal distribution of the weight through the ship; thus the keel may actually sag, under the step of the mainmast, even when the strain, as here calculated, indicates a contrary tendency with respect the curvature of the whole ship.

But the magnitude of the strain on the different parts of a ship is subjected to very material alterations, when she is exposed to the force of the wind and waves. The effect of the wind is generally compensated by a change of the situation of the actual water

* As every addition to our knowledge on the important subject of arching is valuable, and as some of our readers may be desirous of pursuing it farther than the limits of this article will allow, we annex the following elements of the weights and vertical pressures on a ship of 74 guns of the second class, and which we have derived from a very useful and instructive work, entitled, *An Introductory Outline of the Practice of Shipbuilding*, by Mr. Fincham, superintendent of the School of Naval Architecture in Portsmouth Dockyard.

On the Forebody.

Situations of sections.	Weights of sections in tons.	Vertical pressure of sections in tons.	Moments of weights in tons.	Moments of pressure in tons.
From ⊙ to 20.85 feet	511.7	467.2	11[illegible].9	7163.4
20.85 to 37.60 feet	4[illegible]	363.0	14171.4	15572.4
37.60 to 54.35 feet	26[illegible].2	3[illegible]	11[illegible]6.9	15146.1
54.35 to 71.10 feet	[illegible].2	25[illegible].6	1[illegible].8	1[illegible]29.0
71.10 to extremity	14[illegible]	9[illegible].4	5715.1	4812.6
Total on the forebody	1586.3	1501.2	55815.1	53426.8

On the Afterbody.

Situations of sections.	Weights of sections in tons.	Vertical pressure of sections in tons.	Moments of weights in tons.	Moments of pressure in tons.
From ⊙ to 20.85 feet	3[illegible].5	4[illegible].4	[illegible].2	[illegible]4.6
18.23 to 34.98 feet	2[illegible].4	256.8	7[illegible]4.4	9[illegible].4
34.98 to 51.73 feet	2[illegible].2	317.9	9916.6	1766[illegible]
51.73 to 68.48 feet	2[illegible].2	2[illegible]9.0	1578[illegible]	14[illegible]1.4
68.48 to extremity	2[illegible]8.0	15[illegible].8	2171[illegible].5	11829.4
Total on the afterbody	1401.3	1482.0	55819.1	53418.6
Total on the forebody	1586.3	1504.2		
Weight of the hull and all it contains	2987.6	29[illegible]6.2		

† Philosophical Transactions for 1814, p. 308.

line, so that its amount may be estimated from the temporary or permanent inclination of the ship; and the force of the waves may be more directly calculated from their height and breadth. These two forces can seldom be so applied, as to combine their effects, in producing a strain of the same kind in their full extent; it will therefore be sufficient for this purpose, to determine the probable amount of the force of the waves, which is more materially concerned in affecting the longitudinal curvature than that of the wind. As a fair specimen of the greatest strain that is likely to arise from this cause in any common circumstances, we may consider the case of a series of waves twenty feet in height, and seventy in breadth; the form being such, that the curvature of the surface may be nearly proportional to the elevation or depression. A single wave might indeed act more powerfully than a continued series, but such a wave can scarcely ever occur singly. Dr. Young then finds,* that the greatest strain takes place, in a seventy-four gun ship, at the distance of about eighteen feet from the midships, amounting to about 10,000 tons, at the instant when the ship is in a horizontal position, while, in common cases, when the waves are narrower, the strain will be proportionally smaller and nearer to the extremity. Hence it appears that the strain produced by the action of the waves, may very considerably exceed in magnitude, the more permanent forces derived from the ordinary distribution of the weight and pressure; being according to this statement, nearly three times as great: so that when both strains co-operate, their sum may be equivalent to about 15,000 tons, acting on a lever of one foot, and their difference, in opposite circumstances, to about 5000. There may possibly be cases in which the pressure of the waves produces a still greater effect than this; it may also be observed, that the agitation accompanying it, tends to make the fastenings give way much more readily than they would do, if an equal force were applied less abruptly. At the same time, it is not probable that this strain ever becomes so great, as to make the former perfectly inconsiderable in comparison with it, especially if we take into account the uninterrupted continuance of its action; it appears, therefore, to be highly proper, that the provision made for counteracting the causes of arching, should be greater than for obviating the strain in the contrary direction; for example, that if the pieces of timber intended for opposing them were, on account of the nature of their fastenings, or for any other reason, more capable of resisting compression than extension, they should be so placed as to act as *shores* rather than as *ties*; although it by no means follows, from the form which the ship assumes after once breaking, that the injury has been occasioned in the first instance, by the immediate causes of arching; since, when the fastenings have been loosened by a force of any kind, the ship will naturally give way to the more permanent pressure, which continues to act on her in the state of weakness thus superinduced.

The pressure of the water against the sides of a ship, has also a tendency, remarks Dr. Young, to produce a curvature in a *transverse direction*, which is greatly increased by the distribution of the weights, the parts near the sides being the heaviest, while the greatest vertical pressure of the water is near the keel. This pressure is often transmitted by the stanchions to the beams, so that they are forced upwards in the middle: when they are unsupported, the beams are more generally depressed in the middle by the weight of the load which they sustain, while the inequality of the pressure of the water co-operates with other causes in promoting the separation of the sides of the ship from the beams of the upper decks. On the other hand the weight of the mainmast often prevails partially over that of the sides, so that the keel is forced rather downwards than upwards in the immediate neighbourhood of the mid-ships. The tendency to a transverse curvature is observable, when a ship rests on her side, in the opening of the joints of the planks aloft, and in their becoming tighter below: although this effect depends less immediately on the absolute extension and compression of the neighbouring parts, than on the alteration of the curvature of the timbers in consequence of the pressure.

In such a case also there is an obvious strain tending to produce a *lateral curvature*, and shores are sometimes employed to prevent its effects, when a ship is "*hove down*" on her side. This indeed is comparatively a rare occurrence; but when a series of large waves strikes a ship obliquely, they must often act in a similar manner with immense force: the elevation on one side may be precisely opposite to the depression on the other; and the strain from this cause can scarcely be less than the vertical strain already calculated: but its effects are less commonly observed, because we have not the same means of ascertaining the weakness which results from it, by the operation of a permanent cause. When a ship possesses a certain degree of flexibility, she may in some measure elude the violence of this force, by giving way a little for the short interval occupied by the passage of the wave; but it may be suspected that her sailing in a rough sea, must be impaired by such a temporary change of form.

Such are a few of the general principles connected with that alteration of form, which has been denominated arching or hogging, and for which the genius of Seppings contrived so admirable a remedy. The symptoms of weakness which all ships constructed on the old plan exhibited, were generally apparent, by the parting of some of the butts of the plank aloft, at the same time that the angular position of some parts of the structure had as uniformly been more or less altered; and very generally a certain degree of sliding was observable in the planks at the side of some of the ports. At the same time, a degree of permanent compression or crippling below was remarked, the butts of the planks opening when the cause that produced the arching had been removed, and the sheathing more wrinkled than would have happened from the simple bending of the planks. But as the practical details connected with the introduction of the diagonal riders, belong more particularly to the part of the paper devoted to practical construction, we refer the reader to it for further information.

ON THE STERNS OF SHIPS.

The interesting and important investigations, that have taken place respecting the sterns of our ships of

* Philosophical Transactions for 1814, pages 310 and 311.

war, not having yet found their way into any of our Encyclopædias, we shall devote a short space to its consideration, and review the arguments that have been advanced by different writers respecting this great and important change.

It would exceed our limits to follow the history of the sterns of vessels into its earliest stages, and we must therefore content ourselves with briefly remarking, that during the sixteenth century, the sterns of ships of the largest class were formed square, not only above, but some feet *below* the plane of flotation; and every part was loaded, or as the writers of that period say "adorned," with carved work, banners, and every other thing that could add to what was at that time considered as rich and splendid decoration. The forms of the sterns at that time, admitted of four guns, of large calibre, being fired right aft; and we learn from a picture preserved in the society of antiquaries, of the embarkation of King Henry the VIII. at Dover, in the year 1520, that ships at that period, had neither stern walks, balconies, nor quarter galleries; nor is there represented the convenience of a water closet abaft, even in the ship occupied by his Majesty; and but one only in the squadron, which is in a ship bearing the royal standard; and which, it is evident from the colouring, was an appendage for the occasion, and probably put up for the queen of England and her court. The sterns of these ships, Mr. Knowles thinks, were formed by several beams of considerable dimensions, called transoms, lying horizontally, and attached to their frames or ribs, by large crooked pieces of timber, termed knees, and which, it would seem, prevented the guns from being worked in the quarters with any effect.

In the beginning of the seventeenth century, our ships of war were much improved, not only by an increase of their dimensions, but also by the application of science to the construction of their bodies; and Sir Robert Seppings is in possession of a complete draught of the Sovereign, designed by Mr. Phineas Pett, and launched in the year 1637, in which the stern is improved by being *rounded below* and a little above the plane of flotation; and having five transoms and stern and quarter galleries, or balconies. Her draught of water abaft was twenty-two feet three inches, and the height of the stern above the water *fifty feet nine inches*, and she had originally *six decks or platforms abaft*, on which guns might be carried. But not only the sterns of ships, but their heads also were overloaded with the most barbarous and cumbrous ornaments at this time; and the prow of the ship here alluded to, actually extended forty-three feet six inches above the plane of flotation, and was covered in every part with massive and ill-contrived carved work.*

This cumbrous and expensive mode of building and ornamenting the heads and sterns of ships of the first class, continued, says Mr Knowles, until the year 1699, when directions were given by the government, "to be more sparing in the carved work and other decorations"—a proof of a better and improving taste. The balconies in the quarters were however fitted until the year 1729, when these projections were discontinued, and close galleries adopted.

To lower the height and lessen the weight of the sterns in large ships, the poops royal were omitted in those built and repaired after the middle of the last century: but little however appears to have been done in the way of a decided improvement until 1796, when Earl Spencer, who then presided at the Admiralty, directed that the ponderous heads should no longer be continued, nor should there be galleries or carved work on the sterns. This was certainly a step towards a more proper order of things: but it was not until 1811, that Sir Robert Seppings introduced his method for strengthening the bow, by carrying up the timbers so as to give a circular form to it: nor till 1816, that he proposed that the same system should be adopted for the stern, so as to give to it the same advantageous properties that he had previously communicated to the bow.

The advantages to be derived from the circular stern may be principally reduced to the three following heads:

First, A considerable addition to the strength of the ship.

Secondly, Safety to the people employed, both from the effects of a sea striking the stern, and from shot fired by the enemy.

Thirdly, The additional means afforded for attack and defence.

The insufficiency in point of strength of the old method of constructiong the sterns, is proved in Sir Robert Seppings's letter to the first Lord of the Admiralty, by his having given from various official reports, eighty-nine instances in ships of the line, and eighty in frigates, of the great weakness of that part of the ship. These instances of defect being derived from the reports of officers of intelligence and distinction, employed in services of the most diversified and trying kind for the long period of a quarter of a century,† necessarily stamps the body of information

* It is remarkable how this rage for ornament, falsely so called, prevailed at one time, and how low it degraded the national taste. Let the reader compare, in this particular, the cumbrous and overloaded light-house of Winstanley, with the simple and majestic structure afterwards built on the same rock by the immortal Smeaton.

† It may not be uninteresting to our readers to have a few examples of the weakness of the old form of the stern presented to their notice.

In the report relating to the Valiant, it is stated, *that the stern post, and all the stern, worked.* In the Diadem, *the after part of the ship sunk so much, as to cause a considerable friction of the rother against the post.* In the Adamant, *the stern frame was so very much depressed, that the stern timbers were nearly out of their steps on the wing transom* In the Courageux, *the working of the stern frame was so great in a heavy gale of wind, as to occasion the loss of five tillers;* and on the storm assuming afterwards a still more tremendous character, *the working about the stern frame and post was so great, as to render it necessary to throw twelve of her after guns over-board, to ease and lighten her.* And in a similar scene of peril, in which the Albion was situated in 1809, *thirty-one guns were thrown overboard, twenty-four of which were from the after extremity of the ship.* Nor is it always necessary for a gale of wind to exist, in order to prove the weakness of the square stern, since, in the example of the Defence, *the heads of her counter timbers were reported by her Captain to work very much even in moderate weather.* And the stern of the London *was found to tremble much in light winds, and to increase its motion considerably in heavy seas.* In the Aquilon also, *the stern frame was found to be much shook by firing the after guns.* The poop of the Bellona *was found likewise to labour so much as to work the foremost bulkhead partly down;* and when the Minotaur rolled, *the whole body of the poop went over from side to side.* The stern of the Cumberland also, above the wing transom *worked so* which Sir Robert has collected in the letter alluded to, with the utmost importance and value. The defect in the old square form being thus rendered so notorious, led to the consideration of the best mode of remedying it; and the acknowledged strength of the round bow, a part subjected to the action of far greater strains than the stern, naturally led to the consideration of fortifying the latter by the same mode of timbering, and from this arose the circular stern. Moreover, before the application of this system, the new mode of shipbuilding so successfully introduced by Sir Robert Seppings, might be truly said to be incomplete, for the shelf pieces and water ways, as well as all the planking above the wing transom, which may be denominated internal and external hoops, were cut off, and hence left the stern the only weak part in the ship. "In ships with square sterns," Mr. Harvey has remarked, "the application of the diagonal system of trusses does not produce its maximum effect, nor is the continuity of the shelf pieces preserved, since the most abrupt termination of them takes place at the quarters, a difficulty entirely removed in the circular form by the happy introduction of the *ekings*, and affording a perfect illustration of the term 'internal hoop,' so appropriately applied to them by Sir Robert Seppings." "It is the mode of timbering those sterns," as Mr. Knowles with equal propriety observes, "and a continuity of the internal and external planking that constitute their strength, and establishes on a firm and unquestionable basis, their importance and value."

These remarks will be confirmed by an inspection of Figs. 1, 2, 3, and 4. Plate CCCCXCVI. In Figs. 1 and 3, the former of which represents an internal right aft view of a square stern, and the latter a plan representing the mode of connecting a stern of the same kind, with its sides, it will be perceived that the strength of this form of the stern depends in a very great measure on the iron knees at the quarters or angles, which are bolted to the deck transom A, and through the side timbers of the vessel. Now any fracture or defect in the iron knee, will of course weaken the stern, and contribute to all the defects before alluded to, and which have led to the introduction of the new form. It will also be perceived by inspecting both figures, but particularly the former, that none of the water ways C, C, C, C, or shelf pieces D, D, D, D, contribute in any degree to bind together the fabric of the stern, or to add in any manner to its strength: nor do any parts of the stern frame, excepting the transoms, tend to keep the sides of the ship together, and which is only done by means of the iron knees before alluded to, and the dowels, denoted by the dotted circles at their extremities. On the wing transom F, moreover, rests the whole fabric of the stern, every upright timber as B, B . . . B, B, stepping or resting thereon. Now, we will venture to say, that in the whole history of constructive carpentry, a worse example can scarcely be found than this of defective and bad combination; of timbers disposed at right angles to each other,—the worst possible position, where oblique strains are to be endured; without a diagonal timber to prevent even the well-known derangement of form arising from *raking:* trusting to knees and bolts, ill adapted, from their positions, to resist those derangements of form which must arise from the shocks that so ponderous a fabric must receive from the terrible element with which it has to contend, and with the decays also and weaknesses that *time*, the great innovator of mechanical as well as moral systems, is so incessantly producing. Can it be a matter of wonder, therefore, that such an ill-contrived frame as the stern of a ship constructed on the old form, should, in the technical but expressive language of the operative shipwright, "*work:*" *that the whole body of the poop should sometimes move from side, to side*, resting, as the entire fabric of the stern does, on a single timber, massy, of course, but with its strength ill applied, and ill connected with the sides of the ship, the proper and perfect union of which should be inseparable?

But if we turn to the diagrams illustrative of the round stern, we shall discover no such mechanical anomalies as disgrace the ancient form. Every part will be found to be disposed with some reference to the laws that ought at all times to influence mechanical structures. To prove this in its fullest sense, we need only compare Fig. 2. with Fig. 1. and Fig. 4. with Fig. 3.

The slightest comparison, indeed, will prove that weakness has given way to strength; and forms ill adapted to resist strains, have been replaced by mechanical arrangements of the soundest kind. The water ways and shelf pieces, which in the square form were abruptly cut off, in the circular stern are bound into one perfect whole, by the introduction of the eking. This ingenious arrangement may be seen in Figs. 2. and 4. where H, H represent the water ways, I, I the shelf pieces, and G, G the timbers denominated the *ekings*, the whole being bound by the solid timbering of the stern, into one compact and perfect form. The stern, it will also be perceived by a reference to Fig. 4. possesses the same kind of timbering, planking, &c. as the sides: the ekings are united by the strongest bolts, and the archlike fabric of the whole is just that which is best adapted to resist strains and pressures of every kind. If we compare Fig. 2. with Fig. 1. we shall find the timber work of the former, raised regularly from the lowest part, resting on no ill-contrived transom; with no stern timbers raising their upright forms, unchecked by brace or truss; but the whole system of framing, adapted to approved rules of mechanical strength, bound together by internal and external planking like the sides, and capable, like the bow, of resisting all those terrible shocks, to which a vessel exposed to the uncontrolled energies of a storm must be subject.

In the second place, the safety which the present

much as to force the oakum out of the butts of the lower counters, at the rabbet of the stern post, as likewise out of the seams of the lower counters.

"Such are a few of the striking examples," says Mr. Harvey, "in one of his Essays on Circular Sterns, (*Dr. Brewster's Journal of Science*, vol. i. p. [illegible]), on which Sir Robert Seppings grounds his arguments for a change in the figure of the stern; facts which had been silently accumulating for a long period in the records of the navy office, awaiting the hand of a '*master*,' to draw from them incontrovertible proofs of the general weakness of the square form, and at the same time to afford the elements and [illegible] of a new system which has contributed in no inconsiderable degree to the strength and security of our ships of war."

method of constructing the sterns affords to the seamen over that of the old plan, is best shown by some instances of the danger arising from the imperfections of the latter method, which, above the wing transom presented little else then a surface of glazed windows. The Dictator of 64 guns, in her passage from the West Indies in 1797, was struck by the sea on the stern, which stove in the dead-lights and window frames, washed away every thing on the main deck, and the crew were under the necessity of throwing six of the guns overboard to lighten the ship abaft. The Revolutionaire, of 45 guns, on her passage also from the West Indies in the year 1804, met with a similar accident, which stove in the dead-lights, and carried away the bulk-head of the great cabin, and had not the hatchways been barred down, which prevented the water from getting into the hold, the ship must have foundered.

In the sterns formed according to the old plan, the men on all the decks, except those on the lower gun-deck in ships of the line, are exposed to the most destructive raking fire, their sterns being pervious even to a musket ball.

The strength also given to the circular sterns by carrying up the timbers, prevents all the danger to be apprehended from a sea striking the ship abaft, or from the ingress of small shot, as well as from large ones which have not force to pass through the timbers and planking. And from their curved form, the shocks of the sea abaft will be much lessened; and those shot fired at an angle of more than forty-five degrees, will glance off without doing much injury to the ship.

Much has been said with respect to the injury which our men-of-war will undergo in their sailing qualities by the introduction of the circular stern; but we apprehend, that an impartial examination of the question will produce some advantages in its favour. The ships constructed with the new stern have the same form below, and for some feet above the plane of the water's surface, and must therefore enjoy the same buoyancy abaft, as those constructed according to the strictest letter of the old plan. Their seagoing properties are no doubt improved by the omission of the quarter galleries, which doubtless acted as a back sail, when the ships were going on a wind.

On the important question of the additional means of attack and defence afforded by the curvilineal stern, we cannot do better than follow Mr. Harvey in his elaborate "Results of Experiments relating to the comparative means of defence afforded by ships of war having square and curvilineal sterns," published in the 35th Number of Mr. Brande's Journal of Science.

For the purpose of ascertaining, by rigorous and decisive experiments, in what degree the new form of the stern is calculated to improve a ship, Mr. Harvey was permitted by Sir Byam Martin, the comptroller of the navy, to select two frigates of the same class, one having a curvilineal stern, and the other one of the old or square form. In the prosecution of the experiments, moreover, Mr. Harvey was assisted by many distinguished naval officers, among whom he particularly mentions Captains Wise, Richards, and Arthur. Guns were placed on board the Boadicea and Hamadryad frigates, the former having a square stern, and the latter a round stern; and he remarks, that every position and bearing determined, was made the subject of a candid and liberal discussion. In determining also the different bearings of the guns, particular care was taken in every instance to prevent their being *wooded*; an important consideration in a course of comparative experiments of this nature; and also ample room was permitted for recoil. The moment also the position of a gun was finally determined, its bearing was carefully laid down on the deck, and referred to a longitudinal line passing through the middle section of the ship. And, in order to give every possible advantage to the square stern, *the ports of the Boadicea were entirely stripped of their linings, so as to present only the naked timbers; whereas in the ship with the curvilineal stern, the linings were in every case preserved*, and which, therefore, gave to the square form, a very considerable advantage during the comparison; but even with this advantage, Mr. Harvey found that the means of defence it afforded, were decidedly inferior to those presented by the curvilineal form.

For the purpose of comparing the different bearings of the guns, two points K, K, Figs. 1 and 2, Plate CCCCXCVII. were assumed in the longitudinal axis XY of the vessels, at the distance of 17 feet from the afterpart of the counter of the square stern, and also from the afterpart of the lower stool of the curvilineal stern. From these points as centres, and with radii of 27 feet, two arcs of circles *a b c e b a*, *a b e f f e b a* were described, the former, as the figure indicates, surrounding the square stern, and the latter that of the curvilineal form. To these circumferences, the various arcs or ranges swept over by the guns, in their translation from one bearing to another, were in all cases referred.

The first experiments were performed on board the square stern vessel. An eighteen pounder was placed at the after broadside port, and trained to its greatest possible angle *before* the beam, as denoted by the lines A *a*, Fig. 1, or Fig. 3, Plate CCCCXCVII.; forming, in the first mentioned figure, an angle *a* AY of 61°, with the principal longitudinal axis XY of the vessel; the outer extremity of the muzzle of the gun being at the same time within the external edge of the port four inches. This bearing being determined, the gun was next brought into the position denoted by the line B *b*, Fig. 1, being the greatest possible angle at which it could be trained *abaft* the beam; the line of fire forming with the principal axis of the vessel the angle *b* BX of 35½°. The arc *a b*, intercepted between the two bearings, amounted to 46°; and it hence followed, that an object placed in any part of it could be hit by a shot from the after broadside port, confined of course to the limits prescribed by the ordinary charge of powder. The circular dots introduced in the arc *a b*, as also in all the arcs which may be hereafter alluded to, are designed by Mr. Harvey to indicate, that every part of the space contained between the extreme bearings, can be perfectly defended.

The exact position of the point *b* having been determined by the last experiment, the gun was next removed to the adjacent port of the stern, and trained to its greatest possible angle, as denoted by the line C *c*, Fig. 1, or Fig. 4, and forming with the axis XY the angle *c* CX of 32½°. To obtain this bearing, the muzzle was brought 4 feet *within* the fore part of the rail, creating thereby great danger from fire. It will also be observed, by referring to the former figure, that the truck of the gun was brought into immediate contact with the rudder head, so that the utmost bearing was determined.

This being the greatest bearing that could be obtained with a stern gun directed towards the adjacent quarter of the ship, necessarily left the arc *b c*, Fig. 1, amounting to 32½°, *entirely undefended:* and it was also remarked, that the bearings B *b* and C *c* were not in directions *parallel* to each other, but in a state of *divergency*, amounting to three degrees: and that therefore the extreme lines of fire proceeding from the after broadside port, and the adjacent port in the stern, could not, under the present circumstances, be made to "*cross*," and consequently, that a "*point of impunity*" existed.

Desirous, however, of discovering if it would be possible, under any circumstances, consistently with the preservation of the frame of the ship, to make the lines of fire issuing from the last-mentioned ports *intersect* each other, an estimate was made by Mr. Harvey and the naval officers present, to determine what alteration would be produced in the bearing of the gun at the stern port, by supposing the rudder head removed. The utmost effect, however, that could be produced by this arrangement in the bearing of the gun, amounted only to a diminution of a degree and a half of the divergence before determined, the new line of fire being the direction E *e*, and which, therefore, still kept the bearings of the two guns from a state of *parallelism*, and consequently preserved a "point of impunity" between them.

The undefended arc *b c* was of course diminished by the same quantity as the divergence of the stern gun was altered, the arc *b e* in this new condition amounting to thirty-one degrees. And hence it appears that the lines of fire proceeding from the after broadside port, and the adjacent port in the stern, cannot be made to cross even when the rudder-head is removed, unless by destroying one of the sides of the former port, or a port of the stern frame; and that *a point of impunity therefore exists on the quarter of a square stern vessel, which it is impossible altogether to remove, unless by injuring very materially the strength of the ship.*

The next position assumed for the gun was that of D *d*, Fig. 1, Plate CCCCXCVII, forming with the principal axis XY, the angle *d* DY of 27°, this direction affording the greatest possible bearing at the stern, towards the opposite quarter of the ship, when the recoil was limited to four feet.* The magnitude of the arc *c d*, between the extreme bearings at the stern port, was therefore found to be 30½° when the rudder-head was preserved, but nearly a degree more when it was removed.

From the foregoing experiments, it therefore appears that the entire arc *a b d b a* surrounding the square stern, and which amounts in quantity to 204°, may be separated into the

three defended arcs $\begin{cases} a\,b = 46° \\ c\,c = 47° \\ a\,b = 46° \end{cases}$

amounting together to 139°: and into the

two undefended arcs $\begin{cases} b\,c = 32\tfrac{1}{2}° \\ b\,c = 32\tfrac{1}{2}° \end{cases}$

amounting jointly to 65°.

Of the defended arcs, it may be observed, that the first and last *a b*, *a b*, admit of a ready defence in any part from either of the after broadside ports: but the second, or right aft portion *c c*, cannot be defended in every part from the stern ports with the same convenience and security from fire.

For the purpose of affording a more explicit reference to the different bearings of the guns above referred to, the following table is added, of which the first column denotes the several angles formed by the lines of fire with the principal axis of the ship: and the second, the distances of the points of intersection formed by the respective lines of fire and the same axis, reckoned from the point K, the centre of the arc surrounding the stern.

Magnitudes of the angles formed by the respective lines of fire and the axis XY.	Distances of the points of intersection of the lines of fire with the axis XY, reckoned from the common origin K.
a AY = 61°	KA = 9.0 feet.
b BX = 35½°	KB = 16.7
c CX = 32½°	KC = 8.5
d DY = 27°	KD = 20.5

Having considered the effects capable of being produced by guns applied *singly*, let us next follow Mr. Harvey into an investigation of their joint action.

Suppose, therefore, in the first place, a square stern vessel to be attacked at the same instant, both on the stern and starboard quarters. It is evident that it would not be possible to fight the after broadside gun directly a-beam, and the adjacent stern gun right aft, at the *same time*, since the distance between the trains of the carriages, when completely run out, would only amount to fifty inches; and which, when the recoil takes place, would necessarily bring them into contact with each other. One of three things must therefore be done in a case of such a nature: either the former gun must be trained abaft the beam, the fire of the latter be brought nearer to the quarter of the ship attacked, or the latter gun be removed and fought at the other stern port. It might be possible also to fight both the after broadside guns by training them abaft the beam, with both the stern guns trained right aft: but, as before shown, *under no circumstances can the lines of fire be made to cross each other on the quarters of the ship, a point so much to be desired on so many difficult and trying occasions.*

The utmost advantage indeed that can be obtained from crossing the lines of fire, must in strictness be limited to a single combination produced by the stern guns immediately abaft, and confined to the space between the lines of extreme fire *d*D*k*, *d*D*k*, Fig. 1, Plate CCCCXCVII. It is true, by forming new lines of bearings for the guns, within the limits here referred to, an indefinite number of intersecting points may be created; still it is obvious that *one* only can be obtained at the *same* time. For example, a point of cross fire may be found at D, produced by the extreme lines of fire; or by gradually approximating those bearings to each other, other points in the axis XY may be determined, more distant from the stern, thereby commanding the sectorial space D*gg*. So also, other points may be found, out of the principal axis, by corresponding bearings of the guns. Thus

* In such an application of a gun, the breeching must be so ordered as to prevent a greater recoil.

the points gg may be determined, by combining either of the right aft lines of fire I*i*, I*i*, with one of the extreme lines of fire *d*D, *d*D, and sweeping over, by different modifications of these lines of fire, the sectorial spaces *g i k*, *g i k*. In like manner, by varying the bearings of the guns, may any number of points of intersection be determined within the bounds of extreme fire; but only *one*, as before remarked, can be determined at the *same* time. Thus, *the advantage of a cross fire, which in military purposes is always of so much moment and importance, in the case of the square stern, is limited and confined in an extreme degree.*

From the preceding considerations, it therefore appears, that the defence of the square stern is subject to the following disadvantages:

First,—*Two considerable arcs exist on the quarters, incapable of being defended; and hence a point of impunity is created, from the impossibility of crossing the lines of fire, which proceed from the after broadside gun, and either of the stern guns.*

Secondly,—*That to defend even an arc of 47°, right aft, produces much inconvenience, and a considerable waste of time, from the difficulty of obtaining the requisite positions for the guns, in consequence of the rudder head, and the projecting timbers of the stern.*

Thirdly,—*That in defending the arc before mentioned, the dangers of fire are very considerable, from the muzzles of the guns being so very much within the whole of the stern frame.*

Fourthly,—*That only one point of cross fire can be found, at the same time, in any part surrounding the square stern.*

The preceding conclusions having been obtained for the square stern, we shall in the next place proceed to the consideration of the experimental results obtained for the curvilineal stern.*

The first bearing determined in the Hamadryad, was at the after broadside port, an eighteen pounder being trained at the greatest possible angle *before* the beam. The line of fire A*a*, Figs. 2 and 5, Plate CCCCXCVII, so produced, was found to form with the principal axis XY, an angle *a*AY of 53°; the outer extremity of the gun being at the same time coincident with the side of the vessel. From this direction, the gun was trained into that of *b*B, *abaft* the beam, Fig. 2, being likewise the greatest deviation from the line of direct fire the case would admit, without wooding. This line of fire formed with the principal axis XY, an angle *b*BX of 36°; the outer extremity of the muzzle being at the same time two inches within the external edge of the port. The arc *ab* thus swept over by the gun, during its translation from the first-mentioned position to the second, amounted to 48½°, every part of which admitted of a ready and effectual defence.

A gun, in the next experiment, was placed at the port in the adjacent quarter of the ship; the part of the square stern vessel, which was proved in the preceding experiments, to be entirely undefended, but which, in the curvilineal stern, was found capable of making a vigorous defence. To prove this, the first bearing determined, was in the line C*c* *before* the beam, forming with the axis XY, the angle *c*CY of 78°, being the greatest the position would admit, without wooding the gun, or limiting the range of its recoil. From this position, the gun was removed into that of D*d* *abaft* the beam, its direction, Fig. 2, Plate CCCCXCVII, forming with the principal axis, the angle *d*DX of 16½°, the gun having been found capable of sweeping the arc C*d* of 46°, with perfect freedom.

The next situation assumed, was in the adjoining stern port, where the ease with which it was worked afforded a striking contrast to the difficulties experienced in the square form, and called forth the repeated and warm eulogiums of the officers present. Instead of having the projecting timbers of the stern frame, and the rudder head to contend with, in determining the different positions of the guns, as in the experiments performed on the deck of the Boadicea; or the danger of blowing out the entire stern frame,† or of occasioning fire in the vessel, both of which are possible in the case of a vigorous contest, from the muzzle of the gun, when trained right aft, being three feet *within* the stern frame; the gun in the curvilineal stern could be worked, as truly remarked by Captain Wise with all the ease and convenience of one at a broadside port; and that, moreover, when it was trained right aft, its muzzle was found to project considerably *beyond* the stern frame: thus reducing the chances of fire to those of a broadside port whereas in the square stern, they would be increased under similar circumstances, very much beyond them.

The first bearing at the last-mentioned port, was in the direction E*e*, Fig. 2, Plate CCCCXCVII, towards the adjacent quarter of the ship, and forming with the axis XY, an angle *e*EX of 48½°, being the greatest angle from the line of the keel, at which the gun could be trained. The extremity of the gun was an inch within the outer edge of the port; and the di-

* All the bearings hereafter mentioned, were determined with the ports in their ordinary state: no linings having been stripped from them to increase their width, as was done in the experiments on board the Boadicea. It was considered unnecessary in the case of the Hamadryad, because the very superior means of defence afforded by her curvilineal stern, could be most strikingly displayed without removing them. As remarked, however, before, in the text, this difference in the mode of conducting the experiments, gave a considerable advantage to the square stern; but which only served to place in a more striking point of view, the superiority of the new form

† That the blowing out of a square stern is not an hypothetical case, but has in some instances been rendered absolutely necessary, from its imperfect and injudicious form, may be proved by a reference to the gallant action of the Blanche with La Pique, in which the main and mizen masts of the former being shot away, and head sails filling, she payed off before the wind, thus bringing La Pique astern, towing by the bowsprit. The Blanche was immediately much annoyed from her quarter deck guns, which were well served, and pointed forward, without the English frigate being able to return a gun, having *no stern ports* on her main deck. Her gallant commander had no alternative left *but to blow out the stern frame.* To accomplish this, all the firemen, with their buckets, were assembled in the cabin, and both the after guns pointed against the stern, which made a clear breach on both sides, the fire occasioned by the execution of this prompt and judicious plan being immediately extinguished. The La Pique was now raked with great effect, her decks being cleared fore and aft, and soon after she surrendered. An officer remarks, who distinguished himself in this gallant action, that if the expedient of blowing out the stern had not been adopted, the most serious consequences might have been apprehended; at all events, the loss of many men.

rection of the shot passed quite clear of the adjacent water-closet. From this situation the gun was turned towards the opposite quarter of the ship, the line of fire F*f* forming with the axis XY, Fig. 2, Plate CCCCXCVI. the angle *f*FY of 30°, the gun having swept over the arc *ef* of 43°, without the smallest difficulty of any kind. Hence it appears, that the entire range of the arc *af*, from the point *a*, where the limiting fire of the after broadside gun commences, to the point *f*, where the utmost limit of the adjacent stern gun is obtained, is capable of being assailed by an efficient and vigorous fire from either of the ports here alluded to, or from the port in the quarter of the stern: and that, moreover, the weakness of the quarter, which in the square stern has always formed so essential and important an objection, in the curvilineal stern is entirely removed. It may also be added, that when the gun was trained in the last-mentioned position, its muzzle was only an inch without the outer edge of the port. It will likewise be remarked that the line of fire passes entirely clear of the dressing room.

For the purpose of a more convenient reference, the following table is added, the first column of which contains the different angles formed by the lines of fire with the principal axis of the ship: and the second the distances of the points of intersection formed by the same lines of fire with the axis, reckoned from point K, the centre of the circular arc *a b c f f c b a*, which surrounds the stern.

Magnitudes of the angles formed by the respective lines of fire, and the axis XY.	Distances of the points of intersection of the lines of fire with the axis XY, reckoned from the common origin K.
$aAY = 53°$	KA = 10.4 feet.
$bBX = 33$	KB = 18.3
$cCY = 78$	KC = 10.2
$dDX = 16\frac{1}{2}$	KD = 28.2
$eEX = 46\frac{1}{2}$	KE = 8.4
$fFY = 30$	KF = 19.3
$gGY = 65$	KG = 6.2
$hHX = 42\frac{1}{2}$	KH = 3.7
$iIX = 21\frac{1}{4}$	KI = 16.4
$kKX = 90$	K = 0.0
$lLX = 90$	KL = 7.8

Having ascertained the effects capable of being produced by the *separate* actions of the guns, Mr. Harvey next undertook, as in the square stern, the consideration of the advantages likely to result from their combined application.

In the first place, Mr. Harvey remarks, that the points of cross fire are much more numerous than in the case of the square stern, and moreover, that they may be increased *ad libitum*, by varying the bearings of the guns, and which the very convenient form of the stern will permit to be done with so much ease and convenience.

In the next place, Mr. Harvey remarks, that the close approximation of the same points to the parts of the vessel from which the lines of fire issue, is worthy of particular observation. The after broad side port, for example, may be made to cross its fire with the gun into the quarter port at the point *n*, Fig. 2, Plate CCCCXCVII. being little more than two-thirds of a fathom from the side of the vessel; thereby subjecting every part of the sectorial space *n o p*, containing an angle of 66°, and consequently the space beyond it, to the galling action of a cross fire. In like manner, with the stern and quarter guns, it is possible to make the lines of fire intersect each other at *d e*, the distance being less than two fathoms from the quarter of the ship: and therefore exposing every part of the sector *d f s*, whose angle is 41°, and the space beyond it, to the operation of a cross fire, at all distances between the utmost range of the gun, and the point of intersection last alluded to. The close approach of these points to the side and quarter of the vessel, was such as to excite the surprise of all who witnessed the experiment. In a cross fire proceeding from the stern ports, the superiority was equally apparent: the point of intersection F, being found within a fathom of the stern frame, and the sector F *m m* containing an angle of 60°, every part of which was completely commanded.

A more striking example of the advantage which the curvilineal stern affords for producing points of cross fire, may, however, be exemplified, when a ship of this kind is attacked on her quarter. In such a case, the lines of fire proceeding from the after broad side port, and from the adjacent quarter and stern ports, may all be brought to bear on the *same point y*, within less than twelve fathoms of the quarter; the lines of fire being respectively B *y*, H *y*, and E *y*. Fig. 2. Plate CCCCXCVII. In Fig. 2. Plate CCCCXCIX. the guns are represented in the positions necessary to produce this important effect; and where it will be perceived that most ample space is afforded for working them. *Hence it follows, that the quarter, which, in the old form of the stern, was decidedly the weakest part of the ship, in the curvilineal stern possesses the most ample means of defence.*

A like important defence may also be created, supposing it should be necessary at any time to concentrate the lines of fire in some point nearer the principal axis of the vessel: as the point Z for example, Fig. 2. Plate CCCCXCVII. To accomplish this, the guns at both the stern and quarter ports may be employed at the same time, with sufficient space for working them; the lines of fire being D *z*, S *z*, and *f z*, the point where they unite being only twelve fathoms from the stern.

Such are the effects capable of being produced by the extreme bearings of the lines of fire hitherto described; but it is evident that many varieties may be created to meet the diversified circumstances under which ships of war are liable to be placed. In the *first* place, both the stern guns may be evidently fought right aft at the same time, the lines of fire M *m*, M *m*, being in such a case parallel; *secondly*, One of the last mentioned guns may be fought right aft and the other trained to any angle, between the line of fire M *m*, and the limit *f* F; the sectorial figure *m w x*, containing an angle of 30°, produced by the first mentioned bearing, and the limit just alluded to being swept over in such a case. By varying the bearings of these guns, sectorial spaces may be swept over of any magnitude, within the limits of the extreme bearings *f*F, *f*F.

It would be possible, moreover, to fight the guns at the adjacent stern and quarter ports, as indicated by the bearings E i and I i, the lines of fire intersecting in i, and commanding the sector $i\,u\,r$, whose angle amounts to 24°. It is evident also, that by causing the line of fire I i, to approximate towards H h, successive sectors will be created at every new point of intersection. So likewise the bearings of C c and B b may be changed, and an indefinite number of new points determined, between the limits L l and K k. Thus the line of fire C c may be altered into that of L l, commanding in conjunction with the bearing B b, the sector $l\,y\,r$, whose angle amounts to 53°. Or the direction B b may be transformed into any other as K k, intersecting the bearing C c when both are produced.

Any force therefore that may be employed in attacking a ship with a curvilineal stern, will meet with a resistance of a much more formidable kind, than if its energies were expended on a square stern. If we compare, for example, the after broadside ports of a ship of each kind, we shall observe that, in the old form, the insulated fire of a single gun is all the effect that can be produced; whereas in the curvilineal stern, the gun at the quarter port can lend the most effectual aid; and by causing different discharges to converge to the same point, dispense a terrible and destructive cross fire over a very considerable range. And this contrast is increased in a still more remarkable degree, when we compare the conditions of the quarters; since in the new stern, the means of defence, for the same space, are quite equal to those of any other part of the ship, but in the square form vanish altogether. In like manner, if the attacking force were situated directly astern, a much more effectual defence could be created, by means of the former, than could possibly be afforded by the latter, from the great facility it affords in working the guns, and the assistance that may in some cases be obtained from the quarters.

Hence it appears, that even in a greater arc than a semicircle, many points of cross fire be produced about the curvilineal stern: thereby throwing around this important part of a ship the energies of a formidable and perfect defence, and produced by means at once practicable and secure: leaving no point of impunity open to an acute and enterprising enemy, as in the case of the square stern, or any abrupt transition from a well-defended part, to one feeble and insecure.

As a more particular reference may be necessary to the positions of the points of cross fire, the following table has been prepared. The first column indicates the lines of fire which intersect each other: the second column contains the magnitudes of the ordinates representing the distances of the points of cross fire from the principal axis XY; and the third the distance of the ordinates estimated on the principal axis from the common point of origin K. To refer for example the point of intersection produced by the lines of cross fire B b and C c to the axis XY, it will be found that the ordinate n G = 18.2 feet, and the ordinate GK = 6.2 feet. So also for the point of intersection of Bb and Ll, we have the ordinate lL = 19.5 feet, and LK = 8.0 feet.

Lines of Fire producing Different Intersections.	Magnitudes of the ordinates representing the distances of the points of cross-fire from the principal axis XY.	Magnitudes of the ordinates estimated on the principal axis XY, from the common origin K, to the points where the preceding ordinates intersect the same.
Intersection of B b with C c	n G = 18.2 feet	GK = 6.2 feet.
Intersection of B b with L l	l L = 19.5	LK = 8.0
Intersection of B b with H h and with E e	q Q = 59.5	QK = 61.[illegible]
Intersection of C c with K k	t K = 47.5	K = 0.9
Intersection of D d with E e	d N = 15.2	NK = [illegible]2.0
Intersection of D d with F f	x R = 32.0	RK = 76.8
Intersection of E e with I i	i O = 19.0	OK = 25.4
Intersection of f F with f F	F = 0.0	FK = 20.0
Intersection of F f with M m	m P = 4.5	PK = 27.8

The danger of fire, from the explosions of the guns taking place, *within board*, has been briefly alluded to; but as the superiority of the curvilineal stern, in this point of view, is strikingly conspicuous, it may not be improper to allude to this part of the subject more particularly.

By comparing Figs. 6. and 7. Plate CCCCXCVII. it will be perceived that, in the old form (Fig. 6.) the muzzle is twenty-one inches *within* the rail, whereas, in the new form, (Fig. 7.) the muzzle is eighteen inches *beyond* the frame of stern: the guns of each being supposed in a fore and aft direction. It is scarcely necessary to insist on the superiority of the latter form above the former, in relation to this very important consideration: since an explosion can never take place *within board*, without obvious disadvantages and danger. When the guns are trained, the evil will be increased in the square stern; whereas, with the greatest possible angle the case will admit in the curvilineal stern, the muzzle is never *within* the stern frame. These disadvantages in the square stern arise from the over-hanging form of that part of the ship, and from the inconvenient distribution of the timbers of the frame.

With respect to the guns of the after broadside ports of the two frigates, it may be observed, that they are under precisely the same circumstances, their muzzles in both cases being *beyond* the side of the ship, and also in the same degree. A fore and aft view is given in Fig. 8. Plate CCCCXCVII.

With the quarter gun of the new form no comparison can be made with the square stern: but by reference to Fig. 7. which represents a view of the quarter part of the Hamadryad, the projection being square from the side of the ship, and the gun run out as far as possible, it will be perceived that it possesses all the advantages of a broadside port, the only difference being a rather less projection of the muzzle, in consequence of the quarter being nearly perpendicular, and not falling in, as is the case at the broadside. Any explosion must therefore pass clear of the side of the vessel, with nearly the same security as if the gun were placed at a broadside port.

Among the many objections that have been urged against the adoption of the curvilineal stern, is the apparently formidable one, that a broadside port has been lost on each side of every ship to which it has been applied. After a careful examination however of this objection with respect to the Hamadryad, Mr. H. feels no hesitation in stating, that so far from this being the case, *it would not be extravagant to assert that a port has actually been gained on each side, by means of the port at the quarter.*

To demonstrate this, (and the great value of this investigation arises from nothing having been adopted hypothetically,) let a reference be made to the line of fire L*l*, Fig. 2. Plate CCCCXCVII. and by which it will appear that the quarter port may be readily and satisfactorily employed as a broadside port: for since it was found possible, by the naval gentlemen who assisted at the experiments, to train the gun at the quarter port into the direction C *c*, forming an angle of 12° *before* the beam, with much greater ease would it be possible to work it in the line of bearing L*l*, *on* the beam. *This circumstance adds therefore to the ordinary and essential uses of the quarter port, the additional advantage of being effectually employed, when occasion requires, in aiding the defence of the broadside.*

Nor should it be forgotten, that the facility with which *all* the guns can be worked in the curvilineal stern for the different points of bearing before described, and the total absence of all the timbers and other obstacles which, in the square stern, occasion so many serious and decided impediments, increase in a very high degree the advantages likely to result from the general application of the new form. To take the example of a man of war becalmed in the bay of Gibraltar, or at the entrance of the Baltic, situations in which our gallant seamen have sometimes been exposed to the irritating and destructive effects of raking fires from gun-boats; is it not apparent from the preceding experiments, that a ship with a curvilineal stern, so circumstanced, would be enabled effectually to resist any attack of this kind? And that even if the vessel so acting on the offensive should vary her position with all the readiness a steam boat is capable of moving, the guns at the quarters and stern ports of a round stern ship could be as readily made to follow her? Nor would it be possible for the attacking vessel to take up any position in the neighbourhood of the stern, without having a gun or guns ready to resist her. This is an advantage which ships constructed on the old principle never possessed, and forms one among the many good qualities of the new.

The introduction of the round stern excited the most violent opposition: and the keenest controversies were excited amongst naval men respecting it. The publication however of some able papers has diminished in a very great degree the hostility so vigorously raised against it. The disapprobation of change, which at one time assumed the loud voice of thunder, has insensibly melted into tones of a gentler kind. Inquiry has been awakened, and many who imagined they saw in the alterations *indications of decay in the martial energies of our marine*, now contemplate it with respect to the superior strength it affords, and the more ample means of defence it unfolds. Some, however, faithful to the ancient form, still regard the circular stern with unabated hostility. But to such it may be said, are we to arrest the march of architectural improvement? Is the new principle of shipbuilding, which has already conferred such transcendent benefits on our country, to be deprived of one of its essential elements? While every other part of our men of war has received accession of strength, is the stern to remain in all its primitive weakness, without receiving a single benefit from the science and enlarged experience of modern times? Can such an anomaly long remain to mock the efforts of human improvement? Is the naval engineer to be doomed perpetually to reflect, that in the magnificent fabric which his genius has raised, science has lent her best efforts to strengthen the mighty system, in all its parts, save *one?* Or is the old system to be persevered in, to afford another exemplification of the maxim that partial strength is general weakness? Is it consistent, moreover, with that noble spirit of advancement, which so preeminently characterises the age, and which in its general operations, confers so great a lustre on our own beloved country, to allow mere feelings of convenience,* and vague and undefined notions of beauty to stand in the way of genuine improvement? Rather let us, by the universal adoption of the circular stern, prove that we only adopt a system which science and sound experience sanction; and that we only advance another step in the career of that improvement which has been so lately introduced into shipbuilding; and that we are no longer enemies to the doubtful forms of beauty, than when they stand opposed to the progress of real improvement.

The period, however, we firmly believe, is not far distant, when the circular stern will be contemplated by all unprejudiced minds, with more real pleasure than that form which has nothing but time and the false perspective of centuries to recommend it; shedding new lustre on the name of its celebrated author, and adding to the other intellectual trophies he has achieved, one not the least valuable; since it will carry with it the unerring symbol of truth: having made its way amidst prejudices of no ordinary cast, and in spite of an opposition of no ordinary kind; time having proved its unquestionable merits, and numbered it amongst its choicest and most valuable treasures.

OF THE STOWAGE OF SHIPS.

On this important subject, we cannot do better than introduce to our readers Mr. Morgan's valuable paper, contained in the first number of his useful periodical work, named, "Papers on Naval Architecture."

* It has been already observed that in the reign of Henry VIII. our ships were without the convenience of a water closet abaft.

By the stowage of a ship is meant the disposition of the ballast and stores. The great effect produced by different modes of stowage, renders this subject one of the most important connected with naval architecture. Most of the properties of a ship depend in some measure on the situation of the centre of gravity, which is determined by the disposition of the *moveable* weights on board. The great difference found to exist in the qualities of the same ship at different times arises principally from alterations in the stowage and trim. The astonishing improvements sometimes said to be made in ships by the removal of small weights might appear questionable; but as the present state of this branch of the science of naval architecture is not sufficiently known to fix with certainty the best sailing trim, the numerous facts related on the authority of men of experience are to be received with the greater credibility, if not admitting the degree, yet establishing the principle.

This subject has received the attention of many eminent scientific men, as well as experienced naval officers, through whose labours very valuable information has been obtained. In France the best memoir on the stowage of ships was several times made the subject of a prize by the Academy of Sciences. Daniel Bernouilli received the prize in 1757. Euler divided the prize of 1759; and Bossut and the younger Euler divided the prize of 1761.

As the situation of many of the weights in a ship are unavoidably fixed by circumstances, the advantages to be derived from an investigation of the stowage of ships can relate only to the *moveable* weights: the ballast, and *part* of the stores.

The quantity of stores and ballast in a ship is the first consideration in the stowage. The number of months for which vessels should stow provisions depends on their class and general service. No ship should, however, be incapable of stowing four months' provisions with the ordinary complement of stores.

The quantity of ballast is dependent on some of the qualities of a ship: chiefly the stability and the lateral resistance opposed to falling to leeward. An increase of ballast must always produce one disadvantage, an increase of the area of direct resistance, which, *cæteris paribus*, would reduce a ship's velocity in the water. By the increase of ballast, however, judicially stowed, the stability of a ship is frequently increased, so that she will carry so much more sail, that the moving power is increased more than the resistance, and consequently the velocity of the ship is increased. The question arising from this consideration is, whether the advantage produced by an increase of ballast could not be obtained by other means without an equal attendant disadvantage? The stability could be increased in a ship to be built by an increase of breadth preserved above and below the water's surface, so far as the immersion and emersion caused by the inclination, and extending considerably forward and aft. The lateral resistance to prevent the ship's falling to leeward, might be increased by the form below, and forward and abaft. By these means it would not be necessary to increase the quantity of ballast so much as is frequently done. This substitution of *form* for *an increase of ballast*, cannot, however probably be carried so far, but that a considerable quantity of ballast will be necessary. To what extent the quantity of ballast in ships may be reduced might probably be ascertained by experiment.

The properties of a ship which are chiefly affected by the stowage are, the stability, rolling, pitching, holding a steady course, ardency or tendency to fly up in the wind, going about, action of the rudder, and the strain of the materials. The manner in which the stowage influences these properties will be best seen by considering them, as far as is possible, independently of other circumstances.

1. *The stability.*—The disposition of the weights of a ship determines the position of its centre of gravity, which, *cæteris paribus*, increases or diminishes the stability according to its being lower or higher in the ship. This is as well known in practice as clearly demonstrable by science. The distribution of the ballast as low as possible, is therefore always necessary when the stability is required to be increased. The nearer the middle of the ship, in the full parts of the body, the ballast is stowed, the lower it will be, and consequently, the greater the stability. This, in almost all cases, is good stowage, in relation to the stability of a ship, as the case is rare when the lading of the ship is of such great specific gravity as to render it necessary to raise the weights, by putting articles of less specific gravity under.

2. *Rolling.*—In estimating the influence of the stowage on the rolling of a ship, it must be considered independently of the stability. The permanent inclination caused by the force of the wind, depends entirely on the stability; but the vibratory action of rolling depends on other causes, some of which are unconnected with the stability. Two ships of equal stability are frequently known to possess very different qualities in this respect; the one may roll slowly and easily, the other quickly and uneasily.

The rolling of a ship is caused by waves striking a ship's side; it is generally deepest either when a sudden change of wind takes place, and the ship sailing free, is struck on the side by the waves, which continue to run in the direction of the wind before the change; or in a calm, when the swell of the sea gives the body of the ship a constant disposition to incline, without any inclining force to keep the ship steady.

The rolling of a ship is sometimes (as has been before remarked,) considered analogous to the vibrations of a pendulum. Supposing some point below the ship to be the point of suspension, the length of the pendulum is measured by each particle into the square of its distance from the centre of suspension, divided by the whole body into the distance of the centre of suspension from the centre of gravity. The length of the pendulum would, therefore, be increased by removing the weight as far as possible from the centre of suspension. The disposition of the moveable weights in a ship, according to this consideration, therefore, to increase the length of the isochronal pendulum, would be to place them as far as possible from the vertical and longitudinal plane passing through the centre of gravity. By the increase of the length of the pendulum, the time of the oscillation is increased, so that the ship's rolling would be proportionally slower.

The analogy, however, between the oscillations of a pendulum and the rolling of a ship cannot be considered strictly correct.

An easier method of considering the effect of the weights on the rolling of a ship, is, simply, by estimating their resistance to rotatory motion by their inertia. As the inertia of any weight is measured by each particle into the square of its distance from the centre of suspension, the placing these weights furthest from the centre of suspension, would most increase their resistance to motion. In a ship, the centre of suspension must be considered to coincide with the centre of gravity, so that the further the weights are removed from the centre of gravity, the greater would be the resistance to quick and uneasy rolling.

The practice of "winging the weight," as it is technically called, suggested by these principles, is found to be fully justified by experience. Care should, however, be taken that the centre of gravity of the weights may not be raised by this disposition, that the stability may not be diminished by it.

Quick and violent rolling is frequently found to be very injurious to the hull and masts of a ship. Many modes of security of the beam ends and ship's sides have been adopted, which have been of great advantage in sustaining the strain caused by this action. Due consideration to form and good stowage are, however always found greatly to reduce the violence of a ship's rolling.

3. *Pitching.*—When a ship is so far passed over a wave, that the fore part is unsupported by the water, the mean vertical direction of the water acting abaft the centre of gravity, causes the bows to pitch forward into the hollow of the wave. This motion, as far as it is influenced by the distribution of the weights, is subject to the same laws as the rolling. The farther the weights are from a vertical transverse plane passing through the centre of gravity, the greater will be their inertia, and consequently, the slower and deeper the pitching. These two motions are, however, to be considered very differently, as to their effect on the ship. The advantage of increasing the time and depth of the rolling has been considered in diminishing the strain of the hull and masts; but the effect of deep pitching must, on the contrary, be considered as disadvantageous, by retarding the velocity of the ship's motion, and rendering it uncomfortable to the men, by the waves breaking over it.

When a ship has passed a wave, the afterpart falls into the hollow of the waves, by the mean vertical direction of the water acting on the foreside of the centre of gravity. This action, which is called scending is affected by the disposition of the weights similarly to the pitching.

The form of the fore and after parts of a ship determines, in a great degree, these actions of pitching and scending; but as other circumstances frequently require a form not the best calculated to regulate them, it becomes the more necessary that the best disposition of the moveable weights should be made for this purpose. It is therefore necessary to bring as many of the moveable weights as possible near the middle of the ship, to reduce the depth of the pitching and scending.

4. *Holding a steady course.*—When a body moves through any fluid, it is necessary that the lateral resistance abaft the centre of gravity should be greater than before it, to prevent the body having a continual tendency to turn round. This disposition in a ship to turn from the direct course, is technically called *yawing*: it increases the difficulty of steering, and retards the sailing. To prevent this bad quality in a ship, the weights should be so placed that the centre of gravity may be before the middle of the ship's length, by which the moment of the lateral resistance abaft the centre of gravity will be increased, and the moment forward diminished.

5. *Ardency.*—The ardency of a ship, or its tendency to fly up into the wind, depends on the mean direction of the water, the ship sailing by a wind, and the position of the centre of effort of the sails. When a ship is fully stored and properly trimmed, the mean direction of the water passes a little before the centre of gravity. By the loss of the consumable stores the trim may, by improper stowage, be so much altered, that a ship, which at first possessed a weatherly quality in a proper degree, may either lose it altogether, or have it altered so much as to destroy the excellency of this important quality. The stowage should, therefore, be so disposed, that the consumable stores should be taken in such proportions from the fore and after parts of a ship, that the good qualities at first possessed may be retained when lightened. This requires great acquaintance with the qualities of the ship to be stowed, as well as great judgment in the disposition of the ballast and stores.

6. *Tacking.*—The resistance a ship experiences, in coming about, depends on the lateral resistance of the parts before and abaft the centre of gravity. This resistance will be proportional to the squares of the lengths of the parts before and abaft the centre of gravity, which will be a minimum when the centre of gravity is in the middle of the length.

7. *Action of the Rudder.*—As the rotation of a ship must always be referred to the axis that passes through the centre of gravity, the momentum of the power of the rudder to turn a ship is proportional to the distance of the centre of the mean resistance of the rudder from the centre of gravity. This consideration would lead to the moveable weights being placed so that the centre of gravity of the ship should be before the middle of the length.

8. *Strain of the materials.*—The inequality between the weights in different parts of a ship, and the vertical pressure of the water at the corresponding parts, causes a continual strain on the ship longitudinally, which produces an arching, sometimes technically called *hogging*. To equalise these two actions, is the mode immediately suggested by the consideration of the cause of arching, as the best method of preventing it. Circumstances, however, prevent the establishment of the equilibrium; great weights will always necessarily be at the extremities of the ship, and the buoyancy of the corresponding parts of the body must always be very inadequate to their support, from the leanness of the fore and after parts of the body. As far, however, as circumstances will admit, the principle should be attended to, of placing the weights where the buoyancy of the body is best able to sustain them. This requires the ballast and heaviest stores to be placed in the full parts of the body, towards the midship section; reserving, however, the immediate vicinity of the mainmast free from the heaviest weights.

These are the principal considerations on the stowage of ships; and it happens fortunately, that the modes of stowage required by a due attention to the qualities influenced by it are generally compatible with one another. *The stability requires the greatest weights as low as possible, which is agreeable to concentrating them towards the middle of the ship's length, which is required to produce the best effect on the pitching, tacking, and strain of the materials. Holding a steady course, and the action of the rudder, require the weights to be placed so that the centre of gravity of the ship may be before the middle, but not so much as to be practically opposed to the consideration of its being very near to the middle, which reduces the resistance to coming about. The rolling requires the weights to be winged, which may be done by judgment and attention, without raising their centre of gravity, which would diminish the stability.*

The result of these observations is, that *the moveable weights in a ship should be so disposed that its centre of gravity may be low and a little before the middle of its length; and that they should be winged as much as possible without raising their centre of gravity.*

Chapman, says, in his Treatise on Shipbuilding, that the centre of gravity of a ship should be between the limits of $\frac{1}{50}$ and $\frac{1}{100}$ of the length before the middle. This proportion he most probably determined by calculations made on different ships in the Swedish service. The centre of gravity of ships of seventy-four guns, stowed according to the English method, as to the height of its situation, is generally from about six to nine inches above the load water line.

These principles govern the stowage of ships, but the manner and degree to which they should be carried into practice, must be ascertained by experiment. A course of experiments on the quantity of ballast, and the best disposition of weights on every class of ships, would be very valuable to the science of Naval Architecture. By determining the proper trim of the different classes of ships, much valuable information would be obtained for the naval architect in making designs. Many calculations, which are made by assuming the set of the ship in water, but which it is afterwards found necessary to alter, would be made with much greater certainty than at present. *It is by a combination of theoretical and experimental knowledge, in this subject as in most others connected with naval architecture, that this science will arrive at perfection.*

ON THE PARABOLIC SYSTEM OF CONSTRUCTING SHIPS INVENTED BY ADMIRAL F. H. CHAPMAN.

The system which is at present used by the Swedish engineers, in the construction of ships, was the result of the labours of the latter years of Chapman's life; it is called the parabolic method, and is explained in a work entitled, *Försök till en Theoretisk Afhandling att gifva åt Linie Skepp deras rätta Storlek och Form Likaledes för Fregatter och mindre Beväpnade Fartyg. af F. H. af Chapman. Carlskrona*, 1806.

The following paper, drawn up by Lieut. A. G. Carlsand of the Swedish navy,[*] is an outline of this description, with some few alterations, which the writer considers may perhaps render the calculations more simple.

By making calculations on a number of ships which have been found to possess good properties, and subjecting the result to scientific investigation, we are enabled to state what displacement and what dimensions a well-constructed ship should have; we can also determine where the centre of gravity, in respect to length, should be placed; but we cannot by the usual methods of construction, without very great labour, determine the area of the midship section, its distance before the middle of the length, and the areas or forms of the other sections, so as to ensure having this requisite displacement, nor that it shall be so distributed that the centre of gravity shall be in the required situation. It was to supply these deficiencies that Chapman invented the method which is the subject of this paper.

As the above-mentioned elements depend upon the areas and situations of the several transverse sections, Chapman endeavoured to discover whether or not these areas, in well-constructed ships, followed any law; and if so, to find the law. For this purpose, he calculated the areas of the sections of several ships; and, in order to make the numbers more convenient, he divided the areas by the breadth of the midship section; then setting off from the water line, at the respective stations on the drawing, distances equal to the quotients, he traced a curve representing the areas, which he called the curve of sections. He then endeavoured to find the equation to the curve, or rather that of another curve which would coincide with this for the greatest length; and he found that if the power and parameter of a parabola were so determined as to allow that curve to pass through three given points of the curve of sections, the two curves would nearly coincide. In the fore body the three points were taken, one forward, one at the midship section, and one midway between. In the after body the points were similarly situated. In some ships the exponent to the curve was higher in the after body than in the fore body, in some it was the same for both: it was also found that there were ships in which the curve of sections almost exactly agreed with the parabola, and these ships invariably bore excellent characters. Chapman consequently concluded, that if the areas of the several sections of a ship were made to follow the law of the abscissas of a parabola, a vessel possessing good sailing qualities might be formed, and the process of construction much simplified.

This account shows that this method is deduced from experience by theoretical investigation; it is applicable to all sorts of constructions, as it only requires that the relative areas of the sections shall decrease from the midship section towards the extremities, in a certain relation which can be varied to infinity; it is therefore equally useful in constructing the sharpest man-of-war, as the fullest merchantman.

It may perhaps be objected, that the alterations which have taken place in the forms of the bottoms of ships, since the introduction of this method by Chapman in 1806, would probably give different results; it is therefore desirable that this should be ascertained by a series of calculations on the bodies of some of the most modern ships which have been found to answer.

Suppose a ship is found to answer well at some given water line AC, Fig. 4, Plate CCCCXCV. Let the areas of the transverse vertical sections be divided by some constant quantity, as, for instance, the

[*] This ingenious gentleman was a pupil of the celebrated Chapman.

breadth, and suppose the distances $a\,b$, $c\,d$, &c. equal to the quotients, to be set off on the respective sections, from the water line; then a curve drawn through the points b, d, &c. will be the curve of sections. It will be found to be convex to the water line at the extremities.

The order of the parabola which coincides for the greatest distance with this line may easily be found.

Let the general equation to the parabola be expressed by $y^n = a\,x$: then it is always possible to determine n and a, so that the parabola shall pass through two points besides the vertex: any two points between b and C may be taken, but it is evident that the farther apart the three points are taken, the longer will the parabola coincide with the line of sections: of course neither point may be in the convex part of the line of sections. It will be found that the point g, at the foremost frame, and h in the middle between g and b, are the points which should be taken.

Draw a tangent to the curve at the point b, which will be of course parallel to the water line; then $m\,h$ and $n\,g$ are abscissas; $b\,m$ and $b\,n$ ordinates to a parabola passing through b, h, and g: put $m\,h = x'$, $n\,g = x''$, $b\,m = y'$, and $b\,n = y''$; then substituting these values in the equation to the parabola, we have

$$y'^n = a\,x', \text{ and } y''^n = a\,x''$$

$$\text{or } n\,.\,\log\,.\,y' = \log\,.\,a + \log\,.\,x' \text{ and}$$

$$n\,\log\,.\,y'' = \log\,.\,a + \log\,.\,x''$$

$$\text{hence } n = \frac{\log.\,x' - \log.\,x''}{\log.\,y' - \log.\,y''}$$

$$a = \frac{y'^n}{x'}$$

$$\text{and } \log.\,a = \frac{\log.\,x'\,.\,\log.\,y'' - \log.\,x''\,.\,\log.\,y'}{\log.\,y' - \log.\,y''}$$

We have now the value of n and a, and by calculating several other abscissas we can trace the parabolic curve. The same operations applied to the after body will give the exponent and parameter of the parabola, which is the most similar to the curve of sections in that body.

It generally happens that the exponents are nearly the same in both bodies, if the place of the midship section be determined in the manner shown in the sequel.

It will be found that the parabola and the line of sections very nearly coincide; the former being sometimes a little within the latter between g and h, and without at the foreside of h; and sometimes, but much more seldom, the contrary. The parabola always cuts the water line at a short distance from the rabbets, this distance being rather greater forward than abaft.

Several American ships of war have been submitted to this method of investigation, which was found to answer very well with their bodies: indeed there can be no great deviation, as the parabola varies according to its exponent and parameter; if the ship is full, a high exponent adapts it to that shape: and if the ship be lean, a small one. If the body has a long straight of breadth, and sharpens quickly at the extremities, by deducting a part in midships from the comparison, the system may still be applied: or if, as is the case generally with English merchant ships, there is a very great draught of water in proportion to the breadth, by deducting a part from the water line downwards, this method may be applied to the remainder.

From this reasoning it appears that ships may be constructed to coincide exactly with the parabolic line, without deviating from the forms which experience has proved to be the most conducive to giving ships good qualities. Chapman stated that this system would most probably be superior to the old one, and the result has confirmed his statement: for ships of the line, frigates, and merchantmen, have been constructed after it, all of which have been very fine vessels.

From the manner in which the curve of sections is formed, it follows that its area, multiplied by the breadth, is equal to the displacement, and that the centre of gravity of the area is in the same transverse section as the centre of gravity of the body: but the area of this curve, supposing it to be a parabola of a certain power, is a known part of the rectangle formed by the greatest ordinate and the abscissa; hence, by making the areas of the sections decrease in the ratio of the abscissas in the parabola, we obtain certain equations between the quantities. To find these equations, suppose the parabolic line, now also representing the line of sections, to be ACB, Fig. 5. Plate CCCCXCV., cutting the water line at some distance from both rabbets; let C be the place of the midship section, and DC the greatest abscissa. Put AB $= l$ and DC $= d$, let the exponent of the parabola before and abaft $= n$, and the displacement $=$ D; then the area of the parabolic line BDACB $= \frac{n}{n+1}\,.\,l\,.\,d$, and the displacement $= \frac{n}{n+1}\,l\,.\,d\,.$ B (B representing the breadth;) but d B $=$ area of the midship section; hence

$$\frac{n}{n+1}\,.\,l\,.\,(\textit{area of midship section}) = \text{D} \;.\;.\;.\; (1).$$

Let E be the middle point of the water line AB, which we may call the construction water line, F the place of the centre of gravity in point of length; let ED, the distance the midship section is before the middle of the water line, $= k$, and EF, the distance the centre of gravity is before the middle, $= a$: we will now determine the place of the midship section in reference to the situation of the centre of gravity F.

As BCD represents the displacement of the fore body, and CDA that of the after body, the moments of these two parts will give the common moment.

The centre of gravity of the parabolic area is at a distance from the abscissa DC

$$= \frac{n+1}{2\,n+4} \times \text{the ordinate DB;}$$

and for the parabolic area DCA it is

$$= \frac{n+1}{2\,n+4}\,\text{DA}.$$

The moment of DCB from the point E

$$= \left(k + \frac{n+1}{2\,n+4}\,.\,\text{DB}\right)\,.\,\text{DCB},$$

and the moment of DCA from the same point

$$= \left(\frac{n+1}{2\,n+4}\,\text{DA} - k\right)\,\text{DCA}:$$

But the areas of DCB and DCA are proportional to DB and DA, and the sum of the above moments $=$ EF . BCA, or $a\,.\,k\,.\,l$ representing the area; hence

$$a\,l = \left(k + \frac{n+1}{2n+4}\,\text{DB}\right)\,\text{DB} - \left(\frac{n+1}{2\,n+4}\,.\,\text{DA} - k\right)\,\text{DA}.$$

$$= -\frac{n+1}{2n+4}(DA^2 - DB^2) + k(DB + DA)$$

$$= (DA + DB) \,.\, \left(-\frac{n+1}{2n+4} \,.\, (DA - DB) + k\right)$$

but DA — DB = $2k$, and DA + DB = l: hence

$$a\,l = l\,k \,.\, \left(1 - \frac{n+1}{n+2}\right)$$

$$a = k \,.\, \frac{1}{n+2}$$

or $k = a \,.\, (n+2)$ . . . (2).

That is, if the midship section DC is placed at such a distance k from the middle point of the construction water line, the centre of gravity will be in the point F assigned to it.

These two equations, (1) and (2), form the principal foundation of the parabolic method of construction. In the first equation, any quantity may be known by assigning values to the others; and in the second, by fixing a value for the distance of the centre of gravity before the middle, the place of the midship section will be known; then, having by the first equation found the exponent of the parabola, any abscissa, GH or KL, may be calculated. Suppose, for instance, GH to be required; then, in the first assigned equation $y^n = a\,x$, r is known; also y and x are known for a certain point B, through which the parabola passes; the value of y for this point is DB. and of x is DC. This gives

$$a = \frac{DB^n}{DC} = (\text{by putting } DB = f)\,\frac{f^n}{d} \quad . \; . \; . \; (3).$$

Now GH is easily determined in the above equation, by assigning a value to CG, if CG or any other ordinate is expressed by y', the corresponding abscissa GH = x' is determined by the equation

$$x' = \frac{y'^n}{a} \;.\;.\;.\; (4).$$

This equation is sufficient for calculating the areas of all the sections for the fore body; and for those of the after body we have the equation (3), in which, by substituting f for DA, we get the value of the parameter, a', of the parabola of the after body, and substituting this value for a in equation (4), and giving to y' any value CK, a corresponding abscissa LK is obtained; and in the same manner as many may be found as may be thought proper. It is evident that GH and LK must be subtracted from the largest ordinate DC, to give G′H and K′L, which represent the areas of the corresponding sections.

This method of first calculating the abscissas and then subtracting them, may appear indirect, as the true lines G′H and K′L could have been obtained at once by transforming the equation of the parabolic line to another, beginning at the point D; but it would then have lost its simplicity, and the calculations would not have been easier than by this method. One thing may however be done, which is, to substitute the area of the midship section, instead of its quotient, by the breadth; by which the whole areas of the other sections will be obtained, instead of the lines which represent them.

The principles of the parabolic method being now explained, it will be easily seen how very useful its application is to the comparison of all ships, whether they were constructed with or without reference to it.

By referring to equation (1), we find that the displacement, area of midship section, and the construction water line, being known, the exponent of a parabola that coincides most nearly with the line of sections is easily found, and we shall have (putting M for the midship section) the value of

$$n = \frac{D}{l\,M - D} \quad . \; . \; . \; . \; . \; . \; . \; (a).$$

This value of n shows the degree of fulness of the ship: and as it refers us to a geometrical line, it gives us at the same time a geometrical and arithmetical expression for the relative fulness, and is in consequence preferable to the method which is sometimes used,—that of giving the proportion between the displacement and the circumscribing solid, which only gives an arithmetical expression.

This parabolic method may also be applied to show the relative fulness of the midship section of any of the water lines, of the displacement with respect to the water line, and of several other elements.

Let ABC Fig. 6, Plate CCCCXCV. represent a midship section, and let EF be a tangent to the curve at the point of contrary flexure C; the small area ECD, not being of any importance, may be neglected. If the midship section is at all similar to those usually given to ships, a parabola may be assigned which shall pass through the points B and C, and have nearly the same area with the midship section, and also nearly coincide with the curve; so that the exponent will afford means of ascertaining its relative fulness.

Call the breadth at the water line AB = $\frac{1}{2}$B, the depth AE = h, and the area ABE = $\frac{1}{2}$M, and let m be the exponent of a parabola having the same area; then

$$\frac{m}{m+1} \,.\, \tfrac{1}{2}\,B \,.\, h = \tfrac{1}{2}\,M$$

$$\text{and } m = \frac{\frac{1}{2}\,M}{\frac{1}{2}\,B\,h - \frac{1}{2}\,M} = \frac{M}{B\,h - M} \quad . \; . \; . \; (5).$$

In the same manner the exponent may be found for the water line, by supposing a parabola with its vertex at the greatest breadth, and passing through the points in which the water line cuts the middle line. Suppose the exponent of this parabola = r, the length on the water line = L, and, as before, the breadth = B; also let the area of the water line = W; then

$$\frac{r}{r+1}\,L,\ \tfrac{1}{2}\,B. = \tfrac{1}{2}\,W$$

$$\text{and } r = = \frac{W}{BL - W} \quad . \; . \; . \; . \; (6)$$

Lastly, suppose the areas of the several water lines from the load water line downwards to decrease in the proportion of the abscissas to a parabola, and let the exponent = s, the depth from the water line to the tangent of the midship section = h, the displacement = D, and the area of the water line = W; then

$$\frac{s}{s+1}\,W\,h = D$$

$$\text{and } s = \frac{D}{hW - D} \quad . \; . \; . \; . \; . (7.)$$

By calculating these different exponents for ships already built, and which have been found to possess good qualities, a very correct idea of their shape will be obtained, which, in making new constructions, may be referred to; and after a very short practice, the constructer will be enabled to determine, not only the principal dimensions, but the outlines of the body before a drawing is begun.

A collection of such calculations was begun by Chapman, and has, since his time, been considerably augmented; we now, therefore, know what the value of the exponents ought to be, in the different classes of ships, for the services to which they are destined. It is always found that large ships are fuller than small ones, and, in consequence, have larger exponents; and that merchant-men, have larger exponents than men-of-war of equal size.

The exponent of the line of sections in the Swedish navy, in ships of the line, varies from 2.5 to 2.7: of the midship section, from 5 to 3.8; of the water line, from 6.6 to 5.9: and of the displacement, from 2.2 to 1.8: of course the larger exponent belongs to the larger class of ships.

In frigates, sloops, and brigs, they are smaller: the exponent of the line of sections varies from 2.3 to 2.1; of the mid-ship section, from 3 to 1.9; of the water line, from 5.2 to 3.25; and of the displacement, from 1.6 to 1.25. These exponents show that small ships have much larger dimensions in proportion to their displacements than large ones.

The above results were obtained from the displacements and breadths, not including the plank: and the length is that of the construction water line, which, in Swedish ships, is $\frac{1}{24}$ less than the whole water line between the rabbets, $\frac{7}{10}$ of which deduction is made from forward, and $\frac{3}{10}$ from aft. In finding the exponent for the water line, its whole length between the rabbets is taken.

Of course these calculations are equally applicable with the plank on as with it off: in the first-mentioned case the sections near the extremities will have, relatively to the midship section, a larger area, and there will therefore be scarcely any hollow at the ends of the curves, and it will not be improper to take the length of the water line, the whole length between the rabbets.

The following tables are given as an illustration of this method:—

	Length on the water line.	Breadth ex-treme.	Depth from the water line to the lower edge of the Rab-bet.	Dis-place-ment, in-cluding the plank.	Area of the load water section.	Area of the mid-ship sec-tion.
	ft.	ft.	ft.	cub ft.	sq. ft.	sq ft.
Nelson -	[illegible]	[illegible]	25.5	[illegible]	[illegible]	1029
Bulwark -	[illegible]	49.0	19.8	[illegible]	7706	791
Endymion	157.0	41.9	16.0	55807	5656	510

Then from the equations (a), (5), (6), and (7), the following may be obtained:—

	Value of *n*, the exponent of the line of sections.	Value of *m*, the exponent of the midship section.	Value of *r*, the exponent of the water line.	Value of *s*, the exponent of the displacement.
Nelson -	2.836	6.9447	11.8034	2.3445
Bulwark -	2.851	4.4141	6.8273	2.2538
Endymion	2.300	3.1795	6.1235	1.6088

From this table of exponents, we may judge with certainty of the shape of the vessels. The *Nelson*, for instance, has a very full midship section, and an exceedingly full water line, but she is not relatively so full towards the extremities as the *Bulwark*, and her displacement is not relatively much fuller than that of the *Bulwark*. The *Bulwark* has a small midship section, is full towards the extremities, and has a very large water section in proportion to her displacement. The *Endymion* is a very sharp ship of her class, has a small midship section, is rather clean towards the extremities, but her water line is not very sharp: its proportion to her displacement is extremely large.

The four exponents which have been described, will separately only show the degrees of fulness in one direction; but they may be combined in such a manner as to express, at the same time, the longitudinal and transversal fulness; to effect which, the value of the area of the midship section $= \frac{m}{m+1} \cdot \mathrm{B}\,h$ must be substituted in equation (1), which gives

$$\frac{n}{n+1} \cdot \frac{m}{m+1} \cdot l \,.\, \mathrm{B} \,.\, h = \mathrm{D} \quad . \quad . \quad . \quad (b);$$

also by substituting the value of $\mathrm{W} = \frac{r}{r+1}\mathrm{B} \,.\, \mathrm{L}$ in the equation (7), we have

$$\frac{r}{r+1} \cdot \frac{s}{s+1} \,.\, \mathrm{L} \,.\, \mathrm{B} \,.\, h = \mathrm{D} \quad . \quad . \quad . \quad (c).$$

In these equations the products $\frac{n}{n+1} \cdot \frac{m}{m+1} \cdot \frac{r}{r+1} \cdot \frac{s}{s+1}$ show the relative fulness of different ships, in comparison to the circumscribing parallelopiped. When the construction water line is equal to the whole water line, as was supposed in calculating the foregoing table

$$\frac{n}{n+1} \cdot \frac{m}{m+1} = \frac{r}{r+1} \cdot \frac{s}{s+1} \,.$$

By this equation any error in determining the exponents may be detected; and also by using the whole equations (b) and (c), errors in the dimensions or exponents will be detected.

By a method of interpolation, formulæ of very easy application have been deduced; by which the depth of the centre of gravity of the displacement below the water-section, the height of the metacentre, and several other essential elements, may be approximated to, without the usually long calculations: and thus most of the qualities of a ship, which are determinable by calculation, may be ascertained, compared, and altered, with very little trouble, before the construction is begun.

In order to apply this method of construction to practice, nothing more is requisite than to know the limits between which the exponents generally are for the class of ships in question, the proportion between the principal dimensions, and the distance the centre of gravity should be before the middle of the load water line. In Sweedish ships of the line, and frigates, the distance of the centre of gravity of the displacement before the middle of the load water line, is between $\frac{1}{70}$ and $\frac{1}{60}$ of the length, and in smaller vessels it is a little more, depending on the manner in which their stores and rigging are distributed. This quantity being determined, the weight the ship is to carry, the weight of the hull, and the relative proportions of the different dimensions, or the value of the exponents; the calculations will give the areas of every section, leaving the constructer the power of giving them whatever form he may wish.

By inserting the calculations of a steam-boat* which I have very recently constructed according to this method, its application may perhaps be more clearly illustrated.

Suppose the ratio of the breadth to the length to be α, and that of the breadth to the depth to be β, by substituting them in the equation (b), it will become

$$\frac{n}{n+1} \cdot \frac{m}{m+1} \cdot \alpha \cdot \beta \cdot B^3 = D.$$

The values of m and n are known, being assumed from former experience; the displacement is determined by the weight of the engines, added to the weight of the stores, &c. and an approximation to the weight of the hull. By assigning values to α and β, the value of B is obtained, and from that the values of the length and depth. The dimensions being now known, the scantling may be determined, and the true weight of the hull estimated; which, if very different from the approximation which was used, will cause a corresponding alteration in the dimensions, &c. With a steam boat, the stability is of minor importance; therefore it is not necessary to refer to equation (c).

The vessel in question is intended for two 25 horse power engines, the weight of which, with the necessary stores and the other articles, was estimated to be about 2050 cubic feet of water, and the approximation which was at first made to the hull was 1850 cubic feet, which supposed the whole displacement to be 3900 cubic feet.

The vessel was intended to be sharp both at the midship section and at the extremities; hence n was taken = 2.12, and m = 3.0; the proportion between the length and the breadth, or α, was taken = 5.25, and that between the breadth and the depth, or β, = 0.32; by substituting this value in the equation, we have

$$B = \sqrt[3]{\frac{3900 \cdot 3.12 \cdot 4}{2.12 \cdot 3 \cdot 5.25 \cdot 0.32}} = 16.58$$

$$\text{Length} = 5.25\ B = 87.04$$
$$\text{Depth} = 0.32\ B = 5.31.$$

By calculating the weight of the hull according to these dimensions, it was found that the approximation was too small by 175 cubic feet; by adding this quantity to the displacement, and retaining the other values, it will be found from the above equation that the

$$\text{Breadth} = 16.822$$
$$\text{Length} = 5.25 \cdot 16.822 = 88.315$$
$$\text{Depth} = 0.32 \cdot 16.822 = 5.383$$

The weight of the engine, its situation, and its centre of gravity, must determine the place of the centre of gravity of the vessel, which was found to be about 2.25 feet before the middle of the length, on the construction water line: and consequently from equation (2), the situation of the midship section was determined to be 9.27 feet before the middle of the construction water line.

The stations of the other sections were determined by the room and space. The parameters for the fore and after bodies were first determined by substitution in the equation (3.) In the fore body

$$f = \frac{l}{2} - k = \frac{88.315}{2} - 9.27 = 34.887$$

and in the after body

$$f = \frac{l}{2} + k = 53.427$$

The area of the midship section from equation (5),

$$= \frac{m}{m+1} B\, h = \tfrac{3}{4} \cdot 16.822 \cdot 5.383$$
$$= 67.912 \text{ square feet,}$$

and the half area = 33.956.

Hence by equation (3), the parameter of the fore body

$$= \frac{(34.887)^{2.12}}{33.956} = 54.895$$

and for the after body

$$a' = \frac{(53.127)^{2.12}}{33.956} = 135.499$$

The calculations for the sections are contained in the following tables:—

For the Fore Body, $x = \frac{y^{2.12}}{54.895}$				For the After Body, $x = \frac{y^{2.12}}{135.499}$			
Sections. Name.	Sections. Distance from the Midship Sec. or y	Abscissa or x.	Half the Midship Sec. — x	Sections. Name.	Sections. Distance from the Midship Sec. or y	Abscissa or x.	Half the Midship Sec. — x.
	Feet.	Sq. Ft	Sq. Ft		Feet.	Sq. Ft.	Sq. Ft.
End.	34 89	33.960	.0	End.	53 43	33.960	.0
x	32.24	28.730	5 23	34	50 76	30.460	3 50
u	30 00	24.660	9.30	2	48 00	27.060	6.90
q	24.00	15.360	18.60	38	42 00	20.890	13 57
m	18.00	8.349	25.611	24	36.00	14 700	19.26
h	12 00	3.535	30.425	20	30.00	9.990	23.95
d	6.00	.813	33.147	16	24 00	6 225	27.735
Midship Sec.	0.00	.0	33.96	12	18 00	3.382	30 578
				8	12 00	1.432	32 528
				4	6 00	.329	33.631
				Midship Sec.	0.00	0 0	33.96

The areas of the sections being thus determined, the construction of the draught was begun. The midship section and one or two sections in each body being drawn in, and their areas ascertained to agree with the tables, one or two diagonals were got in, and the rest of the sections drawn, always keeping their areas precisely equal to those given by the table. The direction of the diagonals at the extremities, determined the places of the stem and stern post rabbets, and from that the length of the whole load water line was found to be 0.44 feet longer than that of the construction water line; viz. 0.33 at the fore end, and 0.11 at the after end; consequently the length of the load water line between the rabbets = 88.755 feet.

As in a ship constructed according to this method, the situation of the centre of gravity, with respect to

* The subject of steam boats will be resumed in the concluding part of the article.

the length, and also the displacement, are known correctly; during the progress of the work much tedious arithmetical calculation is avoided; and after very little practice it will be found that the forms of the different sections may, with great ease, be drawn to contain the requisite areas; and I am confident that by the general adoption of the method, an amazing saving of time and trouble would be effected.

ON PRACTICAL CONSTRUCTION.*

When a draught of a ship is formed upon the principles which have been laid down, adapting them as much as possible to the nature of the service on which she is designed to be employed, and to the seas or rivers which it is intended that she shall navigate, it becomes the duty of the practical builder to carry into effect the views of the constructer; and the first operation which he has to perform, is to delineate correctly, or as it is usually called, lay off the plane upon the mould loft floor. This practice has usually been considered as coming within the province of the practical builder, and may certainly be correctly performed, without the aid of mathematical learning: but in this, as well as in many other of the useful arts, a knowledge of geometry will correct old methods, or strike out new to forward the architect in his views and operations.

The naval engineer, after having formed his plan of the ship according to certain prescribed dimensions, furnishes the practical architect with the sheer draught, Fig. 1. Plate CCCCXCVIII. a plan of the form of the body at various sections, (Fig. 2.) a half breadth plan, (Fig. 3.) and a scheme of the principal dimensions of the ship, and the scantlings of the timbers, planking, &c. The *sheer draught* or plane of elevation, is chiefly useful for the purpose of giving the length of the ship, the depth in the hold, the hanging of the decks and their height from each other, the longitudinal sheer and height of the topsides at the various sections, the rake of the stem and stern post, with the overhanging of the stern. Upon this plan also is delineated the cutting down line of the floors, the draught of water at which it is intended the ship shall sail; the situation of the wales, the spacing of the timbers, the number, position and dimensions of the parts; the situation of the masts and channels, and the form of the gripe and headrails. The *body plan* or vertical plane of the timbers, gives the form of the ship transversely at different sections, corresponding with those similarly marked on the sheer draught, and with which they agree in height; and the half breadth plan or horizontal plane, shows the form and breadth of the frame of the ship at parts cut by horizontal lines, usually denominated waterlines, or by diagonal ones, which either show the length of the several timbers which form the frames or the stations of the ribbands or harpens, which serve to keep the frames in their places before the planking is brought on; these lines, but more particularly the diagonal lines, are used to prove that the sections on the body plan are fair. The obliquity of the cant timbers in the fore and after bodies is also shown on this plan.

To prevent the inaccuracy likely to take place in transferring the several dimensions of a ship from a drawing on a small scale to the actual size intended, the builder is furnished with a scheme of scantlings, which gives in words at length, or by figures, the principal dimensions, the breadth and thickness of the several timbers, (technically called their siding and moulding,) the nature and sizes of the fastenings, the rounding and dimensions of the beams, the thickness of the external and internal planking, decks, clamps, and shelf-pieces.

Being furnished with these plans and information, it becomes the duty of the practical builder to lay down the ship. The drawing furnished by the engineer being usually made on a scale of one-fourth of an inch to a foot, it is necessary to place the projection on the floor forty-eight times their size, in order to make mouldings for providing the timbers of the frame. This laying off the ship is performed chiefly by horizontal and diagonal lines cutting the body in various directions: the greater number of these employed, the more likely to be the fairness of the lines of the body, and the accuracy of the work.

Vertical lines are also used to lay down the after body: the variety of positions of the timbers, particularly in ships with square sterns, is such as to require in this part of the body the greatest nicety. When the builder is satisfied with the accuracy of the lines, they are slightly raised on the floor to prevent obliteration. It has sometimes been considered that great nicety is not required with the square frames; but care should be taken to conform as nearly as possible to the form and dimensions given, or difficulty will be experienced in adapting the cant frames to the body. In fine, except a ship be accurately laid down, the labour of the engineer has been employed in vain, as the best-constructed plan may be rendered nugatory for a want of due attention in the performance of this duty, and will also give eventually considerable trouble to the practical constructer in adapting the frames to their positions. To give the methods in use for laying down the several parts of a ship would far exceed our limits: and those of our readers who may wish to be informed on all these points are referred to Stalkart's *Naval Architecture:* to *The Elements and Practice of Naval Architecture,* third edition, or to Fincham's *Directions for Laying off Ships on the Mould Loft Floor.*

Before we enter upon the mode of combining, and the means used to unite the several pieces of timber and metals which constitute a ship, so as to form a whole, we must necessarily digress to give some account of the new mode of construction introduced into his Majesty's navy in the year 1810, by Sir Robert Seppings, who is now surveyor of the royal navy, with the modification which time and experience have enabled him to introduce to bring the plan to its present state of perfection.

The chief circumstances to be guarded against in shipbuilding are, a transverse alteration of form by a separation of one side of the ship from the other, but principally a longitudinal one by the two ends being depressed and the middle rising, which is termed arching or hogging, or in some cases the middle sinking, which is called sagging. The transverse alteration results generally from an imperfect attachment

* We are indebted for the article on Practical Construction to J. Knowles, Esq. F. R. S. secretary to the Committe of Surveyors of the Navy.

of the ends of the beams to the side of the ship, and the want of connexion between beam and beam and the longitudinal one, by the weights placed in the body in no degree corresponding with the displacement of water at the several sections. It is the object of Sir Robert Seppings to prevent these changes in figure by constructing ships according to a new application of matter, by which the strains to which they are subject shall be more equally divided throughout the fabric, and the material placed in such directions as are best adapted to resist those forces; and also by a new combination of the parts of their frames, so as to be enabled to bring into use timber which, from form, its smaller size and less length, shall be more easy to be obtained, and therefore less expensive. These improvements have been completely successful, and on this subject, we cannot do better than quote the opinion of a select committee of the House of Commons, which is given in their third report on Finance.

"Your committee deem it their duty particularly to notice Mr. Seppings, one of the surveyors of the navy, to whose abilities and exertions the country is mainly indebted for many of its most valuable improvements in naval architecture; the ingenious models of which have been submitted to the inspection of your committee, with all the necessary explanations of their several uses and application. Your committee do not pretend to describe or appreciate with accuracy the value of these improvements, to estimate which to their full extent, requires considerable professional experience: they are, however, fully convinced, that the result of them will be to effectuate, in the construction of ships of war, a great saving of expenditure to the public, and to secure a proportionate economy of human life, arising from their superior durability, and the great power of resistance to the elements, and to the casualties incidental to nautical life, which the modern system of keeping our ships at sea, at all seasons, and in all weathers, has rendered of the utmost importance. These services, although they have nothing of that brilliancy which forcibly attracts public admiration, will continue to confer a lasting benefit to the British nation long after that period when the beneficial effects of victories, however splendid, shall have passed away."*

* For these splendid and important improvements, Sir Robert Seppings was rewarded with the Copley medal by the Royal Society, the highest and most glorious distinction that that truly eminent scientific body can confer; and as the improvements which this honourable distinction were designed to commemorate, may be regarded as constituting an era in naval architecture, we add the speech made by the president (Sir Joseph Banks) on presenting the medal to Sir Robert, then Mr. Seppings.

"In offering to you this testimonial of the regard of the Royal Society, it gives me particular pleasure to remark, that the improvements which the council of the Royal Society have thought worthy of such a distinction, consist in the application of the first principles of mechanical science to objects of the highest importance, both for the preservation of human life and for the extension of national glory. The first and greatest of the ancient geometers is well known to have exercised his sublime talents in the investigation of the properties of floating bodies of various forms, and many of the most celebrated of modern mathematicians have made the science of naval architecture a favourite subject of research; but in no instance have these elaborate speculations led to a more important practical result than your ingenuity, judgment, and experience have enabled you to obtain, from a combination of arrangements depending chiefly on a very simple and well-known principle, and subservient to the strength and stiffness of the structure of ships, and to their power of resisting the impression of external force, and the various causes of decay.

"In the first of the papers which you have presented to this society on the subject, you have laid down the general doctrines on which your improvements have proceeded; your great object has been to establish oblique braces and riders, situated nearly in the directions of the diagonals of the squares made by the common frames and planks of a ship; and by means of the more effectual resistance which they afford, to obviate all such changes as tend to alter the angles of those squares, and especially that which is denominated arching or hogging, a change which depends immediately on the greater pressure of the water on the middle of the ship where the displacement is the greatest, while the weight is necessarily extended more towards the extremities: and you have succeeded in reducing the extent of this alteration in a newly launched ship of 74 guns, from 4 or 5 inches, which had been its usual magnitude in the hands of the best workmen, to 1 or 2. You have observed that no common carpenter makes a gate of vertical and horizontal bars only without a brace in an oblique direction: and you have found by experience that a solid wall of planks, although the braces are not so essential to it as to a frame, is still materially strengthened by the addition of diagonal riders; and by such riders below the gun deck, and by braces and trusses of smaller dimensions above it, you have so strengthened the whole fabric of the ship, as to increase the resistance equally in every part, very truly observing that any partial weakness does away the whole benefit of general strength.

"But you have not confined your attention to the arrangement of these oblique pieces only, in preventing the effect of arching: you have opposed an obstacle to the change perhaps still more insurmountable, in the additional resistance which you have enabled the lower part of the ship to oppose to compression, by filling up the spaces between the timbers, from the neighbourhood of the keel to the orlop, with firm blocks of old seasoned wood tightly wedged into all the vacancies, which were formerly only receptacles of dirt and vermin, affording ample opportunity for the accumulation of moisture and foul air, equally noxious to the durability of the ship and to the health of the seamen; and you have found that the additional firmness given to the bottom of the ship by this construction fully superseded the necessity of the inner planking or ceiling, and afforded at the same time greater strength and more space in the hold; allowing the ballast to be stowed lower, and increasing at once the buoyancy of the ship and her stability.

"For attaching the beams of a ship to the sides, you have introduced, under each of the decks, a shelfpiece running in a longitudinal direction, which also affords you considerable firmness in resisting a lateral force, and which you employ in concert with a compact iron knee attached at the one end to a chock supporting the shelfpiece, and at the other to the beam, which is thus tied with great firmness to the side. The planks of your decks are also arranged according to your general principle of obliquity, repaying you for some little sacrifice of longitudinal strength, by the great resistance they oppose to transverse forces, as well as by their co-operation in giving strength to the connexion between the decks and the sides, being strongly united to the sides by means of the pieces called waterways, which run along the angular junction, and which are coaked both to the planks and to the sides.

"It cannot be a just cause for lessening the satisfaction which you are entitled to derive from the success of your improvements, that others should have formerly attempted to introduce arrangements of a nature somewhat similar to your oblique braces or riders, but should have done it so awkwardly and unskilfully as to have failed altogether in obtaining any practical benefit from their imperfect inventions. If indeed the merit of mechanical improvement belonged exclusively to those who first had a vague notion of their possibility, the world would be filled with idle schemers and dreamers, multiplying their crude conceits for the mere chance of hitting upon accidental combination, which, when the hands of more industrious and skilful men had

As the arching of ships has been considered in all times as their most serious defect, it has been the object of maritime nations to take measures to prevent it; and we find that some of the ablest mathematicians and engineers have turned their attention to this object, and that their views have been for the most part the same, that of placing some of the materials in a diagonal direction, that the forces may act in the direction of their fibres, either by pulling or pressing upon them, the strongest direction in which materials of metal or wood can be placed. The mode of application in each case has differed according to the notions of the projector. These plans, however, have been severally abandoned after sufficient trial, and the causes assigned were the want of abutments; they are detailed with much ingeniousness by the Baron Dupin in his paper before quoted.

It remained for the genius of Seppings to adapt successfully the laying of the materials diagonally in shipbuilding to a considerable extent, and by a new and happy combination, by substituting the triangle for the rectangle, to effect the purpose so long desired. On which plans (Plate CCCCXCVIII. Fig. 1.) all ships and vessels belonging to our navy are now constructed; nor has it been confined to this country, for the advantages being so apparent, those ships of war which have been recently built by most foreign powers have also been constructed thereby. The arching of ships at the present time is comparatively nothing, and there are many instances of vessels built according to this method, having been saved, which would inevitably have been lost had they been constructed according to the method formerly practised.

As the strength of ships to resist the impulse of waves and accidents from shot, or from taking the ground, not only depends upon the manner in which they are put together, but also upon the size of the material employed, we shall give a scheme of scantlings for all classes according to the latest improvements.

Principal Dimensions and Scantlings of a Ship of each class, built according to the present improved method of construction.

Description.	*Ships of the Line.*						*Frigates.*								*Sloop.*			
	1st Rate. 120 *guns*		*2d Rate.* 84 *guns.*		*3d Rate* 74 *guns*		*4th Rate* 52 *guns*		*5th Rate* 46 *guns*		*5th Rate* 42 *guns*		*6th Rate* 8 *guns.*		*Ships of* 18 *guns*		*Brig of* 10 *guns.*	
	feet.	*in.*	*feet.*	*in.*	*feet.*	*in*	*feet.*	*in*	*feet.*	*in*	*feet.*	*in.*	*feet.*	*in.*	*feet.*	*in*	*feet.*	*in.*
Principal dimensions.																		
Length on the lower deck	205	0¾	196	5	177	1½	173	1	159	6	145	3	113	8	{ 110 1 upper		90 0 deck.	
of keel for tonnage	171	0	162	2¼	145	8⅓	145	7	134	0	121	11⅜	94	7¾	90	3	72	3
Breadth, extreme, to the thickness of plank of bottom	53	7¼	51	5½	48	2	43	10	40	5½	38	3½	31	7½	30	0	24	6
Depth in hold	23	2½	22	6	20	10	14	6	12	9	13	3	8	9	8	2	11	0
Burthen in tons cwt.	2613		2284		1798		1487		1167		951		503		432		231	
Scantlings.																		
Keel which is square in midship	1	8	1	7½	1	6	1	4	1	3½	1	3	1	1	1	0	{ sided 0 11 1 by 3 moulded.	
sides in fore part of the ship	1	6	1	5½	1	4	1	1½	1	1	1	0½	0	11	0	10½	0	9
after part of ditto	1	3	1	2½	1	1½	1	1½	1	0	0	11½	0	10½	0	9½	0	9
The keelsons are of the same dimension as the keel is in midship.																		
Stem, main square at its head	1	8	1	7½	1	6	1	4	1	4	1	3½	1	2	1	4	1	2
sided at its fore foot	1	6	1	5½	1	4	1	4	1	3½	1	3	1	1	1	1	0	10

brought it to perfection, they would be too happy to claim as their own legitimate offspring Other countries may be extremely fertile in speculations of this kind, but Great Britain has long been distinguished for practical excellence in arts and in sciences; and we may willingly consent to share with others some portion of the glory of original invention, provided that we retain as our peculiar patrimony the highest perfection of actual execution.

"We must, however, endeavour to keep always in view the advantage to be obtained by a combination of scientific reasoning with practical experiment; and while we admit the benefit to be derived from strengthening a ship with braces such as yours, we may with great propriety make use of some theoretical principles for determining the situation of the weakest parts which limit the strength of the whole fabric.

"Another Fellow* of this society, distinguished for the accuracy of his physical and mathematical determinations, has given an example of the mode of calculating the strain on the different parts of a ship, derived from the weight and from the pressure of the surrounding medium, and his calculations have been confirmed by a foreign contributor† to our transactions, who has very ingeniously obtained a simple and easy mode of finding the point of a ship at which the longitudinal strain is the greatest, by proving that this point must divide the length in such a manner that the weight of the portion of displaced fluid on either side of the point may be precisely equal to that of the corresponding portion of the ship and her various contents, while, in all other parts, there is an excess or defect of the weight on each side, compared with the pressure.

"You have informed us in a later communication, that not fewer than 38 sail of the line and 30 frigates have been constructed or refitted upon the principles of your method. You have recorded an experiment on the temporary stiffening of an old and worn out ship by oblique pieces, in which the arching was increased 3 inches, as soon as the frames were removed from the hold, and 3⅜ more upon the removal of the braces which had been placed diagonally in the ports, thus demonstrating the nature of the change on which the arching depends, and the proper direction of the forces to be employed for resisting it. You have stated the arching of the best 120 gun ships of the old construction as amounting to 9 inches, while the Howe, built upon your own plan, arched less than four. And you have adduced evidence to prove that in the severe engagement at Algiers, the quarter deck of the Active, laid in the usual manner, was much more injured by the firing than the other decks which had their planks arranged diagonally; and that the result of a comparative experiment in the Northumberland was equally favourable to the merits of your diagonal decks.

"I have now, therefore, only to congratulate you on a success as ample as your most sanguine wishes could have anticipated; and on a professional advancement and encouragement as liberal as becomes an equitable and enlightened administration to have bestowed; and to hope that your labours may still long continue to be immediately employed in the service of your country, and ultimately, if such a necessity should again arise, in the vindication and preservation of the liberties of mankind."

* Dr. Thomas Young, Foreign Secretary of the Royal Society.

† The Baron Dupin.

Principal Dimensions and Scantlings of a Ship of each class, built according to the present improved method of construction—continued.

Description.		Ships of the Line. 1st Rate 120 guns	Ships of the Line. 2d Rate. 84 guns.	Ships of the Line. 3d Rate. 74 guns	Frigates. 4th Rate 52 guns	Frigates. 5th Rate 46 guns	Frigates. 5th Rate 42 guns	Frigates. 6th Rate 28 guns	Sloop. Ships of 18 guns.	Sloop. Brig of 10 guns.
Principal dimensions.		*feet. in.*	*feet. in.*	*feet. in.*	*feet. in.*	*feet. in.*	*feet. in.*	*feet. in.*	*feet in.*	*feet in.*
Post stern square at head		2 1	2 0	1 11	1 6	1 6	1 6	1 3	1 2	0 11
fore and aft on keel, the false port included		3 0	2 10	2 9	2 1	2 0	2 0	1 10	1 11	1 8½
inner fore and aft at upper end		1 2	1 2	1 1	0 11	0 10	2 10	0 8	0 8	0 7
on the keel		1 8	1 7	1 6	1 2	1 2	1 2	0 10	0 10	0 10
Room and space of the timbers		2 10	2 9¼	2 9¼	2 7¼	2 6	2 6¼	2 6	2 5¼	2 4¼
Floor timbers, or (if used,) half floor sided in midship		1 3¼	1 3	1 2	1 1	1 0	0 11½	1 0	1 0	0 8
sided afore and abaft		1 2¼	1 2	1 1	1 0½	0 11¼	0 10¾	1 0	1 0	0 7
moulded at their head		1 2¼	1 2	1 1	1 0	0 11	0 10½	0 8¼	0 8	0 7
Futtock, first sided in midship		1 3½	1 3	1 2	1 1	1 0	0 11½	0 10	0 9½	0 8
moulded at their heads		1 2	1 1½	1 0½	0 11½	0 10½	0 10	0 8¼	0 7½	0 6½
second, sided in midship		1 2½	1 2	1 1	1 0	0 11	0 10½	0 9½	0 8½	0 7
moulded at their heads		1 1½	1 1	1 0	0 11	0 10¼	0 9½	0 8	0 7	0 6¼
third, sided in midship		1 2	1 1½	1 0½	0 11½	0 10½	0 10	0 9	0 8	0 6½
moulded at their heads		1 1	1 0½	0 11½	0 10½	0 9½	0 9	0 7½	0 6½	0 6
N. B. The first, second, and third futtocks are sided from half an inch to an inch less afore and abaft to what they are in midship.										
Futtock, fourth, sided		1 1	1 0¾	1 0	0 11¼	0 10¼	0 9¾	0 8½	0 8	
moulded at gun deck waterway		1 0¾	1 0¼	0 11¼						
at middle deck ditto		1 0								
at upper deck ditto		0 10	0 10	0 10	0 9½	0 9	0 8½	0 7	0 6	
Toptimbers, sided at their keels and upper futtock heads		1 1	1 0¾	1 0	0 11	0 10	0 9½	0 8½	0 8	0 6½
at the top of the side		0 11½	0 11½	0 11½	0 10½	0 9½	0 9	0 8½	0 7½	0 6
moulded at the upper edge of the sheer stroke in the waist		0 6¼	0 6¼	0 6	0 5½	0 5¼	0 5⅛	0 5	0 5	0 5
at ditto, afore		0 7¼	0 7	0 6½	0 6¼	0 5⅝	0 5⅜	0 5	0 5	0 5
at ditto, abaft		0 7	0 6⅞	0 6⅝	0 5½	0 5⅝	0 5⅝	0 5	0 5	0 5
at the upper side of quarter deck and forecastle ports		0 5	0 5	0 5	0 4	0 4	0 3¾	0 3½		
In hold.										
Limber stroke	thick	0 8	0 7	0 7	0 6	0 6	0 6	0 4	0 4	0 3
Diagonal riders, upper and lower	square	1 2	1 1	1 1						
	sided	-	-	-	0 11	0 11	0 11			
	moulded	-	-	-	0 6	0 6	0 6			
Diagonal riders, middle	square	1 3	1 2	1 2						
Diagonal trusses	square	1 0	1 0	0 11						
	sided	-	-	-	0 10	0 10	0 10			
	moulded	-	-	-	0 6	0 6	0 6			
Longitudinal piece at floor head	square	1 2	1 2	1 1						
	sided	-	-	-	0 11	0 11	0 11			
	moulded	-	-	-	0 6	0 6	0 6			
Longitudinal piece at first futtock head	square	1 0	1 0	0 11						
	sided	-	-	-	0 11	0 11	0 11			
	moulded	-	-	-	0 6	0 6	0 6			
N. B. The riders, trusses, and longitudinal pieces are sided one inch less in the fore and after bodies of ships, than the above dimensions.										
Iron trusses	broad	-	-	-	0 6	0 6	0 6			
	thick	-	-	-	0 1	0 1	0 1			
Thick stuff at floor heads	broad	-	-	-	1 8	1 8	1 8	1 6	1 6	1 6
	thick	-	-	-	0 6	0 6	0 6	0 4½	0 3	0 3
at first futtock head	broad	-	-	-	1 8	1 8	1 8	1 6	1 6	1 6
	thick	-	-	-	0 6	0 6	0 6	0 4	0 3	0 2
In the forebody of a ship are placed hooks, in the afterbody crutches of iron.										
Orlop deck.										
Beams, square		1 3½	1 3	1 2	1 0	0 10	0 9			
Halfbeams, square		0 11	0 10½	0 10½	0 10	0 8	0 8			
Shelfpieces	broad	1 0	1 0	1 0	0 11	0 11	0 11			
	thick	0 10	0 10	0 10	0 11	0 11	0 11			
Clamps	thick	0 8	0 7	0 7	0 6	0 5	0 5			
Chocks under shelfpieces	sided	1 0	1 0	0 11	0 11	0 10	0 10			
Strokes on the ends of beams	thick	0 8	0 7	0 7	0 5	0 4	0 4			
Gun deck in ships of the line, and lower deck in those of smaller classes.										
Beams	square	1 5	1 4½	1 3½	0 11¼	0 10½	0 [illegible]	0 8½	0 8	0 6
half	-	0 11	0 10½	0 10½	0 10	0 8	0 8	0 5½		
Shelfpieces	broad	1 2	1 2	1 2	1 2	1 0	1 0	1 0	11	0 11
	thick	0 10	0 10	0 10	0 8	0 7	0 7	0 9	8	0 8
Clamp	thick	0 9	0 8	0 8	0 5½	0 5	0 5	0 4	0 4	0 3
Chocks under shelfpieces	sided	0 10	0 10	0 10	0 9	0 7	0 7	0 7		

Principal Dimensions and Scantlings of a Ship of each class, built according to the present improved method of construction—continued.

Description.		Ships of the Line			Frigates.				Sloop.	
		1st Rate 120 guns	2d Rate. 84 guns.	3d Rate. 74 guns.	4th Rate 52 guns.	5th Rate 46 guns	5th Rate 42 guns.	6th Rate 28 guns.	Ship of 18 guns.	Brig of 10 guns.
		feet. in.	feet in.	feet in.	feet. in.	feet. in.	feet. in.	feet. in.	feet. in.	feet. in.
Spirketting	thick	0 7	0 6	0 6	0 5	0 4	0 4	0 3	0 3	
Waterways	square	1 2	1 2	1 1	1 0	0 10½	0 10½	0 9½	0 9½	
Plank of deck	thick	0 4	0 4	0 4	0 3	0 3	0 3	0 2	0 2	0 1½
Middle deck.										
Beams	sided	1 3								
	moulded	1 1								
half	square	0 10								
Shelfpieces	broad	1 1								
	thick	0 8								
Clamps	thick	0 7								
Chocks under shelfpieces	sided	0 9								
Spirketting	thick	0 6								
Waterways,	square	1 1								
Plank of deck	thick	0 3								
Upper deck.										
Beams	sided	1 1½	1 1	1 1	1 1	1 0	0 11½	0 10	0 9½	0 7½
	moulded	1 0	1 0	1 0	1 0	0 11	0 10½	0 9	0 8½	0 7½
half	square	0 9	0 9	0 9	0 9½	0 9½	0 9½	0 5½		
Shelfpieces	broad	1 1	1 1	1 1	1 1	1 1	1 1	1 0	1 0	1 0
	thick	0 8	0 8	0 8	0 8	0 8	0 8	0 7	0 7	0 6
Clamps	thick	0 6	0 6	0 5½	0 6	0 5	0 5	0 4	0 4	0 4
Chocks under shelfpieces	sided	0 8½	0 8½	0 8½	0 8	0 8	0 8	0 7	0 7	0 7
Spirketting	thick	0 5	0 5	0 4½	0 4½	0 4½	0 4½	0 3½	0 3½	0 3
Waterways	square	1 1	1 0½	1 0½	1 0	0 11½	0 11½	0 11	0 11	0 9
Plank of deck	thick	0 3	0 4	0 3	0 3	0 3	0 3	0 3	0 3	0 2½
Quarter deck.										
Beams	sided	0 9¾	0 9½	0 9	0 11	0 7½	0 7¼	0 6½		
	moulded	0 8¾	0 8½	0 8	0 8	0 7½	0 7¼	0 5½		
Shelfpiece	broad	1 0	1 0	1 0	0 11	0 11	0 11	0 10		
	thick	0 7	0 7	0 7	0 6½	0 6½	0 6½	0 5		
Clamps	thick	0 4	0 4	0 4	0 4	0 4	0 4	0 3		
Chocks under shelfpiece	sided	0 7½	0 7½	0 7½	0 7	0 7	0 7	0 6		
Spirketting	thick	0 3	0 3	0 3	0 3	0 3	0 3	0 3		
Waterways	square	0 10½	0 10½	0 10½	0 10½	0 10½	0 10½	0 10		
Plank of deck	thick	0 3	0 3	0 3	0 3	0 3	0 3	0 2½		
Forecastle.										
Beams	sided	0 9¾	0 9½	0 9	0 9	0 8½	0 7¼	0 6½		
	moulded	0 8¾	0 8½	0 8	0 8	0 7	0 7	0 5½		
Shelfpieces	broad	1 0	1 0	1 0	0 11	0 11	0 11	0 10		
	thick	0 7	0 7	0 7	0 6½	0 6½	0 6½	0 5		
Clamps	thick	0 4	0 4	0 4	0 4	0 4	0 4	0 3		
Chocks under shelfpieces	sided	0 7½	0 7½	0 7½	0 7	0 7	0 7	0 6		
Spirketting	thick	0 3	0 3	0 3	0 3	0 3	0 3	0 2½		
Waterways	square	0 10½	0 10½	0 10½	0 10½	0 10½	0 10½	0 10		
Plank of the deck	thick	0 3	0 3	0 3	0 3	0 3	0 3	0 2½		
Roundhouse.										
Beams	sided	0 7	0 7	0 6½						
	moulded	0 6	0 5¾	0 5½						
Shelfpieces	broad	0 10	0 10	0 10						
	thick	0 6	0 6	0 6						
Clamps	thick	0 3½	0 3½	0 3½						
Chocks under shelfpieces	sided	0 6	0 6	0 6						
Waterways	square	0 9	0 9	0 9						
Plank of the deck	thick	0 2½	0 2½	0 2½						
Wet outboard.										
Wales, main	broad	5 0	4 8	4 5	3 9	3 10	3 8	3 4	3 2	2 3
	thick	0 10	0 9½	0 8½	0 7½	0 7	0 6½	0 5	0 5	0 4
Thick stuff above main wale under ditto.*	thick	0 8½	0 8	0 7	0 6	0 5	0 5	0 4	0 3½	0 3
Wales, middle	broad	3 0								
	thick	0 5½								
Wales, channel	broad	2 8	3 0	3 0						
	thick	0 5	0 5	0 5						
Sheer strokes	thick	0 3½	0 4	0 4	0 4	0 4	0 4	0 3	0 3	0 3
Plank of the bottom	thick	0 4½	0 4½	0 4	0 4	0 4	0 4	0 3	0 3	0 3

* It is usual to work the upper edge of the thick stuff under the main wales of the same thickness as those wales, gradually diminishing the thickness of the planks until the lower edge of the lower stroke is wrought to the same thickness as the plank of the bottom.

The first operation necessary in building a ship is, to place pieces of wood on the slip destined to receive her, about four feet apart, for the reception of the keel: these are called blocks, and are laid at a declivity of ⅝ of an inch to every foot of the length to which they extend, or at an angle of 3° 20′. The keel is usually composed of elm logs, scarphed and bolted together. When it is secured on the blocks by treenails, the dead-wood forward and abaft is placed thereon, the form thereof is given by the line shown in the sheer draught called the cutting down line: as *a* (Plate CCCCXCIX. Fig. 10); the floors are then crossed in the keel, or the half floors put in place, (Plate CCCCXCVIII. Fig. 6,) the stem and stern post are raised, and if the vessel is to be built with a square stern, a frame is got up called the stern frame; this is composed of the stern and inner posts, with horizontal timbers fastened in their middle to the stern post, called transoms, and timbers which give the form to the sides of the stern called fashion pieces. In ships with circular sterns, the timbers are carried round with the same uniformity as in the sides, in order to give strength and security; (Plate CCCCXCVIII. Fig. 4;) those in the fore and after bodies of all ships, are canted so as to give the requisite forms. The frame timbers are formed into bends, being composed of 1st, 2d, 3d, 4th, and 5th futtocks, and top-timbers, (the number of futtocks varying according to the sizes of the ships and lengths of the timbers,) the first futtock a butt on the cross pieces, the second on the head of the floor or half floor, as the case may be, the third on the first, and so on throughout the assemblage, care being taken that the timbers be so disposed that the strength of the whole body be lessened as little as possible by the necessity of having them cut off by port holes.

The heads and keels of the timbers of the frame are converted square, so as to form abutments, and are united with coaks, which are let in two inches into the head of the one timber, and two inches into the heel of the other; when these timbers are properly trimmed, they are bolted together so as to form two bends of timbers in each connected frame. When all the bends are raised and secured in their proper places (so as to give the form of the body,) by shores, ribbands, and cross spauls, the keelson is put in place and bolted, and the ship is then said to be completed in frame, or to apply a term used of an animate to an inanimate body, the skeleton is formed. In this state the frames of ships of the line remain at least twelve months, in order that the vegetable juices may be evaporated before the planking is commenced: those of frigates and smaller vessels six months: this is technically called seasoning.

The frame of a ship is usually converted in its siding from ¼ to ½ an inch larger than the required dimensions, and the heads of those timbers which remain naked, are generally six or eight inches longer than the given scantlings. These are termed overcast. Before the planking is commenced, the frame is dubbed over with an adze till wrought to its proper dimensions, and the timbers are reduced to the length required.

The main wales and thick stuff over them are then brought on coaked to the timbers, and fastened also by bolts and treenails, these are worked top and butt, or anchor stock fashion, or with parallel strokes, according to the nature of the materials employed and their economical use; the ship is shored by the main wales, which shores remain until her completion, to prevent any alteration in form.

The orlop clamps and shelfpieces are then worked, and the beams and half beams placed thereon, these are coaked and bolted thereto, the former are also united to the keels of the chocks under the gun-deck beams by the plates. A solid bottom being a principal feature in the new mode of shipbuilding, not only to give strength to the fabric, but also security to the seamen in case of accident to the plank of the bottom by striking upon a rock, this operation is carried into effect by filling the smaller interstices between the lower timbers as high as the floor heads with strips of wood, and thence upwards by driving firmly in the openings between the frame timbers, on the outside, pieces of oak three inches thick, until they make a fair surface with the timbers; on this is placed a composition formed of two parts of lime of a particular description, called Parker's cement, and one part of drift sand, the mixture is placed on the outer filling of wood until it comes within 2½ inches of the surface inside; an inner filling of oak similar in all respects to the outer is then placed on this, and by being driven firmly against the cement, forces it into all the interstices, and thus renders the bottom to within three inches of the plank under the orlop clamp, one solid mass. The fillings are then dubbed fair, and slightly caulked on one of their sides and well rammed and caulked on the other.

The plank of the bottom is fastened by one copper bolt in each butt, and by one treenail in each timber, and it receives additional security by the bolts passing through it which connect the diagonal frame, and of which we are about to speak. This trussed frame is composed of diagonal timbers, (or braces, Plate CCCCXCVIII. Fig. 1. B.) of horizontal pieces (C) and of trusses (D.) The diagonal timbers are first put in place, and lie at an angle of 45° with the timbers of the frame; they are coaked and bolted to those timbers as well as to the clamps over which they pass. The longitudinal pieces are then put in place, and finally the diagonal trusses: thus the whole combination forms a series of triangles. In the fore body, the keels of the diagonal timbers meet, and being connected with straps of iron, form breast hooks—those in the after body are united in the same manner and form crutches—accuracy of workmanship is highly desirable in the frame, as the closer the horizontal pieces and trusses are in contact with the braces, the less will be the alteration in the figure of the ship from arching or hogging.

Two additional keelsons are worked in midships, (Plate CCCCXCVIII. Fig. 3. H) one on each side: these extend about 33 feet and are placed at such a distance from the regular keelson, that the ends of the step of the mainmast may rest upon them, and by being coaked or bolted to the floors or cross pieces over which they pass, strengthen the ship in that part, and prevent alteration in form by the weight and stress of the mast downwards, or by the pressure of the water upwards, on those floors which lie in nearly a horizontal position.

The gun deck clamps and shelfpiece are got in place, the beams coaked and bolted thereto, the spirketting and waterings worked, and the chock placed under the shelfpiece; the beams of the gun deck are fastened by a forked knee, (Plate CCCCLXXXVIII. Fig. 5.)

The description which has been given will be sufficient to show in general terms the progression made in building ships, as it would be unnecessary to dilate upon a progress nearly similar through the several decks; suffice it to say, that the outside planking proceeds progressively with the inside. We shall proceed to give the methods of putting together and fastening the several parts.

Beams of the principal decks.—These, from their great length and size, are usually made in three pieces, the tops of the trees which make the two end pieces abut, and the deficiency of their scantling in the middle of the beam, is compensated by a middle piece which is coaked and bolted to the two end pieces.

Shelf pieces,—(Plate CCCCXCVIII. Fig. 1. *a*,) are coaked and bolted to the clamps and to the beams of the several decks; they may be considered as internal hoops, and by connecting the frame and beams preserve the form of the ship.

Chocks under shelf pieces.—(Plate CCCCXCVIII. Fig. 3. *c*.) Where the beams do not come directly over the ports, chocks are placed under the shelfpiece and immediately under the beams. Upon the chocks, the face of the iron clasp knee rests, and is bolted. Where the beams do come over the ports, they are attached to the ship by an iron hanging knee, fastened against the side at a sufficient angle of inclination to clear the ports.

Trussing between the ports.—Instead of all the planks between the ports being laid in a horizontal position, a diagonal truss, (Plate CCCCXCVIII. Fig. 1. C,) is placed against abutment pieces (F) between each port to prevent the arching of the ship. The trusses (in midship) at the neutral axis are double (G.)

Waterways, (Plate CCCCXCVIII. Fig. 3, *d*,)—These are rounded in front, are scored down on, and coaked and bolted to the beams; a rabbet is taken out on the fore side to receive the planking of the diagonal decks: this is sufficient depth to give a seam of 3 inches for caulking.

Decks.—The beams and half beams for the reception of the plank of the decks are so placed as to give the greatest degree of strength, but so disposed as to leave such openings as may be necessary for the hatchways, ladderways, rooms for capstans, &c.; the planking of the principal decks is then laid upon them in a diagonal direction, (Plate CCCCXCVIII. Fig 2;) the outer ends of the diagonal planking are received in the rabbet cut in the waterways, the inner ends abut against thick strokes running in a fore and aft direction in midships.

Sterns.—All ships of the line and frigates are now built with circular sterns: the disposition of the timbers is shown, Plate CCCCXCVIII. Fig. 4, and the galleries in Plate CCCCXCIX. Fig. 1.

The foregoing observations have been chiefly confined to the building of ships of the line. The difference in frigates is, that instead of working in the hold a diagonal framing of wood, iron trusses are laid on the timbers at an angle of 45°, and at a distance of 6 feet from each other; and over the joints of the timbers, and crossing these trusses, two strokes of thick plank are worked, Plate CCCCXCVIII. Fig. 7.

In sloops and smaller vessels their bottoms are also made solid as high as the line of water, and a thick stroke placed over the joints of the timbers in the hold. The beams are not in general kneed, but fastened by being coaked and bolted only to the waterways and shelf pieces; two or three iron knees, however, are usually placed under those beams on each side, which are nearly opposite to the mainmast, and the same number to those similarly situated with respect to the foremast.

Having given the general outline of the present improved practice of building ships, the reader is referred for more minute instructions to "The Elements and Practice of Naval Architecture, 3d edit."

When the fabric of the ship is finished, it then becomes necessary to put up magazines, cabins, and store rooms, as internal accommodations; the number, and generally the situation of these, depend upon the size of the ship, the service on which she is to be employed, and the quantity of stores and provisions necessary for the men to navigate her, and to fight her guns.

The internal conveniences and decorations are also to be attended to, such as the cathead for the anchors, the boomkins for the foretack, the channels for the reception of the dead-eyes for the security of shrouds and backstays, the stern galleries and headrails.

During the progress of building a ship, a variety of measures are resorted to for the purpose of preserving the materials from early decay, such as painting the surfaces of the timbers and planks which come in contact, injecting tar and lime into the bottom; but for these and other methods the reader is referred to a recent work, "Knowles on Preserving the Navy."

When the ship is ready to be launched into the water, sliding planks are laid upon blocks of wood on each side, at an inclination of $\frac{7}{8}$ of an inch to every foot of their length, or at an angle of nealy 4° 10′; these planks are usually laid straight, but a slight curvature is preferred by some builders. The distance of these sliding planks from the keel on each side depends upon the form of the body; but as a general principle, it may be considered as one-sixth the extreme breadth of the ship. Ribbands are fitted on the outer edges of the sliding planks to keep the cradles in their places. A combination of large pieces of timber, called bilgeways, is then placed upon the sliding planks, and a cradle fitted thereon to the form of the ship. This cradle is attached to the slip by a shore on each side, called dog-shores, lying at a small angle of inclination. A short time before the ship is to be launched, the bilgeways are canted out, and the sliding planks payed over with a composition made of soft soap, oil, and tallow. When the cradle is replaced and properly fixed, the shores against the sides and stern of the ship are taken away, the blocks under the keel split out, and the dog-shores removed; and thus, being left without any impediment, the ship glides down the inclined plane into the water.

Scholium.

Soon after the introduction of the diagonal system, considerable doubts were entertained by many practical men respecting the proper disposition of the braces and trusses; some asserting that the arrangement given to them by Sir Robert Seppings was just the reverse of that which ought to have been. To obviate any objection on this head, we extract from a paper in the Philosophical Transactions for 1818, an account of an interesting experiment, performed by Sir Robert Seppings, to prove the truth of his mechanical arrangement of the trusses and braces.

"Early," says he, "in the year 1817, the Justitia, an old Danish seventy-four gun ship, was ordered to be broken up on account of her defective state; and having observed her to be considerably arched, or hogged, I determined, notwithstanding her age and defective state, to apply the trussing principle to a certain extent, with a view to observe what effect it would produce on a fabric reduced to so weak and shaken a condition.

"The officers of the yard were directed to place sights on the lower and upper gun decks prior to her being taken into dock; and to ascertain, when she grounded on the blocks, how much she had altered from the state in which she was when afloat. They were then to place a certain number of trusses in the hold, some in the forepart of the vessel inclined *forward* at about an angle of forty-five degrees, and others in the after part of the vessel inclining *aft* at the same angle. Others were also to be placed at right angles to the former, and so as to act against the beams of the deck. In the ports also, other trusses were introduced, those in the ports forward, inclining forward in an angle of 40°, and those in the midships aft, at the same angles, but in an opposite direction. (A drawing of the arrangement of the trusses, &c. may be seen in the part of the Philosophical Transactions referred to.) As it was uncertain where the centre of fracture would take place, a few of the port holes about the centre of the ship had trusses introduced into them in *both* directions. Wedges were applied to the heels of the trusses to set them tight. The ship being thus *partially* trussed, the water was let into the dock, and the ship floated out of it into the basin, where she was to lay one hour, when a committee was to examine the sights, and ascertain how much the ship had altered; and again, what change had taken place in twenty-four hours after floating. This being done, the trusses were to be disengaged in as short a time as possible, in order to observe whether the effect of their removal would be instantaneous or gradual."

The following is an extract from the report of the Committee.

"When the ship was in dock, on blocks perfectly straight, she came down in the midships, by the sights placed on the gun deck, *two feet two inches and a half*; and by those on the upper deck, *two feet three inches and a quarter*: and when undocked, with the trusses complete and in their places, she hogged, or broke her sheer, by the sights on the gun deck, *one foot two inches*; and by those on the upper deck *one foot two inches and five eighths*: and at the expiration of twenty-four hours she had hogged, or further broke her sheer, *two inches and five eighths*, and then appeared stationary and completely borne by the trusses.

We then proceeded to take away the trusses in the hold, and when they were wholly disengaged, she further hogged, or broke her sheer, *six inches*. We next proceeded to take away the trusses in the ports, and when they were wholly cleared, she dropped at the extremities, or further hogged, *three inches and a half*, and was in the same position when tried twenty-four hours after.

We further beg to state, that the whole of the trusses alluded to as placed at right angles to the first introduced, *slackened as the ship floated* from the blocks, and became *short from half an inch to three inches and a half, and partook of no part of the pressure*; which, in our opinion, clearly proves that the direction in which Sir Robert Seppings has applied his diagonal frame is correct, as also the great utility of the trussing system; for although the ship, from her very defective state, was much against so severe an experiment, it has proved to us its good effects most satisfactorily; for many of the trusses in the ports *forced the timbers three eighths of an inch within the ends of their covering planks*, thereby lessening their effect from what it would have been if the ship had been of a sound texture; yet on a ship in this state, *the trussing between the ports alone*, after those in the hold were wholly disengaged, had the effect of sustaining the immense pressure of both ends of the ship in her worst position, and prevented her from breaking, which she otherwise would have done, from three to four inches, and which she actually and *immediately* did on their being disengaged."

This statement of the Portsmouth officers, says Sir Robert Seppings, will, I trust, be considered conclusive as to the benefits to be derived from the princi-ple of trussing in the construction of ships *though it was only applied from the keelson to t* *in the hold, and not to the ribs or frame of th* is the case when ships are regularly built on this system, yet it sufficiently establishes the soundness of the principle.

When the Justitia first floated, continues Sir Robert, after being partially trussed, as described, the noise occasioned by the pressure on the trusses, is stated to have been *truly terrific*, until she was fairly settled on them. The disengaging them also caused a similar crash.

Very recently, Mr. Harvey has shown from theoretical principles, that Sir Robert Seppings's disposition of the diagonal frame is consistent with the soundest principles of mechanical truth. His investigation, originally published in the 42d number of the *Journal of the Royal Institution*, is here given.

Mr. Harvey introduces his subject with the well-known mechanical principle, viz. that if through the point in which the sustaining forces meet, a line be drawn to represent the measure and direction of the straining force, and on it a parallelogram be constructed, as a diagonal, having its sides parallel to the sustaining forces; then if the remaining diagonal of the parallelogram be drawn, and through the point where the sustaining forces meet, another line parallel to the same, all the parts of the framing on *the same side* of this line, as the straining force, will be in a state of *compression*, and all those on the *other side* of the same line in a state of *extension*.

Mr. Harvey illustrates the application of this mechanical principle by two diagrams as follows: In Fig. 7. Plate CCCCXCV. let AB and AC represent two of the braces or ties of a system of a diagonal framing, and GD, DF, HE, EF, corresponding trusses. Let also GH, DE, and BC denote the longitudinal timbers of the same system, and F the fulcrum on which the whole is supported. Then if we apply the mechanical principle in the first place to the brace AC, and the longitudinal timber BC at the point C, where these timbers may be supposed to meet, let the vertical line CI be drawn to represent the measure and direction of the straining force operating at that point. On CI as a diagonal, let the parallelogram C *a* I *b* be constructed, having its sides in the directions AC and BC of the longitudinal axes of the timbers selected for consideration. Draw the other diagonal *a b* of the parallelogram, and through C, where the vertical force is supposed to operate, draw *d e* parallel to *a b*. Then, since the longitudinal timber BC is on the *same* side of *d e* as the straining force CI, it will, by the principle referred to, be in a state of *compression;* and the brace AC, being on the *opposite* side of the same line, will be in a state of *extension.*

To apply the same principle in the second place to the brace AC, and the truss FE, let the straining force be supposed to be applied at E, and EK to denote its measure and direction. Complete the parallelogram E *f* K *g*. Join *f g*, and through E draw *h i* parallel to *f g*. Then the truss FE being on the *same* side of *h i* as the straining force, EK, will be in a state of *compression:* and the brace AC being on the *opposite* side of the same line, will be in a state of *extension* as determined in the preceding case.

To apply the mechanical principle in the next place, to the brace AC or AB and the longitudinal timber DE, let the straining force be allowed to act at D, and let DL be its measure and direction. Complete the parallelogram D *k* L *l*, and join *k l*; and through D draw *m n* parallel to the last mentioned line. Then the longitudinal timber DE being on the *same* side of *m n* as the straining force, it will be in a state of *compression*, and the brace AB or AC, as before determined, in a state of *extension.*

Fourthly, Let the parts now to be selected, be the longitudinal timber GH and the truss HE. Then if the straining force be applied at H, let HM denote its measure and direction; and on it as a diagonal, let the parallelogram H *o* M *p* be constructed, having its sides coincident with the directions of the timbers proposed: join *o p*, and through H draw *q r* parallel to it. Then since the truss EH is on the same side of *q r* as the straining force, it will be in a state of *compression:* and the longitudinal timber AH being on the *opposite* side of the same line, will be in a state of *extension.*

Hence it appears that the resultant of the various forces acting on the diagonal frame proposed will operate so as to *extend the braces* AB and AC *and the longitudinal timber* GH; but on the remaining parts of the frame, viz. the *trusses* GD, DF, HE, EF, and the *longitudinal timbers* DE, BC, the effect will be to produce *compression:* agreeing with the experimental conclusion of Sir Robert Seppings, that the frame with this disposition of the braces "comes more in contact by the pressure."

Let us now endeavour to estimate the effect of a similar system of forces, on a system of framing whose braces and trusses are disposed in *opposite* directions to those of the preceding investigation. For this purpose, let the first application of the lemma be to the longitudinal timber BC, and brace AC, Fig. 8, A being the fulcrum; and let the point C be that to which the straining force is applied. Suppose CI to be its measure and direction, and complete the parallelogram C *a* I *b*. Join *a b*, and through C draw *d e* parallel to that diagonal. Then since the brace AC is on the *same* side of *d e* as the straining force, it will be subject to *compression*, contrary to the effect produced in the former case. But the longitudinal timber BC, like GH in the former figure, will undergo *extension.* In the next place, let the straining force be supposed to be applied at E, in order to estimate its effects on the brace AC, and the truss FE; and let EK be its measure and direction. Complete the parallelogram E *f* K *g*; join *f g*, and draw *h i* parallel to it through the point of application E. Then the brace AE being *below* the line *h i*, will undergo *compression* as before; and the truss FE being *above* the same line will undergo *extension.*

In the *third* place, let the straining force be applied at D to produce an effect on the brace BA and the longitudinal piece DE, and DL be its measure and direction. Complete the parallelogram of force D *k* L *l*. Join *k l*, and through D draw *m n* parallel to *k l*. In this case, therefore, the brace DA being *below m n* must undergo *compression*, and the longitudinal timber DE being *above* the same line, must undergo *extension.*

Fourthly, Let the straining force be applied at H, to estimate its effect on the truss EH, and the longitudinal timber GH, and let its measure and direction be HM. Complete the parallelogram of forces, H *o* M *p*, having its sides in the axes of the timbers proposed. Draw the diagonal *o p*, and parallel to it, through H, the line *q r*. Hence it appears that the truss EH, being *above* the line *q r*, must undergo *extension:* and the longitudinal timber GH, being *below* the same timber, must undergo *compression.*

With this disposition of the timbers, therefore, it appears, that the forces operating on the frame will produce a *compression of the braces BA, CA*, and of the *longitudinal timber* GH; but on the remaining parts of the frame, viz. the *trusses* BD, DA, CE, EA, and the longitudinal timbers DE, BC, the effect will be to produce *compression*, agreeing also with the experimental conclusion of Sir Robert Seppings, that on the application of a straining force, the trusses and middle longitudinal piece "will be immediately disengaged and fall out."

The preceding results may be conveniently arranged in the following table:

	Nature of the strain operating on the timbers				
	Braces.	Trusses.	Upper longitudinal piece	Middle longitudinal piece.	Lower longitudinal piece.
With the braces in the *forebody inclined aft*, and those in the *afterbody inclined forward* as in Fig. 7.	Extension.	Compression.	Extension.	Compression.	Compression.
With the braces in the *forebody inclined forward*, and those in the *afterbody inclined aft* as in Fig. 8.	Compression.	Extension.	Extension.	Extension.	Compression.

The primary object of the diagonal framing is to prevent arching; and if we suppose AF, in both figures, to represent the natural line from which the arching proceeds towards both extremities, it is evident that it is the mechanical combination represented in Fig. 7. which can alone prevent it. For since A, in that figure by the hypothesis, is one of the *neutral* points of the system, it may be regarded as fixed, and the tendency of arching being to depress the point H, C, and G, B, the effect on the braces AC and AB will be precisely similar to the weights applied in the preceding investigation; that is, to produce *extension*, and which is effectually provided for by the fastenings. The effect, moreover, brought at the same time into action by the trusses, in consequence of the disturbing force, is to resist, by the whole longitudinal strength of their fibres all tendency to alteration of form; so that the effect exerted to depress the point C, is at once resisted by the fastenings appertaining to the brace AC, and to the longitudinal strength of the fibres of the truss proceeding from the unchangeable point F. The point E becoming, in this point of view, fixed, the action of the force which tends to depress the point H, in common with the point C, is resisted by the fastenings of the longitudinal timber AH, and by the longitudinal resistance of the fibres of the truss EH; so that, provided the fastenings of the braces and of the upper longitudinal timber are sufficient, and the abutments of the trusses and of the middle longitudinal timber are also proper, all tendency to arching will be resisted in proportion to the perfection of the materials, and the excellence of the workmanship.

But by referring to the converse disposition of the braces, as represented in Fig. 8, it appears, from the preceding investigation, that the braces AC and AB are subject to *compression*. And since the point A is by the hypothesis, the neutral or fixed point, the effect of the compression of the brace AC must be to *depress* the point C, and thus to promote the tendency to arching. Nor is this tendency to lower the point C prevented by the action of the truss FE; since the point F being fixed by the supposition, the tendency to *extension* which takes place in the truss must tend to lower the point E, and thus to promote the further declension of the point C. The point E being thus depressed, must add its effect to the extending force called into action in the truss EH, and thus produce a declension in the point H. Hence the whole effect of the disturbing force is to *lower* every part of the frame from C to H, and thus to promote the arching of the vessel. Hence the superiority of the present system of diagonal framing becomes apparent, and the advantages derived from it are demonstrated by the small alteration of form which ships now undergo in the act of launching.

ON THE CONSTRUCTION OF SHIPS IN THE MERCANTILE NAVY.

It is remarkable that most of the investigations offered to the public notice respecting shipbuilding have an especial reference to the construction of ships of war, their ingenious authors seeming to overlook the great variety of vessels which constitute our commercial marine. That the country is deeply interested in whatever relates to commerce, that great source of our national wealth, there can be no question: and when we know that the tonnage of British shipping belonging to the ports of the united kingdom, amounts on an average to nearly a million and a half annually, transporting from thence the varied products of British industry and skill to every quarter of the globe, it would be unpardonable in an article on shipbuilding, not to make some brief allusion to a subject of so important a kind.

There is a serious and important defect in the present construction of mercantile ships, as regards the putting together of their ribs or frames, and the general arrangement of the materials.

In forming the frames or ribs, *half the timbers only are united so as to constitute any part of the arch*; every alternate couple only being connected together, the intermediate timbers, termed fillings, being entirely unconnected with each other, resting only on the outer planking, without contributing in any degree towards its support. It must be evident that ships so constructed can by no means possess equal strength with such as have the whole of their timbers formed into uniform frames or arches.

This loose, dangerous, and very imperfect mode of shipbuilding, is, according to Sir Robert Seppings, peculiar to the English merchant shipbuilder; and we know even that it is only in latter years that the same system of building has been abandoned in the king's dock yards, while the preferable system of connecting the ribs was common to other maritime powers.

The principle of uniting the frames, lately introduced in the construction of ships of war, might without doubt, be advantageously introduced into the mercantile navy; a system which would communicate to the ships of our commercial marine much additional strength and increased durability, *without adding to the expense of building*.

But the present mode of joining together the several pieces of the same rib, is open also to the heaviest objections. The method adopted is by introducing a third piece, technically termed a *chock* or *wedge piece*, as in Fig. 1. Plate D. of which pieces the number amounts to upwards of 450 in a 74 gun ship, and to not less than that number in an Indiaman of 1200 tons, and to which class of ships the subsequent drawings to be referred to have an especial reference. Of these chocks, not one in a hundred is ever replaced on the general repair of a ship; for they are not only found defective, but very generally to have communicated their own decay to the timbers to which they are attached. Besides this the grain of the rib pieces being much cut to give them the curvature required, contributes in a very considerable degree to the general weakening of the fabric. That they occasion a great consumption of materials is very obvious, as the ends of the two rib pieces must be first cut away, and then replaced by the chock.

The introduction of chocks was done with the view of obtaining that curvature which is so necessary in the formation of a ship, when crooked or compass timber became scarce, as may be seen by a reference to Fig. 2. which describes the shape of a piece of timber in the converted form; and by which also it will be perceived that the introduction of the chocks assists in obtaining the required curve.

The frames of a mercantile ship, on the present mode of building, before they are placed and united to each other, may be seen in Fig. 3. with their chocks or wedge pieces. To the evils already stated of the present practice, may be added that of imperfect workmanship, so that the surfaces of the chocks are seldom in contact with the surfaces of the timbers. The ends of both are moreover frequently reduced so thin, as to split by the fastenings that are necessary to secure the planks to the ribs; and thus the ship, in the event of grounding, or even in the ordinary act of rolling, derives little support from timbers united only in fact by two narrow edges.

Another great defect arising out of the present plan of constructing mercantile ships is, that the ends of the lower ribs or timbers, commonly termed the futtocks, Fig. 3. B, are not continued across the keel C, so that no support is given in a transverse direction when the ship touches the ground: nor any aid to counteract the constant pressure of the mast. This great sacrifice of *strength* and *safety*, is made for no other purpose than that of giving a passage for the water to the pumps.

The floor timbers, which by this mode of construction are the only timbers which cross the keel, are also weakened for the same purpose, as shown at D in the figure last quoted. This mode, moreover, makes the conveyance of the water very uncertain, since the passage is not unfrequently choaked: and the pumps, from its not being practicable to continue them sufficiently down, always leave from six to eight inches of water in the ship; so that these compartments constantly contain a certain quantity of putrid bilge water, offensive and injurious to the health of those on board.

The deficiency of strength causes also an alarming insecurity in the plank of the bottom, termed the garboard strake, as shown at E; and which consequently is in no other way connected with the general fabric, than its connexion with the keel at F, and a slight security at G. Hence it is obvious, that in the event of the keel being disturbed, the garboard strake, from its being attached to it, must share the same fate as the keel, and in that case the loss of the vessel would be inevitable.

To obviate these very serious defects, and to do that for our mercantile marine which he had already so successfully accomplished for ships of war, Sir Robert Seppings laid before the Royal Society in March 1820, a highly important paper, and which was printed in the Transactions of the same year. The principle may be comprehended by a reference to Fig. 4. in which it will be seen, *that the component parts of each rib are of shorter lengths and less curvature, and consequently less grain cut: that they are more firm and solid by the substitution of coaks or dowels, for chocks or wedge pieces: and that the mode of connecting the lower timbers is better adapted, in the event of a ship grounding, to give support and strength to the fabric, as will appear by the line marked H.*

That the frame of the Thunderer, (now Talavera,) built on this principle, is superior in point of strength, says Sir Robert Seppings, to a frame constructed on the common system, is fully established by a report from the officers of his majesty's yard at Woolwich to the Navy Board, who directed them to compare the strength of the frames so united with those of the Black Prince, constructed in the usual way with chocks or wedges.

In alluding to this interesting and important comparison, Sir Robert remarks, that "*the frame of the Thunderer was composed of small timber, hitherto considered applicable only for the frames of frigates.*" "I was prompted," says this ingenious constructer, "to attempt the introduction of the plan on which she is built, from there being a surplus store of small timber in the yard; and from a conviction, *that a well-combined number of small timbers might be made equal, if not superior, both in strength and economy, to the large, overgrown, and frequently grain-cut materials, made use of in constructing the frames of large ships: and the result has shown the correctness of the principle;** the adoption of which cannot fail to prove of great national advantage, in *the application of sloop timber to the building of frigates, and of frigate timber to ships of the line,* whenever larger timber cannot be procured. On this principle, also, may frigates and small ships of war, or merchant vessels, be built of straight fir, without the assistance of oak or elm, which were formerly employed to give the necessary curvature of the sides." The principles here laid down by Sir Robert Seppings, are of vast importance, and we earnestly hope will speedily and generally be adopted.

As it respects the general safety of the ship, it will be seen by a reference to Figure 5, Plate D. and Plate DI. that the timbers uniformly cross the keel; that the frame of the ship is filled so as to form one compact body to the height marked K; and that only certain internal strakes of planks, or thick stuff, as it is termed, are introduced, which are those on the joints of the timbers, for the purpose of giving strength where every alternate timber necessarily joins, as shown at L. The rest of the inner planking may be omitted, and dunnage battens brought in a perpendicular direction upon the timbers *between* the plank, as shown at M, forming regular spaces between each, as is usual at present, *upon* the plank; thereby giving an increase of stowage in proportion to the thickness of the plank omitted. Water courses, as shown by dotted lines at N, are to be left in the joints of the timber under the plank, for the purpose of conveying the water to the pumps: which, by this plan, will reach below the water, instead of being some inches above, as is the case with the present mode, before described. Consequently, by the proposed system, no stagnant water will remain; and farther, the limber passage, or water course, will be one smooth uniform channel, which can be cleared with ease, should it be required, whenever the hold is unstowed; whereas at present it is inaccessible in places, and forms compartments for putrid water, without there being any means of removing it.

It is obvious that a ship constructed on this principle, may sustain the loss of certain planks of the bottom, and also the keel, (which has frequently been found to have happened to ships of war on their being taken into dock,) and still reach the place of her destination, when the loss of *either* would be the de-

* "A just economy of materials should be one of the first objects of the builder's attention, and this desirable object is to be obtained only by judicious combinations of the materials to be used."—See the valuable work of Mr. Tredgold on the Elementary Principles of Carpentry.

struction of a ship built on the present mode. It will be evident also, that a ship constructed as now recommended, possesses greater stowage and more space for leakage than by the old plan, by the omission of the useless inner planking, and by laying the kentlage on dunnage, leaving a space for the water, which was formerly occupied by the inner lining. This dunnage in the bilge may be found in the iron kentlage, and thereby serve as ballast, for which it is well calculated from its situation, and by its occupying a space heretofore forming part of the fabric of the ship, will give an increase of stowage, as before stated.

The best method of closing the openings between the timbers, is by filling the intermediate space with pieces of wood, about three inches in depth, of such lengths as the inferior conversions will supply, abundance of which may be procured from the offal. These fillings are to be well caulked, after which the exterior plank is to be brought on. When the works are going on within board, similar pieces are to be fitted internally, and afterwards taken out for the purpose of filling the spaces between the pieces so fitted with a mixture of Parker's Roman cement and drift sand, in the following proportions, viz.

Parker's Roman cement, $\frac{2}{3}$

Drift sand, . . $\frac{1}{3}$

previously paying the opening well with coal tar. Where there is sufficient space, a brick, or part of one, may be introduced, provided there is room for cement between it and the timbers. When filled in to within about two inches of the surface of the frame, the pieces of three inches already fitted and taken out, are to be well driven in and caulked, and by so doing, no space will be left unoccupied. If considered desirable, these pieces may be driven below the surface of the timber, thereby leaving water courses to convey the leakage to the pumps in channels. And prior to launching or undocking of ships built on this principle, it has been the practice to inject the part filled in with mineral tar by means of a simple forcing pump, boring holes in the joints of the timbers for the introduction of the pipe. By following this method the air will be excluded, which, as experience has shown, tends much to the durability of the fabric. If what is here recommended be attended to, says Sir Robert Seppings, and mercantile ships were built under roofs, as ships of war now are, durability would be obtained in addition to safety from the mode of their construction.

The beams are to be attached to the sides, as shown at O, Plate D. Figure 5, rendering wood knees unnecessary, and requiring only a small number of those of iron.

Plate DI. Figure 1. marked P, describes the old principle of framing the stern with transoms. Q represents the new principle, with timbers similar to the bow, omitting the transoms below the wing or upper transom; and by introducing the new principle on which the floors are made, the necessity of using valuable compass, or crooked timber, hitherto required and with difficulty procured for these purposes, is avoided. Uniform support will thus be given, and also an increase of room for stowage.

In large mercantile ships above 500 tons, Sir Robert Seppings would recommend that plate iron be laid diagonally, as shown in Plate DI.

The principle thus recommended will cause a decrease in the consumption of materials, and the difficulty of procuring the necessary curvature will be obviated. It also affords protection from worms externally, and vermin internally. Leaks may be more easily discovered and stopped than by the old method; and in point of additional strength there can be no doubt. If farther proof were required, Sir Robert Seppings refers to the case of the Malabar of 74 guns, built at Bombay, and which arrived at Portsmouth, loaded to her upper deck with timber, and during her passage encountered four heavy gales of wind, without showing a symptom of weakness, as will appear by the following extract from the survey made by the officers of the Plymouth yard, on that ship, by order of the Lords Commissioners of the admiralty.

"When we consider the nature of the lading that this ship has brought home, with the temporary security to the beams of all the decks, except the orlop, and that on her passage she encountered four very severe gales of wind, it must, we presume, be very gratifying to your honourable board to find, that she does not indicate any past symptoms of weakness or straining in any part."

This ship had no other attachment for her beams than the internal hoops and thick water ways; the remainder of her security, the iron knees, being omitted (from the difficulty of procuring them in India) until her arrival in this country; thus supporting her cargo without the aid of knees, either of wood or iron.*

Having delivered these general observations on the best method for constructing the hulls of merchant ships, we close this part of the article with a few observations on the proportions of their masts and yards.

Chapman remarks on this important subject, that the area and moment of the canvass for merchant ships ought to be determined in the same manner as for ships of war, although the circumstance of their taking cargoes of variable density must occasion a corresponding variation in their moment of stability. There may, nevertheless, be supposed at all times a fixed point for the centre of gravity of the ship and its lading, from which the moment of the canvass may be calculated.

It is most usually the case to proportion the height of the masts to the breadth of a ship, and the length of the yards to the length of the same; and from which it may be inferred, that ships of the same length and breadth, but possessing different degrees of stability, must have the same extent of canvass; whereas the extent of canvass should rather seem to be proportioned to the stability. True as this rule may be for armed ships, there may be reasons of a very strong kind why the same principle should not be followed in merchant ships.

When it is considered, says the celebrated Swedish

* We regret that some circumstances, connected with a patent obtained by Sir Robert Seppings for constructing masts on a new and peculiar principle, prevent us from furnishing any account of it to our readers. An account, however, of the method of construction may be shortly expected from the pen of the inventor.

architect, that the weight of the anchors of a ship is proportional to the length and breadth, or to the square of the breadth, and that the act of weighing the anchors requires a certain number of men, as also the working of sails of a certain size; that large sails require a numerous crew, and that numerous crews are expensive to maintain; it appears that, for a merchant ship it is advantageous to have as small a crew as possible; or that it is most consistent with good management, that the number of the crew should be suited as well to the magnitude of the sails as to that of the anchors.

Hence it appears, that it is the number of the crew which confines the area of the sails to definite limits.

Let us inquire, for a moment, how far the ordinary proportions of masts and yards are proper. Suppose two ships of the same length and breadth, and having, according to the usual practice, the same extent of canvass, but that one of the vessels carries sail better than the other; the usual remark in such a case is, not that *this* has too much or *that* too little canvass, but that the former has greater stability than the latter. Hence we might conclude that it would be better to effect some alteration in the form of the sails, or to make them smaller with relation to the stability, (preserving in other respects the ordinary proportions.) than to augment the number of the crew, in order to be able to use a greater quantity of canvass. At the same time, however, it may be remarked, that when the surface of the sails, according to the usual proportions, is too great with respect to the stability, it should rather be an object to place the parts of the lading which possess a greater specific gravity lower, than to diminish the area of the canvass, particularly if the number of the crew cannot be decreased on account of the anchors.

Moreover, it is worthy of remark, that in different circumstances the same area of canvass may be as proper for a vessel of greater stability, as for one of less. In one case, the surface of the sails may be increased by means of studding sails and stay sails, and diminished in the other, by taking in reefs according to the state of the weather. Hence there is great reason, continues Chapman, to use the rule according to which the masting is proportioned for merchant ships, as that gives most nearly those proportions for the masting which have already been found by experience to be the best. So that the moment of stability, according to which large ships have masts higher, and small ones lower, than the result of the usual rule, will not serve to found thereon the proportions of masts and yards for merchant ships.

As the breadth of ships has the greatest influence on the stability, the lower masts and top masts should be proportioned to the breadth, whence not only the height of the sails, but also the altitude of their common centre of gravity, will be in proportion to the said breadth. With respect to the breadth of the sails, or what is the same thing, the length of the yards, it should be proportioned to the length of the ship, and from which it follows, that the moment of the sails will be as the square of the breadth, multiplied by the length. Small ships will, therefore, have a greater moment of canvass, in proportion to their stability, than large ones; and it is a received practice in small ships to increase the height of their lower masts still more, but at the same time to diminish the altitudes of the top masts. If we assume the breadth of a trading ship equal to B, the height of its main mast, according to Chapman will be $3.23\ B^{\frac{11}{12}}$; and the height of the main top mast, reckoning from the upper side of the cross trees, that of the main mast being denoted by L, will be $\frac{L^{\frac{11}{10}}}{2.73}$ for frigates, and $\frac{L^{\frac{11}{10}}}{2.84}$ for barks. By a reference to Fig. 1, Plate CCCCXCIV, the line BNN will be found to represent the height of the masts in the proportion of the element $B^{\frac{11}{12}}$. The length of the bowsprit, outside the stem, for frigates, is 1.15 B, and for barks 1.1 B, where B denotes, as before, the breadth of the ship.

That ships may be well rigged, it is necessary, in the first place, that the fore stay and main top mast stay should be in a right line, and, in like manner, the main and mizen top mast stay. The fore stay may end on the bowsprit, between one-third and two-fifths of its length from the small end: secondly, that the top sails should be of similar figures, or at least, that their sides should be of the same cut: thirdly, that when the ship is seen, at one or other of the extremities, the shrouds and the breast back stays should appear parallel: this depends partly on the breadth of the channels, which ought to be regulated in a manner conducive to this end. To accomplish it, the length of the head of the main mast, from the under side of the trestle trees, which is $\frac{5}{36}$ of the length of the mast T, the cap of the fore mast should be lower than that of the main mast, by a quantity $2.22\ T^{\frac{1}{3}}$ for frigates, and $2\ T^{\frac{1}{3}}$ for barks. The cap of the mizen mast should be on a level with the main top.

If the length of the main top mast be denoted by S, the length of the mizen topmast will be $1.3\ S^{\frac{6}{7}}$ for frigates, and $1.316\ S^{\frac{6}{7}}$ for barks, supposing the length of the pole to be in the same proportion, as for the other top masts. If it be longer, that difference is added.

The head of the mizen mast ought to be $\frac{3}{4}$, and that of the fore mast $\frac{9}{10}$ of that of the main mast. The length of the fore top mast should also be $\frac{9}{10}$ of that of the main; the heads of these masts $\frac{1}{9}$ or $\frac{2}{17}$ of their length. The length of the top gallant masts to the stop should be 0.54, the length of the top mast. The length of the main yard $0.52 \times$ the length of the ship from the stem to the stern post for frigates; and the main top sail yard $0.79 \times$ the length of the main yard. For barks, supposing their extreme length L, the length of the main yard will be $0.6\ L^{\frac{20}{21}}$: the length of the main top sail yard $0.81 \times$ the length of the main yard. The main top gallant yard $= 0.7 \times$ the length of the main top sail yard. All the yards of the fore mast are $\frac{9}{10}$ of those of the main mast.

Again, Chapman informs us, that the proportion of the mizen top sail yard to its mast, is equal to the proportion of the main top sail yard to the main top mast. The cross jack yard = 1.22 the length of the mizen top sail yard for frigates, and = 1.18 × this length for barks. The sprit sail yard = fore top sail yard; the sprit sail top sail yard = fore top gallant yard. The girth of the yard arms is $\frac{1}{11}$ of their length for the lower yards, and those of the top gallant yards; but $\frac{1}{7}$ for the top sail yards.

The distance of the centre of gravity of the fore mast from the perpendicular at the stem is $\frac{4}{31}$ of the length. The centre of the main mast is $\frac{2}{31}$ behind the middle of the ship. The distance of the centre of the mizen mast from the perpendicular at the stern = 0.182 × by the length of the ship.

The main mast should rake aft one foot in thirty; the mizen mast double the rake of the main mast; the fore mast should be perpendicular, and the elevation of the bowsprit above the horizontal plane, should be about four feet for frigates, and three for barks, in a length of seven feet.

With respect to the diameter, experience has shown that if the respective lengths of the main mast, main yard, and main top mast in feet be denoted by L, R and S, the diameter of the main mast in inches will be $\frac{LR^{\frac{1}{3}}}{13}$; that of the main top mast $\frac{S^{\frac{11}{10}}}{4.68}$; the diameter of the fore mast $\frac{1}{20}$ less than that of the main mast; and that of the fore top mast $\frac{1}{20}$ less than that of the main top mast. The diameter of the top gallant mast = 0.3 × their length reckoning to the stop. The diameter of the bowsprit should be a mean of the diameters of the main and fore masts; the diameter of the jib boom $\frac{3}{4}$ that of the main top mast; the diameter of the mizen mast $\frac{2}{3}$ that of the main mast; and the diameter of the mizen top mast $\frac{2}{3}$ that of the main top mast.

Again, the diameter of the main yard, and that of the fore yard in inches = 0.25 × length of the yard; that of the top sail yards = 0.23 × also by the length of the yards; that of the top gallant yard = $\frac{1}{6}$ of their length. The diameters of the sprit sail yard, and cross jack yard = 0.21 the length. The diameter of the sprit sail top sail yard = that of the main top gallant yard. The diameter of the mizen peak is an inch for four feet in its length. The studding sail booms have two feet greater length than half the yard, and their diameter in inches is $\frac{1}{5}$ or $\frac{1}{6}$ of their length in feet.

The depth of the main trestle trees in inches is the fourth of the height of the top mast in feet, less half an inch; the thickness of the fore trestle trees is $\frac{1}{15}$ less than that of the main trestle trees, and the mizen $\frac{3}{5}$ of the main; the thickness of the top mast cross tree is $\frac{3}{7}$ that of the trestle trees of the respective tops. The breadth of the said trestle trees and cross trees is $\frac{5}{7}$ or $\frac{3}{4}$ of their depth. The thickness of the caps is $\frac{4}{5}$ of the diameters of the top mast.

As the masts and yards taper towards their extremities, it is not only necessary to know their greatest diameters, but also the ratio in which those diameters are diminished, to give them the form which experience sanctions as best adapted to resist strains to which they are exposed. The interval between the greatest and least diameters being divided into four parts, the diameter at each of the divisions should be as follows: The lower masts are found to be well proportioned when their diameter at the place of the trestle trees is one-eighth less than at the deck. So that the diameter at the deck being 128, at the first division it will be 127, at the second 124, at the third 119, and at the fourth 112. The thickness within the trestle trees should be $\frac{4}{5}$, and above at the head, $\frac{5}{8}$ of the diameter at the deck. The top masts should have $\frac{1}{5}$ less diameter under the cross trees than at the cap of the lower masts. So that the diameter at the cap being 80, at the first division it will be 79, at the second 76, at the third 71, and at the fourth, below the cross trees 64. The thickness within the cross trees and above at the head will be $\frac{5}{9}$ of the diameter at the cap.

If the greater diameter of the lower and top sail yards be 27, at the first division it will be 26, at the second 23, at the third 18, and at the end 11. If also the greater diameter of the top gallant yards be 32, at the first division it will be 31, at the second 28, at the third 23, and at the yard arm 16. The bowsprit has usually at its extreme end a diameter only half that at the gammoning. If the diameter at the latter part be for example 60, at the first division it will be 59, at the second 55, at the third 46, and at the fourth 30. Brigs and snows have their fore masts and its appendages, as well as the bowsprit, of the same proportions as frigates. But the height of the main mast of brigs ought to be such, that its top may be on a level with the cap of the fore mast, the head of the main mast being equal to the head of the fore mast. The main top mast should be of the same length with the fore top mast, and the main yard and main top mast yard the same as the fore yard and fore top mast yard. In snows, the main mast is a mean between the masts of a frigate and brig, and so also the top masts; but the main yard and main top sail yard are of the same dimensions as those of frigates.

East India ships should have the length of the main mast = 2.43 × their breadth; the length of the main top mast = 0.586 × the length of the main mast; the length of the main yard = 0.54 × the length of the ship; the top sail yard 0.8 × main yard; the main top gallant yard 0.7 × top sail yard, and the mizen top mast $\frac{3}{4}$ of the fore top mast. The cap of the fore mast is $\frac{2}{5}$ of the length of the head of the main mast lower than the cap of the main mast, and the cap of the mizen mast is on a level with the main top.

The masts and yards are first proportioned, after which a draught of them is made, including the rigging and sails. Their moment is then finally compared with the moment of stability, which will determine the masts and yards suitable to the moment of the sails.

Such are the observations of Chapman on the proportions of masts and yards for merchant vessels—proportions deduced of course from Swedish vessels, but which nevertheless merit much of the attention of the English shipbuilder. And in quoting for the last time the name of this learned and indefatigable man, we would impress most earnestly on the attention of our readers his important investigations, founded as they are on a large and extended experience. To the young naval architect we would hold him up as a model worthy of the closest imitation.*

ON STEAM VESSELS.

The application of steam to the propelling of vessels on the ocean, is likely to produce as great a revolution in warfare as the first introduction of cannon; and its general influence on navigation will claim in its ultimate consequences, a rank almost equal with the splendid discovery of the compass. As an instrument of war, it is destined most likely to change the entire aspect of military operations, and to give to its energies a more fierce and terrible character. In a calm, a ship of war impelled by steam, will possess a decided superiority over an opponent navigated only by sails; and battles that sometimes remain undecided, on account of the failure of the wind, would by the sure and certain energies of steam, be speedily accomplished. Coasts, rivers and harbours, that, according to the ancient plan, were considered as secure, will by this new application of vapour, be assailed and defended by them. The system of warfare will be entirely altered, and perhaps the steam gun will lend its aid in assisting in the work of human destruction. A modification of the energies, however, that render it so terrible in war, will assist the milder and more beneficent purposes of commerce, and direct the steps of civilization into regions now debased by gloom and superstition. Thus it is that art, as well as nature tends to preserve a balance in all its operations. If the application of steam to the purposes of war be likely to increase the sum of human calamity, so will the sum of human happiness be augmented by the impulse it will communicate to the whole social system.

The different modes of propelling vessels on the seas, forms a striking and peculiar picture in the eventful history of man. At first, content from circumstances with the simple application of the lever in the shape of an ore, we find at length the rowers greatly multiplied in number, and their oars augmented to enormous lengths, to give to the vessel as great velocity as possible. With the invention of cannon, and the ability of performing more extended voyages, came also the necessity of increasing the dimensions of ships. The additional altitude thus communicated, prevented the advantageous use of oars; and the great uncertainty of the wind made it desirable to supply its place when its force was insufficient, or when its directive energy operated contrary to that desired, by some other mechanical agent. Hence, by some it was imagined, that the force of the crew might be advantageously employed by other means than oars; and the communication of motion by means of paddle wheels was one of the earliest of these attempts. By some, also, condensed air was proposed as an agent, and by others the explosive force of gunpowder. The fall of water too was proposed; but all have vanished before the triumphant use of steam.

Among numerous attempts, however, the prize of the Academy of Sciences of Paris in 1753, for the best memoir on the subject, "*Sur la maniere de suppléer à l'action du vent sur les grands vaisseaux*," deserves to be particularly noticed, on account of its exhibiting the remarkable fact, that Bernouilli seemed to have looked to the force of man as the origin of propelling power: so little conception had that very illustrious philosopher, of the splendid application of steam affording the motive power. Bernouilli, to whom the prize of the Academy was awarded, entered into many elaborate investigations respecting the velocity capable of being communicated to a ship by the force of the crew, and endeavoured to ascertain the mean strength of a man, which he assumed as equivalent to the power of lifting twenty pounds through three feet in a second for eight hours in a day. The whole of this force not being usually exerted by a man in the action of rowing, he determines the actual part at $\frac{446}{1000}$ of the whole force. Adopting then the plane of resistance at 150 square feet as given by Bouguer, and assuming that the power required to produce a given velocity, is as the cube of that element, while the resistance is as the square, (a supposition not however in accordance with the opinion of many engineers) he computed the following table:

* It gives us much pleasure to remark, that Admiral Chapman's great work on ships of war, including the folio volume of plates, containing draughts of ships from a first-rate to the smallest class, is about to be translated from the Swedish by Mr. Morgan, and enriched with notes by Messrs. Morgan and Bennett.

Table of the Velocities which may be attained in a First-Rate by the Force of Men.

Number of Men to be employed.	*Theoretical velocities, no force being lost.*		*Practicable velocities, a part of the force being lost.*	
	Possible velocity in a second, with ordinary and durable exertion	Possible velocity in a second, with extreme exertion.	Velocity in a second with oars, with ordinary and durable exertion	Velocity in a second with oars, with extreme exertion.
	Feet.*	Feet.	Feet.	Feet.
10	1.50	1.86	0.60	0.75
20	1.90	2.35	0.85	1.05
30	2.17	2.69	1.03	1.27
40	2.39	2.96	1.13	1.46
50	2.58	3.19	1.31	1.62
60	2.74	3.39	1.43	1.77
70	2.88	3.57	1.54	1.91
80	3.01	3.72	1.64	2.03
90	3.13	3.87	1.73	2.14
100	3.25	4.03	1.81	2.24
120	3.45	4.27	1.95	2.43
140	3.63	4.49	2.10	2.60
160	3.80	4.70	2.23	2.76
180	3.95	4.89	2.35	2.92
200	4.09	5.06	2.43	3.07
220	4.22	5.22	2.59	3.21
240	4.34	5.37	2.69	3.34
260	4.46	5.51	2.79	3.45
280	4.57	5.65	2.89	3.58
300	4.68	5.79	2.98	3.69
350	4.93	6.10	3.19	3.95
400	5.16	6.38	3.39	4.20
450	5.36	6.63	3.57	4.43
500	5.55	6.86	3.73	4.63
550	5.73	7.09	3.88	4.82
600	5.90	7.31	4.03	5.00
650	6.06	7.50	4.17	5.17
700	6.21	7.69	4.30	5.34
800	6.50	8.04	4.55	5.65
900	6.76	8.37	4.79	5.94
1000	7.00	8.68	5.01	6.21

This table will show how limited and confined were the views of that celebrated man, and by what more splendid and magnificent means than he anticipated, motion has been communicated to a vessel. It is a remarkable fact, that in the course of his memoir, Bernouilli mentions his having read the description of a steam engine, but remarks, that he does not consider its force, however it may be improved as capable of ever being advantageously applied to the purposes of navigation.

England, however claims the honour of first applying steam to the purposes of navigation. In 1736, Mr. Jonathan Hulls took out a patent for a boat to be propelled by the aid of steam, and in 1737, published a pamphlet in London illustrative of his plan. Its title is "*A Description and draught of a new-invented Machine for carrying Vessels or Ships out of, or into any Harbour, Port or River, against Wind or Tides.*" This little publication is now become exceedingly rare; but a copy of it was lately presented to the library of the Royal Society of Edinburgh, by its distinguished president, Sir Walter Scott.† This important and original thought was, however, never carried into practical execution by Hulls, probably from the want of funds and sufficient encouragement.

It is not our province in this article to trace the many other attempts that were made to carry on and perfect this great invention, but we may remark that in 1802, Mr. Symington actually constructed a steam boat on the Forth and Clyde canal, and that it was only abandoned in consequence of some narrow-minded proprietors of the navigation, conceiving that the undulation of the water occasioned by the motion of the wheel would wash and injure the banks; and in consequence, the boat was with great reluctance laid up in a creek of the canal near Bainford draw-bridge, exposed for years to public view. It is a remarkable fact, however, in the history of this great invention, that Mr. Fulton, for whom the Americans have with some unfairness claimed the original invention of the steam boat, actually visited Mr. Symington in 1802 and having mentioned the interest he felt in this new application of steam, Mr. Symington caused the engine fire of his boat to be lighted up, *and carried Mr. Fulton in the steam boat, from Lock No. 16, where the boat lay, four miles west the canal, and returned to the place of starting, in one hour and twenty minutes*, to the astonishment of Mr. Fulton, and several other gentlemen who happened at the outset to come on board.

This simple and incontrovertible fact decides in the most unquestionable manner, that *the invention of the steam boat is due, both in theory and practice*, TO GREAT BRITAIN.

To Mr. Fulton, however, belongs the great honour of having been the first who endeavoured to investigate on principle, the difficulties of the subject; and it is remarkable, that he derived his data from the experiments of the society for the improvement of naval architecture, a brief allusion to whose most useful labours has been already made at the end of the part devoted to resistance. M. Marestier, in an able report on the steam navigation of America, drawn up by command of the French minister of marine, and published at Paris, in 1824, has described at some length his method of proceeding. It is in principle this: having determined the resistance of the vessel, he inferred that the paddles must experience the same resistance, and that the engine must exert a force at the centre of effort of the paddles, equal to the resistance of the paddles. Assuming then the velocities of the piston and paddles as known, and equivalent to V and v, and the forces on the same as equivalent to F and f, he formed the proportion $V : v :: f : F$; and by dividing the whole force on the piston, by the force exerted by the steam on any given portion of its surface, he obtained the surface of the piston itself, and thence its diameter.

Knowing then the whole resistance on the paddles, and supposing only one paddle on each side to act at the same instant, the area corresponding to that resistance becomes known, the half of which determines the surface of one paddle. Knowing also from the number of strokes made by the piston, the number of revolutions made by the paddle wheels, the diameter of the wheel may be determined so as to ensure to the

* The English foot is equivalent to .9383 French feet.

† An account of this rare pamphlet, with a plate illustrating the steam boat of Jonathan Hulls, may be seen in the Edinburgh Philosophical Journal, vol. ix. It consists of forty-eight pages in duodecimo: was printed for the author, and sold, price sixpence, at the pamphlet shops in London and Westminster.

paddle the velocity originally assumed. Fulton having in this manner determined the force necessary to propel his boat, and accurately considered the mode by which it might be most successfully applied, avoided the great error of his predecessors, viz. attempting too much with an inadequate power, and gave to steam navigation that splendid and triumphant character which it now possesses; so that within little more than the half of a century after so transcendent a philosopher as Bernouilli had declared the utter improbability of its success, and within less than twenty years after its first successful attempt, has steam navigation arrived at such a perfection, that even a voyage to India has been accomplished, and a passage across the Atlantic, by no means regarded as an uncommon thing. What other achievements it is destined to perform, time must develop.

The form of a steam boat must in some degree assimilate to that of a sailing vessel, but there are many peculiar circumstances to be taken into account in considering of their construction: such as the particular kind of navigation for which they are destined—whether for the open sea, or for the shallower waters of rivers and lakes. If for the former an increased draught of water becomes necessary; but for the latter this element must be less considerable.* These considerations are to be inferred from the experiments on the resistance of fluids, in which it has been proved, that the quantity of water beneath the body in motion, has a very important influence on the resistance it experiences; and also, that if the water be at all confined the resistance is very considerably increased. This circumstance indeed is one of common observation among watermen; and it has been moreover observed in steam boats of different sizes on the same river, that as long as the water continued shallow, the smaller boat has had the advantage; but as the water has gradually deepened, the velocity of the larger boat has increased. A similar observation applies to the area of the midship section, which it is necessary to have as small as possible in boats destined for canals or narrow rivers, since the resistance depends on the relation of the area of the section of the boat, to the area of the section of the fluid.

Steam boats have a very considerable rolling motion, owing to the small proportion their breadth bears to their length, and to the height of the common centre of gravity of the principal weights. This motion arises from a deficiency in stability, and it would be advantageous therefore to adopt that form for the body most conducive to that very desirable quality. It is also of importance to have the greatest displacement with the least direct resistance, that is, with the least area of the midship section. Supposing the area of the midship section and the breadth to be given, the condition here alluded to, is in favour of a form, full near the load water line, and lean below. In such a body also, the centre of gravity of the displacement is high, which is favourable to the stability. It moreover enables the body forward and aft to be made finer than could be the case with a flat-floored midship section. The rising of the floor must, however, be limited by the consideration, that if the engines and other material weights are raised by it, the advantages might be counterbalanced by the effect this would have in raising the centre of gravity of the vessel. There is one great advantage in the extra draught of water, resulting from the rising floor, viz. that the keel, which, by its direct opposition to the water must tend very much to diminish the rolling motion, is at a greater distance from the axis of rotation, and consequently has a proportionally greater effect. The rising floor is now generally adopted in the English steam boats.

We have already remarked in a former part of this article, that the form of the sides between wind and water has a very material effect on the rolling of the vessel, and the observation equally applies to steam boats. For this purpose, the moment of stability should increase rapidly but uniformly, and as the vessel performs its alternate oscillations, the centre of gravity of the displacement should remain in the same transverse section. The form of the body also above and below the plane of flotation, should so accord with the position of the centre of gravity, as to cause the different oscillations of the vessel to be performed with the axis of rotation in the same constant plane. The elevation of the chimney, moreover, should be diminished as much as other circumstances will allow, in order that its weight, by raising the centre of gravity of the vessel, does not diminish in too great a degree the stability. The momentum also that the chimney acquires by its almost incessant vibrations, not only increases the rolling of the vessel, but creates also the chance of its being carried away, if the stability be not very well graduated. Not only indeed for the comfort of the passengers, and the perfect ease and security of the engines, but also for the general advantage of the vessel, ought the motions and strains of a steam boat to be rendered as moderate and uniform as possible.

In the English steam boats, the engines are so adapted as to have the axis of the paddle wheel generally *below* the surface of the deck. In the American steamers on the contrary, it is as generally *above*, and even some of their boats which are destined for merchandise have, according to M. Marestier, their engines on the deck. The sides of those vessels being, however, in general nearly vertical for some distance both above and below the water section, it would be advantageous with regard to easiness of motion, to endeavour to adjust the different weights so that the centre of gravity of the boat should be as nearly as possible in the plane of the deck.

In the earlier steam boats it was usual to give great comparative length, in imitation it is said of the relative proportion of row gallies. Thus in the following table, it will be remarked, that the length of the Clermont is to its breadth as 9.3 to 1; whereas the Connecticut, which had precisely the same length, had its breadth so increased as to present the relation of 4.2 to 1. The Clermont was constructed in 1807, and the Connecticut at a much later period. But the Enterprize presents an alteration in this particular of a still more striking kind, her length being 24.38 metres and her breadth 8.84, the two elements presenting the ratio of 2.8 to 1. The objects and destinations of these boats are without doubt very different; but it will be apparent, that in a mechanical structure like

* It is remarkable that until the year 1813, all the American steam boats were constructed with flat bottoms, and the Fulton was the first which had any rising in the floors.

a steam boat, wherein the weights are so very unequally distributed, the length ought not to exceed the breadth in any thing like the ratio first mentioned. In steam boats intended for river navigation, the length may without much impropriety be increased, because the strains are much less considerable than in the open sea. In the construction of steamers for rivers, some attention should be paid to length on account of the space necessary for turning them—a circumstance which may sometimes be productive of inconvenience.

The report of M. Marestier is replete with numerous and important tables, one of which we introduce, for the purpose of illustrating the relative dimensions of the length and breadth. The vessels are arranged according to the numerical relations of these dimensions, and not as M. Marestier has given them, according to the places at which they were built.

Names of the Vessels.	Length.	Breadth.	Relation of the length to the breadth	Draughts of water
	Metres.*	Metres.		
The Clermont in 1807	42.67	4.57	0.107	
The Clermont in 1808	45.72	4.87	0.107	
The Car of Neptune	53 34	7.16	0.134	
Boat of the Union Line	41.50	5.75	0.139	1.37
The Philadelphia	42.75	6.10	0.143	1.22
The Delaware	41.34	6.10	0.148	
Boat being broken up	42.00	6.32	0.150	1.30
The New Jersey	38.00	5.88	0.155	
The Paragon	52.73	8.23	0.156	1.25
The Ætna	34.75	5.50	0.158	1.22
The Washington	40.00	6.40	0.160	1.73
The Surprise	28.65	4.75	0.166	1.22
The Eagle	34.00	5.88	0.173	
The Vesuvius	48·77	8.53	0.175	1.80
The United States	42 64	7.62	0.179	1.52
The Virginia	41.45	7.56	0.182	1.52
The Richmond	46.63	8.53	0 183	1.60
The Fire Fly	30 48	5.64	0.185	
The Norfolk	41.00	7.70	0.188	1.52
The Maryland	41.76	7.92	0.190	1.52
The Robert Fulton	48.16	10.06	0.209	3.05
The Chancellor Livingston	47.55	10.06	0.212	1.83
The Fulton	40.54	8.84	0.218	1.90
The Massachusetts	25.00	5 50	0.220	1.30
The Bellona	28.00	6·25	0·223	
The Olive Branch	37.80	8·84	0·234	1.37
The Connecticut	42.67	10.06	0·236	2.08
The Savannah	30 48	7.92	0·260	4.27
The Enterprize	24·38	8.84	0·363	

The column devoted to the relation of the length to the breadth, was found by dividing the latter dimension by the former. The average length of these boats is 39.82 metres, or 130.64 English feet, and their average breadth 7.15 metres, or 23.46 English feet. The draughts of water, it will be observed, are very variable, arising necessarily from the particular purposes for which the vessels are destined. The Savannah is the steamer that first crossed the Atlantic, and her draught of water, it will be perceived, is the greatest of the whole series. The Robert Fulton, which navigates the magnificent waters of the Mississippi, has a draught of 3.05 metres; whereas the Vesuvius, built for the purpose of navigating the same mighty stream, has only a draught of 1.8 metre, her breadth, however, being 1.53 metre less than the same dimension of the Robert Fulton, but her length two-thirds of a metre more.

With respect to the draught of steam vessels, there is, however, no necessity for its being so considerable as in sailing vessels, because their great length and straight of breadth will, in the event of their using sails, supply the place of depth, any useless degree of which serves only to increase the resistance; neither can there be any advantage in a difference of draught of water forward and aft in boats constructed with a rising floor; but, probably with flat floors, it may be requisite to assist the action of the water on the rudder.

Mr. Augustin Creuze has lately deduced from M. Marestier's drawings of the steam boat, the Chancellor Livingston, and also from several English boats, and from two which have been lately constructed in England for the service of the Norwegian Government, by Lieut. A. G. Carlsund, of the Swedish Royal Naval Engineers, the exponents of their different elements, as recorded in the following table, according to the parabolical method of Chapman, before alluded to.

	Length of the construction water line	Depth to the tangent of the midship section.	Exponent of the line of sections.	Exponent of the midship section.	Exponent of the water line.	Exponent of the displacement.
	Feet.	Feet.				
English Boats,	117.7	7.8	2.7	3.45	5.662	2.10
	98.8	6.2	2.47	5.75	5.206	2.60
	99.8	7.1	2.53	6.96	6.39	2.41
Norwegian	106 8	6.85	2.5	3.55	6.17	2.09
	95 75	6.25	2.4	4.54	6.54	2.13
American	150 47	5.41	2 12	4 72	4.03	2.27

It is of importance that the displacement and also the position of the centre of gravity should be accurately determined, on account of the great and constant weights on board a steam vessel being so considerable. It is usual to distribute the coals as much about the centre as possible, and to adjust the position of the centre of gravity of the engine, to the intended purposes of the vessel. It would be proper also to form an estimate of the stability of a steamer with regard to its length, by calculating what effect the removal of a weight to a certain distance either before or aft the centre of gravity, will produce a given difference in the draught of water. This weight being known might be employed as a scale by which to regulate the disposition of other weights; and it is from a neglect of this important particular, that steam boats float at a different draught of water from what was intended.

Unless the displacement is correctly determined, and the area of the midship section also known, and limited moreover to a constant quantity, the power of the engine cannot be determined, so as to ensure a given velocity. Another necessary cause for accuracy with regard to the displacement is, that any alteration from the water line, in relation to which the height of the axis of the paddle-wheels was determined, might

* The metre is equivalent to 39.37079 English inches.

materially affect the action of the paddles themselves; the height of the axis being adjusted in such a manner, that the wheels having a specific diameter, the paddles may obtain such an immersion in the water, as shall cause their inner edge to have a velocity at least equal to that of the vessel, to ensure the absence of resistance on the fore side of the paddle. Hence it appears, that the depth of the paddle depends on the proportion of the velocity of the vessel to that of the velocity of the outer edge of the paddle wheel. It is, moreover, found in practice, that the paddles will not work well if immersed in the water more than eighteen inches or two feet. This circumstance arises from the great loss of power occasioned by the obliquity of the stroke on their entrance into the fluid, and also on their leaving it, and the great quantity of water, moreover, they will lift.

The breadth of the paddle must be regulated by local circumstances, attending to the condition, that the greater the arc of the paddle, the less is the loss of power occasioned by the motion it communicates to the fluid. Bernouilli estimates this loss for the common oar to be $\frac{297}{1000}$ of the whole force applied. Sea-going boats should in general have their paddles narrower than boats intended for smooth water.

The number of paddles on a wheel is at present wholly determined by practice. One paddle for every foot the wheel is in diameter, is the general rule followed. If they are too near each other, they do not meet the water with all the advantage they ought; and if too far apart, the motion which their successive and distinct impact with the water communicates to the vessel is unpleasant.

Neither theory nor practice has yet determined where the axis of the paddle wheel should be placed with regard to the length of the vessel. M. Marestier has given us the following of its situation in several American boats. Its position is, however, always very much limited by that of the engine.

Positions of the Paddle Axis.			
Names of the Vessels.	Distance of the axis from forward.	Distance of the axis from aft.	Ratios of the preceding distances, the antecedent terms being unity.
	Metres.	Metres	
The Chancellor Livingston - - -	23.775	23.775	1 : 1.00
The Philadelphia of Trenton - - -	18.25	24.53	1 : 1.34
The New Jersey -	17.00	21.00	1 : 1.24
The Delaware - -	16.64	24.70	1 : 1.48
The Powhatan - -	16.50	18.50	1 : 1.12
The Norfolk - -	16.00	25.00	1 : 1.56
The United States -	15.61	27.00	1 : 1.73
The Virginia - -	15.26	26.19	1 : 1.72
The Washington -	14.50	25.50	1 : 1.76
The Philadelphia of Baltimore - - -	14.00	27.00	1 : 1.93
The Eagle - -	14.00	20.00	1 : 1.43
The Bellona - -	12.00	16.00	1 : 1.33
The Fulton - -	10.12	10.42	1 : 1.03

This table proves that the position of the paddle axis is very variable in different vessels. In the Chancellor Livingston it is placed in the middle of its principal axis, and very nearly so in the Fulton: but in the Philadelphia of Baltimore, the deviation from the centre is very considerable, and the greatest of the whole series. In the United States, the Virginia and the Washington, the deviation also is very great. Much remains yet to be done to perfect this important part of the subject.

Many of the boats on the Mississippi have their wheels abaft, that they may be protected from the logs of timber incessantly floating on that mighty river, thus practically exemplifying the original idea of Hulls. Many vessels also, intended only for short passages, and where a small draught of water is necessary, are built with two bodies, with the wheel placed between them. This plan, however, is not found advantageous for boats with any considerable draught of water, because, in addition to their weakness, there is an increase of resistance resulting from the water passing with great velocity through a confined channel. Boats have been tried with two pair of paddle wheels, and the Dutch are now building a steam frigate with four engines, each of 100 horse power, to act on two pair of paddle wheels.

When there are two paddle wheels on each side, their relative velocities, with respect to the water, should be equal, in order that they may exert an equal force on the vessel. If this were not the case, the aftermost wheel would operate disadvantageously: for as the water on which the aftermost wheel acts, has had an increased velocity communicated to it by the action of the foremost wheel, the absolute velocity of the aftermost wheel must be proportionally greater than that of the foremost; a circumstance which would require a greater quantity of steam, and consequently a greater consumption of fuel. There would also be a waste of power, unless each pair of wheels had separate engines: and it is probable that the aftermost wheels would lose a portion of their effect, in consequence of the disturbed state of the water they acted on.

The following important table was communicated to M. Marestier by one of the principal engineers of New York, as the result of his experience with regard to the proportions between the dimensions of a vessel and its engine; and, in order to make this part of his useful and important work as complete as possible, he has added another table, the result of his own inquiries, containing the principal proportions of the engines and paddle wheels, &c. of the steam boats, the dimensions of which have been given in the preceding tables.

A Table of the principal Proportions of Steam Engines as adapted to Vessels of known dimensions.

	Tons.	Tons.	Tons.	Tons.	Tons	Tons.
Dimensions of the Vessel. Burthen -	160	200	260	320	400	500
	Metr	Metr	Metr	Metr	Metr	Metr
Length -	22.5	27.0	33.0	37.5	40.5	42.0
Breadth -	6.6	7.2	8.1	9.6	10.2	10.8
Draught of water	1.2	1.5	1.8	2.1	2.4	2.55
	No.	No.	No.	No.	No.	No.
Horse power of the Engine	20	30	40	60	80	100
	Metr	Metr	Metr.	Metr	Metr	Metr.
Diameter of the Cylinder	0.60	0.75	0.90	1.00	1.10	1.20
Height of the Cylinder	1.50	1.50	1.55	1.55	1.80	1.80
Length of the Boiler -	4.80	6.00	6.00	6.60	6.60	7.20
Breadth of ditto -	2.40	2.55	2.70	3.00	3.15	3.60
Height of ditto -	2.10	2.40	2.40	2.70	3.00	3.60
Diameter of the Paddle-wheels - - -	4.80	5.10	5.40	5.40	5.70	6.00
Length of the Paddles	1.50	1.65	1.80	1.80	2.10	2·10
Depth of ditto - -	0.60	0.60	0.75	0.90	0.90	0 90
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Weight of the Engine	20	25	30	35	40	45

Dimensions of the Engines and Paddle-wheels of the Vessels contained in the former Tables.

Names of the Vessels.	Date of the Construction.	Diameter of the Piston.	Stroke of the Piston.	Diameter of the Wheels.	Number of the Paddles.	*Length of the Paddles.	Depth of the Paddles.
		Metr	Metr	Metr	No.	Metr	Metr
The Clermont -	[illegible]	0.610	[illegible]	[illegible]	8	[illegible]	[illegible]
— Car of Neptune	[illegible]	[illegible]	[illegible]	[illegible]	—	1.20	[illegible]
— Paragon -	1811	0.91	1.22	4.9[illegible]	8	[illegible]	0.75
— Fire Fly -	1812	0.5[illegible]	1.11	[illegible]	—	1.05	0.6[illegible]
— Richmond -	181[illegible]	0.9[illegible]	1.32	4.6[illegible]	8	1.2[illegible]	0.6
— Washington -	181[illegible]	0.711	1.2[illegible]	[illegible]	8	1.35	0.4[illegible]
— Fulton - -	1813	0.91[illegible]	1.22	4.70	8	1.5[illegible]	[illegible].70
— Olive Branch	1816	0.914	1.22	5.00	10	1.45	.75
— Connecticut -	1816	1.016	1.[illegible]7	[illegible]	10	1.45	[illegible].75
— Chancellor Livingston -	[illegible]	1.016	1.5[illegible]	[illegible]	8	1.75	[illegible]9[illegible]
— Phila. of Trenton	—	—	—	[illegible]	[illegible]	—	[illegible]
— Delaware -	—	0.81[illegible]	1.57	[illegible]	1[illegible]	1.7[illegible]	0.75
An old boat at Baltimore - -	—	0.7[illegible]	1.2[illegible]	[illegible]	12	0.9[illegible]	[illegible]
The New Jersey -	—	—	—	5.20	10	1.50	0.65
— Philadelphia of Baltimore -	—	[illegible]	—	5.0[illegible]	16	—	—
— Virginia -	—	[illegible]	1.2[illegible]	[illegible]	—	1.7[illegible]	0.75
— Norfolk -	—	—	—	[illegible]	12	1.75	—
— Maryland -	18[illegible]	1.[illegible]1[illegible]	1.1[illegible]	[illegible]	12	1.75	0.65
— United States	181[illegible]	1.01[illegible]	1.[illegible]2	5.50	1[illegible]	2.[illegible]	0.75
— Massachusetts	—	—	—	[illegible]	8	1.50	0.80
— Robert Fulton	1819	1.13[illegible]	1.52	5.50	10	2.00	—
— Savannah -	1818	1.035	1.52	[illegible]	10	1.42	[illegible]

M. Marestier has also given the following comparative table of the results he has observed, and calculated for ten boats, of which he was able correctly to ascertain the velocities.

In the first column, the measure of the *elasticity of the steam*, is represented by the height of the column of mercury it will support in a vacuum.

The column devoted to *the proportion of the paddles*, is the quotient of the rectangle of the breadth and draught of water of the boat, divided by the area of one of the paddles.

The number which he terms *the factor of the diameter of the wheels*, he obtained by considering, that if the vessels were similar, and the resistances to the paddles bore in all of them the same invariable relation to the resistance of the hull, the diameter of the paddle wheels would be equal to the velocity of the boat multiplied by a constant factor, and divided by the number of double oscillations of the piston. The mean of these factors being between 29 and 30, it follows, that if the proportion the velocity of a steam boat bears to the number of strokes of the piston, be multiplied by 29 or 30, the result will give nearly the dimensions of paddle wheels similarly proportioned to those in the American boats.

The last column denominated *the multiplier*, is a number which Marestier deduced, to show the relation which the true velocity of a boat bears to the following quantity: The square root of the product of the height of the column of mercury the steam will support, the stroke of the piston, and the square of its diameter, divided by the square root of the product of the rectangle of the breadth and draught of water of the vessel, and the diameter of the paddle wheel.

If the different boats were equally perfect in their respective elements, there would be no necessity for a different multiplier for each boat; but, as the forms of their bodies, and the qualities of their engines differ considerably, the multipliers must necessarily vary.

M. Marestier [illegible] that the variation for the first nine boats recorded in the table is between twenty and twenty-five. The Savannah he did not include in his computation, as he had no precise information respecting her.

Table of the comparative proportions [illegible] deduced from ten American Steam Boats.

NAMES OF THE VESSELS.	Elasticity of the Steam.	Number of double oscillations [illegible]	Velocity of the Piston [illegible]	Proportion of the paddles.	[illegible]	Velocity of the Vessel: in a sec.	in an hour.	Factor of the diameter.	Multiplier.
	Metr.		Metr		Metr	Metr	M.		
The Washington	[illegible]	2[illegible]	0.51	13.1	[illegible]	[illegible]	5.[illegible]	[illegible]	[illegible]
— Fulton......	1.1	1[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
— Olive Branch	[illegible]	1[illegible]	[illegible].75	11.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
— Connecticut	[illegible]	17	[illegible]	19.2	[illegible]	[illegible]	6.1	[illegible]	[illegible]
— Chancellor Livingston.	[illegible]	17	0.[illegible]6	11.7	[illegible]	2.9	5.6	3[illegible]	[illegible]
— Delaware...	[illegible]	17[illegible]	[illegible]	[illegible]	[illegible]67	[illegible]	[illegible]	27.5[illegible]	[illegible]
— Virginia	1.1[illegible]	1[illegible]	[illegible]	8.[illegible]	3.7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
— United States	1.1[illegible]	16[illegible]	[illegible]	7.7	[illegible]4	3.3	[illegible]	[illegible]	[illegible]
— Maryland	1.05	17	[illegible]	1[illegible]	1.1	[illegible]	7.0	2[illegible]	[illegible]
— Savannah ...	0.9	15	0.31	[illegible]	[illegible].71	2.6	[illegible]	[illegible]	[illegible]

We shall now endeavour to explain the principles by which M. Marestier deduces so ingeniously the terms *factor* and *multiplier*, the values of which are recorded in the two last columns of the preceding table.

To accomplish this he supposes *the motion of the vessel to become uniform, and the force of the steam constant*: and on this hypothesis, and the data he has collected in the preceding table, he investigates the proportions which exist between the power of the engine, the dimensions of the vessel, of the paddles and the wheel. He assumes, moreover, *that the resistance of the paddles is equal to the resistance of a surface moved in the fluid in a direction perpendicular to itself, and having a velocity equal to the mean velocity of the paddles.* This surface, which he denominates *the resisting surface of the paddles*, is represented by . . a^2

The velocity of the resisting surface by U

The resisting surface of the vessel by b^2

And the velocity of the vessel by . V

Each of these quantities he proposes to derive from experiment.

1. The resistance of the hull being supposed proportional to the square of the velocity, is equivalent to $k b^2 V^2$, the function k being the measure of the direct resistance corresponding to the unity of surface and velocity.

Then the velocity with which the paddles strike the fluid being $U - V$, the resistance they experience will be $k a^2 (U - V)^2$.

Hence it follows, that

$$k b^2 V^2 = k a^2 (U - V)^2,$$

* The nautical mile is equal to 1851.85 metres, or about 6077.58 English feet.

and $U = \left(1 + \frac{b}{a}\right) V.$

The velocity of the vessel is therefore always proportional to that of the paddles, while the resisting surface of the vessel bears a constant relation to the surface of the paddles.

2. The moments arising from the action of the paddles on the water, and the steam on the piston, are equivalent to each other, omitting the effects of friction. The absolute velocity of the paddles being also U, and the resistance they meet with $k\,a^2\,(U-V)^2$ the moment of their action, will be

$$k\,a^2\,(U-V)^2\,U.$$

Supposing q to represent the density of the mercury, h the altitude of the column the steam will support, P the surface of the piston, and v the measure of its mean velocity: then will the moment of the piston be equivalent to $q\,h\,P\,v$,

and consequently $q\,h\,P\,v = k\,a^2\,(U-V)^2\,U.$

3. Since the effect of the friction of the machine is to diminish the effect of the moving force communicated from the piston to the paddles, a portion only of the moving force $q\,h\,P$ is taken, and which is represented by $m\,q\,h\,P$. Hence we obtain the equation

$$m\,q\,h\,P\,v = k\,a^2\,(U-V)^2\,U.$$

and since $U = \left(1 + \frac{b}{a}\right) V,$

we obtain by the necessary reductions,

$$V = \sqrt[3]{\left(\frac{m\,q\,h\,P\,v}{k\,b^2\left(+\frac{b}{a}\right)}\right)}, \text{ and}$$

$$U = \sqrt[3]{\left(\frac{m\,q\,h\,P\,v}{k\,b^2}\left(1+\frac{b}{a}\right)^2\right.}$$

4. From these formulæ we may draw the following conclusion:—that *the cube of the velocity of the vessel is less than the power of the engine, divided by the resistance of the vessel;* and that *the cube of the mean velocity of the paddles is also greater than the same quantity*—a limit only to be attained when the paddles are infinite.

5. If we suppose a second boat to exist, the elements U′, V′ a′, b′, &c. of which are analogous to those of U, V, a, b, &c. adopted for the former boat, we may obtain by the common processes of reduction

$$\frac{V'}{V} = \sqrt[3]{\left(\frac{m'\,h'\,P'\,v'}{m\,h\,P\,v}\cdot\frac{b^2}{b'^2}\cdot\frac{1+\frac{b}{a}}{1+\frac{b'}{a'}}\right)},$$

$$\text{and } \frac{U'}{U} = \sqrt[3]{\left(\frac{m'\,h'\,P'\,v'}{m\,h\,P\,v}\cdot\frac{b^2}{b'^2}\cdot\left(\frac{1+\frac{b'}{a'}}{1+\frac{b}{a}}\right)^2\right)}.$$

So also when the resisting surfaces of the paddles are, in both vessels, proportional to the resisting surfaces of their hulls,

we obtain $\frac{b'}{a'} = \frac{b}{a};$

and consequently $\frac{V'}{V} = \frac{U'}{U} = \sqrt[3]{\left(\frac{m'\,h'\,P'\,v'}{m\,h\,P\,v}\cdot\frac{b^2}{b'^2}\right)}.$

Hence it follows, that *the velocities of the boats are proportional to the velocities of the paddles, and they are also in a direct proportion to the cube root of the power of the engines, and in an inverse proportion to the cube root of the resistance of the vessels.* M. Marestier considers this proposition nearly general; because, unless there is a very great disproportion in the dimension of the vessels, the relation of $1+\frac{b}{a}$ to $1+\frac{b'}{a'}$, cannot differ much from unity.

Throughout these investigations, M. Marestier has regarded h as the altitude of the column of mercury, which the steam when acting on the piston will support, and determined the effort of the piston, under the supposition that the vacuum on the contrary side of the piston is perfect; but as such a condition cannot exist, the quantity h should be diminished by the height which the steam remaining on the contrary side of the piston, will depress the mercury from the altitude at which it would stand in a common barometer. This is an important consideration when comparing one boat with another, because the degree of the vacuum must depend wholly on the goodness of the engine.

6. From the equations $b\,V = a\,(U - V)$,

and $m\,q\,h\,P\,v = k\,a^2\,(U-V)^2\,U$,

we may deduce $U V^2 = \frac{m\,q\,h\,P\,v}{k\,b^2}.$

Therefore whatever may be the dimensions of the paddles, the product of their velocity and the square of the velocity of the vessel is in proportion to the power of the engine.

Although the power of the engine has been considered as known, it is seldom that the velocity of the piston can be taken arbitrarily. The relation of this velocity to that of the paddles is almost always invariable, and therefore the velocity of the piston alters with any increase or diminution in the size of the paddles. This however will not make any change in the conditions of the preceding question; but the value of v will vary according to the alteration. It may happen either that the velocity of the piston is too great to admit of an adequate supply of steam, or that the supply of vapour is too great, and some necessarily escapes by the safety valve. In the first case, the elastic force of the vapour will diminish until the movement of the piston shall correspond to the quantity of steam supplied; and in the second case to prevent the loss of steam, the intensity of the fire must be diminished; but then the power of the engine will be reduced in the proportion of the actual velocity of the piston to that which it ought to have.

That the velocity of the piston may correspond to the quantity of steam furnished by the boilers, the mechanism must be so arranged as to satisfy the equation

$$U = \sqrt[3]{\left(\frac{m\,q\,h\,P\,v}{k\,b^2}\left(1+\frac{b}{a}\right)^2\right)};$$

or if r represents the relation between the velocities of the piston and paddles, we may obtain the equation

$$r = \frac{U}{v} = \sqrt[3]{\left(\frac{m\,q\,h\,P}{k\,b^2\,v^2}\left(1+\frac{b}{a}\right)^2\right)},$$

Of the quantities a, b, h, P, r, U, V, and v contained in the equations.

$$U = \left(1 + \frac{b}{a}\right) V,$$

$$m\,q\,h\,\mathrm{P}\,v = k\,a^2\,(\mathrm{U}-\mathrm{V})^2\,\mathrm{U},$$
and $\mathrm{U} = r\,v$,

any five being known, the remaining three may be readily determined. Thus, if the values of the elements a, b, h, P, r, are known, and it be required to determine the values of U, V, and v, we shall obtain from the preceding equations

$$\mathrm{U} = \left(\frac{1}{b}+\frac{1}{a}\right)\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r}},$$

$$\mathrm{V} = \frac{1}{b}\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r}},$$

$$\text{and } v = \left(\frac{1}{b}+\frac{1}{a}\right)\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r^3}}.$$

Since the velocity of the vessel is independent of the element a, it follows, that as long as the value of r remains unchanged, the surface of the paddles may be either increased or diminished without producing any alteration in the velocity of the boat. At the same time also it appears, from an inspection of the function representing the value of v, that we cannot augment the dimensions of the paddles, without diminishing the velocity of the piston, and causing a greater consumption of steam and fuel.

If the diameter of the wheels be diminished, the velocity of the steam boat will be increased; but the velocity of the piston and the power of the machine being increased also, will require a greater consumption of steam and fuel. Hence an increase of velocity may be obtained by diminishing the diameter of the wheels, provided that the boiler will furnish more steam than the engine consumes.

If, on the contrary, the diameter of the wheels be increased, the vessel will lose velocity: but this cannot be avoided, if after having increased the surface of the paddles as much as is consistent with other circumstances, it is found that the engine has too great a velocity for the supply of steam furnished by the boiler.

If, again, the diameter of the wheels be diminished by taking away a portion of each paddle, the velocity of the vessel will be increased, because the value of the element r is diminished: but then it must be remarked, that more steam will be consumed than if the change had been made in the diameter, without diminishing the surface of the paddles.

When any alteration is made in the mechanism which communicates motion from the piston to the wheels, the elements r, U, V, and v, become respectively r', U′, V′, and v'. Hence we have

$$\mathrm{V}' = \frac{1}{b}\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r'}},$$

$$\text{and } v' = \left(\frac{1}{b}+\frac{1}{a}\right)\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r'^3}};$$

$$\text{Consequently, } \mathrm{V}' = \mathrm{V}\sqrt{\frac{r}{r'}} = \mathrm{V}\sqrt[3]{\frac{v'}{v}},$$

$$v' = v\sqrt{\frac{r^3}{r'^3}},$$

$$\text{and } r' = r\sqrt[3]{\frac{v^2}{v'^2}}.$$

Hence it follows, that when the piston does not partake of the velocity which the steam furnished by the boiler would admit in any change of the mechanism, the velocity of the boat will be reduced in proportion to the cube root of the velocity of the piston: and in order that the vessel may acquire the velocity which the engine is capable of imparting, the value of r must be diminished inversely as the cube root of the square of the velocity of the piston.

The value of $\mathrm{V} = \frac{1}{b}\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r}}$ being more simple than that before deduced for the same element, admits of an easier comparison with the velocities before observed. It admits, however, of further simplification.

For this purpose let p represent the diameter of the piston, and π the relation of the diameter to its circumference, then will

$$\mathrm{P} = \frac{p^2\pi}{4}.$$

In the American vessels, the wheels generally make one turn for every double stroke of the piston; and, therefore, supposing c to represent the length of a stroke of the piston, and n the number of revolutions of the wheel in a minute, we shall have

$$v = \frac{2n\,c}{60} = \frac{nc}{30}.$$

Calling also the absolute diameter of the paddle wheels D, its mean diameter will be δ D, where δ denotes a quantity to be determined by experiment. Hence we have

$$\mathrm{U} = \frac{n\times\pi\,\delta\,\mathrm{D}}{60},$$

$$\text{and consequently, } r = \frac{\mathrm{U}}{v} = \frac{\pi\,\delta\,\mathrm{D}}{2\,c}.$$

The resisting surface of the vessel before assumed as equivalent to b^2, depends essentially on the shape of the vessel, and perhaps on its velocity; but as it is known that it increases in proportion as the draught of water and breadth are augmented, we may suppose it proportional to the rectangle B of the dimensions alluded to, and which therefore furnishes the equation

$$b^2 = \beta\,\mathrm{B},$$

the element β being determined by experiment.

Substituting this value of b^2 in the equation

$$\mathrm{V} = \frac{1}{b}\sqrt{\frac{m\,q\,h\,\mathrm{P}}{k\,r}},$$

$$\text{and we shall have } \mathrm{V} = \sqrt{\frac{m\,q}{2k\,\beta\,\delta}}\sqrt{\frac{h\,c\,p^2}{\mathrm{B\,D}}}.$$

The density of the mercury $q = 13.6$; and it may also be remarked that the value of k, when the body exposed to the impulse of the water is thin, as in the case of the paddles, is about $\frac{6}{100}$, unity being the weight of a cubic metre. There are several causes, however, which render it difficult to determine the values of m, β, and δ, as they vary under different circumstances. The best boats, M. Marestier observes, will be found to be those where the value of $\frac{m}{\delta\beta}$ is the greatest.

8. For the object in view, it is sufficient to know the value of $\sqrt{\frac{m\,q}{2\,k\,\beta\,\delta}}$, which has been designated the

multiplier. Supposing it to be represented by M, we have

$$V = M \sqrt[3]{\frac{h\,c\,p^2}{B\,D}}.$$

In the last table it will be perceived that M. Marestier has deduced the multipliers for several vessels, the values of which, omitting the instance of the Savannah, vary from about 20 to 25, and the mean he fixes at 22. Since, however, the value of the multiplier, all other things remaining the same, depends on the perfection of the engine and vessel, it cannot be strictly correct to apply to one vessel a number deduced by experiments on others far inferior to it. It is to be remarked that the velocities which M. Marestier has given of the American boats are small in comparison to those of the more modern English boats. The latter boats require therefore higher multipliers than the former.

9. The equation $U = \left(1 + \frac{b}{a}\right) V$ before given, will undergo some convenient modifications, by substituting in it the values of b and U deduced from the equations $b^2 = \varepsilon B$, and $U = \frac{n\,\pi\,\delta\,D}{60}$, and also adopting for a^2 the resisting surface of the paddles, the quantity $A\nu$, the function A representing the area of one of them. These substitutions will transform the first-mentioned equation $U = \left(1 + \frac{b}{a}\right) V$, into

$$\frac{n\,\pi\,\delta\,D}{60} = \left(1 + \sqrt{\frac{\varepsilon}{\nu}} \sqrt{\frac{B}{A}}\right) V,$$

and from which we may deduce

$$D = \frac{60\left(1 + \sqrt{\frac{\varepsilon}{\nu}}\sqrt{\frac{B}{A}}\right)}{\pi\,\delta} \cdot \frac{V}{n}.$$

The function $\frac{60}{\pi\,\delta}\left(1 + \sqrt{\frac{\varepsilon}{\nu}}\sqrt{\frac{B}{A}}\right)$ is that which has been denominated *the factor of the diameter of the wheels*, and of which the mean value is thirty. If we designate this function by F, we shall obtain the equation

$$D = F.\frac{V}{n}.$$

10. By means of the equations

$$V = M\sqrt[3]{\frac{h\,c\,p^2}{BD}}, \text{ and } D = F.\frac{V}{n},$$

in which the co-efficients M and F, taken at their mean experimental values are 22 and 30, we can resolve such questions as relate to the proportions and principal dimensions of engines and vessels constructed on principles similar to those of the Americans. We obtain, for example, from the equations referred to

$$n = M\,F\sqrt[3]{\frac{h\,c\,p^2}{B\,D}},$$

which enables us to remark, that though from the first of the two equations given, it appears to be advantageous to diminish the diameter of the wheels, that cannot be done unless the boiler will produce enough of steam to admit of their performing a greater number of revolutions.

Again, by eliminating D from the same equations, we obtain,

$$V = \sqrt[3]{\left(\frac{M^2}{F} \cdot \frac{n\,h\,c\,p^2}{B}\right)};$$

or since,

$$\sqrt[3]{\frac{M^2}{F}} = 2.53 \text{ nearly},$$

we may have,

$$V = 2.53\sqrt[3]{\frac{n\,h\,c\,p^2}{B}}$$

Hence it appears that the velocity of a steam boat is equal to the cube root of the product of the following quantities: *The altitude of the column of Mercury the steam will support, the square of the diameter of the piston, the length of its stroke, and the number of times it is raised in a minute*; divided by *the cube root of the product of the breadth of the vessel into its draught of* water, and the quotient multiplied by *a constant co-efficient*.

By employing this expression for calculating the velocities of the first nine vessels contained in the comparative table it will be found, says M. Marestier, that the error is generally less than one-tenth of the actual value.

The coefficient 2.53 above deduced, depends on the form of the vessel. Its value might be 2.25 for a form experiencing apparently a great resistance; or it may be 2.75, or even more, for a contrary form.

11. If the value of B be regarded as unknown, we shall obtain,

$$B = \frac{M^2}{F} \cdot \frac{n\,h\,c\,p^2}{V^3};$$

or since the value of the co-efficient $\frac{M^2}{F}$ is nearly equivalent to 16, we shall have, $B = \frac{16\,n\,h\,c\,p^2}{V^3}$.

Hence, the engine being given, we can determine the area of a parallelogram, whose base shall be the breadth of a vessel which the engine can move with a given velocity, and altitude equal to the draught of water.

12. From the equation $n\,c\,h\,p^2 = \frac{BV^3}{16}$ we may also find the power it is requisite an engine should possess, to enable it to move a given vessel with a determinate velocity. We see, moreover, that this force increases as the cube of the velocity.

13. Having found that

$$v = \frac{c\,n}{30}, \text{ or } c\,n = 30\,v,$$

we shall obtain, by substituting in the value of V before given, that $V = \sqrt[3]{\left(\frac{M^2}{F} \cdot \frac{30\,v\,h\,p^2}{B}\right)}$;

and when the velocity of v is equivalent to $\frac{8}{10}$ of a metre, which is the case in most of the American boats, we shall farther have $V = 7.3\sqrt[3]{\frac{h\,p^2}{B}}$.

This equation may be employed in the same manner as the preceding, to determine the size of a vessel, or the power of an engine, by supposing B or $h\,p^2$ as unknown.

M. Marestier objects to the method commonly employed of estimating the power of a steam engine, by the number of horses it would require to perform the same quantity of work, since the nominal power of the engine under these circumstances, must very much depend on the estimated power of a horse. He proposes a method, certainly of a much more philosophic character, and capable of affording more accurate results. *Multiply*, says he, *the height of the column of mercury the steam will support, by the square of the diameter of the cylinder, and the mean velocity of the piston; sixty-six and two-thirds of this product will be the number representing the horse power. Then will the velocity be equal to twice the cube root of the quotient of the number of horses, divided by the rectangle of the draught of water, and the breadth of the vessel.*

The power of an engine capable of communicating a required velocity to a boat may be found, he informs us, by multiplying the cube of the velocity by the breadth, and by the draught of water, and dividing the resulting product by 7.26, or by 6, as the circumstances of the vessel may require.

The surface of the parallelogram also, which has the breadth of the vessel for its base, and the draught of water for its altitude, may be determined, by dividing the number of horse power of the engine, by the cube of the required velocity, and multiplying the resulting quotient by 7.26, or 6, as the conditions of the vessel may require.

In considering the motions of steam vessels in rivers, M. Marestier introduces the consideration of the velocity of the current, and also attends to the effect produced, by causing the action of the engine to be applied to winding a rope round a roller, the outer end of the rope being attached to a fixed point on the shore. His general results are as follow: *To stem a current with the least consumption of fuel, the absolute velocity of the vessel should be only half the velocity of the steam. That the velocity resulting from the use of the rope and roller is greater than that which results from the use of the paddle-wheel, in the proportion of the cube root of the velocity of the paddle to the cube root of the velocity communicated by the paddles to the vessel. That to enable the vessel to stem a current with an absolute velocity equal to half the velocity of the current, it requires three times the motive power, if that power acts on board the vessel, that would be necessary if the power were applied to the rope. That when the current is rapid, it is advantageous to use the rope for hauling, in order to stem it; but that if the current is not strong, it is preferable to use the paddles; and that the paddles should always be used in descending a stream, when the absolute velocity of the vessel is greater than the velocity of the paddles, or when the velocity of the stream is greater than the velocity with which the paddles strike the water, which will generally be the case.**

Much remains to be done to perfect the theory and practice of steam boats: yet in a department of knowledge so comparatively new, it is remarkable what rapid steps have been already made towards its improvement. "*The motion of boats, their forms*, and *proportions*," says Mr. Tredgold, in an ingenious and able paper on the subject,† "will afford many fine subjects for the application of science." Let us hope, that "Man, nature's minister and interpreter," will not cease his endeavours to carry it onwards to perfection.

Mr. Tredgold, in his ingenious disquisition, observes, that in still water, it may be assumed, that the resistance of the same vessel is sensibly proportional to the square of the velocity: the variation from the law being, he considers, too small to produce a sensible effect within the range to which the velocity is limited in practice. Therefore if a be the force that will keep the boat in uniform motion at the velocity u, the force that will keep it in motion at the velocity, will be found by the analogy,

$$u^2 : v^2 : : a : \frac{a\,v^2}{u^2},$$

which is the measure of the resistance with the velocity v. Hence the mechanical power required to keep the boat in motion with the same velocity, will be $\frac{a\,v^3}{u^2}$; and from which it follows, that the power of a steam engine to impel a boat in still water, must be as the cube of its velocity. Therefore, if an engine of twelve horses power will impel a boat at the rate of seven miles an hour in still water, and it be required to determine what power will move the same boat at ten miles per hour, we shall have

$$7^3 : 10^3 : : 12 : \frac{10^3 \times 12}{7^3} = 35;$$

or an engine of thirty-five horses power.

This immense increase of power to obtain so small an increase of velocity, says Mr. Tredgold, ought to have its influence in fixing upon the speed of a boat for a long voyage, and its proportion ought to be adapted for that speed, with a proper excess of power for emergencies. A low velocity should be chosen, when goods as well as passengers are to be conveyed. The example before given, places this in a very striking point of view: for to increase the velocity of the same boat from seven to ten miles an hour, requires very nearly three times the power, and of course three times the quantity of fuel, and three times the space for stowing it, besides the additional space occupied by a larger engine. Therefore if seven miles per hour will answer the purposes of the trade the vessel is to conduct, the advantages of the lesser speed must be evident.

According to these principles, Mr. Tredgold has computed the following table, illustrating the power necessary to communicate to a boat different velocities

2 miles per hour	5½ horses power.
4 - - -	13
5 - - -	25
6 - - -	43
7 - - -	69
8 - - -	102
9 - - -	146
10 - - -	200

* The work of M. Marestier is the most important that has yet appeared on the subject of steam navigation, and we earnestly recommend its elaborate content to the attention of our readers. The report to the Institute on it was made by Sane, Biot, Poisson, and Dupin. These distinguished men remark, "Lorsqu'un nouveau genre de forces mécaniques s'introduit d'une maniere utile dans quelque branche de l'industrie humaine, il donne au peuple qui s'en empare le premier, ou que l'exploite sur la plus grande échelle, un puissant moyen de superiorité sur les autres peuples. Souvent, enfin, le renversement des rapports de prosperité, de richesse et de puissance entre les nations, est la suite necessaire de l'adoption et du progrès des appliations d'une espece nouvelle de forces mécaniques."

† See an Essay on Steam Boats by Mr. Tredgold, in Mr. Partington's Historical and Descriptive Account of the Steam Engine.

In short voyages, the extra quantity of engine room and tonnage for fuel is not so objectionable; but in a long voyage, it reduces the useful tonnage to so small a proportion, as to render it doubtful whether such vessels will answer or not. The consumption of fuel to produce a given effect, is much greater than in engines on land; and perhaps much in consequence of the draught of the chimney, and the limited space for the boiler.

When the paddles of a steam boat are in action, there is a point in each paddle, wherein if the whole reaction of the fluid was concentrated, the effect would not be altered. This point Mr. Tredgold denominates the centre of reaction.

By supposing the fluid at rest, the velocity of the centre of reaction V, and the velocity of the boat v, the velocity with which the paddles strike the water will be $V - v$. Or the difference between the velocity of the paddles and the velocity of the boat, is equal to the velocity with which the paddles act on the water. Hence when these velocities are the same, the paddles have no force to impel the boat; and if the paddles were to move at a slower rate, they would retard it.

Now, as $V - v$ represents the velocity, the force of the reaction will be as $(V - v)^2$, since this quantity is proportional to the pressure producing the velocity $V - v$. But during the action of the paddles, the water yields with a velocity $V - v$; and since the velocity of the boat is v, the effective power is as

$$V - v : v : : (V - v)^2 : v\,(V - v).$$

The effect of this power in a given time, is a maximum, when $v^2\,(V - v)$ is a maximum; that is when $2\,V = 3\,v$; or when the velocity of the centre of reaction of the paddles is $1\frac{1}{2}$ time the velocity of the boat.

It is desirable that the action of the paddles should be as equable and continuous as possible, unless they be arranged so that the variation of the power of the engine may coincide with the variation in the action of the paddles. But in attempting to render the action of the paddles equable, their number ought not to be increased more than can be avoided, because there is not then time for the water to flow between them, so as to afford a proper quantity of reaction; neither do they clear themselves so well in quitting the water. If we suppose WL, Fig. 3. Plate DI. to be the line the water would assume when at rest, the most favourable arrangement, with the smallest number of paddles, appears to be, to make the paddle A of the wheel A just entering, when the preceding one B is in a vertical position, and the one C quitting the water. This arrangement allows time for the water to flow between, and for it to escape from the retiring paddles. If a smaller number be employed, there will be a short interval, during which none of the paddles will be in full action. The utmost variation will be between the positions of the wheels A and B, and an intermediate position is shown by the wheel C.

To determine the radius of the wheel, or the depth of the paddles, when the number of paddles is given, becomes an easy problem, when the preceding conditions are to be adhered to.

For this purpose, put AO, Fig. 4. $= r$, and the depth A a of the paddle $= x$. Let also n represent their number. Then $\frac{360^\circ}{n}$ will be measure of the angle AOB, contained between two adjacent paddles; and $r \cos. \frac{360^\circ}{n} = \mathrm{O}\,a$, will be the cosine of the same angle, being the interval from the centre of the wheel to the surface of the water.

$$\text{Hence,} \qquad r \cos. \frac{360^\circ}{n} = r - x;$$

or $r\left(1 - \cos. \frac{360^\circ}{n}\right) = x$, the depth of the paddles; and $\dfrac{x}{1 - \cos. \frac{360^\circ}{n}} = r = \mathrm{A}\,o$, is the radius of the wheel.

From these equations Mr. Tredgold derives the following rules for finding the radius of the wheel, when the number and depth of the paddles are given. *Divide 360 by the number of paddles, which will give the degrees in the angle contained between two adjacent paddles. From unity subtract the natural cosine of this angle, and the depth of the paddles divided by the remainder will give the radius of the wheel.*

Thus, if the number of paddles be 8, Fig. 5. and their depth $1\frac{1}{2}$ foot, we shall have $\frac{360^\circ}{8} = 45^\circ$, the cosine of which is .7071. Therefore $\frac{1.5}{1 - .7071} = 5.12$ feet, the radius of the wheel.

Again, if the number of paddles be 7, Fig. 4. and their depth 1.5 foot as before, we again have $\frac{360^\circ}{7} = 51^\circ\ 26'$, the cosine of which is ·6234. Consequently $\frac{1.5}{1 - .6534} = 4$ feet, the radius of the wheel desired.

Both these examples are illustrated in Fig. 6, and it may be remarked with respect to them, that, when the depth of the paddles is fixed, the greater number of paddles should have the preference, because the first impression on the water is then less vertical. The difference may be readily perceived, by comparing the angles at which the paddles A and a strike the water. It will also be remarked, that the larger wheel must have a less tendency to throw up the water behind at C.

It is obvious, continues Mr. Tredgold, that, by enlarging the wheel, the obliquity of the action on entering the water may be reduced; but it also may be done by lessening the depth of the paddles, as will be evident from Figs. 3 and 4, where the angles are the same in both wheels. Hence it is useful to be able to find the depth: and if the number of the paddles and the radius of the wheel be given, the depth may be found by the foregoing rule:

Multiply the radius of the wheel by the difference between unity and the natural cosine of the angle contained between two paddles, and the product is the depth required. Suppose, for example, the radius to be 4.5 feet, and the number of paddles eight, there will be 4.5 $(1 - .7071) = 1.318$ *feet, for the depth of the paddles.*

Mr. Tredgold thinks eight paddles to be as small a number as ought to be adopted, and where large wheels can be admitted, nine or ten might be used with advantage, but where many paddles are employed, the wheels must necessarily be of large diameter, to keep them narrow. The advantages of wheels of large diameter consist in the favourable direction they strike the water, and also quit it; the paddles are also more distant from one another, and while they have more re-action on the water, they splash it about much less; the weight of the wheel also renders it more effective as a regulator of the forces acting upon it. On the contrary, there are some strong practical objections to very large wheels for sea vessels; they give the force of the waves a greater hold on the machinery, they are cumbersome and unsightly, and they raise the point of action too high above the water line, so that the choice requires both experience and judgment.

The best position for the paddles appears to be in a plane passing through the axis, as represented in the figures. If they be in a plane which does not coincide with the axis, they must either strike more obliquely on the fluid in entering, or lift up a considerable quantity in quitting it. With respect to the shape of the paddle, it is clear that it should be such that the resistance to its motion should be the greatest possible, and the pressure behind it the least possible. These conditions appear to be fulfilled in a high degree by the simplest of all forms, the plane rectangle; but we might learn much from a judicious set of experiments on this subject.

As there is some variation in the force of re-action against the paddles, it may in some measure be compensated by making its periods coincide with the variation in the force of the engine. To effect this, the stroke of the engine should be made in the same time as is occupied by that part of the revolution of the paddle wheel, which is expressed by a fraction, having the number of paddles for its denominator, and the piston should be at the termination of its stroke, when one of the paddles is in a vertical position. For, when one of the paddles is in a vertical position, as in the wheel A, Fig. 2, the re-action is the least, and it is greatest when two paddles are equally immersed, as in the wheel B, at which time the force would be acting at right angles to the crank.

Having shown the power that is necessary to keep a boat in motion in still water, it will be some advantage to resume the inquiry in the case where it moves in a stream or current; and, for that purpose, let v be the velocity of the boat, and c that of the current; a being the resistance when the boat is in motion with the velocity u.

Then the resistance to be overcome to give the boat the velocity v, is, when the motion is *with the stream*,

$$u^2 : (v - c)^2 :: a : \frac{a(v-c)^2}{u^2}.$$

And, when the boat moves *against the stream*, we have

$$u^2 : (v + c)^2 :: a : \frac{a(v+c)^2}{u^2}.$$

Hence the power is expressed in either case by

$$\frac{a(v \mp c)^2}{u^2},$$

the *upper* sign of which is to be attended to when the motion is *with the current*, and the *lower sign when it is against it.*

When c, the velocity of the current, is nothing, the result is the same as before. But the resistance in still water is not the mean between the resistances in the direction of the current, and against the current; consequently, the mean rate of a boat, which alternately goes with and against a current, must be less than the mean rate in still water. The mean resistance is

$$\frac{a\,v\,(v^2 + c^2)}{u^2},$$

while the resistance in still water is only $\frac{a\,v^3}{u^2}$, the difference between which and the former is $\frac{a\,v\,c^2}{u^2}$; a quantity depending on the velocity of the current, and for any particular case, should be calculated from the mean motion of the current.

When a boat advances with a current, the velocity with which the paddles act on the water will be $V + c - v$; and when the boat moves against the current, it will be $V - c - v$; consequently, in either direction it is $V \pm c - v$; and the force of re-action $(V \pm c - v)^2$. But the effective resistance of the boat is as

$V \pm c - v : v :: (V \pm c - v)^2 : v\,(V \pm c - v)$; and its effect in a given time is a maximum, when $v^2\,(V + c - v)$ is a maximum, that is when $V = \frac{3\,v \mp 2\,c}{2}$, or when $V = 1.5\,v \mp c$. Moreover, $v = \frac{2\,(V \pm c)}{3}$.

When c vanishes, or the boat moves in still water. $\frac{2\,V}{3} = v$, the same as before. The mean also between moving against and with the current is $\frac{2\,V}{3} = v$. Therefore, where the velocity cannot be changed to suit the circumstances, this will be the best proportion for all cases. Where the force of a current is considerable, it would be extremely desirable to have the power of altering the velocity of the wheels; but this should not be accomplished by any alteration of velocity in the steam piston, since whatever change is made in its velocity must affect the power of the engine. There is no difficulty, Mr. Tredgold imagines, in adopting such a train of mechanism as would produce the alteration of velocity required, and yet be as strong and durable as the ordinary combination, and not at all expensive, compared with the object to be gained by introducing it. It will only be necessary to provide for an increase of velocity: for, when the boat goes with the stream, the rate of the paddles is already too great; whereas, when a boat moves against the current, both an increase of the velocity of the wheel, and an increase of surface of the paddle, is necessary to maintain the mean rate.

Mr. Tredgold concludes his very interesting investigations, by inquiring into the velocity a boat may be expected to acquire when the power is the same. The power P of the engine may be represented, as we have before determined, by the equation

$$P = \frac{a\,v\,(v \mp c)^2}{u^2};$$

and if the ratio of the current to the velocity of the boat be as $1 : n$; that is, $1 : n :: v : c = n\,v$, we shall have

$$P = \frac{a\,v^3\,(1 \mp n)^2}{n^2},$$

$$\text{or, } v = \left(\frac{P\,n^2}{a\,(1 \mp n)^2}\right)^{\frac{1}{3}}.$$

If the boat moves in a current, of which the velocity is n times the velocity of the boat, we shall have

	Velocity of the current with the stream, 4 miles per hour.	Velocity of the Boat, 8 miles per hour.
	2.3	6.6
	1.53	6.12
Still water	0.00	5.00
Against the stream	1.03	4.34
	1.38	4.16
	1.92	3.85
	2.38	3.53
	3.17	3.17

This table shows that a power capable of moving a boat at the rate of five miles per hour, in still water, will only move it at the rate of a little more than three miles per hour against a current of the same velocity as the boat; and that the speed of the same boat would be eight miles per hour, when moving with a current of which the velocity is four miles per hour. It should be remarked, that these calculations suppose the area of the paddles, and their velocity, to be adjusted to the maximum proportions in each case; were it otherwise, the velocity with the current would be increased, and the velocity against the current diminished.

REMARKS.

Just as this paper was going to press, four ships were equipped,* of the respective constructions of Sir Robert Seppings, Professor Inman, Captain Hayes, and Captain Symonds, for the purpose of contesting their relative qualities; and so important does the Board of Admiralty consider the point in question, that an admiral (Sir Thomas Hardy) has been appointed to command the squadron, to direct its various evolutions, and to report on the respective qualities of the ships. It is needless to add how much naval architecture must be ultimately improved by the knowledge to be derived from the many experimental ships that have been lately constructed. It would be a great advantage, however, if each constructer would publish, in a detailed form, *the principles he employs in the formation of his ship.* It is not sufficient to be merely able to construct a good ship. Science requires that we should know *how* and *why* it is a good ship; *what principles have been employed in its construction, and what general rules may be derived from approved individual examples.*

It is not in the terrible season of war, when the hopes and energies of man are principally occupied by conquest, that naval architecture can be expected to make its greatest steps towards perfection. "In war," as the celebrated Dupin observes,† "the object is to do much in a little time, to sacrifice rigorous methods to means ready and expeditious, and the way the best in itself, to the manner most commonly known. At the return of peace, and when a nation begins to feel the benefit of repose, opportunity is afforded for reflection, and extreme rapidity of operation gives place to inquiries into the best methods of executing the details of duty, and of throwing into the practical operations of the ship-builder, some of the genuine principles of science." Let us hope that this great country, which owes its proud and commanding position among the nations of the earth so essentially to its marine, will lose no opportunity of imparting to it every improvement that the enlarged experience of modern times has disclosed; and to prepare it, if the unfortunate destiny of man should so require, for a more splendid and triumphant maintenance of the national honour and glory, than even our former brilliant achievements displayed.

The preceding article is another proof, to the many on record, of the hostile and unjust spirit prevailing among the writers of Britain against the United States. It says, first, that "the Americans have with some unfairness, claimed the original invention of the steam boat." This claim was never made: all that we contend for is, that Robert Fulton first successfully reduced the principle of steam navigation to practice, which had been in vain attempted with profit, before his time. In this position we are supported by cotemporary Encyclopædists, a British engineer, and the report of a Committee of the House of Commons.

1. The supplement to the Encyclopædia Britannica, (Edinburgh 1824,) article Steam Navigation, contains a letter from Mr. Henry Bell of Glasgow, to the editor of the Caledonian Mercury, dated October, 1816, stating that he built the Comet steam boat in 1811, which was the first built in Europe that answered the end; but the editor adds, that "the first American steam boat which completely succeeded, was launched at New York on the 3d October, 1807, five years before the construction of the Comet of Port Glasgow."

2. In the fifth report of the select committee of the House of Commons on steam boats, &c. published in June, 1822, (Sir H. Parnell, Baronet, in the chair,) after tracing the different experiments, from Mr. Hull's, in 1763, to Mr. Symington's, in 1801, it is said, "*Still no practical uses resulted* from any of these attempts. It was not till 1807, when the Americans began to use steam boats upon their rivers, that their safety and utility were first proved. But the whole merit of constructing these boats is due to natives of Great Britain. Mr. Henry Bell, of Glasgow, gave the model of them to Mr. Fulton, and went over to America to assist him in establishing them. Mr. Bell continued to turn his talents to the improving of steam apparatus, and its application to various manufactures about Glasgow, and in 1811 built the Comet

* About eighteen months since, three corvettes, the Pylades, Orestes, and Champion, were constructed respectively by Sir Robert Seppings, Professor Inman, and Captain Hayes, and several experimental cruises made in them. An account of the comparative merits of these ships may be seen in the first number of the work entitled, *Papers on Naval Architecture.*

† Progres des Sciences et des Arts de la Marine Française, depuis la Paix, par Ch. Dupin, à Paris, 1820.

to navigate the Clyde, &c." The editor of the Literary Gazette adds, "This was the *first practical European steam vessel*, and hence has sprung those hundreds of noble ships which convey us and our merchandise to all ports of the empire, with expedition, regularity and economy."

This report, which was made after a strict examination by the Committee, of persons who were capable of affording the most correct information on the subject, is of itself sufficient to establish the particular merit of Mr. Fulton for which we contend, but when added to other facts, no doubt can remain in the mind of any one on the question. No mention, however, is made in Mr. Colden's life of Fulton, of his having received a *model* from Mr. Bell, nor of his having come to the United States to assist Mr. F. in establishing steam boats, and Mr. Bell is also silent on these points in his letter referred to. It is therefore probable that there is a mistake with respect to them. There can be no doubt of Mr. Fulton having greatly profitted by his conversations with Mr. Symington and Mr. Bell; and the last of these gentlemen states that Mr. Fulton wrote to him "that he had constructed a steam boat from the different drawings of machinery he had sent him, but required some improvements on it."* According to Mr. Colden, the engine was made by Messrs. Bolton and Watt, by order.

3. Mr. Buchanan an English engineer, in his "treatise on propelling vessels by steam," admits the claim of Mr. Fulton so far as is contended for him. He says, "In eighteen hundred and seven, Mr. Fulton of New York, introduced steam Boats in America, *which were the first that succeeded in a profitable way*".

II. The writer of the above article admits, that "the honor belongs to Mr. Fulton of having been the first who *endeavoured* to investigate on principle the difficulties of the subjects of steam Navigation," but he had not candour, or liberality enough to say, that the result of this investigation was full success in an object which his own countrymen had not been able to accomplish. Such however is the fact; Mr. Fulton not only ascertained the "difficulties," but removed them, and his countrymen since his death, have improved upon his plans to a most astonishing degree. In proof of this, it is only necessary to compare the speed of steam boats during several years after they were first built, and chiefly on the British plan, by Mr. Fulton, and at the present time. In a letter from Fulton to his friend Joel Barlow, dated August 2d, 1807, he informs him, that "he ran up to Albany in 32 hours, and down in 30 hours."† The first rout was at the rate of a mile in fourteen and a half minutes, and the last at that of five miles per hour.

In August 1826, the steam boat "new Philadelphia," built by the Messrs. Stevens of New York, made an experimental trip from New York to Albany, and performed it in twelve hours and twenty three minutes, part with, and in part against tide. She must have proceeded at the rate of more than thirteen miles an hour, the distance being one hundred and sixty miles.

On the 25th October 1828, the North America made the passage from New York to Albany in ten hours and ten minutes, say 16 miles an hour. During the passage, she stopped at six wharves. The rate of this boat is one mile in four minutes fifty-eight seconds. In November of the same year, the De Witt Clinton made the same trip, and returned to New York in twenty-four hours.

The first boat built at Pittsburg for the New Orleans trade, was in the year 1811, and partook of the slow motion of the original New York boats. Even in 1817, the quickest voyage made from New Orleans to Shippingport, two miles below Louisville, was twenty-two days, and the time required to go down with the current, was from twelve to fourteen days. The passage up is now made in from ten to fourteen days, and less, and down in six days.

On the Mississippi, the rates of going against a strong current, are eight and nine miles an hour, averaging the voyage from New Orleans to Louisville, a distance of 1580 miles, and which was performed by the steam boat Tecumseh in eight days and two hours. In April, 1827, the same boat did it in nine days and four hours, having lost one whole night, and part of another by fog. The boat Huntress made a voyage in May 1827, from and to the same places, in eight days and eleven hours, against a rapid current, though she lost ten hours by a fog. The Pioneer and Columbia performed the same rout in nine days. Twelve years before, this voyage required four months in common river boats. Three or four years since, the De Witt Clinton left Cincinnati, went to Pittsburg, (against a strong current) transacted business there, and returned on the sixth day, a trip of upwards of one thousand miles!

In March, 1827, the steam boat William Tell, made the voyage from Pittsburg to Cincinnati, a distance of five hundred miles, at the rate of thirteen miles per hour.

The steam boat Independence, in May 1829, made the passage from Frenchtown, on Elk river, to Baltimore, a distance of seventy miles, in three hours and a half.

In April, 1829, the steam boat Benjamin Franklin, made the passage from New York to Providence, Rhode Island, dock to dock, in fifteen hours twenty-three minutes: distance, two hundred miles. The rates of sailing of the steam boats up the Delaware, are from one hour and a half to two hours, to Burlington, against tide, and one hour and twenty-three minutes with tide. The shortest passage was one hour nineteen and a half minutes. The distance is twenty miles.

III. The assertion of the writer of the above article, that "the invention of the steam boat is due, both in theory and practice, to Great Britain," is not correct, for the Marquis de Jouffroy, in the year 1781, constructed a steam boat on the Soane at Lyons, 140 feet long, and made several experiments with it;‡ and our countrymen, John Fitch and Henry Voigt, many years before the experiments of Mr. Symington, viz. in 1787, built

* Supplement to the Encyclopædia Britannica, art. Steam Navigation.

† Colden's life of Fulton. The reader is referred to this interesting work, for a detail of various plans of steam boats in Europe, the difficulties that occurred, and the progressive experiments by Mr. Livingston and Mr. Fulton, which finally led the latter to the adoption of the water wheels at present in use, as propellers.

‡ Supplement to the Encyclopædia Britannica, article Steam Navigation.

a steam boat at Philadelphia,* by subscription, and worked it by paddles. This boat went to Burlington 20 miles up the Delaware, and returned the same day, having the Governor, (Gen. Mifflin,) and many other citizens on board. The manuscripts of Mr. Fitch bequeathed by him to the Library Company of Philadelphia, contain the certificates of several distinguished men of their having gone in the boat at the rate of six miles per hour, several times between the year just mentioned, and 1791. Among these were David Rittenhouse, Dr. John Ewing, Provost, and Robert Patterson, Professor of Mathematics in the University of Pennsylvania, Andrew Ellicott, and others: but it appears that some defect was discovered, or some improvement was suggested in almost every experiment, which occasioned him to make such repeated draughts upon the company, that their patience became exhausted, and the members despairing of ultimate success, and being probably influenced by the unceasing ridicule cast on the project, refused to furnish the funds occasionally required, and gradually withdrew from the concern. The one he most regretted, was Mr. Voigt, to whose mechanical ingenuity, he had been greatly indebted. The debts incurred by Mr. Fitch on account of repairs for the boat, his inability to discharge them, and to obtain the means to proceed with his experiment, obliged him finally to abandon it, after years spent in the greatest anxiety for its completion, and of the most praiseworthy industry, and heroic perseverance to bring it to perfection. If Fulton had been placed in the same circumstances with Mr. Fitch, he would have been defeated from a similar cause, and but for the liberality of Robert R. Livingston, the world might have been, even at the present day, without a steam boat! The following document, written by one of the early patrons of Mr. Fitch, will throw light on the subject.

From the London Monthly Magazine of Oct. 1815.

"*A short account of the origin of steam boats, by Dr. Thornton, director of the patent office Washington.*

Finding that Mr. Robert Fulton, whose genius and talents I highly respect, has been by some considered as the inventor of the Steam Boat, I think it a duty to the memory of the late John Fitch, to set forth, with as much brevity as possible, the fallacy of this opinion; and to show, moreover, that if Mr. Fulton has any claim whatever to originality, in his steam boat, it must be exceedingly limited.

In the year 1788, the late John Fitch applied for, and obtained, a patent for the application of steam to navigation, in the states of Pennsylvania, New York, New Jersey, Delaware, &c. and soon after, the late Mr. James Rumsey, conceiving he had made some discoveries in perfecting the same, applied to the State of Pennsylvania for a patent; but a company formed by John Fitch, under his state patents, of which the author of this was one of the principal share-holders, conceiving that the patent of Fitch was not for any peculiar mode of applying the steam to navigation, but that it extended to all known modes of propelling boats and vessels, contested before the assembly of Pennsylvania, and also before the assembly of Delaware, the mode proposed by Mr. Rumsey, and contended that the mode he proposed, viz. by drawing up the water into a tube, and forcing the same water out at the stern of the vessel or boat, which was derived from Dr. Franklin's works (the doctor being one of his company) was a mode they (Fitch's company) had a right to, for the plan was originally published in Latin, about fifty years before, in the works of Bernoulli the younger; and two of Fitch's company and I appeared without counsel, and pleaded our own cause in the assembly, of Pennsylvania, (the hon. Messrs. Findley and Smiley, of Congress, were then sitting members of the assembly;) and, after a week's patient hearing against the most learned counsel of Pennsylvania, we obtained a decision in our favour, and afterwards also in Delaware. We believed, and contended, that our claim of propelling boats by steam, included all the modes of propelling vessels and boats then known, and that the patent was for the application of steam as an agent to the propelling powers; and the decisions of the legislatures were in favour of this construction, as Mr. Rumsey's company (of which the late Messrs. Bingham, Myers Fisher, and many other worthy gentlemen were members) were excluded from the right of using steam boats on any principle.

We worked incessantly at the boat to bring it to perfection, and some account of our labours may be seen in the Travels of Brissot de Warville, in the U. States; and, under the disadvantages of never having seen a steam engine on the principles contemplated, of not having a single engineer in our company or pay, we made engineers of common blacksmiths; and, after expending many thousand dollars, the boat did not exceed three miles an hour. Finding great unwillingness, in many, to proceed, I proposed to the company, to give up to any one the one half of my shares, who would, at his own expense make a boat go at the rate of eight miles an hour, in dead water, in 18 months, or forfeit all the expenditures on failing; or I would engage with any others to accept these terms. Each relinquished one half his shares, by making the 40 shares eighty, and holding only as many of the new shares as he held of the old ones, and then subscribed as far as he thought proper to enter on the terms: by which many relinquished one half. I was among the number who proceeded, and in less than 12 months we were ready for the experiment. The day was appointed, and the experiment made in the following manner. A mile was measured in Front street (or Water street) Philadelphia, and the bounds projected at right angles, as exactly as could be to the wharfs, where a flag was placed at each end, and also a stop-watch. The boat was ordered under way at dead water, or when the tide was found to be without movement; as the boat passed one flag it was struck, and at the same instant the watches were set off: as the boat reached the other flag it was also struck, and the watches instantly stopped. Every precaution was taken before witnesses: the time was shewn to all; the experiment declared to be fairly made, and the boat was found to go at the rate of eight miles an hour, or one mile within the eighth of an hour; on which the shares were signed over with great satisfaction, by the rest of the company. It afterwards went eighty miles in a day!

The governor and council of Pennsylvania were so

* The boat was 60 feet long, 8 feet wide, and 4 feet deep.

highly gratified with our labours, that, without their intentions being previously known to us, Governor Mifflin, attended by the council in procession, presented to the company, and placed in the boat a superb silk flag, prepared expressly, and containing the arms of Pennsylvania, and this flag we possessed till Mr. Fitch was sent to France by the company, at the request of Aaron Vail, esq. our consul at L'Orient, who, being one of the company, was solicitous to have steam boats built in France. John Fitch took the flag, unknown to the company, and presented it to the national convention. Mr. Vail, finding the workmen all put into requisition, and that none could be obtained to build the boats, paid the expenses of Mr. Fitch, who returned to the United States; and Mr. Vail, afterwards, subjected to the examination of Mr. Fulton, when in France, the papers and designs of the steam boat appertaining to the company."

In the year 1827, there were 109 steam boats of the burthen of 18,597 tons employed in the trade of the Ohio, and Mississippi rivers. The greatest is of the burthen of 375 tons; the average is about 170 tons. In 1826, 35 were plying from New York up the Hudson, and to Connecticut, Rhode Island, and to New Jersey, besides seven steam ferry boats; there were 17 on the Delaware, and 9 or 10 on the Chesapeake.

Upon Lake Erie, the following steam boats were plying in the year 1826:

Superior,	built at Buffalo, New York,	-	346 Tons.
Henry Clay,	" Black Rock, do.	-	300
Niagara,	" do. do.	-	200
Pioneer,	" do. do.	-	150
Enterprise,	" Cleaveland, Ohio,	-	200
William Penn,	" Erie, Pa. - -	-	200
Chippewa,	" Buffalo - -	-	100

Statement showing the amount of steam boat tonnage of each State and Territory of the United States; also, the duty collected on the same, during the year 1827.

States.	Tons.	95ths.	Dolls.	Cts.
Maine,	350	00	21	00
Rhode Island,	178	07	10	68
Connecticut	1,652	72	99	12
New York,	10,264	88	615	84
New Jersey,	1,078	92	64	68
Pennsylvania,	1,580	04	94	80
Delaware,	372	56	22	32
Maryland,	2,207	49	132	42
District of Columbia,	873	12	52	38
Virginia,	946	57	56	76
South Carolina,	3,233	79	193	98
Alabama,	3,100	21	186	00
Louisiana,	17,003	37	1,020	18
Georgia,	719	43	43	14

Treasury Department,
Register's Office, April 15th, 1828.

JOSEPH NOURSE, Register.

Twenty-two steam boats were built in the city and vicinity of Pittsburg, within twelve months preceding March 1829. Their aggregate tonnage was 4570 tons.

The steam boats of the United States are distinguished for their neatness, and comfortable accommodations; and many of them are fitted up in the most elegant style, contributing thereby to the health, and pleasure of the passengers.

MEASE.

SHIRAZ. See SCHIRAZ.

SHIRVAN. See SCHIRVAN.

SHOE MACHINERY. The machines for making shoes, of which we propose to give a brief and general account, were invented by the celebrated engineer Mr. Brunel, with whose ingenious inventions our readers are already well acquainted.

During the late war Mr. Brunel established at Battersea Bridge his machinery for making shoes, principally with the object of supplying the army. The machines were all managed by the invalids of Chelsea Hospital, who were unfit for any other employment.

In shoes of the usual kind the sole was united to the upper leather by sewing, but in the year 1809, Mr. David Mead Randolph, an American, took out a patent for employing rivetting in place of sewing in fixing the soles and heels of shoes to the upper leather. This method was adopted by Mr. Brunel, but he also extended it to all the parts of which the shoe is composed.

The shoes made by this machinery are composed of the following pieces:

1. The upper leather, consisting of three pieces, viz. the *vamp*, or the portion which covers the upper part of the foot, and the two quarters which run round the heel. These three pieces are sewed to one another.

2. The sole part of the shoe, which consists of the real or lower sole with its welt, the heel, and the inner or upper sole. The welt is a running border, fixed by a row of nails on the upper side of the lower sole, so as to increase the thickness of the sole towards its edge, and it lessens gradually inwards.

The upper leathers are made of sufficient size to turn in all round beneath the foot under the edge of the inner sole, for about $\frac{3}{4}$ths of an inch wide, and the inner sole, with its welt, is applied beneath so that the turning in of the upper leather is included between the two soles.

The nails used to fasten together the different parts are as follows:

1. The *long nails*, which form a complete row as near as possible to the edge of the whole shoe, passing through the two soles, the welt, and the upper leather. The heel is also fastened on by a row of these nails round its edge. The heads or thick ends of the nails are seen on the lower side of the soles, and keep the leather from wearing.

2. The *tacking nails*, which are such a size as to pass only through the sole and the welt. Of these there is a row all round the edge of the foot, but farther from the edge than the row of long nails.

3. The *short nails*, which only penetrate through the thickness of the lower sole. These are disposed in parallel rows across the tread of the foot, and also in a double row parallel to the outline of the toe, at about $\frac{3}{4}$ths of an inch from the edge.

The machines which are employed in manufacturing the shoe may be arranged as follows:

1. The cutting up machine.
2. The compressing machine, for pressing the soles.
3. The machine for punching the holes.
4. The machine for cutting the short nails, and inserting them.
5. The machine for punching the long nail holes and inserting the long nails in the holes.

6. The welting stand.
7. The cutting press.
8. The clamping machine.
9. The machine for cutting the long nails.

1. *The machine for cutting out the leather.* The various pieces of leather which compose the shoe are cut out by stamps, each of which is an iron frame or ring bent to the shape of the piece to be cut. The sharp edge of these stamps being placed upon the skin, and struck with a wooden mallet, will cut out the leather of the same form. The leather for the soles being softened, is laid on a table of lead, about two feet long, and one and a half wide, and is cut in a similar manner.

The inner soles are cut by a machine of the following construction. The stamp or knife is placed horizontally, with its sharp edge upwards, and the sole simply cut by a common knife round a wooden pattern, is laid upon the stamp. A lever, with a plate of lead fastened near its fulcrum, is fixed on the frame which supports the knife. The lever being now brought down by the hand, presses the plate of lead upon the sole, and thus enables the stamp to cut it out of the exact shape.

The welts, which must be cut out into strips of an inch wide, are made in a quite different manner. The leather is extended on a flat wooden table, two feet square, having its surface covered with small iron rulers, whose width is equal to that of the strips of leather to be cut, and screwed down upon the table, sufficient spaces being left between the rulers to admit the point of a knife. From these rulers several small pins project upwards, which passing through the leather, hold it firm. An iron frame, fixed to the table by hinges, folds down horizontally upon the leather, and is furnished with similar rulers, whose intervals correspond exactly with those between the fixed rulers, so that the whole leather is divided into strips of the same breadth as the rulers, which are cut out by introducing the point of a hooked knife between the rulers.

Each of these slips is now to be cut lengthwise into two, by an oblique or bevelled cut, and this is done by the following machine. This machine consists of a pair of brass rollers, one of which, turned by a wheel, gives motion to the other by a pair of equal cog-wheels, one wheel being fixed on the end of each roller. The rollers are placed one above another in an iron frame, the lower one having a groove cut round it to receive the strip of leather previous to its being divided. The upper roller serves to press the strip of leather into the groove. The leather is guided into the groove through a square hole in an iron stem fixed in front of the rollers. On the other side of the rollers is fixed a fine sharp steel edge, which being placed obliquely to the surface of the leather, cuts it into two slips with bevelled edges, or it passes through the rollers. The texture of the leather is also improved by the pressure of the rollers.

2. *Compressing machines for preparing the soles.* This machine supplies the place of hammering. It consists of two brass rollers, about five inches long, and five inches in diameter, mounted like the common laminating roller. Instead of screws, however, which are usually employed to hold down the upper roller, and adjust it to the proper distance from the lower one, two plain cylindrical pins are put into the holes where the screws would have gone, and upon the upper one the power of a strong lever, with a weight, is applied, giving a pressure of 1200 pounds. At the end of the axis of the lower roller is a cog wheel, driven by a pinion on the end of an axis turned by a winch handle. One works at the winch while another puts two soles, with the flesh sides together, between the rollers. An iron plate, with thin edges, is placed between the soles, which are passed backwards and forwards four or five times, till they are brought to the proper hardness and solidity.

The heel pieces are too small for this operation, but they are put into a small cell of cast iron, with an iron plate laid above them, and then subjected to the powerful pressure of a single blow of a screw press.

The heel pieces and the soles are bevelled at the place where they are to be joined, so that when they are united by three or four nails the whole is equally thick. The joints are cut to the proper bevel by a single press. The sole is laid flat on the bevelled edge of a bench faced with iron, and a piece of iron is pressed down upon it by the workman's elbow; the knife is thus properly guided to make the bevelled cut.

3. *The machine for piercing the holes.* This machine consists of a semicircular table of cast iron, supported by a column two feet high, which is connected by a projecting iron bracket to the table, which is thus placed between the workman and the column. Two arms project over the table from the column, and have their extremities formed into sockets, in order to support and allow to descend through them a vertical square iron slider, into the lower end of which is screwed the piercer. From a treadle moving on a centre pin fixed to the foot of the iron column, there rises an iron rod through a hole in the table, and also through holes in the projecting arm, and at the upper end this rod is joined to a lever moving on a joint at the upper end of the iron column, while the extremity of the lever is connected with the top of the perpendicular slider. When the foot of the workman presses upon the treadle, the slider and piercer are forced down towards the table, but never so far as to touch it, and these are raised up again without any effort, by means of a counterpoise and short lever.

The next part of the apparatus is an iron plate or pattern, of the size and shape of the sole, which is united to it by two sharp guage pins fixed in the pattern. The pattern is perforated with the same number of holes which it is proposed to make in the sole. The pattern, with the sole united to it, is laid on the iron table with the leather uppermost, and brought to a place where an iron stud rising through a hole in the table, and immediately beneath the piercer, enters every one of the holes of the pattern. The stud being only held up by a spring, is easily pressed down if the point of the piercer should, after penetrating the leather, happen to come down upon the stud. In this way any number of holes may be pierced merely by putting the stud into the holes of the iron pattern. A small piece of iron is fixed immediately above the leather, which prevents it from being lifted up along with the piercer. There is of course a hole in this piece of iron, through which the piercer moves.

4. *The machine for cutting the short nails, and inserting them in the holes.* The apparatus for cutting the nails forms the upper part of the machine. The

shears for cutting the nail consists of a loaded lever connected with a treadle. The lever has a cutter near its centre, so that when the foot depresses the treadle the leaver is raised, and cuts against the edge of a hard cutter. A slip of iron being introduced between the cutters, has a small piece or nail cut off from the end of it. This nail, the instant it is cut, falls into a tube, by which it is conveyed to a small tube over the leather, where it is ready for a subsequent operation.

The pattern, or iron plate, with the sole fixed to it, is now again used, and is brought by the method formerly directed, under a blunt piercer, which descends by the action of the treadle. The workman now bringing a hole beneath the piercer, holds a sheet of iron or copper, and pushes it between the open shears, then depressing the treadle, the nail in the tube is forced down by the piercer into its hole in the leather. At the instant that the nail falls into the leather, the shears close and cut off a new nail, which falls as formerly into a new hole which the operation has wrought beneath it. At every cut the sheet of copper is turned over, in order to form the nails alternately head and point. When all the nails have been inserted, they are beaten down with a hammer.

5. *Machine for punching the long nail holes, and inserting the long nails in the holes.* This machine is exactly like the punching machine already described, but it is furnished with additional apparatus to supply the nails and convey them into the holes. These additional parts are a circular brass wheel, nine inches in diameter, and nearly as thick as the nails are long. Great numbers of holes are perforated in it, and arranged closely in four circles, one within another. The central point within the four circles of holes has six radii like the spokes of a wheel, and in the very centre is a bolt, which fits loosely upon an upright centre pin, placed in the centre of a small circular table fixed laterally to the upper projecting arm which holds the upper end of the perpendicular slider. The wheel being fixed horizontally, about 18 inches above the table which holds the sole, has a nail put into every hole in its four circles. The holes are large enough to allow the nails to drop through them, but the points rest upon the circular table, at one part of the circumference of which an opening is cut through it, and a small tube descends from the opening to conduct a nail down to the point of the piercer. By the revolution of the wheel, the nails are brought successively over the mouth of the tube, so that each falls with its point downward into a small cell exactly beneath the point of the piercer when at its highest position. By depressing the piercer with the treadle, it forces the nail through the cell into the hole in the leather, brought beneath it in the form and manner formerly described. The construction of this cell deserves particular notice. It is conical inside, but when the nail which it grasps is to be forced down by the piercer, the cell opens in two halves, being formed by semiconical notches in two pieces of steel, which are held together only by being screwed together at one end. They are made so thin as to spring together to form the conical cell. While the piercer is ascending, another nail drops from the wheel through the tube into the space or open joint at which the two halves of the cell separate, so that the nail lies close beside the piercer. As soon as the piercer has risen out of the cell its two halves spring together, and the space containing the nail having its faces inclined inwards, these faces throw the nail into the cell, where it sticks till the piercer descends to drive it into the leather.

In order that the circular wheel may furnish a fresh nail after the preceding one has been inserted, the edge of the wheel has serrated teeth equal to the number of holes in each of the four circles. A detent tooth goes into these teeth by a hook, so that it will turn the wheel when moved in one direction, but slip over them when turned in the other direction. The detent tooth is jointed to a short lever fixed to the upper end of an upright axis, which, passing downwards through the projecting arms of the main columns, so as to be as near as possible to the perpendicular slider, and a short lever attached to this axis, is kept by a spring against a wedge fixed to the slider. When the slider, therefore, descends, its wedge forces away from it the end of the short lever. This movement is conveyed by the upright axis and upper lever to the detent tooth which slides over the inclined sides of the teeth of the wheel. When the slide reascends, the wedge permits the lever and detent tooth to return to the action of a spring; and a hook of the detent catching a tooth of the wheel turns it round through the space of one tooth or the distance between two nails. When the nails are all put in they are beat down with a hammer, so as to drive all their heads to a level with the surface, leaving the points projecting through the leather. The sole is then severed from the iron pattern, and put into the welting stand.

6. *The welting stand.* A small square cast iron table is fixed upon the top of a pedestal so as to turn round upon it; an iron frame is connected with the table by hinges on one side, so that it can be made to rise from it, or to lie flat upon it, and in this situation it may be fixed by a clamp. This frame has an opening in it nearly of the same shape as the sole of the shoe which is placed flat on the table, so that when the iron frame is brought down upon it and the clamp fixed, it encloses the sole as it were with an iron hoop or elevated border. The sole is now lying as it were at the bottom of a cell of iron, with the projecting points of the nails upwards. The welt is now applied by laying the strip of leather upon the edge of the sole, and binding it so as to follow the outline of the sole. Whenever any part of the welt is placed in its position, it is struck down upon the sole with a mallet, which draws it upon the points of the nails. When the welt is brought quite round the sole and heel, it is bevelled at its extremities, which thus form a joint without any increase of thickness. The welt and sole being well beat together, they are next carried to the cutting press, by which the edge of the sole and welt are cut precisely and exactly to the same size. Previous to this operation, the sole is confined between two iron patterns, made exactly of the size to which the sole is to be formed.

7. *The cutting press.* A horizontal spindle, like that of a turning lathe, passes through two standards rising from a horizontal plate. It goes through a collar in one standard, projecting some inches beyond it, and carries at its extremity a piece of wood with a flat surface, and of the same shape as the sole. The sole between the two iron plates is pressed against

this flat surface by a screw fitted into an iron standard rising from the same horizontal plate, and pressing by the intervention of a lever upon the iron plates opposite to the end of the spindle. By this pressure the spindle retreats in the direction of its length a small quantity: and in consequence of this, a flat circular plate, fixed upon the spindle like the pulley of a lathe, presses against a similar flat plate fixed to the frame, and unable to turn. The spindle becomes immoveable by the friction of these two surfaces, and the sole is kept firm in the press, while the workman with a drawing knife, worked by both hands, cuts the edge all round. After having pared the uppermost part of the edge, he releases the screw of the press, and the spindle, pressed forward by a spring, advances and separates the friction plates. The spindle with its sole being turned round, a fresh part of the edge is pared, and so on till the whole is finished. The edge of the sole thus cut is then ground smoothly on a rapidly revolving grindstone, and polished on a wooden wheel with a little bees wax spread upon it.

8. *The clamping machine.* The object of this machine is to close or rivet the shoe together. The upper leather being put upon a last, is fixed with its sole upwards about six inches above a small oval table, capable of turning round upon the column which supports it. The sole of the last is a solid piece of cast iron, but the lower part which receives the upper leather is of wood. The last is then fixed firmly on the table by two steady pins, and by a strong pin projecting downwards through the table, and confined by a wedge. To the oval table are attached a number of pieces of brass by hinges, which are so arranged round the last that they can be bound up against the upper leather, and form clamps, which, when they are all up, form a complete cell or box embracing the upper leather. Each clamp is forced into its situation by an independent screw, tapped obliquely through the edge of the table, and pressing up by its point the end of a small rod jointed to the clamp, near the part where it presses upon the leather. By releasing this screw, the clamp turns back on its hinge and falls back upon the table. The inner sole of the shoe being fastened to the sole of the last by two short pins, one in the sole and the other in the heel, the upper leathers are put on in their true position, and the last is fixed in its place in the middle of the clamping table. The clamps are now turned up, and the upper leathers drawn up all round with a pair of pincers, so as to fit them to the last; the clamps are screwed tight up. The edges of the upper leather are now turned over, and the operation is carried on as in common shoemaking till the sole is put on. The nail which fastens the inner sole to the last is now drawn out, the real sole is applied and put in its proper place by an iron frame or saddle. This frame, which is of thin iron, has its inside figure of the same size as the row of rivetting nails which project through the sole. It is made in two halves, united by a hinge at the heel part, and there are two holes at the toe in which a pin can be put to hold the frame together. This pin, and the joint pin of the hinge at the heel, projects far enough into a hole in each of the two clamps at the toe and heel, so as to guide the frame into its proper position.

When all the long nails are inserted in the soles by the machine already described, it is put into an iron box, and by a blow of the fly press it is made concave inside so as to fit the last. When taken from this mould, the inner frame is put together round the row of nails, the inside of the frame just receiving the projecting points of the nails so as to keep them perpendicular to the leather, and prevent them from spreading out. The sole being then applied by the guide pins of the frame, and the heads of the nails struck, their points penetrate through the turned in upper leather and the inner sole. When they are well entered, the iron frame is removed by opening it at its hinge, and the nails are driven down into their places. The nail points fall into a slight semicircular groove round the sole and the last, which turns their points all the same way. The last being taken out of the shoe, which is easily done from the heel of the last being made in a separate piece, the shoe is carried to the rivetting last, without a semicircular groove, upon which it is beaten, so as to rivet all fast, and smooth the sole inside. The heel is then put on in its place, and the long nails put through its holes by the nailing machine, and driven down in the same way as for the sole.

All the nail heads are now levelled with a rasp, the shoe is ground and polished up with a composition of bees wax and ivory black, the upper leathers being brushed with a circular brush, and the shoes made ready for sale, except those which require to be bound and lined.

The machine for cutting the long nails. The nails are cut from slips of sheet-iron, which is so cut, that when the nails are cut off from the end of the slips, the grain of the iron will be in the direction of the length of the nail.

In cutting the nails, the workman applies the iron with his hand, and draws the machine, by the action of his foot upon a treadle; the treadle drives a crank and heavy fly; from the crank there proceeds a rod to the longer end of a strong lever, whose axis is supported on pivots above the fly and the crank. A fixed cutter being attached to the frame, a steal cutter, which acts against it, is fixed at a small distance from the centre of the lever, and at the opposite side of the axis to the long lever. This cutter is sharpened on the lower side, and the fixed one on the upper side. As the lever rises and falls by the revolution of the crank, the edge of the moveable cutter is brought close to that of the fixed one without touching it. The slip of iron being admitted between the cutters, a small portion of the end of it hangs over the edge of the fixed cutter, and is cut off into a nail by the descent of the fixed cutter. On the ascent of the moveable cutter, the strip of iron is pushed forward, and another nail is cut. The nails are narrow at the end which is to be the point, but at the other end they are as broad as the thickness of the plate, so as to have a square figure. In the direction of the thickness of the plate, they are as broad at the point as at the head, so that the nail is a small wedge instead of a pyramid. For this purpose the cut across the slip of iron is not perpendicular to the length of the strip of iron, but a little inclined to it; and as the inclination of the cut is reversed at every successive cut, the head of one nail is cut from the same side as the point of the next. The thickness of the nail is regulated by the quantity by which the extremity of the slip of iron projects over the edge of the fixed cutter, and the angle of inclination may be made to vary by two stops, against which the end of the slip bears. This is effected by a part projecting from the lever beneath the edge of the moving cutter, and curved to the arc of a circle described from the axis. This slip is as far behind the edge of the cutter as the thickness of the nail intended to be cut off. The reversing of the cut is effected merely by turning the under side of the slip uppermost after every cut.

We have been induced to give this particular account of the shoe machinery, not merely from the ingenuity displayed in its construction, but from the probability of its being, with some modifications, more extensively employed in various branches of the useful arts. Several of the machines above described were executed by Mr. Henry Maudslay with that ingenuity and accuracy which characterise all his works.

SHOEING. See Veterinary Surgery.

SHOREHAM, New, a market and borough town of England, in the county of Sussex, is situated on the coast of the English channel, and about a mile west of the harbour on the river Adur. It consists chiefly of one street parallel to the river, which is crossed by long wooden bridge. The principal public buildings are the church, market-house, custom-house, and town-hall. The church, which has been lately repaired and beautified, is an interesting specimen of Norman architecture. As the nave to the west ol the tower had been destroyed, the east part only was formerly fitted up for divine service. It appears to have been built about the end of the twelfth century. There is much elegance, richness, and variety, in the architectural details within. The market-house, situated in the middle of the town, is supported by Doric columns. The harbour, which is a tide one, is not good. In spring-tides it has about 18 feet of water, about 12 in common tides, but only 3 at ebb tide. The town has nevertheless a custom-house, and ships of considerable burden come up to the town. Shipbuilding is the chief business carried on in the town; vessels of 700 tons have been launched here. The trade of the place is limited to a little coasting trade, and to the mackerel and herring fishery. The river is navigable for barges as high as Steyning, from which large quantities of timber are brought down for the dock-yards. The borough is governed by two constables annually elected. It sends two members to Parliament, elected by about 1300 voters, every forty-shilling freeholder within the rape of Bramber being entitled to vote. Population about 800. See the *Beauties of England and Wales*, vol. xiv.

SHORTSIGHTEDNESS. See Optics.

SHORT, James, a celebrated Scottish optician, was born at Edinburgh, on the 10th of June, in the year 1710. Having lost both his parents at the age of 10, he was received into Heriot's Hospital, where he exhibited his mechanical talents in constructing bookcases with a knife and the few tools which fell in his way. After remaining there two years, he went to the High School to receive a classical education; and in 1726, he entered the University, where, after following the usual course of instruction, he took the degree of M. A.

His friends were desirous that he should enter the church, and with this view he attended a course of theological lectures; but his passion for mathematics and mechanics withdrew him from his theological studies, and soon engrossed all his time and attention. Mr. Maclaurin, under whom young Short had studied mathematics, saw the bent of his mind, and encouraged him to prosecute his studies and mathematical pursuits as a profession. He accordingly began in 1732 to make reflecting telescopes, and the progress which he made will be best described in the following letter to Dr. Smith from Mr. Maclaurin, dated December 28, 1734.

"Mr. Short, an ingenious person, well versed in the theory and practice of making telescopes, has improved the reflecting ones so much, that I am fully satisfied he has far outdone what has yet been executed in this kind.

He has not only succeeded in giving so true a figure to his speculums of glass quicksilvered behind, as to make the image from them perfectly distinct, but has made telescopes with metal speculums, which far surpass those I have seen of any other workman.

He has made six reflecting telescopes with glass speculums, three of 15 inches focal distance. and three of 9 inches. One of the first is at present in my Lord Islay's hands, with which it is easy to read in the Philosophical Transactions, at the distance of 230 feet. Another of them is in the hands of Mr. *Alexander Bayne*, our professor of Law, with which he easily reads the Philosophical Transactions at the distance of 280 feet. I made some trials with one of the speculums of nine inches, and can read with it very easily in the Philosophical Transactions at the distance of 138 feet; but at that time had not an opportunity to try it at a greater distance. At another time I read with it a much smaller print cross the street, at the distance of 125 feet. It cost him a great deal of trouble to make these of a true figure, and with parallel surfaces, and several, when finished, were found useless by reason of veins that then appeared in the glass.

In the glass speculums every thing else was very well, only the light was somewhat faint compared with that reflected from his metal speculums. This I take to have been owing to the speculums not having been well quicksilvered, and partly to the thickness of the glass. For one of them, I observed, had a brighter reflection, when fluid quicksilver was applied to its back surface than after it was foiled.

After he found the light in these glass speculums fainter than he expected, and also because of the great difficulties in finishing them, he applied himself to improve the telescopes with metal speculums. By taking care of the figure, he finds himself able to give them larger apertures than other workmen do; and, by adjusting the speculums and the whole instrument, he has much improved it.

He executes every part himself, and takes vast pains to make the instruments as perfect as possible, and has made them of focal distances of two inches and six-tenths, of four inches, of six inches, of nine inches, and of fifteen inches. He perforates the large speculums, and uses a concave little speculum.

By those of four inches focal distance he saw the satellites of Jupiter very well, and read in the Philosophical Transactions at above 125 feet distance. By those of six inches focal distance he read at 160 feet distance. By those of nine inches focal distance he read at 220 feet distance. By those of fifteen inches, he and Mr. Bayne have read in the Transactions at 500 feet distance, and have several times seen the five satellities of Saturn together, particularly on the 24th of November and the 7th of December last; which very much surprised me, till I found that Mr. Cassini had sometimes seen them all with a seventeen foot refracting telescope.

I have compared some of these with such as have been brought from *London*, and find one of Mr. Short's, of six inches focal distance, compared with one of the best I have seen from London, of nine inches and three-tenths focal distance, to exceed it in brightness, distinctness, and magnifying power; and when I called an indifferent person, who knew not who had made the instrument, to give his opinion, he very readily preferred that of six inches focal distance. It also manifestly exceeded another I had from London, of eleven inches and a half focal distance. The same was the result of some other comparisons.

Upon the whole, I am convinced he has much improved this excellent invention, and that his instruments are by far the best of their lengths that have yet been executed."

In 1736 Mr. Short was invited to London by Queen Caroline to give mathematical instructions to William Duke of Cumberland, and he was soon after elected a Fellow of the Royal Society, to whose Transactions he contributed several valuable papers. In 1739 he accompanied the Earl of Morton to the Orkney Islands where he was employed in a geographical survey of that part of Scotland.

Upon his return to London, Mr. Short established himself as an optician, and in 1742, he was employed by Lord Thomas Spencer to make for him a reflector of 12 feet focal length, for which he received 600 guineas. He soon executed several other instruments with different improvements, and in 1752, he completed one for the king of Spain, which cost £1200. Mr. Short paid two or three visits to Scotland, the last of which was in 1766. After a short illness, he died of a mortification of his bowels, at Newington Butts, near London, on the 15th June, 1768, in the fifty-eighth year of his age. He left a fortune of about £20,000, about £15,000 of which was bequeathed to two nephews, and the rest in legacies. To Lady Mary Douglas, the daughter of his patron, the Earl of Morton, he left £1000, and the reversion of his fortune, if his nephews died without issue; but this lady, at the desire of her father, relinquished the reversion by a deed in favour of Mr. Short's brother, Mr. Thomas Short, and his children.

SHOVEL, Sir Cloudsley, a celebrated British naval officer, was born about the year 1650, of humble parents. Having been for some time apprenticed to a shoemaker, he took a dislike to his profession, and went to sea as a cabin boy under the patronage of Sir John Narborough. By his talents and industry he became an able seaman; he obtained promotion through the interest of Sir Christopher Myngs. Having distinguished himself under Sir John Narborough, in burning the ships of the Dey of Tripoli in 1672,—an enterprise with which he was intrusted,—he was soon after appointed to the Sapphire, a fifth rate, and subsequently to the James galley, a fourth rate, in which he continued till the death of Charles II.

At the time of the revolution, Captain Shovel commanded the Dover, a fourth rate. At the battle of Bantry bay, where he commanded the Edgar, he distinguished himself so much, that King William conferred upon him the honour of knighthood. In 1690, he was employed to convey the king and his army to Ireland, and he was on that occasion appointed rear-admiral of the blue, and his commission delivered to him by the king himself. In 1691, he accompanied the king to Holland; and in 1692, he was made rear-admiral of the red, and a second time attended his sovereign to Holland. Upon his return he joined rear-admiral Russel with the grand fleet, and shared in the glory of the battle of La Hogue. In the expedition to Camaret bay under Lord Berkeley in 1694, he embarked the forces with great skill in that unlucky expedition. In the same year he bombarded Dieppe, Dunkirk, and other places on the French coast. In 1702, he went to Riga to bring home the spoils of the French and Spanish fleet.

In 1703 he had the command of the grand fleet in the Mediterranean, and exerted himself in aiding the Protestants who were in arms in the Cevennes. Owing to the great share which he had in the victory of the 13th April, 1708, he was in January 1709 appointed rear-admiral of the fleet of England, and in the same year he commanded, along with the earls of Peterborough and Monmouth, the fleet which was sent to the Mediterranean. After aiding in the reduction of Barcelona, he made an unsuccessful attempt upon Toulon, and sailed for Gibraltar, where he left a sufficient force for the defence of the coast of Italy. From Gibraltar he set sail for England with ten ships of the line, five frigates, four fire ships, a sloop, and a yacht. On the 22d October, 1707, he came to soundings, and next morning he had ninety fathoms water. About noon he lay by, but about six P. M. believing he saw the light on St. Agnes, one of the Scilly Islands, he set sail again. Soon afterwards several of his ships made signals of distress. The Royal Anne, with Sir George Byng, with difficulty saved herself. Several others encountered the most imminent perils, but the admiral's ship and some others perished with all on board. The body of Sir Cloudsley Shovel was cast ashore next day on the island of Scilly. The fishermen stripped and buried it, and took an enamelled ring from his finger, which proved the means of discovering the body of the gallant admiral. It was accordingly disinterred, and deposited with great solemnity in Westminster Abbey, where a magnificent monument of white marble was erected to his memory, by order of Queen Anne. The fate of this distinguished man, however, who was cut off in the fifty-seventh year of his age, was lamented by the whole nation. See Campbell's *Lives of the Admirals*.

SHREWSBURY, a borough and market town of England, in Shropshire, is situated on two gentle eminences, which are surrounded on all sides but the north by the river Severn. At this open part of the peninsula, a junction is formed on the north-east with the Shrewsbury Canal, and on the north west with the Ellesmere Canal. On the north and west sides, the streets approach close to the river, but in other points a strip of meadow or garden ground separates the houses from the river. An uninterrupted range of well-built houses, commanding beautiful and extensive views, encircles the town, and on the western side is a noble field of twenty acres, called the Quarry, ornamented with columns of trees. The interior appearance of the town is of a different character. The streets are ill arranged, and are in general narrow, steep, and badly paved. The eaves of the old houses project so as almost to meet those on the opposite side; and the mixture of ancient and modern buildings produces a disagreeable effect.

The principal public buildings are the castle, the town-hall, the five churches, the town and county gaol and bridewell, the market house, the theatres, the bridges, and charitable institutions.

The castle occupies a neck of land about 500 yards broad. The buildings which remain, are the keep, the walls of the inner court, and the great arch of the interior gateway. The keep is now a handsome dwelling house, composed of two round towers embattled and pierced, and connected by a square building about 100 feet long and 100 feet high; the inner court is now a garden, and the arch of the gateway is eighteen feet high. A few traces of the ramparts and walls which defended the town on its north and east sides still remain.

The *town-hall* is a modern building, completed in 1786. It has a handsome stone front. In the grand jury room are portraits of George I. and II., and Admiral Benbow; and in another room is a valuable collection of books.

The *churches* on the establishment, are St. Giles', St. Chad's, St. Mary's, St. Alkmund's, and St. Julian's. St. Giles, consisting of a noble chancel and north aisle, seems to have been partly built in the Norman era. St. Chad's church, built in 1791 of freestone, is, generally speaking, a splendid and well-ornamented structure; the body of it is externally a circle 100 feet in diameter. St. Mary's church, in the north-east part of the town, is a large venerable building, in the form of a cross, with a nave, side aisles, transept, choir and chapels, and with a tower at the west end. At the extremity of the chancel is a spacious window, nearly filled with stained glass. From the ruins of old St. Chad's church near the town, which is very large, and seventy-four feet in height, there rises a lofty and beautiful spire, which is a great ornament to the town. The height of the tower and the spire is 212 feet. The monuments in the church are numerous and some of them curious. St. Alkmund's church is built on the site of the old one taken down in 1793. It is an unseemly imitation of the ancient pointed architecture. The church of St. Julian is a plain and commodious edifice, rebuilt in 1750. The places of worship for dissenters are a Roman Catholic chapel, and meeting houses for Presbyterians; Unitarians, Baptists, Methodists, and Quakers.

The *Town and County Gaol and Bridewell* form an edifice beautifully situated near the castle. It has a good freestone front, with an arched gateway, containing a bust of Howard by Bacon. It is a spacious, airy, and commodious building.

The *Market-house*, remarkable for its size and magnificence, was erected in 1595. In the principal front, which is towards the west, the portal is decorated with two Elizabeth's arms in high relief; and on each side of it is an open arcade of three large circular arches supported by columns. Large open arches likewise decorate the north and south sides, and over one of them is a statue of Richard, Duke of York. Close to this building is a conduit, which supplies with water a great part of the town.

The Market Cross was a massy building of brick and stone, having a reservoir over it. It was taken down in 1819. The reservoir was removed farther back, and a handsome new market house built by subscription.

The *Theatre* is supposed to be part of the palace which formerly belonged to the later princes of Powis. It is fitted up with tolerable neatness.

The *two bridges* over the Severn are called the Welsh Bridge and the English or East Bridge. The former consists of 5 handsome arches, and is 226 feet long, 20 feet high, and 30 feet broad. A quay faced with stone, and with warehouses, adjoins to the bridge. The English Bridge, built of fine freestone, consists of 7 semicircular arches. It is 400 feet long. The middle arch is 60 feet span and 40 high, and the rest 35 feet span and 20 feet high. The width between the balustrades is 25 feet, and the ornaments are light and graceful.

The principal charitable establishments are a small hospital dedicated to St. Giles, Millington's Hospital, several alms houses, an infirmary, a house of industry, a free grammar school, and several charity schools.

The *Infirmary*, opened in 1747, is a plain but respectable brick building, with a stone portico in front and stone corners. It is in a healthy situation, and its internal arrangements are on the most approved footing. It is supported by voluntary subscription. The House of Industry, opened in 1784, maintains about 275 persons. The school-house and the free grammar school is a large and lofty building, forming two sides of a square court. In consequence of this institution having declined, an act of Parliament was passed in 1798, vesting its management in the Bishop of Lichfield and Coventry as visiters, and in 13 trustees, of whom the mayor is one. These trustees elect two schoolmasters, one of whom is superior to the other. The other public schools are Bowdler's Charity, founded in 1724, for educating and clothing poor children; Allart's Charity School, founded in 1798; and a Subscription Charity School, founded in 1708, for instructing poor children.

A few inconsiderable remains of the Abbey of St. Peter and St. Paul still exist in the suburb called the Abbey Foregate. The ground which it occupied is in a great measure converted into a garden. Among the remains is a small octagonal stone building generally called the Stone Pulpit, which is overhung with ivy, and much admired. The abbey was a spacious and magnificent building. The only existing part of it is the nave, which is now used as a Romish church under the name of the Holy Cross. The beauty of its original structure may still be traced in many parts. Among other ancient private structures in the town is one called the Council House, which was once the residence of the Court of the Marches of Wales.

Shrewsbury is governed by a mayor, a warden, steward, town clerk, an alderman, 48 assistants or common councilmen, and other officers. There are in the town 16 chartered companies. Shrewsbury sends to Parliament 2 members, who are elected by the inhabiting burgesses.

The principal manufactures carried on in the town are two of linen yarn, an extensive iron foundry, and a porter brewery. Shrewsbury carries on a considerable trade principally with Wales; and about 20 vessels are employed on the Severn between Gloucester, Shrewsbury, and Bristol. Flannels were formerly the staple articles, and Welsh webs, which were a coarse kind of woollen cloth made in Montgomeryshire. They were dressed in Shrewsbury for importation to Holland, Germany, North and South America, and the West Indies. These webs are now bought up in the counties where they are made.

At the entrance to Shrewsbury by the London road there has been erected a magnificent column of freestone, with appropriate inscriptions, to commemorate the gallant achievements of Lord Hill, a native of the county. It was completed in 1816 at the expense of above £6000, which was defrayed by subscriptions in the town and county. Population in 1821, 21,695. See *the Beauties of England and Wales*, vol. xiii, and *Some Account of the Ancient and Present State of Shrewsbury*, 1808, and Philip's *History and Antiquities of Shrewsbury*.

SHROPSHIRE, or SALOP, one of the midland counties of England, is bounded on the south by the counties of Worcester and Hereford, on the east by that of Stafford, on the north by Cheshire, a detached part of Flintshire and Derbyshire, and on the west by Derbyshire, Radnorshire, and Montgomeryshire. Its shape approaches to that of an oval, and it is about 44 miles long from north to south, 28 broad from east to west, and 134 in circumference. It contains 1341 square miles, or 854,240 statute acres, and about 140 inhabitants to each square mile. This county is divided into fifteen hundreds, which are again subdivided into 229 parishes. It contains 262 churches, of which there are 114 in the diocese of Lichfield and Coventry, 127 in that of Hereford, 12 in that of St. Asaph, 3 in that of Worcester, and 6 in the peculiar jurisdiction of Bridgenorth. Shropshire contains 16 market towns, and sends 12 members to Parliament.

This county presents a very diversified aspect; on the eastern side the surface is partly undulating and tolerably well wooded, exhibiting in many places fertile and well cultivated districts, enclosed with good hedges. On the western side it exhibits the bold and lofty character of Welsh scenery.

The principal mountain elevations are the Brown Clee Hill, 1805 feet high, and the Titterston Clee Hill in the southern part of the county, both of which are surrounded with much picturesque scenery. The Wrekin is a singular insulated mountain of a sugar loaf form, rising from a plain to the height of 1324 feet. From it there proceeds northward, across the Severn, a range of trap mountains, consisting of the hills of Acton, Burnes, Frodesley, the Lawley, Caer Caradoc, and Hope Bowdler hill. These mountains are separated by a valley from a singular mass of hills, called the Lionmynd, 1674 feet high. A high rocky track rises between the road from Shrewsbury to Bishop's Castle and the vale of Montgomery, and in the most elevated peak of it, called the Stiperstones, are situated the lead mines.

The principal river in Shropshire is the Severn, which runs through the county from north-west to south-east, and nearly divides it into two parts. It enters the county from Montgomeryshire at its confluence with the Vyrnwy, and running eastward to Shrewsbury it bends towards the south, and passing by Wroxeter, Madely, and Bridgenorth, it leaves the county near Bewdley on the borders of Staffordshire and Worcestershire. It flows about 70 miles within the county, in every part of which it is navigable at all seasons except the height of summer, for barges, trams, wherries, and boats. In this navigation men are employed instead of horses to draw the barges against the stream. Salmon, pike, flounders, grayling, and eels, are found in the Severn while it flows through Shropshire. The principal streams tributary to the Severn are the Camlet, the Vyrnwy, the Pery, the Meole brook or Rea, the Tern, the Cund brook, the Warf, the Mor brook, the Bore brook, and Dowles brook. The other rivers in the county are the Terne, the Shell-brook, the Elf-brook, the Weaver, the Clun, the Morles, the Ony, and the Corve.

The lakes in Shropshire, though numerous, are not of great extent. The largest is that of Ellesmere, which contains about 116 acres; that of Marton Pool contains 45 acres; and at Shrawardine is a fine lake of 40 acres. The other lakes are Fennymere, Lyncly's-pool, and Ancot. There are many canals and several iron bridges in this county, but we have already given a full account of them in our articles BRIDGE, and NAVIGATION INLAND.

The climate of Shropshire varies with the elevation. On the eastern side, where the land is warm and flat, harvest often begins a fortnight earlier than in the middle of the county, and hay and grain are both gathered earlier there than in the western side. The easterly winds prevail in spring, and the westerly ones in autumn. The former are the most regular, while the latter blow for five or six months strong and frequent, the other for nearly the same length of time with less violence. The cold of winter is felt very intensely on the hills in the western part of the county.

The soil in the eastern side of the county is generally of a sandy nature. For the most part it is more tenacious, and there is often a stiff but rich clay in the bottom of the wider vallies. In the most western parts the soil is very shallow, resting principally upon rocks of different kinds, and is more or less used for pasturing sheep than for raising grain. The rapid progress of improvement in enclosing and draining has greatly diminished the moor lands. A very great part of the soil of the county rests upon a limestone subsoil.

The operations of agriculture are better conducted in Shropshire than in many other counties in England. The farms are commonly large. They are, in some instances, held on leases for life—in others, on leases of seven, ten, and twenty-one years, and in many cases from year to year. The crops commonly cultivated are wheat, barley, oats, pease, turnips, and potatoes. Hops, hemp, flax, and cabbages are raised only in small quantities. The growth of hay, and the improvement of pasture land, have been more overlooked than any other branch of rural economy. On the banks of the Severn, however, and on the margin of several of the lesser streams, there are many excellent tracts of meadow land, which are enriched solely by the deposits of the rivers when in flood. Almost all the cultivated lands in Shropshire are enclosed. The principal commons that remain are that of Morf, near Bridgenorth, about five miles long, and three broad, and the high lands between Church Stretton and Bishop's Castle, and from Clun to the borders of Radnorshire. There are several large mosses in the county. The principal herd of sheep is the Southdowns, but there are many of the New Leicesters, and several of the fine-woolled Welsh sheep in the hilly districts. In the neighbourhood of the Wrekin of Bridgenorth and of Clun, the wool is considered to be equal in quality to that of Leicester.

Shropshire has been long distinguished for its mineral productions, and the trades and manufactures to which these have been subservient. The principal of these are coal, iron, lead, limestone, freestone, petroleum, and pipe-clay. Good *coal* is found in abundance in different parts of the county. The most important coal field, however, occupies a district near Colebrookdale, about eight miles long and two broad. The coal is here found at various depths, alternately with ironstone, sandstone, and other rocks. The strata slope to the east in Madeley parish, and to the north and north-east near Wellington and Lilleshall. A long broad range of sandstone bounds the coal district on the east, commencing north of Shiffnall, and following the line of the Severn till it leaves the county. On the south and west it is bounded by limestone, and the basalt of the Wrekin. The southern part of the coal district, and indeed nearly the whole of it, is considerably elevated above the plain of Shropshire, so that at one part the height is 500 feet above the Severn. Near the north-west boundary of the county is another bed of coal, which is wrought to a considerable extent, and is employed in the lime works of Chirk and Llanymyneck. On the west this coal field is bounded by, and lies above an irregular bed of limestone, which in some places scarcely appears above the surface, and in others rises to a height of 500 feet. On the east the coal field is bounded by a ridge of sandstone, stretching from Ellesmere along the Perry, crossing the Severn, and ending at Bicton and Onslow. Another coal district in the south of the county, particularly on the Brown Clee and Titterson Clee Hills, consists of various detached beds or hollows, in which the strata has the form of a cup. In the first of these hills the strata are so thin that they are wrought only by poor colliers: but in Titterson the chief stratum is six feet thick, and there are here six coal fields, the principal of which is the Cornbrook, the Newbury, and the Hillwork coal fields. The first is a mile long, and half a mile broad.

The *ironstone* occurs in the neighbourhood of the coal, and frequently close to it. It is not rich, but being found along with coal and lime, the fuel and the flux, it has rendered Colebrookdale the seat of the most extensive iron works in the kingdom.

Lead is procured in considerable quantities from various parts of the Stiperstones, but particularly from the Hope and Snailbeach mines. Its matrix is crystallized quartz, sulphate and carbonate of barytes, and carbonate of lime. It occurs in the form of sulphuret of lead, and the carbonate. It is reduced at Minsterley and other places near the mines, and is sent by land to Shrewsbury, where it is shipped for Bristol in the Severn barges.

Limestone is quarried in various places, but particularly at Lilleshall, Porth-y-wain, and Llanymynech, and likewise in the parishes of Cardiston and Alderbury. The limestone in the south forms the northern extremity of a long range, which joins Wenlock, in a south-west direction, to Hope Bowdler Hill, near Church Stretton, and thence in a southerly direction to the neighbourhood of Ludlow. In many parts of the irregular band of limestone, mentioned in the paragraphs on coal, especially near Oswestry, the limestone is in the state of perfect marble, and there have been found in it small quantities both of lead and copper.

The *sandstone*, which is found so extensively in Shropshire, is chiefly red; but in some places it is found white, particularly at Grinshill, where it has been quarried to a great extent, for the churches, bridges, and other public edifices in Shrewsbury.

In the coal field of Colebrookdale there is a spring of petroleum, which formerly yielded a great quantity of this mineral tar. It also exudes from a red sandstone at Pitchford, about seven miles south-east of Shrewsbury. From this rock has been extracted an oil known by the name of Betton's British oil. A quartz and clay have been found in the lordship of Cadington, the first of which is said to be superior to that imported from Caermarthenshire for the potteries of Staffordshire. Copper and blende, which yields calamine, is also found in the Stipertones, but neither of them have been wrought with any success. There is a brine spring in the same district with the Pitchford rock.

The principal seat of the manufactures of Shropshire is Colebrookdale, "which," says Authur Young, "is a winding glen between two enormous hills, which break into various forms, being all thickly covered, and forming most beautiful sheets of hanging woods. The noise of the forges, mills, furnaces, &c. with all their vast machinery; the flames bursting from the furnaces, with the burning coal and smoke of the limekilns, are altogether horribly sublime." Iron works exist also at Ketley and Oakengates. Besides the process of separating the iron from its ore, and bringing it into the state of bar and pig iron, iron goods of various kinds are manufactured. All the iron bridges in the county, the iron work of Pontcysylte aqueduct, which is all of iron, except the piers, and many of the iron bridges erected in other parts of the kingdom, have been made in Shropshire. At Coalport, coloured china of all kinds, and likewise Queen's or Wedgewood ware, is manufactured. At Caughley there is an excellent china manufacture; and at Brosely, garden-pots, tobacco, paper, and coarse articles of earthen-ware are made. Considerable potteries have been established in the district of Colebrookdale, particularly one for ironstone china, which has greatly lowered the price of that article. A work is also carried on here for obtaining coal tar from the condensed smoke of the coal. Cotton manufactories have been established at Coleham and other places, which rival the largest in Lancashire. Many branches of the linen trade have been carried on in the northern part of the county, and some of the coarser kinds of woollens have been manufactured in different districts, and several mills have been established for dyeing woollen cloths.

The trade of Shropshire has been greatly benefited by the canals which have been carried on to a great extent, and of which a very minute account will be found in our article Navigation Inland. The navigation of the Severn yet requires much improvement. Pathways have for some time been constructing along its banks, in order that horses may be employed in place of men in towing the barges up the river.

At the time of the Roman invasion, during the reign of Claudius, Shropshire was inhabited by the Ordovices and Cornavii. It was afterwards part of the province of Flavia Cæsariensis. The principal Roman stations were Uriconium, now Wroxeter, Mediolanum, near Drayton, and Rutunium, near Wer. Watling Street enters the county on the east between Cracklay bank and Weston, and passes through it in a bending line to Leintwardine, in Herefordshire. Some of the principal remains of ancient architecture are Haugmond Abbey; the walls of Wroxeter, which are of Roman and British construction; the abbey of Buildwas; the monastery of Wenlock; Ludlow Castle, the residence of the Sidneys and the place where some of Milton's works were composed; Wannington Castle; Lilleshall Abbey, remarkable for some highly ornamented Norman arches; and Roscabel House, with the oak which sheltered Charles II. after the battle of Worcester. The most remarkable encampments are the Roman camp, called the Walls at Quatford, and those of Buryditches, Purslow, Basford Gate, and Hawkstone.

The estates are here of various sizes. A few noblemen and gentlemen possess estates from 10,000 to 25,000 acres. The number of freeholders entitled to vote for the two members sent from the county amount to 5000, and the total rental, including tythes, is about £900,000.

The following are the principal residences in the county. Wolcat Hall, Earl Powis; Hardwicke, Lord Hill; Rosshall and Welley Park, Lord Forrester; Apiey Park, Thomas Whitmore, M. P.; Dudmaston, William Whitmore, M. P.; Pitchford, Hon. Mr. Jenkinson, M. P.; Hodnett, Reginald Heber, M. P.; Hawkstone, Sir R. Hill, Bart. M. P.; Kinlett Hall, W. C. Childe, Esq. M. P.; Stanley Hall, Sir T. Tyrwhitt Jones, Bart.; Allingham, Lord Berwick; Manor House, Sir G. Jernyingham, Bart.; Pradoe, Hon. T. Kenyon; Pentrapent Hall, Hon. F. West; Orlaton Hall, W. Cludd, Esq.; Downton Castle, R. Payne Knight, Esq.; Oakley Park, Hon. Robert Clive; Plowden Hall, Edward Plowden, Esq.; Audlem, Lady Cotton.

The following is the population of the county and principal towns in 1821:

	Members of Parliament.		Population.
Shropshire,	two		206,153
		Males	102,056
		Females,	104,079
		Families	41,636
		Do. in trade,	17,485
		Do. in agriculture,	18,414
		Inhabited houses,	38,663
Shrewsbury,	two		21,695
Wenlock	two		17,265
Wellington,			8,390
Hales Owen,			8,187
Ellismore,			6,056
Ludlow,	two		4,820
Bridgenorth,	two		4,365
Oswestry,			3,910
Newport,			2,313
Bishop's Castle,	two		1,880

See the *Beauties of England and Wales*, vol. xiii. Archdeacon Plymley's *General View of the Agriculture of Shropshire*, 1803. See also our articles BRIDGE, NAVIGATION INLAND, and RAILWAY. See also ELLESMERE, and BRIDGENORTH.

SHRUBS, See HORTICULTURE.

SHUS, See KHUZISTAN.

SHUSTER, the principal district of KHUZISTAN, already described in that article.

SHUSTER, a city of Persia, and capital of the province of Khuzistan. It is situated at the foot of the Backtiari range of mountains, and on an eminence which commands a view of the rapid course of the Karoon, which is here crossed by a bridge, of an arch 80 feet high. The Persians are said to throw themselves with impunity from the summit of this bridge into the river. The river defends the town on the west, and on the east a decayed old wall performs this function: the streets are narrow and dirty, but the houses are principally built of stone, and many of them are good. The castle is situated on a small hill to the west of the town. It is defended on two sides by a ditch almost filled up with sand, and on the other two sides by a branch of the Karoon. It has one gateway, which was formerly entered by a drawbridge. The hill on which it stands is almost wholly excavated, and formed into subterraneous aqueducts, through which the water still continues to flow. In the vicinity of the castle, is the dyke which Sapor built across the Karoon, in order to irrigate the adjacent lands.

It consists of hewn stone, bound together with clamps of iron, and is about 20 feet broad, and 400 yards long, with two small arches in the middle. Mahomet Ali Meerza, governor of Kermanshaw, has lately rebuilt it, with great advantage to the country. The artificial canal of water, obtained by means of the dyke, falls, after a long winding course, into the Dezphoul, near Bundekeel. There is near the canal, a bridge built of hewn stone, consisting of 32 arches, of which 28 are entire. There is in this city a considerable manufacture of woollen stuffs, which are sent to Bassirah, and there exchanged for Indian goods. This city is resorted to by invalids for its salubrity. In summer, the heats are so excessive from 9 A. M. till 9 P. M. that the inhabitants spend the day in subterraneous apartments, and pass the night on the flat roofs of their houses. The population, which amounts to 15,000, is composed of Arabians and Persians. East Long. 48° 59′ North Lat. 32°. See Macdonald Kinneir's *Memoir of the Persian Empire*, p. 97.

SHWANPAN is the name of a Chinese instrument, for assisting them in their computations. It is a variety of the Abacus (See ABACUS.) and consists of several series of beads strung on brass wires, and extended from the top to the bottom of the instrument, and divided in the middle by a cross piece going from one side to the other. In the upper row, each string has two beads, each of which counts five, and in the lower row, each string has five beads, the *first* being reckoned 1, the *second* 10, and the *third* 100, &c. The Chinese Shwanpan differs from that of the Roman, in having strings and beads in place of pins and sliding grooves. Instead of four pins for units as the Roman had, the Chinese have five beads, so that the Chinese instrument seems intended for the decimal, whereas that of the Roman was suited to the duodecimal scale. Mr. Smethurst has described a new Shwanpan, formed "on the plan of our nine numbers, that in no case falls short of the Chinese Shwanpan, but in many excels it." See *Phil. Trans.* 1749, vol. xlvi. p. 2. See also some observations by Dr. Hooke on the Shwanpan in the *Phil. Trans.* 1686, vol. xvi. p. 63.

SIAM, a kingdom of Asia, situated beyond the Ganges, and bounded on the west by the Birman Empire, on the south by the Gulf of Siam, on the east by Cambodia and Cochin China, and on the north by portions of China and Tartary. This kingdom consists properly of the wide valley of the Menam, (a large river which flows from Thibet,) lying between two ranges of mountains; but it comprehends also an extensive territory, including almost the whole peninsula of Malacca, and comprehending the following states, beginning from the North at Bankok:*

Rachpuri,	Ligor,
Puchpuri,	Dalonny,
Chimpohim,	Singoora,
Chaiya,	Kingdom of Queda,
Salang,	Kingdom of Perah.

The province of Tenasserim, lying to the east of the three first of the above states, has been wrested from the Siamese. As this territory has been already described under the article Malacca, we shall at present consider Siam in reference only to the valley of the Menam, and the province of Chantibond, which recently was joined to Siam. A great part of this kingdom consists of mountains, at the base of which are extensive and unproductive swamps and jungles. The agriculture of Siam is limited to the production of rice and sugar, which are raised on the grounds bordering on the river Menam; and as these are inundated during part of the year, the crops are abundant; though what is raised on dry soil is preferred.

The sugar cane has been introduced into Siam within the last *twenty* years. The culture of it is managed solely by the Chinese, and it is supposed that it may be carried to an almost unlimited extent. The annual produce in 1821, was about 30,000 peculs, or nearly 1788 tons. The other productions of Siam are pepper, the annual produce of which, in Chantibond, is 20,000 peculs, 133 lbs. each, benzoin, tea, ivory, aguila wood, rhinoceros' horns, hides of cows, buffalos, and deer, gamboge, cardamoms, &c. Most of these articles are obtained most abundantly from Chantibond, where precious stones and gold, &c. are also found.

The principal fruits are the durio, the mangosteen, pine apple, tamarind, banana, areka, betel, cocoa nut, from the last of which they obtain milk, oil, and pitch which makes good torches.

Among the animals of Siam, the elephant holds the principal place. The hunting of them is a royal monopoly. The finest are kept for the king's use, and the rest exported. A white elephant is reckoned beyond all value; and in the time of the French embassy, there was one which was served by 100 attendants. It was lodged in a gilded stable, and drank out of a trough of massy gold. In 1822, there were five of these in the king's possession. These animals are, in short, albinos, and their eye was natural and sound, though the iris was pure white. In one or two of them, the colour was strictly white; and in all of them the iris was of that colour, and the margin of the eyelids; but in the rest, the colour had a cast of pink in it. In none did the colour and texture of the skin appear entirely healthy. They were small, but in excellent condition; and one of them, which was handsome, was treated with great attention. Fresh cut grass was placed in abundance before them, and they were fed with sliced sugar cane, and branches of plantains. They stood on a small boarded platform kept clean; and a white cloth was spread before them. Mr. Finlayson describes another elephant covered with black spots the size of a pea, on a white base. The discoverer of a white elephant is rewarded with a crown of silver, and with a grant of land equal in extent to the space of country over which the elephant's cry may be heard. He and his family are freed from all sorts of servitude, and their land from taxation, to the third generation. The other animals are tigers, rhinoceroses, leopards, white monkeys, tortoises, hedge-hogs. Domestic animals are few, and little esteemed, excepting the hogs, the flesh of which is superior to that of Europe.

Commerce is in a very singular state in Siam. The king and his ministers are the sole merchants, holding the monopoly of all articles of importance. Great encouragement is given to the Chinese traders, who have sown the seeds of commercial enterprise in Siam. All the Siamese are totally ignorant of maritime science; the king employs native Christians, Arabs, and other Mahommedans, to navigate his vessels. He, nevertheless, sends every year to China ten or twelve junks, of moderate size, laden with sugar, pepper, japan, and iron wood. He is, however, anxious to establish commercial relations with Europe; but the regulations are so illiberal, as to disgust the fair trader. The introduction of opium has been long, and is still strictly prohibited.

The principal towns in Siam are Bankok, the capital or the residence of the king, Siam, Juthea, or Odia, formerly the capital, and situated on the Menam, Loub and Porselone on the Menan, and several others along the west shores of the Gulf of Siam. Bankok contains many splendid temples, including the Prachadi, of a spiral form, probably the sepulchral monument of Buddha. The palace is situated on an island two or three miles long, and it and the whole island is surrounded by high walls, and bastions, and numerous gates. The persons attached to the court reside here in wretched huts, made of palm leaves. The greater part of the space which the wall encloses, consists of waste ground, swamps, and fruit gardens. The city, which is continuous with the palace, extends on both sides of the river Menam, to the distance of three or four miles. It is built entirely of wood; the palaces, temples, &c. having brick or mud walls. The houses rarely extend more than one or two miles from the river, *and by far the greater number of them float on bamboo rafts*, secured close to the bank. The houses not thus floated, are built on posts driven into the mud. Every house has a boat. The principal shops are in the floating houses. The Chinese appear to exceed the natives in number. The floating houses consist of one floor, and have a very neat appearance, being thatched with palm leaves, and sometimes with tiles. They are divided into several apartments, the centre

* This information is taken from a sketch of the Siamese States between Bankok and Queda, surveyed in 1825, and sent to us by a correspondent in India. According to Hanel, Siam and Malacca contain about 143,000 square miles.

one of which is allotted for the household goods. The principal traders are the tinsmith, blacksmith, and currier. Tin vessels are made to a great extent. The preparation of leather for covering mattresses and pillows, and for exportation to China, is very extensive. The skins chiefly used are those of the deer, ox, and buffalo. The skins of leopards and tigers, with the fur on, are exported to China. There are one or two manufactories of shallow cast iron pots, conducted by Chinese. In 1827, two dreadful fires destroyed above 1500 houses in Bankok.

Juthea, the old capital, stands on the Menam, about 40 miles above Bankok. It is surrounded with a turreted brick wall. The town is intersected with several large canals; the streets run along them, that the ships may land their goods at the principal houses. Most of the streets are narrow and dirty. The larger bridges over the canal are of stone, and the smaller of wood. There are three palaces in the city, the chief of which is of Chinese architecture. The suburbs are numerous; some of them consist of floating houses, and of houses fixed in the water on posts, as at Bankok.

The government of Siam is perfectly despotic. In cases where the interests of the king and his minions are not immediately concerned, the laws are often equitable and severely just; but the judges are corrupt.

The revenue of Siam is considerable. The land-tax is paid chiefly in kind. The privilege of fishing and distilling arrack produces a considerable sum. The most important fruit trees are taxed, and the tax is said to yield 7000 catties of silver. Gambling houses are also taxed.

The inhabitants seem to be of Mongol descent. Their average height is five feet three inches. Their complexion is yellow. Their face is very broad and flat, their hair is always black, and they have a tendency to obesity. They have the frame without the energy of London porters.

The poorest of the Siamese are, after death thrown into the river. Those a little above them are burnt, and their partially consumed bones left to bleach on the plain. Children, before the age of dentition, and women who have died pregnant, are interred in a superficial grave, till after the lapse of a few months the remains are taken up and burnt.

With these exceptions, the practice of cremation extends to all ranks. In many instances previous to cremation, the muscular and soft parts of the body are cut into small pieces and thrown to dogs, vultures, and other carnivorous animals. Among the higher classes, the body is embalmed previous to cremation, but this art is very little known.

The music of the Siamese is soft and lively. They are very fond of music, and have arrived at great proficiency in the art. Their vocal music is plaintive and melancholy.

The history of Siam, beyond what is given in our account of the Birman empire, is scarcely worth noticing. The late king, who ascended the throne in 1782, has been constantly at war with the Birman empire, and it was the boast of his reign that he has lost nothing in the contest.*

The population of Siam is not known. That of the province of Chantibond is stated by Mr. Finlayson to be nearly one million. As very little is known of the modern state of Siam, we have not occupied our pages with any of the antiquated information which is generally detailed. Those, however, who wish such information, may consult La Loubere's *Description du Royaume de Siam*, Amst. 1719. Turpin's *Histoire civile et naturelle du Royaume de Siam*, Paris, 1771. This work was compiled from the MSS. of the bishop of Tavolia, apostolical vicar of Siam, and other Missionaries. *Bemerkungen uber Siam*, in the *Connaiss ance de la literature des pays*, 1786, cap. 12. The most recent information respecting Siam will be found in Finlayson's *Account of the Mission to Siam and Hue* in 1821-2, Lond. 1826. See also Birman Empire.

SIAMPA, or Tsiampa, or Chiampa, or *Binh-tuam*, is a state included in the empire of Tonkin. It is inclosed in Cochin China, which bounds it on the north and south, the Chinese sea bounds it on the east, and Camboge on the west. It is a small mountainous country, which may be crossed in three days. The eastern part is a desert composed of mountains, some of which extend their roots to the sea. They are so steep that a horse cannot ascend them. The road from lower to central Cochin China passes across these mountains, though there is no water fit for drinking in the whole of this route.

The middle part of Siampa is inhabited and cultivated, and western Siampa is a mountainous country where there are some wandering savages, many of whom are not clothed.

The inhabitants of Siampa, particularly the mountaineers, are unknown to their neighbours the Cochin Chinese. They are not known to have any religious belief. They are circumcised, but it is uncertain whether this operation is a precaution, or a medical measure, or an act of religion.

No European is known to have penetrated their country.

The villages are said to be very agreeable, and the mountains abound with wild buffalos.

There are only very small villages in Siampa. The population is reckoned at from 6 to 700,000. See *Exposé Statistique du Tonkin, de la Cochin China, du Camboge du Tsiampa*, &c. from M. M——n, Londres, 1811.

SIBERIA, an extensive territory in Asia, which includes the whole of the northern frontiers of that quarter of the globe. As a part of the Russian empire it has received the name of Asiatic Russia. Siberia is a flat track of country, declining gradually to the frozen ocean, by which it is surrounded on the north, rising gradually towards the south till it joins a great chain of mountains distinguished by the name of the Altai mountains, and the mountains of Sagansk and Yablonay, which separate Russia from independent Tartary, and the territories subject to China. On the east it is bounded by the Eastern Ocean, and

* He was succeeded within these two or three years by Prince Prom Chit, his natural son, who declared when he ascended the throne, that he would no longer be a king merchant, but would allow a general free trade. A commercial treaty was concluded in 1826 by a mission to Siam, between Great Britain and that country; and many points arranged which must facilitate the operations, and protect the person of the British trader.

on the west by the great chain of the Uralian mountains, which divide it from Russia in Europe, and from the provinces of Orenbourg and Astrakan. Siberia extends from the 57th to the 75th degree of North Lat. and from the 60th to the 190th degree of East Longitude. It varies from 1200 to 2000 miles in breadth from north to south, and is about 4500 miles long from east to west.

Siberia is divided into three provinces, which form the 49th, 50th, and 51st, of the Russian Empire. These provinces have the following extent and population.

	Population in 1810.	Extent in square miles.	Inhabitants for each square mile.
Tobolsk,	427,066 }	85,387	8⅔
Tomsk,	293,967 }		
Irkutsk,	376,720	127,888	3

In our article Irkutsk, we have already given a full account of that province, which forms the whole of the eastern part of Siberia. And in our articles Tobolsk and Tomsk, we shall describe the western part of this territory.

In our article Russia, will be found many interesting details of a general nature respecting the territory of Siberia. See also our articles Aleutian Islands, Altai Mountains, Asia, Bhering's Islands, Kamtschatka, Kurile Islands. See also the works referred to under our article Russia.

SIBYLS, from σιου or Θεου *of God*, and βουλη *counsel*, is the name given to certain sages who were supposed to possess prophetic powers, and who uttered oracular responses. They were supposed by some to be four in number, viz.—

The Erythræn Sibyl,
The Egyptian Sibyl,
The Sibyl of Samos,
The Sibyl of Sardis, or the Delphian.

Capella enumerates only two, the Phrygian and the Erythræn; Solinus makes three, viz. the Cumean, the Delphic, and the Erythræn. Varro raises them to ten, while more modern writers suppose that there was only one who uttered her oracles in different places.

The Sibylline oracles, which were a collection of the responses of the Sibyls in nine books, were written in verse, and were offered to Tarquin the elder, according to Varro, by an old woman for 300 pieces of gold. This sum being rejected, she threw three books into the fire, and asked the same sum for the remaining six. This demand being refused also, she burnt other three, and asked the same sum for the remaining three. Tarquin now began to fear that she would destroy the last three, and gave her the sum required. These books, which were in the custody of two patrician priests, were burnt in the fire which destroyed the capital in the year 83 B. C. For farther information, as to these and other books to which the name of Sibylline has been applied, see Hyde, *De Relig. Vet. Pers.*; Prideaux's *Connexions, &c.* vol. iv. p. 185; and Lardner's *Credibility of the Gospel History*, vol. iv.

SICILY, the largest island in the Mediterranean sea, situated close to the southern extremity of Italy, from which it is separated on the west by the straits of Messina. In consequence of its approximation to a triangular form, it was called *Trinacria*, or *Triniquetra*, by the ancients. Its length from east to west is 180 miles; its greatest breadth about 130, and its extent, including the small islands upon its coast, is nearly 12,533 square miles.

Sicily was formerly divided into three parts:

1. The Val di Mazzara, or western part.
2. The Val di Demona, or north-eastern part; and
3. The Val di Noto, or southern part.

But since the year 1815, when the government of Murat was overthrown, it has been divided into seven intendancies, the population of which and of the principal towns are as follows:

Intendancies.	Population in 1817.	Towns.	Population of the chief towns.
Palermo	405,231	Palermo	180,000
Messina	236,784	Messina	44,650
Catania	289,496	Catania	45,081
Siragossa	192,710	Siragossa	13,850
Caltanisetta	155,225	Caltanisetta	15,627
Girgente	288,877	Girgente	14,882
Trapani	145,712	Trapani	24,330
Total	1713,945		

The following table contains the population of the other principal towns in Sicily, in the order of their magnitudes:

Marsala	25,000
Modica	24,000
Ragusa	20,000
Termini	20,000
Noto	16,000
Syracuse	14,000
Nicosia	13,000
Salemi	12,000
Alcamo	12,000
Agosta	12,000
Naro	12,000
Corleone	12,000
Licata	12,000
Castel Vetrano	12,000
Randuzzo	12,000
Sciacca	11,000
Scicli	11,000
Vittoria	11,000
Mazzara	10,000
Castro Giovanni	10,000
Cefalu	10,000

The general aspect of Sicily is that of a highly mountainous country, variegated with numerous vallies. The principal chain of mountains extends from east to west, and has been regarded as a continuation of the Apennines. Other lesser ranges branch off from the main range from north to south; and there are some insulated mountains, of which Ætna is the most remarkable, and of which we have already given a very full and elaborate description in our article Ætna. The north coast of Italy presents a very level surface for nearly 100 miles to the east of Trapani, and also near the gulf of Castello Mare on the opposite side of the island. The plains of Melazzo and Catania, on the north-east of the island are the most extensive, and next to them those of Terra Nova in the south, and of Syracuse in the south-west. In the west of the island there are very extensive districts uninhabited and destitute of cultivation.

The principal rivers in Sicily are the Fiume Grande, the Giaretta, anciently the *Simoethus*, and the Salso. These rivers, and the other smaller ones that water the island have but a very short course, and descend very rapidly from the mountains. As there are almost no carriage roads except in the vicinity of Palermo, there are of course very few bridges over the rivers.

The principal lakes in Sicily are the Biviere and the Pergusa. The Biviere, about eight miles south of Catania, has, in the winter season, a circumference of about 20 English miles, while in dry weather it is reduced to very small dimension, leaving an extensive swamp, which is most injurious to health.

The climate of Sicily is, generally speaking, an agreeable one. In summer the weather is very hot; the thermometer at Palermo varying from 73½° to 80½° in June and July. When the *sirocco* or south wind blows, which happens during a few days of July and August, the thermometer rises suddenly to 112°. Though the summer heat is often alleviated by fresh sea breezes, yet March is the only month in which any chilling winds are felt; and the shade is found refreshing even in the beginning of January. The spring is the finest season of the year. Snow is never seen excepting on the lofty mountains, and in the low grounds are found the productions of the tropical countries, such as the banana, the aloe, the sugar cane, &c. Against these advantages, we have to balance the insecurity of particular districts, the season of the sirocco, and the exposure of the island to frequent and desolating earthquakes.

Sicily was laid waste by earthquakes in the years 1638, 1693, 1726, 1783, 1805, and 1818-19; but the most tremendous effects were produced by that which took place in March 1823*. On the sea coast east of Palermo, the shock was immense. At Altavilla, the bridge was shaken. At Trabia, the castle was destroyed. At Godiano, the cathedral and some houses fell, and enormous masses were loosened, and fell from Bisambra, a neighbouring mountain. At Termini, the shocks exceeded all that had happened in the memory of its oldest inhabitants. The warm springs then became turbid and increased in quantity and warmth. In Sarcari most of the houses were rendered uninhabitable. To the west of Palermo, the earthquake had little power; but as it advanced to the east, its effects were very injurious. At Cefalu, the sea made a violent and sudden rush to the shore, carrying with it a large ship laden with oil, and when the wave retired she was left dry; but a second wave returning with immense force, dashed the ship to pieces. Boats which were approaching the shore, were borne rapidly forward to the land; but they were carried as rapidly back, at the return of the sea. Some damage was done at Messina. At Catania, it was felt so slightly, that the people went to the theatre that same evening. It was slightly felt at Syracuse, scarcely at all towards Cape Passaro, and no bad effects were produced in the southern part of the island.

Sicily has long been celebrated for the fertility of its soil. Excepting in the vicinity of Ætna, the soil is calcareous loamy mould of considerable depth. The copious dews of June supply the want of rain, and the melted snows which fill the rivulets with water, afford excellent means of irrigation. Although it is not cultivated at present, as when Sicily was deemed the granary of Rome, yet the crops of wheat are so abundant, as not only to supply the inhabitants, but to leave a considerable surplus for exportation. It was only, however, in 1819, that the export of corn was declared to be free. Mr. Brydone assures us, that one good crop of wheat is sufficient to feed the island for seven years. Large quantities of barley and pulse grow on the island; and maize, flax, hemp, aloes, saffron, wine and cotton, are among its productions. Canary bird seed, which is almost peculiar to this island, is exported in large quantities. Potatoes were introduced in the eighteenth century; and in consequence of the goodness of the pasturage, milk, cheese, and butter are obtained in considerable quantities.†

Silk is considered the second source of riches in Sicily. The management of the silk worms, and the art of manufacturing the silk, were introduced by Roger, king of Sicily: a quantity of silk, equal in value to a million of ducats, or £187,500 sterling, was annually exported, but this has greatly declined. Palermo and Messina are the principal seats of the manufacture. Palermo employed 900 looms, Messina 1200, and Catania rather more. Palermo exports little. A variety of silken fabrics, made at Messina, went to the Levant. Cotton, linen, and woollen goods are likewise manufactured in these three towns, and also bits, cutlery, harness, carriages, and household furniture. Large quantities of oil were exported from ports in the north of the island, and also wines and brandy. The fisheries are productive, and great quantities of herring, anchovies, and sardines, are sold and exported.

Sicily has not yet attained that commercial importance to which it is entitled from the excellence of its harbours, and the safety of its shores, for navigation. Its inland communications are fettered by the want of roads; and the want of banks, insurance offices, together with a bad system of quarantine laws, retard the progress of its commerce. The principal exports from Sicily are corn, nuts, hemp, flax, senna, oil, wine, sulphur, fish, silk, and fruits, the whole amount of which is said not to exceed 11,000,000 ducats, or about £240,000 Sterling.‡ The imports, which consist of colonial produce, hardware, jewellery, lead, and manufactured articles, are estimated at the same sum as the exports. Money accounts are kept in ounces, taris, and grains.

1 Grain equal to ¼ Sterling.
20 Grains equal to 1 tari, or 5d. Sterling.
30 Taris equal to 1 ounce, or 12s. 6d. Sterling.

Sicily abounds in valuable minerals. Mineral springs, both hot and cold, frequently occur. Iron and copper are found in the region of Ætna, and cinnabar sulphur, alum, nitre, and sulphate of iron also occur. A large mine of coal has been discovered near Messina, and salt mines have been found near Castro Giovanni in the middle of the island. The quarries of marble

* Very minute and interesting details respecting this earthquake will be found in Dr. Brewster's *Edinburgh Journal of Science*, vol. iv. p. 1[illegible]5, and 362, where the reader will find a translation of Professor Ferrara's Memoir upon these earthquakes.

† A full account of the productions of Mount Ætna will be found under that article.

‡ Another account states that the exports do not exceed £1,500,000. This discrepancy must be founded on some typographical error.

are numerous, and good building stone is found in almost every part of the island. Porphyry, jasper, and agates likewise occur.

Sicily used to be governed by a viceroy, in whose absence the archbishop of Palermo was regent. The parliament, before its reformation in 1810, was composed of three branches, viz. 229 nobles, 66 prelates, and 43 demaniale or deputies from cities, universities, and crown estates. Out of each of these branches four deputies were chosen to conduct the public business. The ecclesiastical government is in the hands of three archbishops and seven bishops. The administration of justice was in a very deplorable state, and of this we have given some examples in our article on Catania. During the residence of the British army in Sicily from 1806 to 1816, very essential reforms were introduced both into the Sicilian parliament and the administration of justice, and we trust that these salutary changes will not be permitted to go into desuetude.

In the year 1820, the revenue of the island amounted to 1,637,332 ounces, and the expenditure to 1,665,355 ounces. The expenses are limited to 1,817,680 ounces, out of which 150,000 ounces are employed to pay that part of the debt which bears no interest, and when that is discharged, this annual sum is to form a sinking fund to extinguish the debts which do not bear interest, but the amount of which is not publicly known.

The Sicilian army amounts to about 10,000 men, including cavalry, infantry, and artillery, and in addition to this, there is a militia of 8000. The navy consisted formerly of 1 ship of the line, 2 frigates, 5 sloops, with numerous gunboats, but more recently it has been united with the Napolitan navy. Many of the officers were paupers, and so small was the pay of the troops, that, in years of scarcity, the soldiers were dependent on public charity.

The Sicilians bear a striking resemblance to the Italians and Spaniards, not only in their complexion and general aspect, but also in the indolence of their habits, the licentiousness of their morals, and their passion for gaming and public amusements. Education was for some time an object of interest in Sicily. The colleges of Palermo and Catania have already been referred to in this article, and are on a very imperfect footing. The Normal schools established in 1789, are on a better footing. The pupils are limited, and the qualifications of the teachers are previously ascertained. At the age of nine, girls are put to a convent, where, for about seven years, they are taught reading, writing, and the ceremonies of their religion. Several schools on the system of Bell and Lancaster have been recently established, and there is reason to hope that an improved system of public instruction will banish the ignorance, credulity, and superstition, which so peculiarly visit the Sicilian mind. The religion of Sicily is of course catholic; and the number of ecclesiastics has been computed at 70,000, exclusive of a still greater number of monks and nuns.

For an account of the history of Sicily, see our articles Italy, Naples, and Messina.

For farther information respecting this island, see the works quoted under our article Ætna, Watkin's *Travels through Switzerland, Italy, Sicily, &c.* Munter's *Memoirs relative to Naples and Sicily*, Vaughan's *Views of the Present State of Sicily*, 1812, Thompson's *Sicily and its inhabitants*, 1815, and Smyth's *Sicily and its Islands*, 1823. See also our articles Catania, Messina, and Palermo.

SIENITE, See Mineralogy Index.

SIENNA, or Siena, an ancient city of Italy in Tuscany, and capital of a province of the same name, is pleasantly situated on three hills. The streets are consequently uneven, winding, and narrow, and a great part of the town impassable for carriage. The town is about 5 miles in circumference, and has a very imposing aspect when approached from the south. The houses are in general built with brick, and the streets are paved with the same. The only public square that is reckoned handsome is that which contains the town-house, and also a beautiful fountain. The cathedral is a noble gothic building, begun in 1284 and finished in 1333. It is faced both within and without with white and black marble, and considered next in grandeur to St. Peter's. The nave is supported by rows of beautiful columns, and its pavement is decorated with mosaics. The front is prodigiously loaded with ornaments, and the marble sculpture on the pulpit, and the carving in wood on the choir are much admired. Many of the chapels and altars, which are extremely rich, are decorated with beautiful paintings and statues. The church of St. John's, which lies directly underneath the cathedral, may be seen from an opening in the pavement of the choir. The entrance is without on the hill, and the cathedral may thus be said to stand on the church of St. John's.

The town-house already mentioned, is a large Gothic building, surrounded with porticos. The castle, built at an extremity of the city, is not a place of great strength. The university contains 60 professors. It was founded by Charles V. who conferred particular privileges on the German students. An academy of physics and natural history established here, acquired some celebrity from their published memoirs. Near the castle, the university has an academy for martial exercises. A great number of the gentry and literati reside in Sienna; and the town has acquired a reputation for politeness, for a taste for literature and the arts, and for the purity of the Italian which is spoken. The archbishop's palace stands near the cathedral, and opposite to it is a large and well endowed hospital, founded by a shoemaker. Sienna contains many palaces, fountains, churches, and convents. In the Venhuini Chapel of the churches of the Dominicans, is an ancient picture of wood, representing the Virgin with the infant Jesus, by Guido Janese, dated 1221. The manufactures carried on here are very trifling. They consist of woollen goods, hats, leather, and paper. There is a little trade in corn; and the marble quarries in the vicinity might be rendered valuable by enterprising capitalists. One of the principal objects of interest to strangers is the Piazza, a large extent of ground laid out in walks, and decorated with statues. It is the place of public resort in the evening. The esplanade is an avenue leading to the citadel, the ramparts of which are planted with trees, and laid out in the form of terraces.

Sienna is mentioned by Pliny under the name of *Colonia Senensis*. During the middle ages, it enjoyed great prosperity, and was more populous than at present. The territory was once a free republic, but was conquered by Charles V. The Siennese, a territory of Sienna, is now a province of the Grand Duchy of Tuscany. It is about 62 miles long, and contains 34,000 square miles, and 190,000 inhabitants. The population of the town is about 24,000. East long. 10° 15′, north lat. 43° 22′.

SIERRA LEONE, the name of a British settlement on the west coast of Africa. It derives its name from the river called the Mitomba, or Sierra Leone, which traverses it, but the origin of which has not been explored. The territory of Sierra Leone lies both on the north and south side of the river. The country on the north is low and flat, but that on the south speedily rises into a long mountainous ridge, which, from being the residence of lions, gave the name of Sierra Leone to the river. From this ridge descend many mountain streams, which unite in the Bay of France, a large basin, which is the best watering place in the whole coast of Guinea, and which is described as a most delightful and picturesque spot.

The general aspect of this country is that of an impenetrable forest, a few small portions of which only have been cleared and cultivated. Rice is raised on those grounds which are capable of irrigation, and forms the food of the rich, while millet, yams, and plantains, are raised by the poor. The principal fruits are pine apples, oranges, lemons, limes, &c. and a fruit like the melon. A wholesome liquor is obtained from the palm tree.

The woods and mountainous regions abound with animals, particularly lions; apes occur in great quantities. Serpents are particularly numerous; and the river abounds with large alligators, and contains a species called the monatea, or sea cow. Among the articles of trade here, may be enumerated elephants' teeth, which are remarkable for their size and perfection. A considerable quantity of civet is likewise brought to market here.

The colony of Sierra Leone consists of *sixteen* small towns or villages, the population of which, in 1818, was 9565, whereas in 1820, it had risen to 12,509, and in 1825, it was estimated at 18,000. The following is a list of the towns and villages, with their population, according to the census of 1820.

	Population.
Freetown and suburbs	4,785
Leopold, township	469
Charlotte, township	268
Bathurst	469
Gloucester	563
Regent town and vicinity	1,218
Kissey and vicinity	1,033
Wilberforce	409
Kent and vicinity	296
Waterloo	395
Hastings	195
Wellington	456
York	297
Leicester Hamlet	78
Villages in Peninsula	1,468
Peninsula and the islands	115
Island of Gambia	37
The population in 1820	12,509

This population consists of	
Males	5,796
Females	3,020
Boys	2,015
Girls	1,678

The different nations to whom this population belongs may be arranged as follows:

Negroes liberated	8,076
Natives	2,939
Nova Scotians	730
Maroons	594
Europeans	120

The principal town of this colony is Freetown. The next town in importance is Regent's Town, established in 1813. When this town was visited in 1816 by Mr. Johnson, the missionary teacher, he found it occupied by 1100 captured negroes from 22 different nations. The most deadly enmities prevailed among them. Some lived in the woods, subsisting by plunder, and in stealing fowls, which they ate raw. When clothes were given them, they either threw them away or sold them. Destitute of the idea even that marriage was a tie, they were addicted to the most shameful debaucheries, and, crowded together in their miserable huts, they contracted various diseases, of which several died every day; and, in the first years of the colony, there were only six births among these 1100 individuals. A deplorable superstition prevailed among them. They erected numerous chapels in honour of the evil spirit. Nothing could induce them to cultivate the fields, and the few that did exercise that species of industry, had their crops destroyed by their neighbours. By the exertions of Mr. Johnson, and a few intelligent negroes, the most remarkable improvements were effected.

The negroes were at length civilized; they now lead a quiet and laborious life. They frequent divine service. Several of them partake of the sacrament, and many of them lead a truly Christian life. By their industry, Regent's Town has been laid out with great regularity. Nineteen new streets have been formed, and good roads made in its vicinity. Among its buildings there is already a good church built of stone; a government house, a house for the clergyman, a bridge of several arches, school-houses and warehouses, and many of the houses of the natives are built of good stone. All of the people are farmers. Every house has an enclosed garden attached to it. The land in the vicinity is cleared and under cultivation, and in some places even to the distance of three miles. Vegetables, and all the finest fruits of the torrid zone, are raised in abundance, and of domestic animals there is an ample supply. Many of the negroes, at the same time, carry on trades. In 1818 there were 50 masons and bricklayers, 40 carpenters, 30 sawyers, 30 shingle makers, 20 tailors, 4 blacksmiths, and 2 butchers. In that way upwards of 600 negroes provided for their own maintenance. The females have learned to make their own clothes. In 1818 about 400 couple had been married. About 1400 attend divine service; and the schools, which began with 140 children and 60 adults, now contain above 500 scholars.

The excellence of the moral and intellectual qualities of the pupils, suggested to the society belonging to the Church of England, the establishment of a seminary called the *Christian Institute*, where the young natives may be prepared for the missionary service. This establishment, at first founded at Leicester, was afterwards transferred to Regent's Town, and it now contains a considerable number of pupils from 12 to 18 years of age. Several of them who have already gone out have paved the way for the missionaries in the interior of Africa. They carried along with them the first elements of civilization, and disposed their less cultivated brethren to submit to the discipline of Christianity.

The townships of Charlotte, Leopold, Gloucester, and Wilberforce, are in the immediate vicinity of Freetown, and, along with Freetown, contains upwards of 2000 scholars in a regular course of instruction.

In consequence of these accessions to the population, four new and more distant stations have been founded since 1818, viz. Waterloo, Wellington near Kissey, Hastings, and York. The three first are on the eastern side of the colony, while York is on the south-west side, bordering on the Sherbros, among whom a settlement called Kent had already been formed.

In connexion with the colony of Sierra Leone, a settlement called Bathurst has been established at St. Mary's, at the mouth of the river Gambia, and to the north of Sierra Leone. In 1820 the population was only 469; but it is now 2000. The natives are all Mahometans. The climate is healthy, and provisions are much cheaper than at Sierra Leone. From the opportunities which it has of communication with the populous countries on the Gambia, it will, no doubt, become an important station for commercial enterprise. The missionaries who reside here have been sent out by the Wesleyan Society.

About eight miles from Bathurst the quakers have formed an establishment at Birkow, a place in the country of the Mandingos, on Cape St. Mary. A young negro has opened a school at Birkow, for the instruction of children of both sexes.

Since the year 1822 the Americans have founded a colony at the mouth of the river Mesavada, to the south of Sierra Leone. This colony has been called Liberia, and the principal town Monrovia. The population consists of African-Americans, and of free negroes.

The following were the number of scholars educating in the year 1820, at the different establishments in Sierra Leone. Since that time we know that they have very greatly increased; but the exact increase we are not acquainted with:

Freetown and Islands	575
Regent Town	432
Gloucester	258
Kissey	158
Leopold	154
Bathurst	113
Charlotte	106
Waterloo	86
Kent	77
Wilberforce	75
Hastings	57
Wellington	16
	2107

The first settlers in Sierra Leone were the Portuguese. The English afterwards established a footing in Rance Island in the middle of the river; but it was not till near the end of the eighteenth century that the negro colony was established. In 1783, Dr. Smeathmar suggested the idea of it. After the American war, a number of negroes who were discharged from the army and navy, were collected, to the amount of about 400, and along with about 60 whites, they were embarked on board transports, furnished by government, and were conveyed to Sierra Leone, where they arrived on the 9th May 1787, with arms, provisions, and agricultural implements. Captain Thomson of the Nantilus purchased a piece of ground 20 miles square from King Haimbanna. A proper site for a town, called Freetown was chosen, occupying a rising ground fronting the sea. When the lands were divided among the colonists, they abandoned themselves to indolence and vice: and the consequence of this was, a dreadful mortality, which reduced them to 276. In addition to that calamity, the town was plundered in November 1789, by an African chief, who compelled the colonists to seek for shelter in Rance Island. In 1791, Mr. Falconbridge went out with a supply of stores. He collected the scattered colonists, and having persuaded the native chiefs to cede again the former territory, a new site for the colony was chosen at Granville town. While these things were going on, the original African Association (See article Association. Africa.) was incorporated by act of parliament in 1791, with a charter for thirty-one years. They immediately sent out five ships with stores, articles of trade, and several new settlers. A considerable number of whites and free negroes, to the amount of 1200, who had taken shelter in Nova Scotia, after the American war, accepted of the offer of the company to go to Sierra Leone; and they arrived there in 1792. Freetown was again made the capital of the colony, and for some time it flourished. Discontents, however, soon arose, and complaints were personally made to the Company by the Nova Scotian negroes, respecting the lowness of their wages, and the high price of the Company's goods. When these dissatisfactions were removed, the town was plundered in September 1794 by a French squadron, and the colonists were thrown into the most destitute condition. The Company, however, repaired this disaster: but so great had been their losses, and so profuse the expenditure, that they found it prudent to make an arrangement with government, by which Sierra Leone was placed like other colonies under its jurisdiction.

The establishment of the African Institution about that time for the improving the condition of that vast continent, induced government to place Sierra Leone under its management. The method which they have adopted for recruiting its population was, to send to the colony all the negroes captured by the vessels sent to put a stop to the slave trade. From this source of supply, the colony has rapidly increased in numbers, and the colonists now enjoy all the advantages of English law. From the unhealthiness of the climate, and the smallness of the salaries allowed, it has been found difficult to get qualified persons to fill the official situations; but these evils have gradually diminished, and the colony has prospered in the manner which we have described in a preceding part of this article.

Its tranquillity has been very recently disturbed by the surrounding native powers: and unless some more effectual means of defence are provided, there is reason to fear that it may yet fall under their repeated assaults.

Since the above article was written, government has, we understand, resolved to abandon Sierra Leone, and to remove the colony to the island of Fernando Po, where the new buildings for the accommodation of the troops and the civil authorities are already in a state of progress.

SIGHT. See Optics, and a popular treatise by Dr. Brewster, *on the Defects of Sight, and on the means of removing them*—now in the press; and also Science, Curiosities in.

SIGNALS. See Telegraph.

SIKHS. See India. See also Sir John Malcolm's *Sketches of the Sikhs*, in the *Asiatic Researches*.

SILESIA. See our article Prussia, and a short notice in the same article, *note*.

SILICA. See Chemistry Index, and Mineralogy Index.

SILHET, an extensive country of Bengal, on the east of the Burrampooter. It consists of bleak mountains and level plains, which are generally laid under water in the rainy season. Great crops of rice are produced. It is traversed by several rivers, the chief of which are the Megna and the Soormah. They abound with fish, and during the rainy season boats may sail over a great part of the country. Its chief exports besides rice, are lime, ivory, timber, oranges, fragrant aloe wood, and a kind of wild silk called Muggadooties. Elephants are found in the woods, but they are not deemed valuable. The principal town is Silhet or Sirihat, the capital of Azmerigunge. In 1801 the population was 492,495, there being two Mahommedans for three Hindoos.

SILIUS Italicus Caius, a Roman poet of some celebrity, was born about A. D. 15. He is supposed to have been born at Italica in Spain; but he spent most of his life in Italy where he possessed several estates. He was consul at the time of Nero's death, and possessed the friendship of Vitellius. After discharging the duties of proconsul in Asia, he retired into private life, and spent his time in adorning villas which he quitted for new ones. He spent the latter part of his life at his seat in Campania. In his 75th year he was attacked with an incurable ulcer, and it is stated that he died of abstinence from food.

His only work is an epic poem on the second Punic war, the best editions of which are those of Drakenborch in 4to. *Utr.* 1717, Lefebvre de Villebrune in 1782, in 4 vols. 12mo.

SILISTRIA, or Dristra, a town of Turkey in Bulgaria. It stands on the south of the Danube, and is well fortified and tolerably built. It contains several elegant mosques and baths. Population 20,000. East. Long. 27° 6', North Lat. 44° 15'.

SILK, the name given to a soft, delicate, and shining fibre, the production of different species of larvæ or caterpillar. It is most commonly produced by the *Phalaena bombyx*, though the *Phalaena atlas* is said to yield it more abundantly.

The ancients knew little concerning this substance. The manufacture of silk, including the rearing of the worms, was introduced into Europe in A. D. 555 by two monks, who, under the patronage of Justinian, brought great quantities of the worms from India to Constantinople. Athens, Thebes, and Corinth, established manufactories of silk, and from them the Venetians supplied the west of Europe for many centuries with it. From Greece the art passed to Palermo and Calabria, from which it was propagated through Italy and Spain. It came into France a little before the time of Francis I.; and in 1489 it was introduced into England, though so early as 1455 there was a company of silk-weavers.

The silk worm seems to be a native of China, where it has been reared from a very remote period. The insect remains for nearly six months in its egg, which is about the size of a pin's head. From this it emerges in the form of a caterpillar, with eight pair of feet. It now feeds on the leaves of the mulberry or lettuce, and it increases so rapidly in size, that in six or seven days after birth its skin bursts, and the insect appears in a new form, advancing for seven days more to another stage. When the worm is about to quit its *fifth* skin, it then winds for itself a silken bag or cone about the size and form of a pigeon's egg, called the *Cocoon*. Here it throws off its last skin, and in twenty days after the transformation of the larva into the chrysalis, which is effected within the cocoon, it becomes a moth with white wings. This moth lays eggs, and these eggs about six months after produce larvæ as before.

It has been stated, that a fibre of silk uncoiled from a cocoon is 406 yards long, and weighs when dry three grains. One lb. avoirdupois would extend 535 miles, and forty-seven pounds would encircle the globe.

The method of rearing the silk worm may be thus shortly described:—The eggs being laid upon shallow trays of brown paper, the chopped leaves of the white mulberry are strewed over the trays. In its second or third stage, the larvæ are taken to larger trays, placed in a small compartment, where the temperature is about 75° Fahr., and an increased quantity of the leaves given them, as will appear from the subsequent tables of Count Dandolo. The trays are now removed to a large apartment, where the temperature, at first about 72° Fahr., is allowed to diminish gradually to 69°.

When the cocoons are ready, the *nymphæ* within these, intended for silk, are destroyed by putting them in boiling water, and they are afterwards dried by artificial heat; but those designed for the future crop are laid out in a coarse linen cloth stretched on a table in a room not used and dark. From every lb. of cocoons (male and female) two ounces of *ova* or *eggs* may be obtained by Count Dandolo's method, as afterwards exhibited in the tables, where, if the management is bad, from ten to 30 lbs. may be sacrificed for a single oz. of eggs. In order to ascertain the cocoons in which the *nymphæ* are perfect and sound, we must see if the extremities of it are less abundantly supplied with silk, and if it is confusedly arranged; when this is the case, the nympha is likely to be sound.

The male are distinguished from the female nymphæ by the greater size of the latter, so that the female cocoons are likely to be larger than the male. The weight of 1000 male cocoons is 1700 grains, while that of as many female ones is 3000 grains.

When a proper number of each has been selected, those intended for moths are placed, as already mentioned, on a cloth in a room whose temperature does not exceed 72°, a higher temperature occasioning unhealthiness. Stillness and diminished light are considered favourable. When the moths have deposited their eggs on the cloth, they soon die, and the ova adhere to the cloth by a silky gummy substance. The temperature is now brought down to 66°, and when the colour of the ova has changed to ash-colour, the cloth stretched on a frame may be removed to a cool apartment, where the eggs should be kept dry. When the eggs are required, they are detached by immersing the cloth in fresh water, which dissolves the mucilage. The ova are then dried with care.

The uncoiling of the silk from the cocoons is effected by collecting the ends of the threads, and winding them on reels, the greatest care being taken that the uncoiling goes on freely through all the extent of the cocoon. This effect is promoted by throwing them into caldrons of water nearly boiling. The threads are then collected by a whisk or brush, and passing through plates of steel they are wound upon a reel by machinery, attached to a water wheel, or any other power.

"Gensoul of Italy," says Mr. Murray, "has invented an apparatus by means of which the water is heated through the medium of steam, and the nymphæ that fall are collected on a grating of iron wire at the bottom of the boilers, which is frequently raised for the purpose of removing the husks. By this ingenious method much fuel is saved, one furnace with its boiler serving to heat twenty vessels, and from the decreased temperature the cocoons do not suffer any decomposition or change, as is the case in the ordinary way wherein they are immediately exposed to the direct agency of the fire. Another saving might still be effected by this method, in the substitution of vessels or cisterns of wood for boilers of copper. In the month of August last, at Buffalora, on the Milanese frontier, I visited an establishment for unwinding the silk. Women were arranged in two rooms, opposite each other, and conducted the process. The cocoons contained in baskets on one side were thrown by handfuls into caldrons of water, kept boiling by charcoal fires beneath. Each by a *whisk* (of peeled birch) collected the threads *en masse*, the first confused portions were rejected, till the threads unwound regularly, freely passing over glass-rods to prevent the injuries of friction. The first portions are necessarily useless, and are separated by the hand. When the threads came off uniformly, the cocoons were raised suspended to the hand by their respective threads, and thus handed over to those on the opposite side, who, in their turn, threw them into caldrons of water, the temperature of which was nearly that of blood heat, and more than milk warm—thus sustained by a steam pipe. The water was thus kept clear, and the silk preserved pure and unsoiled. From these the threads were finally wound. The proprietor informed me that this establishment cost 60,000 francs."

The following tables, containing a general view of the process carried on, and the results obtained by Count Dandolo, were abridged by Mr. John Murray from Count Dandolo's work, and first published in Dr. Brewster's Journal of Science, No. III, p. 59, Jan. 1825. The zero of Bellani's hygrometer corresponds with that of Saussure.

Management of the Silk-worms, produced from five Ounces of Ova.

1813 First Age.	Months.	Leaves supplied.	Internal Temperature.	External Temperature.
Days of Treatment		lbs. oz.	Fahrenheit.	Fahrenheit.
1	May 18.	*2 14	74 .75†	[illegible].75
2	19.	4 0	74 .75	63 .50
3	20.	8 0	74 .75	65 .75
4	21.	4 14	74 .75	65 .75
5	22.	1 0	74 .75	61 .25
		20 0		
Second age.				
6	23.	12 0	73°.75	63°.58
7	24.	20 0	73 .75	63 .50
8	25.	22 0	72 .50	64 .62+
9	26.	6 0	72 .50	65 .75
		60 0		
Third age.				
10	27.	20 0	71 .37	
11	28.	60 0	71 .37	
12	29.	65 0	70 .25	
13	30.	35 0	70 .25	
14	31.	20 0	70 .25	
		200 0		
Fourth age.				
15	June 1.	— —	70 .25	
16	2.	65 0	70 .25	
17	3.	110 0	69 .12+	
18	4.	150 0	69 .12+	
19	5.	170 0	69 .12+	
20	6.	85 0	69 .12+	
21	7.	20 0	69 .12+	
22	8.	— —	69 ·12+	
		600 0		
Fifth age.				
23	9.	120 0	69 .12+	
24	10.	180 0	69 .12+	
25	11.	280 0	69 .12+	
26	12.	360 0	68	
27	13.	540 0	68	
28	14.	650 0	68	
29	15.	600 0	68	
30	16.	440 0	69 .12+	
31	17.	330 0	69 .12+	
32	18.	160 0	69 .12+	
	Fifth age,....	3660 0		
	Fourth age,..	600 0		
	Third age,....	200 0		
	Second age,..	60 0		
	First age,.....	20 0		
		4540 0		
	Unconsumed,	475 0		
	Lost,........	350 0		
	Total,........	5365 0		

* The common lb. of silk (*libra grossa*) contains eight light ounces.

† Corresponding to 17° Réaumur.

Management of the Silk-worms, produced from five Ounces of Ova.

1814. First Period.	Months, &c.	Leaves consumed.	Internal Temperature.	External Temperature, at 5 o'clock, A. M.—Western exposure.	Hygrometer of Belani.	Weather.
		lbs. oz	Fahren.			
Days, 1.	May 23.	1 7	72°.50 var.	50°.25	....	Rain.
2.	24.	2 7	70 .25	47 .75	....	Rain occasionally.
3.	25.	3 0	70 .25 var.	43 .25	....	Rain and fair.
4.	26.	6 0	59 .12	45 .50	....	Cloudy & sunshine.
5.	27.	5 0	70 .25	50	....	Cloudy.
6.	28.	2 14	71 .37+	54 .50	....	Rain.
		20 0				
2nd period						
7.	29.	5 14	70 .25	47 .75	68°	Rain.
8.	30.	11 0	70 .25	53 .37+	70	Mist and sunshine.
9.	31.	15 14	68	56 .75	64	Ditto.
10.	June 1.	15 0	68	56 .75	65	Rain.
11.	2	7 0	68	63 .50	65	Rain and sunshine.
12.	3	1 0	59 .12+	61 .25	70	Cloudy.
		55 0				
3rd period						
13.	4.	14 0	69 .12	54 .50	68	Rain and sunshine
14.	5.	30 0	68	54 .50	69	Cloudy, &c. &c.
15.	6.	40 0	69 .12+	61 .25	70	Rain and sunshine
16.	7.	60 0	69 .12+	57 .75	75	Rain.
17.	8.	50 0	69 .12+	55 .62+	74	Rain.
18.	9.	20 0	69 .12+	52 .25	79	Rain and sunshine
19.	10	2 0	69 .12+	56 .75	78	Ditto.
		216 0				
4th period.						
20.	11.	50 0	69 .12+	56 .75	76	Rain and sunshine.
21.	12	85 0	69 .12+	63 .50	75	Cloudy, &o.
22.	13	120 0	68	64 .62+	71	Fine.
23.	14.	130 0	66 .87+	61 .25	74	Cloudy & sunshine
24.	15	160 0	66 .87+	63 .50	75	Sun and rain.
25.	16	70 0	68	65 .75	72	Ditto.
26.	17	5 0	69 .12	56 .75	70	Fine.
		620 0				
5th period						
27.	18.	120 0	68	60 .12+	72	Fine.
28.	19	180 0	68	61 .25	73	Rain and sunshine
29.	20.	240 0	68	56 .75	73	Ditto.
30.	21.	310 0	66 .87+	59	75	Rain.
31.	22.	360 0	68	56 .75	73	Cloudy and rain.
32.	23.	450 0	68	52 .25	72	Rain and sunshine
33.	24	550 0	68	54 .50	74	Ditto.
34.	25	650 0	68	53 .37+	73	Ditto.
35.	26	500 0	69 .12+	54 .50	73	Ditto.
36.	27.	280 0	59 .12+	54 .50	73	Cloudy and Rain.
37.	28.	180 0	69 .12+	50	72	Rain and sunshine.
Fifth Period - -		3820 0				

Management of the Silk-worms, produced from five Ounces of Ova.—Continued.

Fifth Period, - -	3820	0
Fourth Period, - -	620	0
Third Period, - -	216	0
Second Period, - -	55	0
First Period, - - -	20	0
Leaves devoured, -	4731	0
	400	0
	290	0
Total,	5421	0

For each ounce of ova, 1084 lbs. of leaves have been taken from the tree.

The silk-worms, from five ounces of ova, have consumed the above 5421 lbs. of leaves, and produced 401 lbs. of cocoons, &c.

For each pound of cocoons there have been consumed about 13½ lbs. of mulberry leaves.

The Temperature required for the Production of the Silk-worms from the Ova, anterior to 23d May, 1814.

1814. Month	Internal Temperature.	External Temperature.	1814 Month	Internal Temperature.	External Temperature.
May 11	Fa. 63.50	Fa. 50 26	May 18	Fa. 70.25	Fa. 50.00
12	63.50	45.50	19	72.50	50.00
13	63.50	45.50	20	74.75	52.25
14	63.50	45.50	21	77.	52.25
15	65.75	47.75	22	73.25	54 50
16	65.75	52 25	23	81.50	52.25
17	68.	50.00			

The external temperature was ascertained at five o'clock, every morning, from a western exposure.

During the thirteen days in which the silk-worms were developed from the ova, 134 lbs. of food were consumed. The lb. of 28 ounces is to be understood, or 2 lbs. Troy equivalent to 0.7625 kilogrammes of France.

The following is the Daily Decrease in Weight of 1000 *ounces of Cocoons in a Room, the Temperature of which was from* 70° 25 *F.* 72° 50 *F.*

Day 1st,	1000 oz.		Day 7th,	960	less 6.
2d,	991	less 9.	8th,	952	less 8.
3d,	982	less 9.	9th,	943	less 9.
4th,	975	less 7.	10th,	934	less 9.
5th,	970	less 5.	11th,	925	less 9.
6th,	966	less 4.			

So that the 1000 ounces have lost in 10 days, during the mutation, 75 ounces. There is a gradual declension for the first five days inclusive, and a regular gradation for the last five days.

8 oz.	of ova have lost	in 5 days	in wt.	100 gr.	in 8 days	360,	& in 10 days	410.
6 oz.	do.	do.	do.	86 gr.	do.	172,	do.	248.
5 oz.	do.	do.	do.	60 gr.	do.	168,	do.	216.
4 oz.	do.	do.	do.	80 gr.	do.	161,	do.	224.

Each grain contains about 68 ova, and an ounce weight 39,168 ova. The *oncia Milanese* contains 575 grains. The above number is to be understood of *fecundated* ova. Those which are badly impregnated contain 43,080, and are of a *reddish* colour: and of those not at all impregnated, and of a *yellowish* tinge, there are in the ounce 44,100.

The Expense of the Contingencies of the 5 *ounces of Crop in* 1814, *are thus calculated by Count Dandolo.*

Cost of 5 ounces of ova, - - - - -	15.
Wood for fuel - - - - - - -	1.15
5500 lbs. of leaves of the mulberry at 7 lire per 100 lbs.	335.
Expense of gathering the leaves, - - -	96.5
100 lbs. light and heavy wood, at 32 soldi - -	32.
Supplemental husks, - - - -	4.10
Supplemental paper, - - - - - -	4.
Oil for light, - - - - -	9.

Preservative phial, - - - - - - -	1.10
Daily labour, - - - - - - -	100.
Lire Milanese,	612.
Interest, &c. on capital, - -	90.
Total expense -	612.
401 lbs of cocoons obtained, which, being sold at 78 soldi per lb. produced, - - -	1,563.18
Nett profit, -	Lire 831.18

Note.—A *Lira Milanese* is equal to about 8d. and there are 20 *Soldi* in a *Lira M.*

The calculation, as above, includes not only interest on capital, but a valuation on the mulberry leaves, which is about one-half of the total expense.

The Augmentation and Diminution of the Silk-worms in Weight and Size.

Increasing Progression.	Weight.	*Increasing Progression.*	Weight.
100 ova weight about	Grain 1	The ova in the 1st instance, say	1 line
After the 1st change, about	15	After the 1st change, length say	4
2d change, say	94	2d change, -	6
3d change, say	400	3d change, -	12
4th change, say	1628	4th change, -	20
5th change, say	9500	5th change, -	40

Note.—In 30 days the silk-worm has increased in weight 9500 times; and, in 28 days, the animal has augmented in size about 40 times.

The French Line is equal to 1.67 Lines English, calculated 100 Lines English to the inch.

Decreasing Progression.

	Grains.
100 Silk-worms, at their greatest size, weigh about	7760
100 chrysali weigh - - - - - -	3900
100 females weigh - - - - - - -	2990
100 males weigh - - - - - - -	1700
100 females, after the ova are deposited, weigh -	980
100 females, naturally dead, and the eggs or ova deposited, &c. - - - - - - -	350

In the space of about 28 days more, the silk-worm has diminished in weight about 30 times. Thus, the length of the silk-worm from the time of its greatest increase to the moment it is converted into the chrysalis, has diminished about three-fifths. The chrysalis is the intermediate state between the caterpillar and the winged insect. The *larva* emerges from the ova, spins its cocoon or domitory, and therein passes into the state of the *pupa*. It finally emerges from thence the *imago*, or winged insect, which dies so soon as the ova are deposited.

Space occupied by each ounce of Ova cultivated.

In the first age, an area of square Braccia,	4
In the second, an area of ditto -	8
In the third, an area of ditto -	19
In the fourth, an area of ditto -	45
In the fifth, an area of ditto -	100

Note.—The *Braccio di Milano* is divided into 12 *ounces* or inches, and corresponds to 5.95 palms, which may be calculated at 22 English inches nearly.

Amount in Weight of Mulberry Leaves consumed by the Silk-worms. 1073 lbs. of Leaves, for every ounce of Ova, have been consumed, divided as follows, viz.

First age, eaten -	lbs. 4	Leaves, &c. destroyed unused.	
Second do. -	12	In first age,	lb. 1
Third do. -	40	In second do.	2
Fourth do. -	120	In third do.	6
Fifth do. -	732	In fourth do.	13
	lbs. 908	In fifth do.	68
			lbs. 95

In the course of the management of the silk-worms, the 1073 lbs. of leaves from the tree (from evaporation, and other causes) will have lost 70 lbs.

Note.—There have been devoured by the silk-worm about 515 lbs. of pure mulberry leaves. The 1073 lbs. of leaves as taken from the tree will yield [illegible] lbs. of cocoons, calculating from one ounce of ova.

The artificial heat necessary in Count Dandolo's process, is kept up by a stove of tile, those of iron being injurious. The necessary dryness of the air may be produced by absorbent substances, and when it is too dry, shallow vessels of water are placed on the floor.

For farther information on this subject, see Reaumur, *Mem. Acad. Par.* 1710. Aglionby, *Phil. Trans.* 1699, vol. xxi. p. 183. Bon, Id. Id. 1710, vol. xxvii. p. 2. Daubenton, *Mem. Acad. Par.* 1779, p. 1, 1785, p. 45. Rev. G. Swayne, *Transactions of the Society of arts*, vol. vii. p. 123, 148. Dr. Anderson's *Bee*, No. 72, 95, 156. Dr. Anderson *on the Culture of Raw Silk on the Coast of Coromandel. Transactions of the American Philosophical Society*, vol. ii. Count Dandolo, *Dell' Arte di Governare i Bachi da Seta 2 da. Ediz.* Milano, 1818. Murray, in Dr. Brewster's *Journal of Science*, No. III. p. 59; and Murray's *Remarks on the Cultivation of the Silk Worm, with Additional Observations made in Italy during the Summer of* 1825, Glasgow, 1825. An Account of the History, Value, and Present State of the Silk Manufacture in *England* will be found in our article England.—of *France*, in our article France.—in *Italy*, in the article Italy.—and in *India*, in our article India.

SILVER. See Chemistry, Metallurgy, and Mineralogy.

SILVER, Fulminating. See Chemistry, and Fulminating Powders.

SILURUS, See Ichthyology, and Electricity.

SIMIA. See Mazology.

SIMPSON, Thomas, a celebrated English mathematician, was born at Market Bosworth in Leicestershire, in 1710. He was brought up to his father's profession of a weaver, but such was his love of study, that he soon quitted his profession and supported himself by teaching a school. An absurd propensity for astrology, while it rendered him a sort of oracle in his neighbourhood, involved him in some difficulties, which obliged him to remove to Derby, where he continued some years, following his trade in the day, and teaching a school in the evening. Notwithstanding his industrious habits, he found it difficult to provide for his family, and he was then induced to remove to London in 1736. Here he followed his business in Spittalfields, and taught mathematics at his leisure hours, and so great was his success, that he brought his wife and three children to London, where he settled himself permanently.

His first work was a *New Treatise of Fluxions*, which was published by subscription in 1737, and such was its reception, that, in 1740, he published *A Treatise on the Nature and Laws of Chance*, which was followed in the same year, with his *Essays on several curious and interesting subjects in Speculative and Mixed Mathematics*. These works extended his reputation even to foreign countries, and he was elected a member of the Swedish Academy of Sciences. His *Doctrine of Annuities and Reversions*, appeared in the same year, and an *Appendix* to it in 1741. Supported by the influence of Mr. Jones, the father of Sir William, our author was, in 1743, appointed professor of mathematics in Woolwich, and in the same year he published his *Mathematical Dissertations*. In 1745, he was admitted a fellow of the Royal Society, having been excused his admission fees on account of his limited income. In 1744, he published his *Treatise on Algebra*, which was enlarged in 1755. In 1747, he published his *Elements of Geometry*, which was reprinted in 1760, and subsequent years. In 1748, Mr. Simpson printed his *Trigonometry Plane and Spherical, with the Construction and Application of Logarithms*. His *Select Exercises for Young Proficients in Mathematics* appeared in 1752, and his last work, viz. his *Miscellaneous Tracts*, came out in 1757.

Mr. Simpson was likewise the author of several papers which appeared in the Philosophical Transactions, and he edited the Lady's Diary from 1754 till 1760, a work to which he had been a contributor since 1736, and which he raised to a very high degree of respectability. By the closeness of his application, his health began to suffer. A languor of mind and body supervened, and the vexation arising out of a difference with one of his colleagues exaggerated the calamities under which he suffered. In February, 1761, he set out for Bosworth, to seek in his native air the elements of health, but he gradually grew worse, and expired on the 14th of May, 1761, in the 51st year of his age.

SIMSON, ROBERT, M. D. a celebrated Scotch mathematician, was born on the 14th October, 1687, O. S. at Kirktownhill, Ayrshire, a small property which, for some generations, had been the residence of his immediate progenitors. He was the eldest son, and was educated at the university of Glasgow, where he devoted his attention principally to the philosophy and theology of the schools, and such was his progress that, at an early age, during the illness of the professor, he taught the class of oriental languages.

While he was studying theology at the divinity hall he took a fancy for mathematics, and amused himself occasionally with this new study; but it soon gained upon his affections, and it was not long in supplanting his passion for theology. He accordingly abandoned himself wholly to the study of geometry, preferring the sure methods of the ancients to the analytical method which had now so many supporters.

At the early age of twenty-two, the members of the college offered him the mathematical chair in the University of Glasgow, in which a vacancy was soon expected. Reluctant, however, to advance at so early an age from the situation of a student to that of a professor in the same college, he solicited and obtained permission to spend one year in London. Here he became acquainted with Mr. Jones, Mr. Caswell, and Mr. Ditton, who gave him ample information respecting the progress of mathematics both in England and on the continent of Europe. When the vacancy in the mathematical chair occurred in 1711, he was unanimously elected, after giving a specimen of his skill in mathematics, and of his dexterity in teaching geometry and algebra.

Immediately after his admission, which took place on the 20th November, Mr. Simson entered upon the duties of his class with much zeal and success, and, instigated by the advice of Dr. Halley, he directed his private studies to the restoration of the ancient geometers. His first labour was to restore the Porisms of Euclid, the history of which we have already given in our article PORISMS. The next object of his labour was the "Loci Plani" of Apollonius, which he completed in 1731, but which he did not venture to publish till 1746. Notwithstanding all this caution, he recalled all the copies in the hands of his bookseller, and kept the impression by him for several years. He afterwards revised and corrected this work, which greatly extended his reputation, and obtained him a high place among the geometers of his age.

In 1750 our author published his *Sectionum Conicarum libri Quinque*, a work which he intended as an introduction to the study of Apollonius.

The restoration of the elements of Euclid was the great object of Dr. Simson's care; and, along with the data, he published this valuable work in 1750.

The *Sectio Determinata* of Apollonius next occupied his attention; but this work was not published till after his death, when it was printed, along with the Porisms of Euclid, and published at the expense of Earl Stanhope.

"As he never entered into the married state, and had no occasion for the commodious house in the university, to which, as professor, he was entitled, he contented himself with chambers spacious enough for his own accommodation, and for containing his large, but well selected collection of books, but without any decoration or even convenient furniture. His official servant acted as valet, footman, and bed-maker; and as this retirement was entirely devoted to study, he entertained no company at his chambers; but on occasions when he wished to see his friends, he repaired to a neighbouring house, where an apartment was kept sacred to him and his guests. He enjoyed a long course of uninterrupted health, but towards the close of life he suffered from acute disease, which obliged him to employ an assistant in his professional labours. He died on the 1st of October, 1768, at the age of 81, leaving to the university his valuable library, which is now kept apart from the rest of the books. It is still regarded as the most complete collection of mathematical works and manuscripts in the kingdom, many of them being rendered doubly valuable by the addition of Dr. Simson's notes. It is open for the public benefit, but the use of it is limited by particular rules and restrictions. Dr. Simson was of a good stature, and he had a fine countenance, and even in his old age he retained much gracefulness and dignified manner. He was naturally disposed to cheerfulness; and though he seldom made the first advances towards acquaintance, he always behaved with great affability to strangers." Those who wish for a more particular account of the life and writings of this able geometer, we must refer to "Dr. Trail's *Account of the Life and Writings of Dr. Simson*," Lond. 1822, a work of great ability and interest. See also our articles ANALYSIS, EUCLID, and PORISMS.

SINAI, Mt. See ARABIA.

SINDE, SINDY, or SCIND. See INDEX.

SINES. See TRIGONOMETRY.

SINGAPORE, or SINCAPORE, is a town situated on a small island of the same name at the southern extremity of the Malay peninsula.

The town and principality were founded by adventurers who emigrated originally from Sumatra, and it was a place of little importance till 1819, when a British settlement was formed there under the direction of Sir T. S. Raffles, Lieutenant Governor of Bencoolen.

The town, though still in its infancy, is rapidly extending according to a regular plan adopted some years ago. It is built near the shore, and the part of it devoted to trade stretches along an inlet of the sea, about 300 feet wide at its mouth, and affording a safe and well sheltered harbour. Several parallel and cross roads extend from this over the plain, which is occupied chiefly as a military cantonment. Behind the cantonment is a hill on which it is intended to erect a government house.

The rapid rise of this important station, says Sir T. Stamford Raffles in a letter written in 1822, is perhaps without a parallel. When I hoisted the British flag, the population scarcely amounted to 200 souls. In three months, the number was not less than 3000, and it now exceeds 10,000, chiefly Chinese. No fewer than 173 vessels, principally native, arrived and sailed in the first two months. The following is the state of its trade in 1822:—

Exports,	66,978 Tons.	
Imports,	63,661	
Total,	130,639	
Number of vessels importing in 1822,		1,593
Ditto exporting in do.		1,733
Total,		3,326
Value of Imports in 1822,	3,610,206 Dollars.	
Exports do.	3,172,332	
	6,782,538	
Not in official returns,	1,713,639	
Total Exports and Imports in Dollars,	8,496,177	

The interior of the island exhibits a succession of hill and dale, covered with wood. The soil is fertile, the water good, and the climate cool and healthy. The mean annual temperature of Singapore for 1822 was 80° 18, and for 1823 79° 81, giving a mean of 80°.* In 1822, there were 218 rainy days, and in 1823, 208. The mean annual height of the barometer for these two years, was 29.91 English inches. An account of the method of collecting the Fucus Saccharinus, (or *agar-agar*) on the coral shoals, near Singapore, and of preparing it for the Chinese market, will be found in Dr. Brewster's Journal of Science, No. XV. p. 162.

The Straits of Singapore consist of innumerable little islands of various shapes, and covered with wood, indented with little bays and caves, in which the finest turtle abound. At the east end of the Straits, lies the rock of *Pedrabanca*, so called from its being covered with the white excrements of birds. Among the animals at Singapore we may mention the halicora dugong, the flying squirrel, and the galeopithecus variegatus. The junks which visited Singapore in 1821, when Mr. Finlayson was there, were from Canton, Amoy, Cochin China, and the islands to the east. The larger ones were from 200 to 300 tons burden. They had neither chart, nor book of any kind, but merely a rude compass. A newspaper, called the Singapore Chronicle, is published here. See Finlayson's *Mission to Siam and Hue*. Lond. 1826, p. 45-77. East Long. 104°, and North Lat. 10° 24'.

SION, or SITTEN, the *Civitas Sedunorum* of the Romans, is a town of Switzerland. and capital of the Canton of Valais. It is situated on the Rhone, at the foot of three insulated rocks, and is traversed by the Sitten, a brook which springs from an adjacent glacier. The town is tolerably well built and contains a cathedral, an Episcopal palace, a town-house, a public school, six churches, and several monasteries. On the highest of the rocks above mentioned, called Tourbillon, stand the ruins of the old Episcopal palace. On the second rock, called Valeria, stand the remains of the old cathedral, and a few houses, in which the canons reside; the third rock, Mayoria, is occupied by the Episcopal palace, an ancient stone building, erected in 1547. In one of its apartments the diet assembles, and in the other the bishop holds his court. Population 5000. East Long. 7° 9', North Lat. 46° 11.

SIR JAMES LANCASTER'S SOUND, an immense inlet opening from Baffin's Bay at N. Lat. 74°, and about 30 minutes of Long. W. from the meridian of Washington City. This Sound, the existence of which was long doubted, has been recently explored and made memorable in geographical discovery by Captain Parry, of the British navy, who entered it in 1820, penetrated to Melville Island, and ascertained its existence as far West as 117° W. from Greenwich, or 40 W. from Washington City. Reduced to English statute miles, Sir James Lancaster's Sound is determined eight hundred miles from Baffin's Bay, and gives precision to the geography and hydrography of the earth in those Arctic regions. Commencing with Cape Farewell, the separation of North America and Greenland is shown upwards of 2000 miles. Hearne, McKenzie, and Franklin, have found the open northern ocean, at N. Lat. 68, and 69°. The discoveries of Hearne and Franklin, have placed the termination of North America, directly south, 7 degrees of latitude from Melville Island. The mouth of the Unjigah is, according to our best maps, at N. Lat. 69°. The discoveries of the British and Russians, when combined, leave uncertain but a small portion of the northern coast of North America, and prove two very important facts in Geography, the existence of a Polar continent, or very extensive group of islands, and the slight connexion, if not entire separation of America and Greenland.

DARBY.

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* See Dr. Brewster's *Journal of Science* No. XV. p. 61.

SIRENE.—The Sirene, an instrument for measuring the number of vibrations of the air, which are required to produce a sound, was invented by Baron Cagniard de la Tour. It was made on the principle that if, as is the general opinion, the sound of instruments is produced by the regular impulses given to the air, by their vibrations, then any mechanical means of striking the air with the same regularity and velocity should also produce sound.

The invention is as follows: A current of air is passed from a bellows by a small orifice, which is covered by a circular plate, moving on a centre, at a little distance on the side of the aperture. Through this plate there is bored a certain number of oblique holes in a circle round the axis, which passes over the orifice of the bellows; and the holes are placed at equal distances from one another. When the plate is made to turn round, which, owing to the holes being oblique, may be easily done by the current of air itself, or by mechanical force, the aperture is alternately open and shut to the passage of the air, by which means a regular succession of blows is given to the outward air, and produces sound similar to the human voice, and varying in the degree of acuteness, according to the velocity of the plate.

In the instrument, in place of one aperture, there are many, which are opened and closed at the same time, by which means its strength is increased, without the height of the sound being at all interfered with. The instrument is a circular copper box, four inches in diameter, having its upper surface perforated with a hundred oblique holes, each a quarter of a line wide, and two lines in length; there is an axis upon which the circular plate moves, on the centre of this surface; this plate is also pierced with 100 holes, similar to those below, and equally oblique, but lying in a contrary direction. The circumstance of their being oblique is not necessary to produce sound, but it gives motion to the plate by the passing air. The connexion between the box and the bellows that supplies with air, is effected by means of a tube.

In the experiments made for the purpose of ascertaining the vibrations for each sound, the revolution of the plate was accomplished by wheel work, set in motion by a weight: the bellows were then put in action only to judge whether the sounds of the instrument agreed with the notes of the harmonica, which consists of an arrangement of iron or steel bars, made to vibrate by a bow.

Thus constructed, the instrument was made to produce the diatonic notes of the gamut, and even some beyond them: the revolutions of the plate were estimated by the revolutions of a wheel, which turned with a velocity of thirteen times and a half less than that of the plate.

The following table is the result of these experiments; but the inventor of the instrument intends to refine and improve his machinery, and then repeat and extend them.

Notes.	No. of revolutions made by the wheel in 1′.	No. of revolutions made by the plate in 1″.	No. of vibrations produced in 1′.
la	19	$4\frac{27}{100}$	427
si	$21\frac{1}{4}$	$4\frac{77}{100}$	477
ut	$22\frac{3}{4}$	$5\frac{11}{100}$	511
re	25	$5\frac{67}{100}$	567
mi	28	$6\frac{30}{100}$	630
fa	30	$6\frac{75}{100}$	675
sol	34	$7\frac{65}{100}$	765
la	38	$8\frac{55}{100}$	855
si	$42\frac{1}{2}$	$9\frac{55}{100}$	955
ut	$45\frac{1}{2}$	$10\frac{23}{100}$	1023
re	50	$11\frac{25}{100}$	1125

The first la corresponds to the second of the harmonica, and is the unison of the common diapason.

If water is passed into the Sirene in place of air, sound is produced, even though the instrument be entirely immersed; and the same number of concussions produces the same sound as in the air. It was owing to this circumstance of the instrument being sonorous in water, that it has acquired the name of Sirene.

The instrument now described is nearly the same as one invented by the late Dr. Robison and described in his *System of Mechanical Philosophy*, vol. iv. p. 405. The following is the passage which contains it.

It seems to be the general property of sounds that a certain frequency of the sonorus undulations gives a determined and unalterable musical note. The writer of this article has verified this by many experiments. He finds that *any noise whatever*, if repeated 240 times in a second, at equal intervals, produces the note C *sol fa ut* of the guidonian gamut. If it be repeated 360 times, it produces the G *sol re ut, &c.* It was imagined that only certain regular agitations of the air, such as are produced by the tremor or vibration of elastic bodies, are fitted for exciting in us the sensation of a musical note. But he found, by the most distinct experiments, that any noise whatever, created the same effect, if repeated with due frequency, not less than 30 or 40 times in a second. Nothing surely can have less pretension to the name of musical sound than the solitary snap which a quill makes when drawn from one tooth of a comb to another: but when the quill is held to the teeth of a wheel whirling at such a rate that 720 teeth pass under it in a second, the sound of G *in alt* is heard most distinctly; and if the rate of the wheel's motion be varied in any proportion, the noise made by the quill is mixed, in the most distinct manner, with the musical note corresponding to the frequency of the snaps. The *kind* of the original noise determines the kind of the continuous sound produced by it, making it harsh and fretful, or smooth and mellow, according as the original noise is abrupt or gradual; but even the most abrupt noise produces a tolerably smooth sound when sufficiently frequent. Nothing can be more abrupt than the snap now mentioned, yet the *g* produced by it has the smoothness of a bird's chirrip. An experiment was made of a sound which was less promising than any that can be thought of. A stopcock was so constructed that it opened and shut the passage through a pipe 720 times in a second. This apparatus was fitted to the pipe of a conduit leading from the bellows to the wind chest of an organ. The air was allowed to pass gently along this pipe by the opening of the cock. When this was repeated 720 times in a second, the sound *g in elt* was most smoothly uttered, equal in sweetness to a clear female voice. When the frequency was reduced to 360, the sound was that of a clear but rather harsh man's voice. The cock was now altered in such a manner that it never shut the hole entirely, but left about one-third of it open. When this was repeated 720 times in a second, the sound was uncommonly smooth and sweet. When reduced to 360, the sound was more mellow than any man's voice at the same pitch. Various changes were made in the form of the cock, with the intention of rendering the primitive noise more analogous to that produced by a vibrating string. Sounds were produced which were pleasant in the extreme. The intelligent reader will see here an opening made to great additions to practical music, and the means of producing musical sounds, of which we have at present scarcely any conception; and this manner of producing them is attended with the peculiar advantage, that an instrument so constructed can never go out of tune in the smallest degree. See the *Annales de Chim. et de Phys.* vol. xii. p. 167, and Robison's *System of Mechanical Philosophy*, vol. iv. p. 403—405.

SITTINGBOURNE, a small town of England, in the county of Kent. It forms chiefly one wide street, extending along the high road, which here descends towards the east. The church, which is the principal public building, is a spacious edifice, with a nave, two aisles, a chancel, two chapels, and a tower at its west end. With the exception of the tower, the whole has been rebuilt since 1762, when it was destroyed by fire. There is a curious monument in the north or Bayford chapel, having in its recess the emaciated figure of a female in a winding sheet. There are here many urns, some of which are very elegant and commodious. In 1821 the town and parish contained 294 houses, 325 families, 269 families employed in trades, and 1,537 inhabitants. See *Beauties of England and Wales*, vol. viii. 697.

SIVAS, anciently Cabira or *Sebaste*, a large town of Asiatic Turkey, and capital of a government of the same name. It is situated on the great river Kizil Irmak, near its source, and on the north side of a plain which it traverses. There are two stone bridges about a mile distant. The town is dirty and ill built, being composed of wood, roofed with masses of stone and clay. In the middle of the town are some extensive gardens, and on an artificial hill is an old castle falling into ruins. Some of the public buildings are said to be elegant, and some of the monuments lofty. There is a celebrated Armenian monastery not far from the town. Numbers of horses are reared in the vicinity, and corn is grown in great abundance in the valley. The size and population of the town is said to equal Liverpool. See Jackson's *Journey from India*.

SIUT, Assiout, supposed to be the ancient *Lycopolis*, is a large city of Upper Egypt. It stands on an artificial eminence about half a mile from the Nile, with which it communicates by a canal, crossed by a bridge of three arches. It is a well built town, and is copiously supplied with water. In the mountain above the city there are several spacious caverns, in one of which, hewn out of a free stone rock, there are three chambers, one 60 by 30, another 60 by 26, and a third 26 by 25. Caverns still more spacious occur farther up the mountain. The caverns are carved with hieroglyphics and emblematical figures. The Soudan caravans pass through this town, and form its chief support. Fine flax grows in great quantities in the neighbourhood. Flax and wheat are exported to Upper and Lower Egypt, and salt and other goods are brought back in exchange. Population about 25,000. East Long. 31° 38'. North Lat. 27° 25'.

SIWAH, or Siouah, a town and an oasis in the Libyan desert, celebrated as being the most probable site of the temple of Jupiter Ammon. Hornemann represents the valley as fifty miles in circumference, and Brown, as six miles long and four broad. The town is situated upon and around a mass of rock, in the subterranean caverns of which the ancient inhabitants are said to have resided. The houses still have the appearance of caves, and are huddled together in such close confusion that many of them have no light, and a stranger requires a guide to conduct him through the labyrinth. It is said to resemble a beehive, from its dense population and the confused hum which it emits. The territory is said to furnish about 1500 men capable of bearing arms. From being on the great caravan route, it is a place of considerable trade, many of the inhabitants being employed in the conveyance of goods between Egypt and Fezzan.

From the fertility of this territory, in the middle of an extended desert, and the catacombs in the neighbouring mountains, Siwah has been thought to be the site of the temple of Jupiter Ammon. Accordingly, there occurs a few miles to the westward a remarkable mass of ruins, called by the natives Ummebeda, and the original purpose of which cannot now be discovered. In the middle of a space enclosed by a wall about 900 feet in circumference, are found the ruins of what seems to have been the principal edifice. It is about 30 feet long, 27 feet high, and 24 wide. The walls are six feet thick, and the roof consists of large blocks of stone cemented together with small stones and lime.

There is no sculpture on the exterior of the walls, but in the interior are three rows of emblematical figures, apparently designed for a procession, and the space between them is filled with hieroglyphics. In some places even the colours remain. One of the springs near this building is sometimes cold and sometimes warm. After the rains, the ground in the vicinity of Siwah is for many weeks covered with salt.

SKELETON. See Anatomy, Index.

SKIDDAW. See Cumberland.

SKIPTON, a market town of England, in the West Riding of Yorkshire, is situated in the middle of a fertile vale of the same name. It consists principally of one long and wide street, and the houses are built of stone. The church, which stands at the end of the main street, is a spacious building, with a tower at the west end, and seems to have been rebuilt in 1655. The other buildings are a new town-house, and a grammar school, which has a good library. Skipton castle, a little to the east of the church, is said to have been erected soon after the conquest. Its works and defences were destroyed in 1646. Skipton is a great mart for grain, and great quantities of cattle and sheep are sold at its numerous fairs. There are here a paper mill and a cotton manufactory. The Leeds and Liverpool canal passes close by the town, and has numerous warehouses and wharfs on its banks.

In 1821, the township of Skipton contained 667 inhabited houses, 684 families; 462 families employed in trade, and 3411 inhabitants. See the *Beauties of England and Wales*, vol. xvi. p. 723.

SKY, Isle of, from *Ski*, which expresses mist or clouds in the Scandinavian language, the second largest of the Hebrides, or Western Isles of Scotland, is separated from the main land by various channels, the narrowest of which is less than one third of a mile in breadth. Its form is extremely irregular. Its greatest length is 45 miles, and its breadth from 10 to 24 miles. It occupies 342,000 English acres, of which about 30,000 are arable. It is deeply indented with inlets of the sea, so regularly distributed, that there is no spot of the island more than four miles from salt water.

The shores of this island, excepting at the bottom of the bay, are extremely rocky, and in the north-east and north-west, the coast sometimes rises to a height of more than 700 feet. In its general aspect the island is extremely mountainous. Blaven, the highest mountain in Sky, exceeds 3000 feet in height, and the mountain ranges vary in height from 1500 to 2500. Some of these hills are remarkable for the dark blue tints which they reflect, while others present a deeply indented outline, and inaccessible and overhanging peaks.

The principal sea lakes, or arms of the sea, are, Loch Oransa, Loch Ainort, Loch Portree, Loch Snizort, Loch Fallart, Loch Braccadale, Loch Harport, Loch Eynort, Loch Brittle, Loch Scavig, and Loch Eishert. The fresh water lakes, which are few in number, are, Loch Cornisk, Loch Creich, Loch Columb Kill, and Loch Shiant, or the Sacred Lake. The vallies are watered with rapid streams, which scarcely deserve the name of rivers. That which issues from Loch Correisk is the longest, but the largest are those which fall into Lochs Snizort and Portree, the principal of which is the water of Snizort, and the rivulets which issue from Loch Fud and Loch Leatha, the last of which forms a fine cascade at its exit from the lake. A stream near Loch Staffin falls into the sea through a height of 300 feet. The rivers abound in trout and salmon, and in the small rivers Kilmartin and Ord, is found the great horse muscle, in which pearls occur.

The climate of Sky is very wet, and scarcely three days out of twelve are free from rain. The clouds attracted by the hills sometimes break in useful and refreshing showers, and at other times burst in water-spouts, which deluge the plains and destroy the crops. Stormy winds, too, set in about the end of August and the beginning of September, and often greatly injure the standing corn. The temperature of the Island corresponds with its latitude. It is, however, very variable, like the Scottish climate in general, and about the end of winter and early in spring the air is cold and sharp. The prevailing diseases are agues, fevers, rheumatisms, and dysenteries. The people, are, however, healthy, for in 1821 there were in the parish of Sleat a woman upwards of 100, and in that of Portree *two* men and *five* women upwards of 100, and in that of Duirinish *one* male and *three* females.

The Island belongs to the county of Inverness. It is divided into seven parishes, whose population in 1821 was as follows:

	Houses.	Families.	Families in Trade.	Population in 1821.
Braccadale	375	376	18	2103
Duirinish	669	707	53	4147
Kilmuir	624	638	40	3387
Portree	530	555	21	3174
Sleat	459	476	37	2608
Snizort	525	534	32	2789
Strath	462	472	21	2619
Total	3644	3758	222	20,827

The presbytery of Sky includes, besides the above parish, that called the Small Isles, which is mostly in Argyllshire. The king is the patron of all these livings. The two principal proprietors are Lord Macdonald and Macleod of Macleod, the former of whom possesses three-fourths of the island, principally in its east end. The estate of Macleod occupies the N. W. portion. Strathard belongs to Mr. Macalister, and Macleod of Rasy owns a small track near Portree.

The principal towns or villages are Portree, the capital of the island, Stein, Kylehaven, and Broadford.

There is in Sky every variety of soil, except pure sand. In the district of Trotternish there are 4000 acres of loam, and loam and clay upon a gravelly bottom. In Sleat and Strath, and in Macleod's country, are extensive tracts of light friable mould upon gravel, and likewise some loam mixed with peat earth, well adapted for the established rotation of crops. The crops usually cultivated are beans, oats, potatoes, and some flax. Artificial grasses and hemp have been lately introduced. The grain raised in good years is estimated at about 10,000 bolls. The live stock of Sky is reckoned to be 4000 horses, of a small but hardy breed; 18,000 head of cattle of an excellent breed, of which about 3800 are exported annually. The sheep are estimated at about 40,000, consisting chiefly of the Cheviots and the black-faced Lintons. Hogs, goats, and rabbits abound, and game of all kinds is plentiful.

There are many ancient forts and monuments of a Druidical character in this island, various cairns and stones. At Struan, on the top of a rock, are the remains of a circular fort, 42 feet in diameter. The romantic castle of Dunvegan, the seat of Macleod, situated on a high rock at the bottom of Loch Fallart bay, forms two sides of a small square, and on the third side there is a Danish tower. The walls are, in two places, about seventeen feet thick. Between Dunvegan and Talisker are the remains of a massy wall, and the vestiges of a ditch encircling a precipitous rock, accessible only on one side; and on the summit of another adjacent rock is a Danish inclosure of a circular form, consisting of strong masonry without cement. The diameter of the inside is forty-two feet, and within it are vestiges of five small circular apartments. The entrance, which is covered with flags, is six feet high, and the walls of the inclosure are considerably higher. There are two large cairns about two miles to the north of this.

Duntuilm castle, or the castle of the large grassy eminence, was originally a seat of the Macdonalds. It stands on a lofty precipice near the north end of the island. Though in ruins, it is still in tolerable preservation. The remains of the castle of Dunscaich, the poetical residence of Cucullin, is boldly situated on an insulated rock, which a drawbridge connects with the shore. The ruins of the castle of Knock stand on the opposite side. The huge cairn of Bencallfach is said to have been erected over the grave of a Norwegian princess.

The geology of this island is exceedingly interesting, but even the briefest notice of it would exceed the limits of an article like this. In our article SCOTLAND, we have already given a general view of it in relation to the rest of the kingdom.* Many fine groups of basaltic columns occur on the island. In the parish of Snizort there is a perpendicular obelisk about 360 feet round at its base, and about 300 feet high, and on the same side of the parish there is a fine cataract about 90 feet high, with an arched hollow path in the middle across the rock, through which five or six persons can walk abreast. The *Spar Cave*, one of the greatest geological curiosities in the island, has been already fully described in our article GROTTO.

Many beautiful and even rare minerals are found in Sky, viz. perfect crystals of analcime at Talisker, chabasie in the rocks of the Storr; stilbite, mesotype, madelstein, laumonite, apophyllite, hyperstene, actynolite, and steatite.†

Sky is particularly distinguished, not only in Scotland, but perhaps in the world, for its grand and romantic scenery. Every part of its coast and finely indented shores abounds with scenes of unrivalled beauty and grandeur. Among these the most singular is Loch Scavaig and Loch Coruisk. The former is a narrow lake, encircled by rocky mountains dipping into the sea, and variegated with numerous isles of rock. From this we pass on a sudden into the sequestered lake of Coruisk, which occupies a glen about four miles long and half a mile wide, walled in with tremendous rocks of bleak and desolate grandeur. The lake, with its verdant isles, is about three miles long. All is here dreary silence and gloomy sublimity.

Sky is the country of caves: one of those in Strathaird sheltered prince Charles. Another in Loch Braccadale, disappointed Dr. Johnson. For farther information respecting this interesting island, see Johnson's *Tour to the Hebrides*, 1775. Martin's *Description of the Western Islands*. Dr. Anderson's *Account of the Hebrides*. Macdonald's *Survey of the Hebrides*. Macculloch's *Description of the Western Islands*. Macculloch's *Letters on the Highlands*, 1824.

SLATE. See MINERALOGY, Index.

SLAVE LAKE, if correctly delineated in Tanner's map of North America, is the third if not the second most extensive body of fresh water on this planet. The two great sources of the Unjigah appear to rise from the eastern slope of the Chippewayan mountains, and flow to the north-east. The most southern stream, Elk river, after a course of eight hundred miles, enters the western end of Athapescow lake, from which it again issues, and immediately below the outlet receives the Unjigah, an equal if not superior volume of water. The united stream, marked as Slave river, between N. Lat. 58° 30′ and 61° 30′, flows NNW., and expands in the great body of Slave Lake. The position and extension of this recipient is from NE. by E. to SW. by W. 350 miles, with a very unequal, but mean width of about 40 miles. From its extreme western angle issues Mackenzie's river, or more correctly the Unjigah river. The body of Slave Lake extends from 33° to 42° W. from Washington City, 1400 miles NW. from Lake Superior, and very nearly equi-distant, 700 miles from the Pacific Ocean and Hudsou's Bay.

DARBY.

SLAVE TRADE, is the name given to that commerce in slaves carried on principally between Africa and the West India Islands. This trade was begun by the Portuguese about the year 1481, when they established their first fort at D'Elmina. The other nations in Europe gradually followed the example, and a system was established by which the chiefs of the African tribes doomed their prisoners of war and their convicts to everlasting servitude, and exchanged them for the luxuries of European commerce. As the West India Islands advanced in prosperity, the demand for slaves increased. Speculators and adventurers from every part of Europe carried to the coast of Africa the alluring articles of their respective manufactures. Thus tempted on all sides, the African tyrants resolved to use every practicable method of obtaining slaves. War was excited for the purpose of taking prisoners. The innocent were charged with crimes which they never committed. The helpless were seized by violence, and the inhabitants of their own villages were sometimes carried off in a body to supply the means for the inhuman barter.

The victims thus seized are marched like cattle in droves to the river side or to the sea coast. They are coupled two and two by the neck with pieces of wood, or by other contrivances. Some are loaded with their provisions or with articles of trade for the masters. The weak must keep up with the strong, and the old must proceed at the same pace with the young.

When they reach the coast purchasers innumerable appear on all sides. The sale commences and the slaves when purchased are conveyed to their respective ships. The men are confined together two and two by fetters of iron, and put into the fore part of the vessel, the women occupy the after part, and the boys the middle. These apartments are grated at top for the admission of light. In good weather they are brought upon deck for air. They are ranged in a row on each side of the ship, and a long chain passes through the fetters of each pair to secure them to the side of the ship. After their meals, which consist of horse beans, rice and yams, with a little water, oil and pepper, they are forced to jump as high as their shackles will permit to the beat of the drum. When the cargo is made up, the ship weighs anchor, and the horrors of the *middle passage* commence.

The slave vessels vary from 12 to 800 tons, and carry from 30 to 1500 slaves. The height of the apartments varies from three to six feet, so that in some it is impossible to stand erect, and in others to sit down. In the best ships each person has scarcely as much room as a man has in his coffin. Lying on the bare boards, suffocated by the heat and moisture exhaled from themselves, excoriated by the rolling of the vessel, and immured in the filth of their lair, death is often

* The fullest details on this subject will be found in Dr. Macculloch's work on the Western Islands of Scotland.
† See our article SCOTLAND, for a list of Scottish minerals, in which the localities of the above species will be found

the least evil which befalls them. Some destroy themselves, and others seek revenge against their oppressors.

In this condition the blood-freighted vessel reaches its destined harbour. Wafted into the peaceful bay of a tropical shore teeming with the luxuriance of animal and vegetable life, it floats its living cargo among scenes of purity and peace. Here the slaves are prepared for sale. Sometimes they are disposed of to the highest bidder by public auction, and sometimes by a process called the "scramble." For this purpose the main and quarter decks are covered with sails, and the slaves are brought out into the gloomy area. The purchasers at a signal rush in among them with long ropes, and endeavour to enclose as many of them as possible. On some occasions the scramble is held on shore in an apartment or court yard, at the doors of which the purchasers are let in in a similar manner. The terror of the poor Africans is beyond description. The women cling to each other, and some of them have been known to expire with fear. Friends are here separated for ever. The father parts from his child, and the expressions of affection which often accompany the act of separation, are checked and even punished by the merciless purchasers.

About one fourth of the slaves shipped on the African coast expire during the passage; and during the first ten years of their servitude in the West Indies, which is called the period of seasoning, nearly the same number perish. From these two causes the annual loss of negroes was computed to be 45,000. The treatment of the slaves in the West India islands varies with the character of the proprietor; but there can be no doubt that in general it was severe and harsh, and in some instances marked with a brutality incompatible with the usages of civilized life.

Such is a brief view of that traffic which long stained the character of enlightened Europe. Many philanthropists raised their voice in favour of the unhappy Africans;—many politicians attempted to remove the stain from their country, and many Christians wept over the thought that such crimes could be tolerated in a Christian land. The miseries of the poor Africans were sung by our poets, were declaimed upon by our orators, and even discussed by our sages; but neither the song, nor the declamation, nor the argument mitigated their destiny. It was reserved for a band of men,—of Christian men,—entrenched in the strongholds of their faith, pure in their patriotism, and firm in their purpose, to free their religion and their country from the reproach of partaking in the odious crime. The men who took the leading part in bringing about this moral revolution, were Mr. Granville Sharpe, Mr. Thomas Clarkson, and Mr. Wilberforce, aided by many wise, and pious, and honourable men, whose names we cannot undertake to enumerate.* The active and persevering mind which gave life and motion to every combination, and which carried through even the drudgery of its details, was that of Mr. Clarkson, a man whom Providence seems to have endowed with all the qualities which were demanded for so difficult a work. The most deep-rooted prejudices everywhere beset his progress. The sophistry of metaphysics arrayed all its subtleties against the cause. The sordid views of self interest brought into the field still more formidable antagonists; but the most alarming enemy of all was the apathy and indifference of the nation. All these difficulties he contrived to surmount. He unmasked the man of syllogisms in his quibbles. The speculator he arrested behind his counter, and with the hand of Prometheus he put life into the inert mass of the people.

It would be interesting to trace in detail the steps by which these grand objects were effected; but our limits will not permit us: and the subject is perhaps more suited to a chapter in the life of Mr. Clarkson, when it shall please Providence to call him to his reward. A rapid notice however will be expected by our readers.

When Dr. Peckard became vice-chancellor of the university of Cambridge in 1785, he gave out as the subject of the bachelor's prize, "*Anne liceat invitos in servitutem dare?* Is it right to enslave others against their will?" Mr. Clarkson, who had gained the bachelor's prize of the preceding year, gained also this. His mind was turned to the subject, and at the age of twenty-four he resolved to devote himself to the cause of the negroes. His Prize Essay be was induced to publish in an enlarged form, under the title of "An Essay on the Slavery and Commerce of the Human Species, particularly the Africans," which was honoured with the first prize in the university of Cambridge for the year 1785. The judicious and extensive distribution of this book made the great cause generally known; and Mr. Clarkson began with zeal to devote himself to the arduous labours which he had undertaken. By conversing with those who had been in Africa and the West Indies—by visiting the slave ships in the Thames—by an extensive correspondence with persons in Liverpool, and by repeated intercourse with members of parliament, he made himself master of the details of his subject, and he interested influential persons in his cause, by the information he communicated to them. Among those who entered most ardently into his views was Mr. Wilberforce, one of the members for Yorkshire, who pledged himself to bring forward the measure of abolition in the House of Commons, and who used his influence and his talents in every way in which they could be subservient to Mr. Clarkson's views.

A committee of zealous and good men was formed on the 22d May 1787, to carry through the abolition of the African slave trade. Mr. Clarkson now drew up a "Summary View of the Slave Trade, and of the probable consequences of its abolition." This little work of about twelve pages, containing the substance of the question, was circulated throughout the kingdom, and Mr. Clarkson set out on a journey to collect evidence and new information. About 100 petitions to parliament were presented by those who favoured the abolition; and, in consequence of Mr. Wilberforce's severe illness, Mr. Pitt introduced the question into the House of Commons, on the 9th May 1788, by a motion "that this House will early next session take into consideration the circumstances of the slave trade complained of in the petition, and what may be fit to be done thereupon." Pursuing the same views, Sir William Dolben, on the 21st May, brought in a bill

* It is due to historical truth to state, that the society of Friends took a most active and benevolent interest in this great work. As individuals and as a body, they have done honour to their species, and exalted themselves in the estimation even of those who differed most from them on speculative points in religion and politics.

for regulating the number of slaves to be carried by the tonnage of the vessel. This bill, after a warm opposition, passed both Houses, and received the royal assent on the 11th of July.

Having gained these preliminary points, Mr. Clarkson and the committee were roused to new exertions. Above 50,000 pamphlets were circulated, and much fresh evidence procured. On the 19th March 1789, Mr. Wilberforce moved the House to consider its own resolution of last session. This motion was agreed to; but it seemed only to rouse all the passions and interests which it affected. An opposition of the most tremendous character was excited, and such was the cry which was raised against the motion, against the characters of the abolitionists, that many well-wishers of the cause began to waver in their opinions. Mr. Wilberforce's motion was, on a motion of Mr. Pitt's, postponed till the 12th May, when Mr. Wilberforce, in a speech of three and a half hours, introduced the question into parliament, and laid down twelve leading propositions. These lay on the table till the 21st May, when the opponents of the measure insisted upon bringing forward evidence against it. In this way they gained time, and from the slowness with which they adduced their evidence, the question was postponed to next session.

In order to get the better of these dilatory measures, Mr. Wilberforce carried a motion that the witnesses should be examined in a committee room. The opponents of the measure closed their case, and that of the abolitionists came to be heard. Mr. Clarkson, who had been in Paris pleading the cause among the leaders of the French revolution, and who had been on board every ship of war at our naval stations to collect witnesses, now arranged his evidence for the House of Commons. Twenty-five witnesses were examined this session, and forty-five gave their evidence at the beginning of the next. The revolution in St. Domingo, however, and an insurrection in Dominica, furnished the anti-abolitionists with plausible arguments. The complete emancipation of the slaves, the indemnification of the planters, the massacre of the whites, and the total ruin of our colonies, were held forth as the immediate consequences of abolition. These circumstances produced a powerful effect, and notwithstanding the powerful, and eloquent, and argumentative appeal of Mr. Wilberforce, on the 18th April 1791, the question was lost by 163 votes against 88. This minority was graced with the names of Pitt, Fox, Burke, Grey, Sheridan, Wyndham, Whitbread, and Francis; and mortifying as the defeat was, it served perhaps to advance the cause, by enlisting on its side the feelings of the great body of the people, and by giving the committee an opportunity of unmasking the specious pleas of their opponents, and placing in their true light the imaginary horrors which had been held out as the legitimate consequences of the abolition.

In June 1791, Mr. Clarkson undertook to abridge the evidence taken before parliament. It was printed in September, and in order that it might be perused by the people, he followed his book through the island; he employed influential individuals to peruse it, and lend it out to others, and with the aid of Mr. William Dickson, a zealous ally, he completed his arduous task.

By the end of March 1792, no fewer than 517 petitions against the slave trade were laid before parliament. On the 2nd of April, Mr. Wilberforce moved that the African slave trade be abolished. The house agreed to its *gradual abolition*, but various divisions took place both then and on the 23d and the 25th of the same month, on the question whether it should terminate in 1793, 1795, or 1800. Both 1793 and 1795 were rejected; but the intermediate year of 1796 was preferred to 1800, by a majority of 151 to 132.

It now came to the House of Lords, where evidence was again heard, and the matter postponed to next session.

In 1793, Mr. Wilberforce again moved the Commons on the subject; but his motion was lost by a majority of 61 against 53. In May, he again moved for a bill to abolish that part of the trade by which British merchants supplied foreigners with slaves. This motion was carried by a majority of seven, but the bill was lost on the third reading by a majority of 31 to 29.

Thus defeated on all hands, the abolitionists were thrown into a state of inconceivable perplexity. Vexation and disappointment had begun to affect even the powerful mind of Mr. Clarkson. His bodily frame now gave way, and he nearly lost his memory, his hearing, and even his powers of articulation. Mr. Wilberforce, however, still kept the field, and tried the question in 1796, 1798, and 1799, but he could gain nothing but the acknowledgment of the principle of abolition in a limited time. The year 1800, 1801, 1802, and 1803 were allowed to pass without any new application to parliament; but in 1804, after the union with Ireland, which added to the House of Commons several warm friends of abolition, Mr. Wilberforce resumed his motion of abolition in a limited time, which was carried by very considerable majorities. When taken up to the Lords, however, it was postponed to next session.

In 1805, Mr. Wilberforce's renewed motion was actually lost by a majority of 77 to 70; but this defeat, severe as it was, was compensated by the re-appearance of Mr. Clarkson at his post. The cause had declined with his health, and was again destined to revive under his management. The death of Mr. Pitt in January 1806, led to the formation of a new ministry under Mr. Fox and Lord Grenville, who, to a certain degree, took up the question of abolition as a cabinet measure. With this view the Attorney-General brought in a bill to prohibit British merchants and British capital from being employed in the foreign slave trade. This bill passed both Houses, and in the debate which took place, both Lord Grenville and Mr. Fox declared that they would exert themselves to effect the abolition of the slave trade, and that they would consider their success as adding more glory to their administration than any other measure which they could pass. Mr. Fox accordingly, on the 10th June, moved "that this House, considering the African slave trade to be contrary to the principles of humanity, justice, and policy, will, with all practicable expedition, take effectual measures for the abolition of it in such manner, and at such a period as may be deemed most advisable." This motion was carried by 114 against 15. Mr. Wilberforce then moved an address to his Majesty, praying him "to direct a negotiation to be entered into by which foreign powers should be invited to co-operate with his Majesty in measures to be adopted for the abolition of the African slave trade." This was carried without a division.

The resolutions and the address were submitted to the House of Lords, on the 24th June, by Lord Grenville in a speech of great power. They were both carried by a majority of 41 against 20. It was now generally believed that the slave trade would be abolished during the next session; and therefore it was feared that the merchants would avail themselves of this last year to carry on the trade to a tenfold extent. Another bill was therefore introduced and carried, to prevent any new vessel from going to the coast of Africa for slaves.

The session of 1807 was not far advanced when the subject was again introduced. Lord Grenville thought it expedient to introduce it into the House of Lords under the name of an act for the abolition of the African slave trade. It was presented on the 2d January. Four counsel were heard against it on the 4th, and on the 6th, after a brilliant debate, it was carried at six in the morning by a majority of 100 to 36. On the 10th January, it was brought before the Commons; on the 20th counsel was heard against it; and on the 23d January, upon the motion of Lord Howick (Earl Grey,) it was carried by the triumphant majority of 283 to 16. After the blanks were filled up, it again passed both Houses, and received the royal assent on the 25th January 1807, a day memorable in the annals of humanity.

SLEAFORD, New, a market town of England, in Lincolnshire, is agreeably situated on the Slea. The place is flourishing, and has a handsome Gothic church, with a tower and spire 144 feet high. It has a free school, and a hospital for twelve poor men. Population of the town and parish in 1821 about 2220. See *Beauties of England*, vol. ix. p. 758.

SLESWICK, or South Jutland, is a province of Denmark. It occupies 3600 square miles, and has a population of 300,000 on the mainland, and 40,000 on the islands. The chief towns are

	Population.
Flensborg	15,000
Kiel	7,000
Sleswick	7,000
Tondern	2,600
Tonningen	2,000

See our articles Denmark, and Kiel.

SLESWICK, the capital of the above province, is agreeably situated on the river, or Gulf of Sley. It is very long, and irregularly built. The houses are of brick, and resemble, in their neatness and general aspect, those of the Dutch. The principal buildings are the cathedral, five churches, the town-house, the orphan house, the work-house, and the nunnery of St. John. There is here a refinery of sugar, and manufactories of leather, earthen ware, and sail cloth. The Sley is now navigable by means of a canal. The old palace of Gottorp, which is a large brick building, encircled with a rampart and moat, stands close to the town. East Lon. 9° 35′. North Lat. 54° 32′.

SLIDE is the name given to an inclined plane for facilitating the descent of heavy bodies by the force of gravity. In general, they have been objects of no great importance; but one was lately erected at Alpnach, in Switzerland, which has excited great interest throughout Europe.

For many ages, the craggy sides and the deep ravines of Pilatus, a lofty mountain near Lucerne, were thickly clothed with vast and impenetrable forests of spruce fir, of the largest size, and the finest quality, surrounded on every side by the most terrific precipices, inaccessible to all but a few daring hunters, who, at the risk of their lives, scaled these precipitous rocks and crags, in pursuit of the chamois. It was from these bold adventurers that the first intelligence was derived concerning the size of the trees, and the extent of the forests, until a foreigner, who had visited their sequestered glades and gloomy recesses, in pursuit of the chamois, was struck with amazement at the sight, and pointed out to the attention of several Swiss gentlemen, the vast extent, and superior quality of the timber. The project of making use of these rich natural stores, was however rejected as chimerical by persons, whose experience and skill made them competent to judge; and it was consequently abandoned. This attempt having failed, these immense and valuable forests would, in all probability, have been suffered to flourish and decay, without ever being applied to the use of man, if it had not been for the enterprising genius, and the unwearied exertion of M. Rupp, a native of Wirtemberg, who, owing to some political changes which had taken place in his own country, had settled near the Lake of Lucerne. His curiosity being strongly excited by the accounts he had heard of the forest, he was induced to visit it. He was so much struck by its wonderful appearance, that he entertained the idea of being able to convey the trees into the Lake of Lucerne, solely by their own gravity. During his long residence in Switzerland, his character and talents were so much appreciated, that, with the assistance of three Swiss gentlemen, he soon formed a company from among the proprietors, with a joint stock, to enable them to purchase the forest, and to construct a road or *Slide*, down which it was intended the trees should be precipitated in the Lake of Lucerne, an arm of which washed the bottom of the mountain, from which they could be easily conveyed by the Rhine to any part of the German Ocean. This stupendous undertaking was finished in 1816.

The Slide of Alpnach was composed of between 25,000 and 30,000 large pine trees, squared by the axe, and formed into a sort of trough, about six feet broad, and from three to six feet deep. In the bottom of the trough there was a groove for the reception of a small stream of water, let in over the side of the trough every now and then, in order to keep the whole structure moist, and thereby to diminish the excessive friction, occasioned by the rapidity of the descent of the tree.

The slide was sustained by cross timbers, and these cross timbers were themselves supported by uprights fixed into the ground. It was sometimes carried along the faces of the most rocky eminences, sometimes it went under ground, and again it crossed the deepest ravines, where it was supported by scaffoldings 120 feet high. The skill and ingenuity which were displayed, and the difficulties which were surmounted, in this vast undertaking, gained a just tribute of admiration to the enterprising individual who projected and carried it through. Before the work could even be begun, it was necessary to cut down many thousand trees, to obtain a passage for the labourers through the impassable thickets. And M. Rupp was himself frequently obliged to descend the steepest precipices, suspended by ropes, at the imminent hazard of his life. And though he was attacked by a violent fever, yet his ardour was so great that he had himself conveyed every day, on a barrow, to the mountain, in order to superintend the operations of his workmen. The expense attending this undertaking was, according to one account, £9,000 or £10,000; but according to another only £4,250. Before the trees were launched into the slide some previous preparation was necessary, which consisted in lopping off the branches, and stripping them of the bark, that they might descend with the greater ease. Every thing being prepared, the tree was introduced into the trough, with the root foremost; and it descended with such velocity as to reach the lake in 6 minutes, a distance of about three leagues or nine miles; but the largest trees performed the same distance in about three minutes. In order to prevent the accidents, which might take place, if the tree was let off before every thing was ready at the lower end, a regular telegraphic communication was established between the two extremities of the slide; and workmen were posted at regular distances, of about a mile from each other, and so arranged that every station should be visible from the ones both above and below it. When the tree was launched the workmen at the upper end hoisted their telegraph, (which consisted of a board, turning at its middle on a horizontal axle. The board when placed upright was visible from the two stations above and below it, but when it was turned horizontally it was not perceptible from either,) the same signal was repeated by all the rest in succession, so that the workmen at the lower end of the trough received intimation of the approach of the tree almost instantaneously. In a few minutes the tree came thundering past the men, and plunged into the lake. The lowest board was then turned down, which was followed immediately by all the rest, and thus the workmen at the top were informed of the safe descent of the tree. The same operation was repeated during the rest of the day; and it was so arranged that a tree should descend every five or six minutes. When the progress of the tree was impeded by any obstacle, or when it started out of the trough, the board was only half depressed; and as the workmen knew by this signal that something was wrong, those who occupied the stations above and below the place where the tree had stuck, came and assisted in removing the obstruction, which was generally occasioned by the springing of a beam in the trough.

In order to prove the enormous force which the trees acquired by the rapidity of their descent, M. Rupp caused some of them to spring from the trough. The result was, that they penetrated the earth by their thickest ends to the depth of 18 and sometimes 24 feet. And one of them having accidentally come in contact with another, cleft it from top to bottom with the violence and rapidity of lightning. In order that none of the small wood might be lost, M. Rupp constructed several extensive manufactories in different parts of the forest, for the purpose of reducing it to charcoal. He also built magazines for preserving it when made. The trees, after having reached the lake, were made up into rafts, and floated down the Reuss by the Aar, into the Rhine. By this rapid conveyance, they generally arrived at Basle a few days after they had left Lucerne. At Basle they passed out of the hands of the company. They were still floated down the Rhine in rafts to Holland; and thus performed a journey of about 4000 miles in less than a month from the time they left Pilatus, until they arrived at the German Ocean.

We are sorry to add that this stupendous work of art is now totally destroyed; and that almost every trace of it is obliterated on Mount Pilatus. The great demand which formerly existed for the timber having entirely ceased, owing to political causes, the cutting and transporting of the timber was necessarily discontinued, and the slide was suffered to go to ruin. See Playfair's *Works*, vol. i. Appendix, No. 2, p. 89.

SLIDING RULE. See Arithmetic, where we have given a drawing and description of this useful instrument. In the Philosophical Transactions for 1815, p. 9—29, Dr. Roget has published a "description of a new instrument for performing the involution and evolution of numbers," in which will be found many useful observations and improvements on the sliding rule. An account of it will be found in the Supplement to this work, together with a description of Dr. Young's improved sliding rule for gauging casks. See Brande's *Journal*, vol. xvi. p. 367.

SLIGO, a county of Ireland, in the province of Connaught, is bounded on the east by Leitrim, on the south by Roscommon, on the south-west and west by Mayo, and on the north by Donegal Bay. Its greatest length from north to south, from Bunduff to the Curlew mountains, is 39½ miles, its greatest breadth 38, and its area 465,280 English acres. It contains six baronies and 39 parishes, and sends to parliament three members. About a third part of this county is occupied with bogs, mountains, and lakes. The best part of it is to the south of Sligo, where the county is fertile and beautiful, there being about 140 square miles where the soil is suited for grazing or tillage. In other places a good deal of the soil is shallow and moorish, lying above what is called *lea-clea* or grey flag. The waste land lies principally in the north and west.

The principal streams are the Sligo, Bonnet, Owenmore, Arva, Cooloney, Esky, and Moy, which separates the county for several miles from Sligo. The Sligo, which flows out of Lough Gill, is navigable to Sligo, and the Moy is navigable for six or seven miles from the sea.

The chief fresh water lakes are Lough Gill, Arva, Talt, and Gara. Lough Gill, which possesses some charming scenery, has a number of wooded islands, on one of which, viz. Innismore, are the ruins of a church, and the remains of other buildings. Lough Arva is about eight miles long, covered with islands, and irregular in its form. The Arva flows out of it northward to Ballysadere, and throws itself in a stupendous cataract into the ocean. The chief bays are those of Killala and Sligo, which communicates with Lough Gill. The island of Innismurry lies to the north of Sligo Bay. There are salmon fisheries of considerable importance on the Sligo and the Moy. Trout abounds in the Talt and Gara, and white fish is found plentifully on the coast.

The principal minerals in Sligo are iron, which has for some years been wrought, lead, manganese, copper, and silver. There are strong indications of coal near Lough Gill, and there are various fine clays fit for pottery. Limestone, and limestone gravel abound, and also marl.

The estates in Sligo vary from £5000 to £9000 a year, and belong chiefly to absentees. The size of farms varies from three Irish acres to 500. The leases are for 36 years and three lives, and sometimes for 61 years and three lives. The chief articles of produce are oats, barley, and potatoes. Illicit distillation is carried on very generally. Cattle and sheep are reared to a considerable extent.

The principal articles of export are linen, salt, kelp, butter, and corn.

The principal places in this county are Sligo, and about 20 hamlets, at which fairs are held.

The state of the peasantry in Sligo is nearly as bad as in any part of Ireland, with respect to their labour, their food, and their clothing. In 1815 the price of labour was only 10d. a day, and 1s. 1d. in seed time and harvest.

The population of the county was about 60,000 in 1790; but in the last census, taken in 1821, it was 127,879. The catholics are to the protestants as 80 to 1; and in 1815 there were in the parish of Kilmactige 1200 catholic, and only ten protestant families. See Parlan's *Statistical Survey of Sligo*, 1802.

SLIGO, a seaport town of Ireland, and capital of the preceding county, is agreeably situated at the mouth of the river Sligo, where it falls into Sligo bay. The chief buildings are a court-house, a jail, barracks, an infirmary, and a charter-school, handsomely endowed by the family of Wynne, the patrons of the burgh. The castle of Sligo, now in ruins, was built in 1262. There was a monastery built about the same time, the ruins of which are of some magnitude. Three sides of the cloister, covered with an arched roof, still remain; the workmanship of the arches and pillars is extraordinary, and sculpture adorns some of the pillars. The great east window is beautiful, and the relievos on the high altar deserve notice. The nave is spacious, with a sort of gallery round it, supported by stone pillars.

The harbour of Sligo admits vessels of 200 tons close to the quay. The exports consist of large quantities of linen for the English market in a finished state, and also of salt, butter, and kelp. There is here a linen hall, and in the county there are many bleaching greens. The town is governed by a provost and a town clerk. The population is above 10,000. The town sends one member to parliament.

SLING. See ARMS.

SLIP, among shipbuilders is used to denote a place with a gradual slope on the banks of a river, suited for shipbuilding.

Mr. Thomas Morton, late shipbuilder, Leith, has given the same name to an apparatus for hauling vessels out of the water, in order to be repaired. This contrivance is a substitute for dry docks, and having erected it in his own building yard at Leith, and brought it to perfection by successive improvements, Mr. Morton secured the exclusive right to it by a patent.

Mr. Morton's slip is represented in section in Plate DII. Fig. 1, where A, B, C, are the sections of three railways, forming a plane, inclined at nearly the same angle, as the slips generally used by shipbuilders. This railway is placed on a sloping beach, and extends from above the reach of the tide down to low water mark. A carriage or frame of timber seen in section at D, E, F, G, H, runs along the iron railway upon rollers on truck wheels, guided by flanges. Blocks are laid upon the middle or keel beam E of the carriage to such a height, that the keel of the vessel may clear the ends of the cross pieces D and F, and each block embraces four trucks, two on each side of the beam. The blocks seen at M and N, which slide upon the cross pieces, are made up to suit the rising of the ship's bottom; they run out to the extremity of the cross pieces, and their ropes *r*, *s*, (*r* belonging to the left hand blocks, and *s* to the right hand ones) crossing the carriage, are reeved through a sheave attached to the opposite cross piece, up to the top of the rope rod. The shores S, S, (when any are necessary) are put into their places, turn upon a joint at T, and are prevented, when the vessel is floating on, from falling outwards by a small chain. Mr. Morton was at first in the practice of using shores; but having never found the slightest inconvenience or risk, even with vessels of the sharpest bottoms, many of which have been upon the slip, he has not of late found it necessary to use them, though they are particularly specified in his patent. He is still of opinion, however, that they may be useful when ships of war are brought upon it, for which, he is confident, it is well calculated.

In order to haul ships ashore, the carriage thus prepared is let down the inclined plane generally at low water. The chain of a powerful purchase is then attached to the carriage, and a waterstaff is placed at the fore end of the keel beam, to mark the depth of the water, and to be a guide in floating the vessel on. The vessel is then brought to the lower end of the carriage, and hauled over it, (having bow and quarter lines to steady her) till the advanced part of the keel takes the blocks between the fore foot guides. The ends of the ropes *r s* are now taken on board from the rods R R, but kept slack, and the vessel is hauled forward as the water flows, until the keel takes the blocks at the contracted part of the guides, which are just wide enough to receive it. Being still afloat abaft, having been previously so trimmed, the vessel is then adjusted over the blocks abaft by a water line. When the iron guides *a b*, *c d*, are hauled up by their ropes *a e*, *d f*, they confine her to settle down truly. By heaving the purchase, she will soon take the blocks abaft, which is observed by the water mark left upon her bottom. She is trimmed upright, and the foremost bilge, or sliding blocks, hauled in tight. As she rises out of the water, each succeeding block is hauled in, but not till the weight of the vessel has settled well on her keel; and the shores (if used) are brought to her sides, and there secured. Thus prepared, she is hauled up the inclined plane at the rate of from 2½ to 5 feet per minute, by six men to every hundred ton. When hauled up, she is shored from the ground; the keel beam is secured from moving; and the sliding blocks, with the cross pieces are, in a few minutes, removed, when the vessel is ready to be repaired.

The blocks being relieved of the vessel in the usual manner, the keel beam, with the after cross beam will run from under her. The carriage is again put together, and another vessel can be hauled up astern of the former. In point of fact, it is usual to have more than one vessel on the slip at the same time.

In launching a vessel, the cross pieces with their blocks are placed beneath her, and she immediately descends into the water. In order to launch and haul up vessels the same tide, temporary blocks are put under the bottom of the vessel to be launched, upon the cross pieces, instead of the sliding blocks which are prepared as before to suit the bottom of the vessel to be taken up. The vessel is then launched, and she and the temporary blocks which steadied her, float from the carriage. The other vessel is then taken on and hauled up as formerly described.

The advantages of this invention are numerous and important. It can be erected in situations where it is impracticable to have a dry dock, and at an expense which is comparatively inconsiderable; and it can be removed from one place to another, and may even be carried on board a ship, and applied to use on voyages of discovery and in remote situations, where repairs would otherwise be impracticable. The apparatus and the ship under repair being both above ground, the air has a free circulation; the men work with more comfort, and in winter they have the light much longer than within the walls of a dry dock. There is a saving of time in carrying the materials for repairing the ship; and such is the facility of the whole operation, that ships can be hauled up and inspected, and even get a trifling repair, and be launched again the same tide. As the mechanical power is attached solely to the carriage, the vessel is exposed to no strain, and the work of repair on one vessel is never interrupted by hauling on another, as in dry docks.

The whole expense of Mr. Morton's slip, exclusive of the cost of preparing the foundation and laying down, (which must vary according to circumstances) may be stated nearly as follows, viz.

For vessels of	100 tons	£450
	200	600
	300	800
	400	1000
	500	1100

and for vessels of greater burden in proportion.

An attempt was made about four years ago to invade Mr. Morton's patent; but his right was finally established by a court of law. On this occasion a number of witnesses were examined, including several officers of high rank in the royal navy, who all agreed that the slip was an invention of great practical utility; the naval officers being farther of opinion, that it might be made to answer for hauling ships of war out of water as well as mercantile vessels. The editor of this work has also seen the most satisfactory statements from a number of shipbuilders and others who have used the slip for several years, during which not a single accident has occurred in their practice, any more than in that of the patentee himself. It is now in use in many of the seaports of Great Britain and Ireland; slips have also been sent by Mr. Morton to France and Russia by the orders of the governments of these countries; and one, we understand, has been recently forwarded to Philadelphia.

With reference to the introduction of the slip into the United States of America, it may be mentioned, that within these three years an apparatus, meant to serve the same purpose, has been erected at New York by a native of Great Britain, all the valuable parts of which seem to have been taken from Mr. Morton's slip, with the addition of other contrivances of little or no utility, to give it the appearance of an original invention. The expense of this construction must have been several times that of Mr. Morton's. The apparatus laid down at Manhattan Island, understood to be for vessels of 400 or 500 tons, having cost, (but every thing included till it was ready for use,) nearly £17,000; and it does not appear to be calculated to receive more than one vessel at a time. We have looked into the documents containing these facts, and think it due to our country and our countrymen, that our transatlantic brethren should not be allowed the merit of an invention to which they have no just claim.

Such we conceive to be its importance to the mercantile interest, that we think it may be useful to mention some of the ports in different parts of the United Kingdom, where it may be seen in use, viz.

Aberdeen	Harwich	Shields
Arbroath	Ipswich	Shoreham
Berwick	Irvine	Sunderland
Borrowstownness	Leith	Swansea
Dublin	Liverpool	Waterford
Dumbarton	Maryport	Whitehaven
Dysart	Newcastle	Workington
Edinburgh (Union Canal)		

SLOANE, Sir Hans. See Botany.

SLUICE, Governor. See Hydrodynamics.

SLUICE, an account of several new and ingenious sluices invented by Mr. Thom of Rothsay, will be found in Dr. Brewster's *Journal of Science*, vol. ii. p. 100, 102, 288; vol. iii. p. 154, 155, 343: and vol. iv. p. 180. A drawing and description of the most important will appear in the Supplement to this work.

SLUSE, René Francis, an eminent Dutch mathematician, was born of a noble family at Vise, near Liege, in 1622. He filled the office of canon of St. Lambert in Liege, and abbot of Amaz, and grand chancellor to the bishop and prince of Liege. He died at Liege in 1685, in the 63d year of his age. Slusius was a man of great literary as well as mathematical attainments. His principal work is entitled *Mesolabium seu duæ mediæ prop. per circulum et ellipsin vel. hyp. infinitis modis exhibitæ*, Leod. 1659, the second edition of which appeared in 1668, with an addition on analysis and geometrical miscellanies. He was a fellow of the Royal Society, and published the following papers in the *Philosophical Transactions*.

1. A Short and Easy Method of Drawing Tangents to all Geometrical Curves.
2. Demonstration of the same.
3. On the Optic Angle of Alhazen. See Montucla's *Hist. des Mathematiques*, tom. ii. p. 66, 159, &c.

SMALL-Pox. See Inoculation.

SMEATON, John, a celebrated civil engineer, was the son of an attorney, and was born at Austhorpe, near Leeds, on the 28th May 1729. At a very early age he evinced a great passion for mechanical pursuits, and displayed much ingenuity in the formation of his tools, and in various pieces of mechanism which he constructed; but it does not appear that he had devoted his time to scientific pursuits till he had reached the period of full manhood.

In 1742 his father who was anxious that he should follow his own profession, took him to London, where he attended the courts in Westminster Hall; but finding that nature had intended him for other purposes, he addressed a memorial to his father, which obtained him permission to follow the bent of his own genius.

From this time Mr. Smeaton continued to reside in London, and about 1750 he established himself as a mathematical instrument maker, a profession which brought him in contact with the ingenious men in the metropolis, and from this time he seems to have devoted himself particularly to philosophical pursuits.

In the same year he communicated to the Royal Society an *Account of Dr. Knight's Improvement of the Mariner's Compass.* In 1752 he communicated to the same body three papers, viz. an account of *some improvements on the air pump:* a description of *an engine for raising water by fire, being an improvement on Savary's construction to render it capable of working itself. invented by M. de Moura of Portugal;* and *a description of a new tackle of pulleys.* In 1751 he had invented a *machine for measuring the way of a ship at sea*, and he made two voyages in company with Dr. Knight to try it, and also a compass which he had invented. This instrument he subsequently described in the *Philosophical Transactions* for 1754.

In the year 1753 Mr. Smeaton was admitted a member of the Royal Society. In 1754 he laid before them an account of his *New Pyrometer,** and in the same year he undertook a voyage to Holland and the Netherlands, to see the works of art which these countries contained. The inland navigation of Holland must have particularly occupied his attention, and it is probable that he henceforth resolved to devote himself to the profession of an engineer.

In December 1755, when the Eddystone lighthouse was destroyed by fire, the proprietors applied to Lord Macclesfield, the president of the Royal Society, to recommend a proper person to rebuild it. His lordship recommended Mr. Smeaton, who executed the work to the satisfaction of all parties.

A full account of all Mr. Smeaton's operations has already been given in our article LIGHTHOUSE.† Mr. Smeaton's own account of this great work appeared in a folio volume in 1791, and he is said to have remarked that this work cost him more trouble than the erection of the lighthouse itself.

So early as the years 1752 and 1753 he was occupied with *an Experimental Enquiry respecting the natural powers of water and wind to turn mills and other machines depending on circular motion.* This inquiry was carried on by means of working models of undershot, breast, overshot, and wind mills, and an account of it under the above title, was in 1759 laid before the Royal Society, who honoured it with the Copley medal. A full account of these experiments has been already given in our article HYDRODYNAMICS and in MECHANICS.

Notwithstanding the reputation which Mr. Smeaton derived from the Eddystone lighthouse, he does not appear to have been fully employed as an engineer even five years after its completion. In 1764 he was appointed one of the receivers of the Derwentwater estates, and in the discharge of this duty he made many improvements on the mills, and on the estates of Greenwich Hospital. In 1775, when his business as an engineer had greatly increased, he was desirous of resigning that appointment, but at the urgent entreaty of his friends he consented to continue two years longer.

In 1771 he and his friend Mr. Holmes became proprietors of the works for supplying Deptford with water; and on this occasion it is likely that he made those experiments on the friction of water in conduit pipes, and on the discharge of water through orifices, which were found among his papers, and which were first printed in our article HYDRODYNAMICS, through the kindness of Mr. John Farey.

In the construction of mills our author exhibited sagacity and practical talent, improved by theoretical knowledge. Descriptions and drawings of his overshot and breast wheels are given in our article Hydrodynamics. He erected also a steam-engine at Austhorpe, in order to determine the power of Newcomen's steam engine, upon which he made considerable improvements.

About the year 1785, when his health began to give way, Mr. Smeaton withdrew himself, as much as possible, from the cares of business, in order that he might complete his description of the Eddystone lighthouse and some other works. These he fortunately lived to finish; but when he was walking in his garden at Austhorpe, on the 16th September 1792, he was afflicted with a paralytic stroke, which cut him off on the 28th October 1792, in the 69th year of his age.

Mr. Smeaton was a man of plain and unassuming manners, which were enlivened by a considerable portion of the fervour of genius. In his domestic and social capacity he was affectionate, kind, and sincere, and an ardent and unsolicited patron of merit. Besides the works which we have already mentioned, he published the following papers in the Transactions.

On the Effects of Lengthening the Steeple and Church of Lestwithiel in Cornwall, Phil. Trans. 1757, p. 198.

Remarks on the different Temperatures of the Air at the Eddystone Lighthouse and at Plymouth. Id. 1758, p. 488.

On the Menstrual Parallax arising from the Mutual Gravitation of the Earth and Moon: its Influence on the Observation of the Sun and Planets, with a Method of Observing it. Id. 1768, p. 156.

Description of a New Method of Observing the Heavenly Bodies out of the Meridian. Id. 1768, p. 170.

Observations on a Solar Eclipse. Id. 1769, p. 286.

Description of a New Hygrometer. Id. 1771, p. 198.

An Experimental Examination of the Quantity and Proportion of Mechanical power necessary to be employed in giving different degrees of velocity to heavy bodies from a state of rest. Id. 1776, p. 450.

Observations on the Graduation of Astronomical Instruments: with an explanation of the Method invented by the late Mr. Henry Hindley of York, to divide circles into any given number of parts. Id. 1786, p. 1‡

* See our article on EXPANSION.

† The original models of this national work, and the piece of lead found in the stomach of the lighthouse keeper, were given by Mr. Smeaton, to the late Earl of Morton, at whose death lady Morton presented them to the Museum of the Royal Society of Edinburgh

‡ For an account of this valuable paper, by M. Troughton, see our article GRADUATION.

New Fundamental experiments on the Collision of Bodies. Id. 1782, p. 337.

Observations on the Right Ascension and Declination of Mercury out of the Meridian near his greatest elongation, September 1786, with an Equatorial Micrometer of his own invention and workmanship. Id. 1786 p. 318.

A volume of Mr. Smeaton's reports was published in 1797. Mr Smeaton had the merit of establishing the *Society of Civil Engineers* in 1771; but in consequence of his having received some improper treatment from one of its members, it was dissolved in 1792, by the mutual consent of the members. Another Society of Civil Engineers is now in full activity, under the auspices and presidency of our distinguished countryman, Mr. Telford.

Mr. Smeaton was invited, upon his own terms, by the Empress of Russia, to superintend the great projects which she had in contemplation. He resisted, however, all the inducements which were proposed; and the Princes Dashkoff, through whom the invitation was made, is said to have replied to his refusal. "Sir Robert Walpole was mistaken, and my sovereign has the misfortune to know that there is one man at least who has not his price."

At an early period of Mr. Smeaton's life, he met with a curious adventure, arising from his likeness to the poet Gay. When he was walking with Mrs. Smeaton at Ranelagh, he observed an elderly lady and gentleman fix their marked attention upon them. After some turns, the strangers stopped, and the lady addressing Mr. Smeaton, said, "Sir, I do not know you, but so strongly do you resemble my poor dear Gay, we must be acquainted: you shall go home and sup with us; and if the minds of the two men accord as much as their countenances, you will find two cheerful old folks who can love you well; and I think you can as well deserve it." The strangers were the Duke and Duchess of Queensberry. Mr. Smeaton accepted the invitation, and the friendship of the parties continued without interruption.

SMELTING. See Metallurgy.

SMITH, Adam, a celebrated Scottish moral and political philosopher, was born at Kirkaldy, in Fifeshire, on the 5th June 1723. He was the only child of Mr. Smith, comptroller of the customs in that town, and who had formerly been private secretary to the Earl of Loudon, when he was principal secretary of state for Scotland. His father died a few weeks after the birth of his son, whose constitution was long infirm and sickly. When he was only three years old, and on a visit to his uncle, Mr. Douglas of Strathenry, he was stolen by a party of tinkers; but in consequence of an active pursuit of the vagrants, he was rescued from them in Leslie Wood. From the grammar school of Kirkaldy he was sent, in 1737, to the College of Glasgow. In 1740, he went to Baliol College, Oxford, as an exhibitioner on Snell's foundation. At Glasgow, his principal studies were mathematics and natural philosophy; but the lectures of Dr. Hutcheson seem to have inspired him with that taste for moral and political sciences, which guided all his future inquiries.

After a residence of seven years at Oxford, he spent two years with his mother at Kirkaldy. He had been destined for the church of England; but his love of study induced him to settle in Scotland, in the expectation of one of those moderate appointments which our country offers to literary men.

In 1748, he delivered lectures on rhetoric and belles lettres at Edinburgh, under the patronage of Lord Kames, and about this time he seems to have obtained the acquaintance of David Hume and Lord Loughborough. In 1751, he was chosen professor of logic in Glasgow, and in the year following he was removed to the chair of moral philosophy. This important situation he filled for thirteen years. In 1755, Mr. Smith contributed a review of Dr. Johnson's Dictionary to the Edinburgh Review, which was begun in that year. In the year 1759, Mr. Smith published his *Theory of Moral Sentiments*, to the second edition of which he added a dissertation *On the Origin of Languages, and on the different genius of those which are original and compounded.*

Mr. Charles Townsend was so delighted with this work, that he invited Mr. Smith, about the end of 1763, to accompany the Duke of Buccleuch on his travels; and the liberal terms which were offered to him, and the strong desire he had of visiting the continent induced him to resign his professorship.

Early in 1764, the Duke and Mr. Smith set off for the continent. From Paris they went to Geneva, round by Thoulouse, and after their return to Paris in December 1765, they spent nearly a year in that capital, where he enjoyed the society of Turgot, Quesnay, Neckar, D'Alembert, Helvetius, and Marmontel. Mr. Smith returned to London with the Duke in October 1766.

The next ten years of Mr. Smith's life were spent chiefly at his mother's in Kirkaldy, with the exception of a few visits to Edinburgh and London: and his time seems to have been devoted to the composition of his *Inquiry into the Nature and Causes of the Wealth of Nations*, which appeared in 1779, and which extended the reputation of its author to every corner of Europe.

In the year 1778, Mr. Smith was appointed one of the commissioners of the customs in Scotland. He therefore removed with his aged mother to Edinburgh, where he spent the most of his time principally in the society of his literary friends. In 1787, he was elected rector of the university of Glasgow; but his constitution had now begun to give way, and his health and strength gradually declined till the period of his death, which took place in July 1790, and which arose from a chronic obstruction in the bowels. A few days before his death, he gave orders to destroy all his papers, excepting a fragment of a great work on the History of Astronomy. Mr. Smith never sat for his picture; but the medallion of Tassie gives a correct idea of his profile, and of his general expression. He bequeathed his library and the most of his property to his cousin, Mr. David Douglas, late Lord Reston, on whose education he had employed much of his leisure.

Those who wish to peruse a fuller account of the life and writings of this eminent individual, are referred to the admirable account of him by Mr. Dugald Stewart, published in the *Edinburgh Transactions*, vol. iii. p. 55. See also our article on Political Economy.

SMITH, Robert, LL.D. and D.D. celebrated as the author of a treatise on *Harmonies*, and of a *Complete System of Optics*. His early history is not recorded, but it appears that he was admitted A.B. in

1711, LL.D. in 1723, and S.T.P. by royal mandate in 1737. In 1716, he succeeded his cousin, the celebrated Cotes, as Plumian professor of natural philosophy at Cambridge; and in 1722, he published Cote's *Harmonia Mensurarum* with additions. In 1742, he succeeded Dr. Bentley as master of Trinity college, Cambridge. Having been tutor to the Duke of Cumberland, he was made master of mechanics to the king. In 1738, he published his *Complete System of Optics*, in four books, viz. a popular, a mathematical, a mechanical, and a philosophical treatise, 2 vols. 4to. It is dedicated to the right honourable Edward Walpole, and contains many original investigations and observations. In 1747, he edited a second edition of Cotes's *Hydrostatical and Pneumatical Lectures*, and in 1748, he published his *Harmonics*, of which a second edition, improved and enlarged, appeared in 1758. He died at Cambridge in 1768, in the 79th year of his age. He bequeathed two annual prizes of £25 to two commencing bachelors of arts who should be the greatest proficients in mathematics and natural philosophy. He left also £2000 for repairing Trinity College, and £2500 to the university. See Harmonics.

SMITH, one of the northern counties of Tennessee, bounded by Sumner county of Tennessee W., Wilson SW., Warren and White SE., Jackson E., and Allen and Monroe counties of Kentucky N. Length from north to south 36, mean width 15, and area 540 square miles. The surface is rather broken, with much excellent soil. Some of the sources of Big-Barren branch of Green river rise on its northern extremity and flow into Kentucky. Cumberland river is its principal stream, entering from the east, and with a curve to the southward, traverses the entire breadth of the county, receiving a large confluent, Caney Fork, near the middle, at the seat of justice, Carthage. Population, 1820, 17,580, or a fraction above 32 to the square mile. Central latitude 36° 23′ N. Long. W. from Washington City 8° 50′.

Darby.

SMOLENSKO, a town of Russia in Europe, and the capital of a government of the same name. It is situated on two hills, and on the intermediate valley, watered by the Dneiper which is here navigable. The part of the town on the right bank of the river is defended by a wall thirty feet high, fifteen thick, and about three-fourths of a mile in length. This wall, the lower part of which is of stone, and the upper part of brick, traces the course of the hills, and has towers at every angle. A ditch and a covered way, and some modern redoubts add greatly to its strength. The houses of the common people are chiefly built of wood, and are generally one story high. It is divided into two parts by a wide street paved with stone, but all the other streets are floored with planks.

It was at this town that the Russians in 1812 gave battle to the French, and were defeated; and on this occasion the town was bombarded and set on fire;* and it was here, on the retreat of the French, that part of the town was blown up, when they were compelled to fly from it by the Russians.

Since that time, so disastrous to Smolensko, a part of the town has been rebuilt in a good style, and the public buildings are now considerable. The principal edifices and establishments are twenty churches and chapels, two cathedrals, a Lutheran and a Catholic church, a gymnasium, a military and trades' school, a seminary for priests, a foundling hospital, and a consistory. The principal manufactures are those of linen, leather, hats, and soap; and a very active trade is carried on in corn, flax, hemp, timber, masts, planks, honey, wax, hides, hogs' bristles, and Siberian furs. Riga, Dantzic, and the Ukraine are the places with which the trade is carried on.

Population 12,000. East Long. 31° 56′ 36″. North Lat. 54° 50′.

SMOLENSKO, Government of. See Russia.

SMOLLETT, Tobias, an eminent Scottish novelist and poet, was the son of Archibald Smollett, the fourth son of Sir James Smollett of Bonhill. He was born at Dalquhurn, near Renton, in the parish of Cardross, Dumbartonshire, in 1721.

Smollett was educated at the parish school of Dumbarton, and he afterwards prosecuted his studies at the college of Glasgow with diligence and success. Here he contracted a fondness for the medical profession, and was apprenticed to Mr. John Gordon of that city. In this capacity he studied medicine and the belles lettres. He occasionally indulged in satirical effusions, not only against those who merited it, but against the more decent and respectable persons whom he knew, and his conversation has been described as a "string of epigrammatic sarcasms against one or other of the company." In the seventeenth year of his age he wrote a tragedy, called the *Regicide*, the subject of which was the assassination of James I. of Scotland.

In 1740, when his apprenticeship was finished, he set out for London to solicit employment in the army or navy, and to bring his tragedy upon the stage. Although the exertions of his friends could not recommend his play to the favour of the theatres, they procured for him the situation of surgeon's mate to one of the ships of the line that went out in the unfortunate expedition to Carthagena in 1741, under Admiral Vernon.† Disgusted with the navy, our author quitted the service in the West Indies, and resided for some time in Jamaica, where he became acquainted with Miss Lascelles, a beautiful woman, whom he afterwards married.

In 1746 he returned to London, and though a whig in politics, yet the love of his country predominated, and he expressed his feelings respecting the cruelties of the English troops during the rebellion, in a poem, entitled, the *Tears of Scotland*,—a poem written with elegance and spirit. In the same year he published his *Advice*, a Satire, an acrimonious attack upon several individuals of rank and fortune. In the same year he wrote an *Opera*, entitled *Alceste*, for Mr. Rich, manager of Covent Garden; but in consequence of a dispute, which exposed the manager to the shafts of his wit, it was neither acted nor printed.

* See our article France.

† Smollett afterwards gave an account of this expedition in *Roderick Random*, and one more circumstantial in the *Compendium of Voyages*, in 7 vols. 12mo. 1756.

In 1747 he published his *Reproof*, a Satire, being the second part of the *Advice*, continuing the same system of inveterate attack upon all the leading personages of the times. In the same year he married Miss Lascelles, who expected a portion of £3000 in West India property. Trusting to this expectation, he lived elegantly and hospitably; but being able to recover only a small part of the above sum, and that by means of expensive litigation, he got into serious pecuniary difficulties, which compelled him to have recourse to his pen.

He accordingly devoted his time to literature, and brought out in 1748 his *Adventures of Roderick Random*, in 2 vols. 12mo. a work which both bettered his pecuniary circumstances, and widely extended his reputation.

The tragedy of the *Regicide*, already mentioned, was published by subscription in 1749, and he derived from it considerable emolument. He went to Paris in 1750, and about this time he composed his *Adventures of Peregrine Pickle, with the Memoirs of a Lady of Quality*, which appeared in 1751 in 4 vols. This work is marked with broad humour, and great knowledge of the world. Real personages and real incidents are often described, as in Roderick Random, but the adventures, and frequently the language, were stained with an indelicacy and immorality that were highly reprehensible. The edition was quickly sold; another was bought up in Ireland; and the work was translated into French. Our author received, too, a very handsome sum for inserting in this novel the *Memoirs of Lady Vane*, which were furnished by herself, and which gave additional popularity to the work.

Notwithstanding the great success of Roderick Random and Peregrine Pickle, Smollett seems to have been anxious to quit the profession of an author. He obtained about this time the degree of M. D. probably from some foreign university, and he announced his intention to practise medicine, by a work entitled, *An Essay on the External Use of Water, in a Letter to Dr. ———, with particular Remarks upon the present method of using the Mineral Waters at Bath in Somersetshire, and a plan for rendering them more safe, agreeable, and efficacious*, 1752, 4to. In the practice of physic, however, he was not successful, and was compelled again to have recourse to his pen. In 1753 he published his *Adventures of Count Fathom*, in 2 vols. 12mo. but it was neither so ably written nor so popular as its predecessors.

Encouraged by a liberal subscription, Smollett published, in 1795, a new translation of *the History of the renowned Don Quixote, from the Spanish, &c. illustrated with 28 new copperplates*, in 2 vols. 4to. When this work was printed, he made a visit to Scotland, to visit his mother, who then resided at Scotston in Peeblesshire; and he took an opportunity of visiting various parts of his native country, particularly the vicinity of Glasgow, the scene of his early affections, where he spent two days with Dr. Moore, then an eminent surgeon in that city.

When he returned to London, he was induced to take the chief management of the *Critical Review*, a new literary Journal, which began in 1756 under the patronage of the tories, and in opposition to the *Monthly Review*, which had commenced in 1749. His next work was, *A Compendium of Authentic and Entertaining Voyages*, digested in a *Chronological Series*, in 7 vols. 12mo.

In 1757, when a stain had been left on the courage of England, our author wrote the *Reprisal, or the Tars of Old England*, an after-piece in two acts, intended to excite the national spirit. It was favourably received at Drury Lane, and is still a favourite on the stage.

Early in 1758, Smollett gave to the world his *Complete History of England, deduced from the descent of Julius Cæsar to the treaty of Aix la Chapelle in* 1748, in four vols. 4to. This work is said to have been composed and printed in fourteen months, a mental effort almost unrivalled. It was reprinted in the following year in eleven vols. 8vo. and the weekly sale was above 10,000.

When Sir John Mordaunt was tried for his unsuccessful expedition against Rochefort in 1757, some blame was cast upon Admiral Knowles, who defended himself in a pamphlet bearing his name. This pamphlet was reviewed in the Critical Review with such improper acrimony, that the Admiral prosecuted the printer for a libel. When sentence was about to be pronounced against the printer, Smollett avowed himself the author, and was sentenced to a fine of £100 and three months imprisonment. This spirited conduct on the part of our author was highly applauded, and he was visited in the King's Bench prison by many of the most distinguished characters of the day.

During his confinement he composed his *Adventures of Sir Lancelot Greaves*, which first appeared in detached portions in the monthly numbers of the *British Magazine* for 1760 and 1761, but it was afterwards published separately in two vols. in 1762. About this time he wrote the histories of *France, Italy* and *Germany*, for the modern part of the *Universal History;* and in 1761, 1762 and 1765, he published, in five volumes, his *Continuation of the History of England* down to 1765.

The unpopular administration of Lord Bute was naturally defended by Smollett, when he perceived that its unpopularity was in some measure owing to the premier being a Scotsman. For this purpose he established a weekly paper called the *Briton*, which gave rise to the *North Briton*, under the management of the celebrated Wilkes.

In 1763 our author had the misfortune to lose his only daughter, who died in the fifteenth year of her age, and left him in a state of hopeless despondency. The state of his own health, which too assiduous study had impaired, combined with this domestic calamity, induced him to quit England for a milder climate. He accordingly spent about two years in France and Italy, and on his return in 1766, he published his *Travels through France and Italy, containing Observations on Character, Customs, Religion, Government, &c.* with an account of the *Climate of Nice*, and a *Register of the Weather*, in 2 vols. 8vo.

Having arrived in Edinburgh in the beginning of 1776, and spent some time with his mother, he went to Glasgow and made a visit to his cousin Mr. Smollett of Bonhill. At this time he was distressed with rheumatism and an ulcer in his arm. He left Scotland in August without much change upon his health, and spent the winter in Bath. Here his ulcer assumed an alarming appearance, but by mercurial applications, and corrosive sublimate taken internally, a cure almost miraculous was quickly effected.

Thus restored to health, he resumed his laborious toils, and in 1767 he published his *History and Adventures of an Atom*, in two vols. 12mo., a political romance, supposed to be written in 1768, and displaying under *Japanese* names the different party men in Great Britain from 1756 to 1761.

A recurrence of his ill health induced Dr. Armstrong and his other friends to recommend a journey to Italy; and from the inadequacy of his pecuniary resources, they applied to government for the office of consul at Nice, Naples, or Leghorn. Even this paltry situation was refused by the government of Britain to one of the most distinguished of her citizens, though it was asked not as a promotion to administer to his luxuries, but as a medicine to preserve his life. The minister who thus dared to insult the sufferings of genius, and to bring discredit upon the character of his sovereign and his country, merits what he will receive, the indignation of future ages. The government who had refused this pittance to a man whose name will throw a lustre over England when oblivion has mercifully withdrawn theirs from execration, had been supported in office by his wit and argument, and the only blame which they could lay to his charge was, that he refused to degrade himself by the sacrifice of his independence.

The mental agonies of Smollett, already too severe for his delicate and susceptible frame, were deeply aggravated by this act of base ingratitude. Dr. Moore has justly observed, that many feel remorse in a fearful degree on their death-bed from the thought of dying rich; but that none feel it from the thought of dying poor. Smollett enjoyed at least this consolation when he set out for Italy in 1770. After a short residence at Leghorn he retired to Monte Nuovo, a romantic situation in its vicinity. Here he composed and published in 1776, his *Expedition of Humphry Clinker*, in three vols. 12mo. a work which met with high approbation, and is regarded as one of the best of his works. This was the last effort of his pen. His bodily strength gradually declined, and he died at his house near Leghorn on the 21st October 1771, in the 51st year of his age.

His widow erected a plain monument to his memory, with an inscription by Dr. Armstrong. In 1774 a Tuscan column was erected to his memory on the banks of the Leven by his cousin, James Smollett, Esq. of Bonhill, with an inscription partly written by Dr. Johnson, Professor G. Stuart, and Mr. Ramsay of Ochtertyre.

An edition of Smollett's works, in 8 vols. 8vo., was published in 1797, with Memoirs of his Life; to which is prefixed a *View of the Commencement and Progress of Romance*, by the celebrated Dr. Moore. Dr. Anderson had previously collected the poetical works of Smollett, which appeared with an excellent Memoir of his Life, in the works of the British Poets. The same learned editor published a new edition of his *Miscellaneous Works*, in 1796, and in 1803, he published in a separate volume, *The Life of Tobias Smollett, M. D. with Critical Observations on his Works*, which went through several editions. The following is Dr. Moore's estimate of Smollett's character:—

"The person of Dr. Smollett was stout and well-proportioned, his countenance engaging, his manner reserved, with a certain air of dignity that seemed to indicate that he was not unconscious of his own powers. He was of a disposition so humane and generous that he was ever ready to serve the unfortunate, and, on some occasions, to assist them beyond what his circumstances would justify. Though few could penetrate with more acuteness into character, yet none was more apt to overlook misconduct when attended with misfortune.

He lived in a hospitable manner, but he despised that hospitality which is founded on ostentation. He invited to his plain but plentiful table, the persons whose characters he esteemed, in whose conversation he delighted, and many for no other reason than because they stood in need of his countenance and protection. * * *

Free from vanity, Smollett had a considerable share of pride, and great sensibility; his passions were easily moved, and too impetuous when raised; he could not conceal his contempt of folly, his detestation of fraud, nor refrain from proclaiming his indignation against every instance of oppression. * * *

He was of an intrepid, independent, imprudent disposition, equally incapable of deceit and adulation, and more disposed to cultivate the acquaintance of those he could serve, than of those who could serve him. What wonder that a man of his character was not what is called successful in life."

SMUT. See Agriculture.

SMYRNA, a city and seaport of Natolia in Asia Minor, situated towards the northern part of a peninsula upon a long and winding gulf of the same name, which is capable of containing the largest navy in the world. The town is about four miles round. It presents a front of a mile long to the water, and when approached by sea, it resembles a capacious amphitheatre, with the ruins of an ancient castle crowning its summit. The interior of the city, however, disappoints the expectations thus raised. The streets are narrow, dirty, and ill-paved, and the bazaars are in no respect handsome. Two caravanserahs with quadrangles within have a showy appearance from the cupolas which cover them. The shops are arched over, and have a handsome appearance, notwithstanding the gloom which the houses wear; those along the shore have gardens attached to them, at the foot of which are summerhouses overhanging the sea. The castle of Smyrna, which was probably built by the Genoese, occupies a large hill at the east side of the city, and about three-fourths of a mile in circumference. There are no appearances of its having been very magnificent, the remains of a very thick and strong wall, being very like that which surrounded the city.

There is now scarcely a trace of those once splendid edifices which rendered Smyrna one of the finest cities of Asia Minor. The foundations of the theatre still appear on the slope of the hill. On the gateway of the castle is a fine, though mutilated colossal statue, supposed to be that of the Amazon Smyrna. There are marks of an extensive aqueduct, but its antiquity is doubted.

The river Meles which is here from 50 to 100 yards wide, waters an extensive and fertile plain behind the city, covered with numberless olive trees. This city is subject to earthquakes, and it has often suffered from the plague, which, in 1814, carried off above 50,000 of the inhabitants.

The bay of Smyrna affords excellent anchorage, and the water is so deep, that sloops of considerable burthen can anchor close to the wharf.

Smyrna carries on an extensive trade with Europe on the one hand, and Asia on the other. Of all the Asiatic nations the Armenians carry on the greatest trade with this city, and the caravans from Persia are principally composed of them. The European shipping regulate their motions by the periods at which these caravans arrive and depart, in order that they may supply the Asiatics with the merchandise of the west, and may reload their own vessels with the goods of Asia. The English carry on the greatest trade with Smyrna, and are most esteemed. The French trade is carried on chiefly from Marseilles, and the Italian trade from Leghorn. The exports from Smyrna are coffee, cotton, wool, camel and goat's hair, currants, wax, soap, pearls, and lapis lazuli, precious stones, opium, rhubarb, amber, musk, and gums. The imports from Europe are piastres, cloth, silken stuffs, paper, cochineal, argol, indigo, sugar, lead, tin, glass, spices, dyewoods, &c.

The whole town is a continual bazaar, abounding with the best commodities of Europe and Asia. In 1790, 1791, and 1792, the exports to London were £779,610, and the imports thence to Smyrna, £848,240.

The inhabitants of Smyrna are generally estimated at 100,000, and are composed as follows:—

Turks - - - - -	50,000
Greeks - - - - - -	30,000
Armenians - - - - -	15,000
Europeans - - - - -	5,000

The governor is appointed by the Porte. He decides the civil matters of the city; but in criminal cases he is subject to the cadi who is judge of the district. In the neighbourhood of Smyrna, there are some very fine villages, such as Bournabat, Cuklireiah, Bugiah, and Sadig, to which the more opulent inhabitants resort in summer. East Long. 27° 4′ 45″, North Lat. 38° 29′.

SNAKE. See OPHIOLOGY.

SNELLIUS, WILLEBROD. See OPTICS.

SNOW is the name given to the watery vapour in the upper region of the atmosphere, when frozen during its descent to the earth.

Snow is a congeries of an immense number of separate and transparent crystals of ice; and its whiteness is owing to the same cause as the whiteness of froth or of painted glass, namely, to the accumulated light which each separate crystal reflects to the eye of the observer.

The specific gravity or density of snow is very variable, as the following table will show.

		No. of inches of snow that yield one inch of water.
Sedileau	-	5½
De la Hire	-	5½
———	in 1710	12
Weidler	1728	9
Muschenbroek	1729	24* Utrecht.
Mr. Bryce	1766	10 Kirknewton in Scotland.
Mean of the above		11

When the snow falls during frost the flakes are always less, and they are greater when the air is warm. In July 1819, in the neighbourhood of Edinburgh, a slight shower of snow fell, in which the flakes were fully *two inches and a half* in length. Two or three years afterwards a similar fall was noticed in another part of Scotland.

Snow is occasionally found in North America in *balls* and in *cylinders.* On the 1st April 1815, Professor Cleaveland observed a great number of balls of snow from 1 to 15 inches in diameter, the small ones being nearly spherical, and the larger ones somewhat oval. Their texture was homogeneous, and they were extremely light, being composed of minute prisms of snow irregularly aggregated. These balls were formed by having been rolled through a considerable distance by the wind, their paths upon the snow being, in general, distinctly visible. The smaller balls, however, were decidedly formed in the atmosphere, as they occurred in woods and in small enclosures. See Professor Silliman's *Journal*, vol. vi. p. 169.

Cylinders of snow were first observed by the Rev. D. A. Clark in Morris county, New Jersey. When a deep snow was on the ground a shower of rain fell, and in consequence of a sudden cold the rain was congealed on the surface of the snow, and formed upon it a cake of ice. Another shower of snow fell to the depth of 3-4ths of an inch, and the sky having suddenly cleared, the cold became very intense, and the wind blew a gale. Nature, says M. Clark, now began her sport. Particles of snow would move upon the icy crust from 12 to 20 inches, and would then begin to roll, making a track upon the ice shaped like an isosceles triangle. The balls enlarged according to circumstances, and aided by the declivity of the ground, the rolls were of the size of a barrel, and some even larger. Thus the whole creation, as far as the eye could see, was covered with snow balls differing in size from that of a lady's muff, to two and a half or three feet in diameter, hollow at each end to almost the centre, and all *as true as so many logs of wood shaped in a lathe.*

In 1812 or 1813 Mr. Hitchcook observed at Deerfield, Massachusetts, similar cylinders of snow: none of them, however, were more than six or seven inches in diameter. See Professor Silliman's *Journal*, vol. ii. p. 132 and 375.

In the Arctic Regions, as Mr. Scoresby informs us, it snows *nine* days out of ten in the months of April, May, and June. With southerly winds near the borders of the ice, or where moist air blowing from the sea meets with a cold breeze from the ice, the heaviest falls of snow occur. In this case a depth of two or three inches sometimes falls in an hour. These heavy falls frequently precede sudden storms.

The crystals of snow present an endless variety of forms. Descartes and Dr. Hook seem to have been among the first who observed and delineated the

* This was what Muschenbroek calls starry snow, or that which was finely crystallized in the form of stars.

figures of the crystals.* Dr. Green and Dr. Langwell likewise observed them.† Dr. Stocke has delineated several beautiful forms of snow which fell at Middleburg in Zealand, in 1740 and 1742.‡ The most elegant delineations, however, of the particles of snow are those which were executed by Dr. Nettis of Middleburg, to the number of 80, and given in the *Philosophical Transactions*, 1755, p. 644, and those which were observed by Mr. Scoresby in the Polar seas, given in his "Account of the Arctic Regions," to the amount of 96. The general size of the particles which exhibit these regular figures, is from one-fifth to one-twentieth of an inch. We should have copied several of the figures given by Dr. Nettis, but we prefer taking those of Mr. Scoresby, because he has described the magnitude of each particle which he has delineated, and the state of the barometer, thermometer, and weather, at the time when it fell. Mr. Scoresby arranges the various modifications and crystals which he has observed under five kinds.

1. Lamellar. 2. A lamellar or spherical nucleus, with spinous ramifications in different places. 3. Fine spiculæ or six-sided prisms. 4. Hexagonal pyramids. 5. Spiculæ, having one or both extremities affixed to the centre of a lamellar crystal.

1. *Lamellar crystals.* Mr. Scoresby assures us that the varieties of this modification are very numerous, occurring abundantly at all temperatures, and being very thin and transparent, and of a highly delicate structure. These, he says, may be divided into several distinct species.

a. Stelliform; having six points radiating from a centre, with parallel collateral ramifications in the same plane. This species, represented in Plate CCCCLXXXVIII. Fig. 1. is the most general form met with. It varies in size from the smallest speck, to about one-third of an inch diameter. It occurs in greatest profusion when the temperature approaches the freezing point.

b. Regular hexagon. This occurs in moderate as well as in the lowest temperatures: but it becomes more delicate and thin, and diminishes in size as the cold increases. Some specimens consist of simple transparent plates, (Fig. 23.) others are beautifully variegated, within the perimeter, by white lines, forming smaller hexagons or other regular figures, in immense variety; Fig. 25, 27, 28, 30; Fig. 49, &c. The size of this species is from the smallest visible speck to about one-tenth of an inch diameter.

c. Aggregations of hexagons. This beautiful species admits of immense variety. It occurs chiefly at low temperatures, and presents great limits of dimensions: Figs. 2, 9, 10, 11, 17; and Figs. 29, 34, 37, 39, &c. afford examples of this species.

d. Combinations of hexagons, with radii or spines, and projecting angles. This constitutes the most extensive species in the arrangement: and affords some of the most beautiful specimens. Fig. 7, is an elegant combination of spines and hexagons; and Figures 50, 55, 58, 59, 60, &c. together with all the others distinguished by the letter *s* after the numbers, constitute a novel and beautiful variety, which I have only once observed. The parallel lines that appear in these figures, are not intended as shadings, but actually occurred in the crystals, though with this difference, that the lines which appear black in the plate, were all white in the originals. Figures 56, 63, 64, and 93, were opaque crystals, and were not so thin as the others.

The latter of these, as well as Fig. 94, each having twelve spines, appear to be accidental varieties, and are produced probably by the correct application of two similar crystals upon one another.

2. *A lamellar or spherical nucleus with spinous ramifications in different planes.*—This genus not being easily represented, is not illustrated by any figure. It consists of two or three species.

a. The fundamental figure, consisting of a lamellar crystal of any of the species above described, from the lateral and terminal planes of which arise small spines, similar to the collateral ramifications of Fig. 1. These spines arise either from one or both of the lateral planes or principal surfaces, or from both lateral and terminal planes; and always maintain the usual angle of 60° with the plane from which they take their rise.

The diameter of this figure sometimes exceeds the fourth of an inch. This species falls most frequently at a temperature of 20° or 25°.

b. Having a spherular nucleus, giving rise to radii in all directions. In the former species, the central figure is a transparent crystal; in this it consists of a small rough white concretion. The spines or radii are similar in both figures. The diameter of this seldom reaches a quarter of an inch. The form is echinose. This species falls when the degree of cold is near the freezing, and sometimes in rather low temperatures.

3. *Fine spiculæ or six-sided prisms.*—These are sometimes very delicate and crystalline; at others white and rough. The finest specimens, which resemble white hair cut into lengths not exceeding a quarter of an inch, are so small and clear, that the exact figure is not easily determined; and the larger exhibit a fibrous or prismatic structure. Some of these are occasionally the third of an inch in length. This genus is only seen when the temperature is near the freezing point. When the thermometer is about 28 degrees, the finer specimens occur; when about the freezing, the coarser appear. The latter are very common during fog showers, and appear to be composed of aggregations of the frozen particles of the fog, and to have their origin in the lower parts of the atmosphere.

4. *Hexagonal Pyramids.*—This kind of snow-crystal I have but once seen. A variety, consisting apparently of a triangular pyramid, was observed; but whether its base was a triangular or six-sided figure, similar to No. 95, is doubtful. These pyramids were about the thirtieth part of an inch in height, and fell along with some other curious figures, during a fresh gale of wind from the northward, in very large quantity. Figures 44, and 47, represent this kind of crystal.

5. *Spiculæ or prisms having one or both extremities inserted in the centre of a lamellar crystal.*—This is the most singular genus I have ever seen, and has been observed but twice. It resembles a pair of wheels, united by an axletree; the wheels consisting of hexagonal or other lamellar crystals, and the axle of a slen-

* *M[illegible]graphia*, p. 83, and Fig. 7—27. † *Phil. Trans.* 1693, No. 92. p. 5123. ‡ Muschenbrook's *Elem. of Nat. Phil.* Eng. Edit. vol. ii. p. [illegible]8, and Plate XXVI. and *Phil. Trans.* 1762, p. 112.

der prism. Fig. 43, 45, 46, and 48, represent this modification of snow-crystal. Fig. 46, consists of but one tabular crystal and a prism: and Fig. 45, of three laminæ and two prisms. The length of this was one-sixth of an inch: of the other kind, from one-thirtieth to one-tenth. Some of this extraordinary figure occurred along with the last-described genus: of which kinds, principally, a quantity of snow three or four inches in depth, once fell on the deck of the ship in which I sailed, in the course of a few hours. The temperature, when this kind of crystal fell, was in one instance 22°, and in the other 20°.

Plate CCCCLXXXVIII. contains representations of ninety-six different snow-crystals, magnified from thirty to about four hundred times. The Italic letter following the number of the figure, refers to the second column of the annexed Table, by which, the state of the atmosphere and weather, when each crystal was observed, may be seen. The fractional number which succeeds the Italic letter, shows the diameter of the crystal in parts of an inch. The largest crystal represented was one-third of an inch diameter; the smallest one-thirty-fifth. They were all perfect figures. Many instances, it may be observed, occur of mutilated and irregular specimens; some wanting two or three radii, and others having radii of different sizes and shapes. But in low temperatures, the greatest proportion of crystals that fall are probably perfect geometrical figures. This constant regard to equality in the form and size of the six radii of the stellates; the geometrical accuracy of the different parts of the hexagons; the beauty and precision of the internal lines of the compound figures, with the proper arrangement of any attendant ramifications, and the general completion of the regular figure,—compose one of the most interesting features in the Science of Crystallography.

A Table showing the State of the Atmosphere when each of the Figures of Snow delineated in Plate CCCCLXXXVIII. were observed.

Date.	Reference to the Parts	Thermometer.	Barometer.	WINDS.		REMARKS.
				Direction.	Force.	
1809, April 15	*a*	21	29.92	N.N.E.	Fresh gale	Snow very profuse.
17	*b*	19	29.84	N.N.E.	Fresh gale	A considerable quantity of snow.
29.	*c*	19	29.63	E.N.E.,N.N.E.	Light wind	Snow profuse.
May 1.	*d*	12	29.68	N.E.	Strong br.	Occasional crystals deposited.
2	*e*	10	29.84	N.N.E.	Fresh gale	Delicate crystals floating in the air.
3	*f*	18	29.87	N.E.erly	Strong gale	Snow in considerable quantity.
11	*g*	14	30.10	N.N.E.	Fresh br.	Profuse in quantity, accompanied by much opaque small gran snow
15.	*h*	22	29.78	E.	Strong gale	Ship's deck covered with these curious crystals, three or four inches deep.
30.	*i*	20	30.04	N.E.,N.	Fr. or str. ga.	Slight showers of snow.
June 16.	*k*	32	29.50	[Nearly	calm]	Fell in great quantities.
1810, April 12.	*l*	22	29.8[illegible]	E.N.E.	Strong gale	A constant light shower.
14	*m*	16	30.98	N.N.E.	Fresh br.	Small showers. Many rough crystals formed of opaque grains.
20	*n*	21	29.7[illegible]	S.erly	Strong gale	A moderate but continued deposition of snow.
21.	*o*	20	29.67	N.E.rly	Strong gale	Snow in considerable quantity.
May 16.	*p*	19	29.7[illegible]	N.	Brisk gale	Small showers; delicate crystals.
1816, April 29	*q*	23	29.95	N.N.W.	Mod. breeze	Small showers of fine crystals.
1817, May 2.	*r*	17	29.75	N.erly	Fresh gale	Showers of delicate well-formed crystals.
6.	*s*	27-26	29.80	S.E.	Fresh breeze	Various and beautiful figures vastly profuse; deck of the ship covered several inches deep.

The crystals thus described by Mr. Scoresby, and those delineated by Dr. Nettis, are obvious ice compound crystals: but they afford us no clue to determine the primitive form of the simple crystals of which they consist. This form has generally been supposed to be the rhombohedron: but Mr. Mohs and Mr. Haidinger maintain, "that there is not, in the whole compass of rhombohedral forms, an example of the same formation as the stars with six radii of snow, while it is common enough in those species which belong to the *prismatic* system." From Dr. Brewster's experiments on ice, (See our article on Ice.) it necessarily follows that the form of crystallized water must, as he has inferred, belong either to the *rhombohedail* or to the *pyramidal* system. The prismatic system being thus excluded, so far at least as ice is concerned, Mr. Haidinger considers the *pyramidal* form as the most probable one,* from the circumstance of *tin ore* and *rutile*, which belong to the pyramidal class, producing, by regular composition, crystallizations similar to the star-like figures of snow. That this is the case, has been put beyond a doubt by more recent observations by Dr. Brewster, made during the frost of the 18th and 19th November 1827, in which he found numerous and regular quadrangular plates, in the hoar frost, crystallized upon leaves and stones.

SNOW, Red, the name given to snow of a red colour, which was found by Captain Ross at Baffin's Bay on the 17th August 1819. The mountains that were dyed red with the snow were about eight miles long, and 600 feet high. The red colour reached to the ground in many places ten or twelve feet deep, and continued for a great length of time.

* *Edinburgh Journal of Science*, No. xii. p. 287.

Although the red snow had not previously excited much notice, yet it had been long before observed in Alpine countries. Saussure discovered it on Mount Breven in 1760, and on Mount St. Bernard in 1778. Ramond found it on the Pyrenees: and Sommerfeld discovered it in Norway. In 1818, red snow fell on the Italian Alps and Appennines. In March 1808, the whole country about Cadore, Belluno, and Feltri, was covered with a red-coloured snow, to the depth of six and a half feet; but as white snow had fallen both before and after it, the red formed a stratum in the middle of the white. At the same time, a similar fall took place on the mountains of the Valteline, Brescia, Carinthia, and Tyrol. Another fall of red snow is stated to have occurred between the 5th and 6th March 1803, at Tolmezza in the Frioul, and a still more remarkable one on the night of the 14th and 15th March 1813, in Calabria, Abruzzo in Tuscany, at Bologna, and over the whole chain of the Appennines. Red snow has also been found in New South Shetland.

Saussure had found that the colouring matter of the red snow was of vegetable origin, and he supposed it to be the farina of some plant. The Italian naturalists found in the red snow, clay, an oxide of iron, with a considerable portion of some organized substance; and M. Peschier of Geneva got the same ingredients in the red snow of Mount Bernard. Dr. Wollaston and M. Thenard obtained similar results.

The following is Mr. Peschier's analysis of red snow:

Siliceous matter,	65.5
Alumine,	6.35
Peroxide of iron,	21.35
Organized matter,	6.8
	100.0

In other specimens, the alumine was less, and in others there was none. In some there were traces of lime.

The botanists, however, have been more successful than the chemists. Mr. Bauer regarded the red matter as a fungus of the genus *uredo*, and called it *uredo nivalis*. M. R. Brown was of opinion that it had a great affinity to the *Tremella cruenta*, while *Sprengel* considered it as approaching near to the *Vaucheria radicata*.

In this state of the subject, Professor Agardh of Lund drew up a learned memoir on the subject, which is published in the *Nor. Act. Acad. Nat. Curios*, vol. xii. and of which a copious abstract has been published by Dr. Hooker in the *Edinburgh Journal of Science*, No. vii. p. 167-173. The conclusion to which he arrives is, that the red colouring matter "must either be an *alga*, or an *animalcula*, between which I know no certain limits. There are forms amongst them which may, with equal propriety, be ranked with either or both. There are *algæ*, which become *animalcules*, and *vice versa*. Lastly, there are *infusoria*, which, at one period of their existence, are endowed with the power of motion, while at another, they exist only in the state of a vegetable.

The colour of the red snow is not without analogy among the algæ. In autumn, there is produced on shaded walls a green powdery substance, composed of globules, which afterwards, according to circumstances, change either into *oscillatoria muralis*, or into *ulva crispa*. This substance comes nearest to *lepraria kermesina*. It has also a great affinity with *tremella cruenta*, (*Engl. Bot.*, and which must not be confounded with *ulva montana* of Lightfoot.) Both are red, and both consist of globules; but *lepraria kermesina* differs in this particular, that its globules are free, not sunk in a gelatine. I have accordingly placed *lepraria kermesina* of Wrangel in my *systema algarum*, as a peculiar genus, under the name of *proto-coccus kermesinus*." An account of Bauer's observations will be found in Brande's *Journal*, vol. vii. p. 222, 229; Peschier's Analysis will be found in the *Bibliotheque Universelle*, vol. xii. p. 266. See Saussure's *Voyages dans les Alpes*, tom. iii.

SNOW Blindness is a disease to which the inhabitants of the arctic regions are subject; though it sometimes occurs in more southern climates; it generally commences with a sensation similar to that of sand or dust getting into the eyes. A solution of acetate of lead is found to remove the complaint in two or three days; and its recurrence is prevented by defending the eyes either with a piece of crape, or a pair of snow spectacles. Xenophon informs us that many of the Greek soldiers were blinded by the brightness of the snow in crossing the snowy mountains of Armenia, between the Euphrates and Phesis, in the middle of winter; and he mentions, that they covered their eyes with something black.

The Greenlanders and Laplanders, who are especially subject to this disease, use a network of black horse hair, a little convex anteriorly. The Esquimaux on the coast of Labrador, use snow spectacles, which consist of a smooth piece of wood like poplar, which is driven on the Labrador coast. The back surface which covers the nose is pretty deeply cut. There is a notch at each side on the lower margin to give passage to the tears. The upper margin of the front projects to keep off the snow, and to act as a shade. The other side is blackened with soot. The apertures for vision are narrow, and slits are placed horizontally, so as to correspond to the opening of the eye-lids when nearly shut. These spectacles may be used with great advantage by persons with weak or inflamed eyes. This apparatus aids also the sight; and Ellis says, that the savages use it principally to see remote objects more distinctly.

For farther information on this subject, see Xenophon, *Cyrop.* iv. 5, p. 296, fourth edition of Hutchinson, *Cambr.* 1785. Kaud Leem, *on the Laplanders of Finmark*, p. 52. Crantz's *History of Greenland*, Cartwright's *Journal of a Residence in Labrador*, vol. i. p. 102. Ellis, p. 143. Chardin's *Travels*, vol. i. p. 211. Bell of Antermony's *Travels*. Captain Parry's *Voyage*, 1819-20, vol. i. p. 84. and M. Blumenbach, in *Edinburgh Philosophical Journal*, vol. viii. p. 260.

SNOWDON, is the name of a group of lofty mountains in Caernarvonshire. But the name is particularly applied to the highest mountain of the group, which, according to the results of the ordinance survey, is 3571 feet above the level of the sea, 3548.9 according to General Roy's barometrical observations, and 3546.25 according to Mr. Wollaston's thermometrical barometer. It is generally ascended by Llyn Cawellyn, half way between Bedgellas and Caernarvon. From the summit the view is grand and extensive. The mountains and part of the coast of Scotland, the county of Wicklow in Ireland, the Lancashire hills, the Westmoreland and Cumberland hills, with the Isle of Man, are all seen in the distance; while the intermediate country appears like a map to the observer. Camden says that Snowdon is covered with snow throughout the year: and though this is not the case at present, it might have been, and if we believe human testimony, must have been in his time. His words are, "It harbours snow continually, being throughout the year covered with it, or rather with a hardened crust of snow, and hence the British name of Craig Eryri, and the English one of Snowdon." Snowdon was held sacred by the ancient Britons, as Parnassus was among the Greeks, and it was said that whoever slept upon Snowdon would wake inspired. Leland informs us, that stags were found here in his time, and according to Pennant they were extirpated in 1626.

The following description of the summit of Snowdon is given by Pennant:

"The summit which, by way of pre-eminence, is called *Y Wyddfa*, or *the Conspicuous*, rises almost to a point, or at least there is but room for a circular wall of loose stones, within which travellers usually take their repast. The mountain from hence seems propped by four vast buttresses, between which are four deep *cwms* or hollows; each, excepting one, has one or more lakes lodged in its distant bottom. The nearest was *Fynnon Las* or the *Green Well*, lying immediately below us. Its waters appeared black and unfathomable, and the edges quite green. From thence is a succession of hollows, surrounded by lofty and rugged hills, the greatest part of whose sides are perfectly mural, and form the most magnificent amphitheatre in nature. The Wyddfa is on one side; Cribb-y-distill, with its serrated tops, on another; Crib-Gotch, a ridge of fiery redness, appears beneath the preceding; and opposite to it is the boundary called Lliweed. Another very singular support to this mountain is Y Clawdd Gotch, rising into a sharp ridge so narrow as not to afford breadth even for a path." Pennant's *Tour in Wales*, vol. ii. See the *Beauties of England and Wales*, vol. xvii. p. 411, &c.

SOAP Manufacture. The soap which is manufactured for domestic purposes is a combination of the fixed alkalies, with different kinds of fat or fixed oils.

The recent discoveries of M. Chevreul have thrown much light on the chemical nature of soap. The fats and fixed oils he has found to consist of two substances, one of which *stearine* from στεαρ, *suet*, is solid at common temperatures, while the other, *elaine* from ελαιον, *oil*, is fluid at ordinary temperatures. Suet, lard, and butter, contain a greater quantity of stearine than of elaine, whence arises their solidity; while the fixed oils contain a greater quantity of elaine, and are on that account fluid. If we press congealed fixed oil between folds of bibulous paper, the solid stearine will be obtained separate, and if we press the bibulous paper under water a substance is obtained, which is pure elaine.*

In the formation of soap the stearine and elaine disappear entirely, and are converted into *margaric acid, oleic acid, and glyceine.* These two acids combine with the alkali, and form soap.

The following processes will convey to the general reader a tolerable idea of the manufacture of the different kinds of soap.

1. *Process for making Hard White Soap from Oil.* This process is that of Macquer. *Two* parts of good Spanish soda, and *one* part of quicklime are boiled in a vessel with twelve times as much water. The ley thus formed is to be filtered and evaporated till a phial, which contains one ounce of water, holds one and three-eighths of an ounce of this concentrated ley. In a vessel of glass or earthenware a mixture is made of *one* part of this ley, with *two* of oil of olives, or oil of sweet almonds; and it is occasionally stirred with an iron spatula till it is thick and white. The ingredients gradually combine, and in seven or eight days a firm and very white soap is obtained.

2. *Process for making Pure White Soap from Tallow.* Mix with 200 gallons of ley ten cwt. of the best home melted tallow. Let the whole be melted with a moderate fire, and when it is disposed to boil over, damp the fire either with ashes or with a damper. At the end of two hours it may be drawn away, and the pan allowed to settle about two hours, when the ley may be drawn off. Two or three boilings may be given every day, and they must be continued day after day till the whole assume the appearance of a curdy mass. A little is then taken upon the fore finger; and if it squeezes into a thin, hard, clear scale by the pressure of the thumb, it is fit for finishing. If, on the contrary, it appear greasy, and stick to the finger, and is of a soft consistency, add more ley, and if this does not sufficiently harden it, it must be boiled another time. When it has become such as to squeeze into a scale it must get a good boiling, and the fire be then drawn. After being cooled down with two or three pails of ley, pump off the ley as clean as possible in about two hours. When this is done, add eight or ten pails of water, (each pail containing nine or ten English gallons.) Apply the fire, and when the water and soap are properly incorporated by constant stirring, take some from a boiling part, and having laid it on the handboard see if the ley runs from it. If it does, more water must be added, and the boiling continued. But if no ley runs from the soap, continue boiling for a short time longer, and then add a pail of a solution of one-third of salt in two-thirds of water. This will effect what is called *cutting up the pan*, or separating the soap from the water. When this is done withdraw the fire, let the whole stand for half an hour, and pump off the water, which will carry along with it the remainder of the alkaline ley of the former boiling. This is called the *first washing*; and if kelp ley has been used the water pumped off will have a bottle-green colour. Six or eight pails of water must soon be added, and when the whole is again boiled and incorporated, try if the water runs from the soap. If it does, add water in small quantities at a time, until the ley, when put upon the handboard, does not run down from the soap, but appears as it were just starting from the soap. When this is done give the whole a good boiling, and swell the soap up in the boiler to near its brim, and having withdrawn the fire, spread it about to die away.

The boiling process being now finished, the whole may stand twelve or fourteen hours, and if the quantity be two or three tons, it will be the better of stand-

* As the elaine requires a cold of 20° Fahrenheit to freeze it, it is peculiarly adapted for oiling the wheels of watches, &c.

ing double that time, keeping it however close and warm in the boiler. If any blueness remains, the washing must be repeated.

The frames into which it is now to be cast should have a bottom, and be lined with coarse cloth. If a perfume is wished for, a little of the essential oil of Caraway seeds, mixed with a small portion of alcohol, may be incorporated with the soap in putting it into the frames, stirring in a little of it at a time to diffuse it through the mass.

When it is cast into the frames, the whole should be covered up with old sheets, mats, &c. and allowed to cool gradually for three or four days, when it may be taken out, and cut into pieces of the required size.

2. *Process for making hard, brown, or yellow soap.*

In order to charge a pan for hard yellow soap, pour in 150 or 200 gallons of ley, and add 10 cwt. of tallow, and 93 cwt. of rosin broken into small lumps. The whole is now to be boiled and stirred, taking care always to damp the fire when the materials swell up. After two or three hours boiling, withdraw the fire, and allow the whole to stand four or six hours, when the weak ley is to be pumped off and fresh ley added. If it is wished to pump off sooner, a few parts of cold ley must be thrown in a short time after the fire is drawn. The whole is now to be boiled a second time for two or three hours, and the boilings continued day after day till the soap squeezes into a scale between the finger and thumb, as described in the preceding process. When this is effected, the pan is to be treated in the same way as in the process for white soap, *six* or *eight* parts of water being in this case put in, in place of eight or ten in the white soap. If we wish to give a beautiful colour to the soap by means of palm oil, put 20lbs. of the oil into the boiler, when the soap is considered to be finished, then after boiling for half an hour draw the fire, and allow the whole to stand for 48 hours, when it may be cast into the frames. If the frames are 30 inches deep, the soap may be cut in bars in about *three* days.

The following table has been given as showing the average proportions of the materials for yellow soap.

	cwt.	qr	lb.			cwt.	qr	lb.	
Tallow	13	0	11		Soap	13	0	25	independent of water.
Rosin	3	2	18						
Palm oil	1	2	0						
Barilla	6	2	14		Refuse of tallow, rosin, and palm oil.	5	3	4	
Potash	1	0	16						
Lime	5	0	9						
Soap	25	1	21	with its water.					

3. *Process for making black or green soft soap.*

The difference between hard and soft soap is, that in the former the whole of the ley is extracted, while in the latter the whole is retained, forming a compound body with the other materials. This soap is of two kinds, viz. *first crown soap*, made of *tallow*, *hogs' lard*, and *olive oil*: and *second crown soap*, made with *tallow* and *whale oil*.

1. *First crown soap.* For a charge of eighteen barrels take

	cwt.	qrs.
Tallow - - - - - -	2	2
Hogs' lard - - - - - -	2	2
Olive oil - - - - -	70 gallons.	
Ley from Hungarian ashes eight parts, and English ashes one part - -	400 gallons.	

When one-third of the ley, or 133 gallons, is put into the boiler, add the tallow, and after it is melted, put in the olive oil. Let the fire be now drawn a little, and the whole stand *two* hours. When the fire is again lighted, put in twenty gallons additional ley. As the whole boils, add occasionally a little more ley to prevent the soap from boiling over, until the soap is considered to be half boiled, when it will be time to ascertain whether the soap has got too much or too little ley. This operation, called *proving*, and which is requisite frequently, is thus performed: With a knife take up a piece of the soap, and if it turns white upon the knife, and falls from it in short pieces, too much ley has been put in, and consequently a little more olive oil must be added. But if it fall from the knife in long ropy pieces, an additional quantity of ley must be added. If, on the other hand, it is neither too white nor too ropy, but transparent, it neither needs oil nor ley. When it arrives at this state it may be put into the barrels or other vessels destined to hold it. After the second lighting of the fire, the boiling should be briskly kept up, and when the soap is nearly ready, it should boil slowly till it is put into the barrels.

2. *Second crown soft soap.* For this soap take,

Tallow - - -	280 lbs.
Whale oil - - - -	82 gallons.
Ley - - - -	140 gallons.

When 100 gallons of the ley are put into the boiler, add the tallow, and when it is melted, put in the whale oil and draw the fire. When the whole has stood two hours, light the fire and add twenty gallons of ley. Continue to boil briskly till the soap is considered to be half finished, and then put in ten gallons of additional ley. Add the other ten gallons during the rest of the boiling, and finish the soap as in the last process.

Hard soap in a proper state for the market, should contain thirty per cent. of water; but by fraudulent practices it may be made to contain sixty per cent.

The simplest and the most beautiful soap, is the fine white soap made of olive oil and soda obtained from the best barilla. A more expensive kind is made of soda and oil of sweet almonds. The former kind, which is made at Marseilles, Naples, and several parts of Italy, is sometimes streaked throughout with red and blue veins. This is effected by a solution of sulphate of iron, and by the brown red oxide of iron.

4. *Method of Improving Soap.*—Mr. Pope of Lombard Street, has given the following method of improving soap. Take one cwt. of good soap, slice it into thin pieces, and mix with it seven lbs. of marl of the purest kind, and a sufficient quantity of water, to reduce the whole into a fluid state. When the whole are stirred together till they are of the consistency of cream, they are boiled, and then poured out into suitable moulds for making them into cakes. By this process, the soap is rendered smooth and soft, and the action of the caustic alkali upon the skin is destroyed. See Dr. Brewster's *Journal of Science*, No. xiv. p. 361.

5. *Method of Making Transparent Soap.*—Put into a thin glass phial half a brick of Windsor soap, cut into small pieces; fill the phial half full of alcohol, and place it near the fire till the whole is dissolved. This mixture, put into a mould and boiled, is *transparent soap*. If well prepared, it should have the appearance of fine white sugar candy. It may be co-

loured; but vegetable colours should be used in preference to mineral ones.

Tallow soap is preferable, in making transparent soap, to olive oil soap, as the latter forms a paste too difficult to melt, and its odour too powerful for mixing with perfumes. Dr. Brewster's *Journal of Science*, No. xiii. p. 172.

Both the vegetable and the animal kingdom have supplied the inhabitants of different countries with a substitute for soap.

In America, the outer rhind of the seed of what is called the soap tree, is used by the natives; and in Africa, soap is made with a small insect of the carab genus. M. Geoffroy de Villeneuve, who a few years ago sent home some of this soap to Paris, gives the following account of it. "Being in the village of Portudal, a few leagues from Senegal, employed in collecting insects, and inviting the negroes to procure me supplies, one of them presented me with a pot, containing many thousands of a small insect of the carab genus. They were ready dried, and the numbers showed that they had been collected for some particular purpose. On inquiring, I learned that this insect entered into the composition of the soap used in the country. The same negro also showed me a ball of this soap, which was of a blackish colour, but had all the properties of our common soap; and I learned, in the sequel, that these insects are converted to the same purpose all along the coast of Senegal. This carab is black, but the edges or borders of the corslet, and also the elytres, are of a reddish colour; the feet and the antennæ are of a pale colour."

For farther information concerning soap, see *Experiences relatives a la Fabrication des Savons durs*, from M. Colin in the *Ann. de Chim.*, September 1816, vol. i. and a Memoir *on the Causes of the Diversities found in Soap, in reference to their hardness and smells*, in the *Ann. de Chim.*, *&c.* vol. xxiii. p. 16.

SOCIAL WAR. See Roman Empire.

SOCIETIES, Literary and Philosophical, are institutions established in the principal cities of all civilized countries, for the purpose of promoting literature, science, antiquities, and the fine and useful arts. These establishments have received the names of *academies*, *institutions*, and *societies*: and we have already described a great number of them in our article Academy. When this article was written, it was our design to give a similar article under the present head, and we have accordingly referred to it more than once. In the progress of the work, however, the authors of individual articles have, in general, described the societies established in particular cities, so that they have anticipated the greater number of those which might have been expected here. As the Royal Societies of London and Edinburgh, which, together with the Royal Irish Academy, (already described) form the three metropolitan institutions of Great Britain, have only been slightly noticed in our account of these cities, we shall now proceed to give a short account of them.

I. Royal Society of London.—This distinguished institution had its origin in 1645; but it was not till 1662 that it was established by royal charter. The Society held its first meeting at Gresham college in 1667. The following are the volumes of the *Philosophical Transactions* which it has published:—

From	1665 to	1678	-	12 volumes
	1683	1751	-	34
	1751	1800	-	44
	1800	1825	-	23
In all			-	113 volumes.

This valuable work, down to 1800, has been abridged by Drs. Hutton, Pearson, and Shaw, and published in 18 thick 4to volumes, with another volume containing a learned and interesting history of the Society by Dr. Thomas Thomson, in which the reader will find the most ample information respecting this institution.

The Royal Society of London adjudges three prizes, viz. the Copley medal, the Rumford medals, and the Royal medals.

1. The *Copley Gold Medal*, presented by Sir Godfrey Copley, Bart. who was a member of the Society from 1691 till his death in 1710. This medal used to be adjudged annually for the most important paper published in the transactions; but it has lately been adjudged to foreigners for discoveries not communicated to the Royal Society. The value of the medal is not above £5, 5s. It has been adjudged to many of the most distinguished ornaments of English science.

2. *The Rumford gold and silver medals.* These medals were presented by Benjamin Thomson, Count Rumford, in 1796, who presented L.1000 of 3 per cent. stock, the interest of which, or L.60, was to form a biennial prize "for the most important discovery or useful improvement in any way made known to the public during the two preceding years, on *heat* or on *light*." The form of the prize is a large gold and also a silver medal struck in the same die. As the medal has not been adjudged during eight of the biennial periods, the principal of L.1000 has been considerably increased, and as the interest of the additional sum is given along with the two medals, the prize is a very valuable one.

The following is a list of the philosophers who have received the Rumford medals:—

Count Rumford		
Professor Leslie	-	1804
M. Malus	- - -	1812
Sir Humphry Davy	-	1814
Dr. Wells	- -	1816
Dr Brewster	- -	1818
M. Fresnel	- -	1826

3. The *Royal Medals.* At the anniversary dinner of the Royal Society, on the 30th Nov. 1825, Mr. Peel announced his Majesty's intention of granting the sum of one hundred guineas annually, to establish two scientific prizes, to be awarded every year for the most important discovery or invention.

These medals were adjudged in
1826 to Mr. John Dalton, and
James Ivory, Esq., and in
1827 to Sir Humphry Davy.

The Royal Society of London have a valuable library. The admission fee, and the composition for the annual contribution of L. 5, 5s. amounts to about L. 50. The members receive the Transactions gratis, and authors of papers are allowed separate copies of them, but at their own expense.

II. Royal Society of Edinburgh.—In the year

1718, a Literary Society was established in Edinburgh by Ruddiman and others. In 1731, it was succeeded by a Medical Society. In 1739, the celebrated Colin Maclaurin and others extended it under the name of the Philosophical Society of Edinburgh, and between 1754 and 1771, they published three volumes of papers entitled *Essays or Observations, Physical and Literary.* In 1783, it was incorporated by a royal charter of the most degrading kind, being prohibited from forming either a library or a museum, and being bound to deposit the books presented to them in the Advocates' Library, and all objects of natural history in the College Museum! In 1811, this charter was rescinded and a new one obtained, which gave them the power of forming a library and a museum of their own; but it will scarcely be believed that at such a period of liberality, they are actually prohibited "from appointing a professor, lecturer, or doctor of mineralogy, geology, or natural history, or for using their collections to promote any such institution, excepting that which is, or shall be in the University of Edinburgh."

The Society has now a respectable library, and museum containing several objects of interest, which has recently obtained large and valuable accessions from the liberality of George Swinton, Esq. secretary to the government of Bengal.

The society has published the following Transactions:—

		Periods.	
From 1783	to 1788	5 years	1 volume
1788	1790	2	1
1770	1794	4	1
1794	1798	4	1
1798	1805	7	1
1805	1812	7	1
1812	1815	3	1
1815	1818	3	1
1818	1823	5	1
1823	1826	3	1
In all -	-	-	10 volumes.

The Royal Society of Edinburgh adjudges one prize, known by the name of the *Keith Medal.*

This prize was presented in 1819, by Alexander Keith, Esq. of Dunottar, an ardent lover and patron of science, and who was the first treasurer to the Society in 1783. He left L.1000 Sterling, under the management of Sir Alexander Keith, Dr. Keith, and Dr. Brewster, for the purpose of advancing the sciences and the arts of his native country. Out of this sum the trustees above mentioned offered L.600 to the president and council of the Society, the biennial interest of which, viz. L.60, was to form a biennial prize for the most important discoveries in science made in any part of the world, but communicated by their author to the Royal Society, and published in their Transactions. The trustees suggested that the form of the prize should be a gold medal, together with a sum of money, or a piece of plate, bearing the devices and inscriptions on the medal.

This offer was accepted by the Royal Society, and the Keith Medal was adjudged for the first time, in January 1828, to Dr. Brewster for his discovery of two new fluids existing in the cavities of several minerals, published in the 10th volume of the Society's Transactions.

The society consists of about 300 ordinary members, 21 honorary and 36 Foreign members. These two last classes are limited to the number mentioned.

The admission fee of £5, 5s. and the composition for the annual contribution of £3, 3s. amounts to about £36. The members receive the Transactions gratis, and the authors of papers receive 24 copies of them free of all expense.

Societies recently established in London.—Among the scientific societies recently established in London, and not described in that article, we may enumerate

Linnean Society, founded in 1788. Incorporated in 1802.

Entomological Society, founded in		1806.
Geological Society,	.	1811.
Horticultural Society,*	.	1804.
Royal Asiatic Society,		
Society of Civil Engineers,		1771 and 1793.
Zoological Society of London.		

Besides these, we may enumerate the following provincial institutions:—

Philosophical Society of Cambridge.

Literary and Philosophical Society of Leeds.

Natural History Society of York.

An account of the societies of Manchester, Newcastle, Plymouth, and the institution of Liverpool, will be found under these articles.

Societies recently established in Edinburgh.—Among the societies recently established in Edinburgh, and not described under that article, we may mention the

Caledonian Horticultural Society, established in† 1809.

Society for Promoting the Useful Arts in Scotland, founded in 1819.

Among the provincial institutions, may be mentioned the Literary and Antiquarian Society of Perth, already described in that article; and the Northern Institution of Inverness, a flourishing society established in 1825.

Among the other societies connected with Great Britain, we may notice, 1. the *Asiatic Society of Calcutta*, already described under that article, and which has published fifteen volumes of Transactions. 2. *The Medical and Physical Society of Calcutta*, established in 1823. This excellent institution has already published two volumes of Transactions in 8vo. containing many interesting papers. 3. *The Royal Society of Göttingen.* This society was established by George I. in 1751, and has published many volumes of commentaries in different series.

SOCIETY Islands, a group of islands in the Pacific, including Ulietea, Otaka, Bolabola, Huaheine, Tubai, and Maurua. Captain Cook gave them this name in 1769 from their contiguity. They lie in South Lat. 16° 30′, and 151° 30′ of West Long. The inhabitants, as well as the climate and productions of these islands resemble those of Otaheite. The first four of these islands have been converted to Christianity, the number of converts being above 5000. This happy change we owe to the zeal of the missionaries who distinguished themselves so much in Otaheite.

SOCINIANS. See Ecclesiastical History.

* See Horticulture.

† See Horticulture.

SOCOTRA, or SOCOTARA, an island in the Indian sea, is about twenty-seven leagues long and seven broad. Its surface is mountainous, and its precipitous shores afford many good harbours, of which Benin and Cora are the best. It has long been celebrated for its aloes, which are in great request. It yields also dragon's blood, ambergris, frankincense, and coral; and bullocks, goats, fish, rice, and dates may be obtained at reasonable prices. The town which is handsome, from the houses being built of stone, contains several mosques. The king's residence is in East Long. 53° 33', and North Lat. 12° 39'.

SOCRATES, an ancient moral philosopher of distinguished eminence, was born at Alopece a village near Athens, B. C. 469. His father Sophroniscus was a statuary, and his mother Phænaretta a midwife. Having lost his small patrimony by the dishonesty of a relation, he pursued his father's profession, and is said to have executed statues of the habited graces, which were thought worthy of a place in the citadel of Athens.

Crito, a wealthy Athenian, engaged him to educate his children, and in this situation he found leisure to attend the lessons of Archelaus and Anaxagoras, two of the most eminent teachers of the day. His valour was exhibited in saving the life of Alcibiades, and in carrying off Xenophon when left wounded on the field of battle; and his wisdom and integrity were equally conspicuous when he served his country in the senate of 500.

Afflicted with the moral and intellectual condition of his countrymen, Socrates resolved to become a public instructer at Athens, by conversation and by public lectures addressed at all seasonable times to all classes of the community, from the mechanic up to the senator. In these communications with his fellow citizens, his object was to convince his hearers of their individual follies and vices, to inspire them with a love of virtue, and to impress upon them the conviction of the narrow limits of the human understanding. His plan consisted in asking a series of questions, and in gaining the assent of his pupils to certain truths which they themselves could not but deduce from their own previous admissions; and such was the skill with which he often concluded these examinations, that his pupil was not aware of the conclusion till he found it irresistible upon his own principles.

The humility which characterised the deportment of this great man, the uniform excellence of his conduct, the abstemiousness of his life, and his contempt of wealth and popular applause, point out Socrates as one of those superior beings whom Providence occasionally exhibits to the world as an example for future ages. "The man," says Xenophon, "whose memoirs I have written, was so pious that he undertook nothing without asking the counsel of the gods; so just, that he never did the smallest injury to any one, but rendered essential services to many: so temperate, that he never preferred pleasure to virtue; and so wise, that he was able in the most difficult cases, without advice, to judge what was expedient and right. He was eminently qualified to aid others by his advice; to penetrate into men's characters: to reprehend them for their vices, and to excite them to the practice of virtue. Having found all these excellencies in Socrates, I have always regarded him as the most virtuous, and the happiest of men."

It was not to be expected that the enemy of public immorality, and of political corruption and oppression, could escape the hostility of those who smarted under the exposure of their vices. The immoral youth of Athens hired Aristophanes to lampoon him on the stage, in the comedy of the "Clouds," written for this purpose. Socrates himself attended the performance of the piece, and when the person who represented himself appeared upon the stage, Socrates stood up to exhibit the original of the character to the inquiring audience. When he was asked by a spectator if he was not chagrined at this public derision, he replied, "By no means, I am only a host at a public festival, where I provide a large company with entertainment."

Baffled in this attempt to disgrace the philosopher, the malice of his enemies was directed into a new channel. He was publicly accused before the senate, by one Melitus a rhetorician, of "not acknowledging the gods which the state acknowledges; of introducing new deities, and of violating the laws by corrupting the youth." Anylus, a leather-dresser and the principal accuser, offered to withdraw the charge if Socrates would desist from censuring his conduct: but Socrates replied, that "while he lived he never would disguise the truth, nor speak otherwise than his duty required."

On the day of the trial, Plato rose to address the court in favour of his master, but he was soon commanded to sit down. Socrates then made his own defence, and unveiled in the most powerful manner, the characters and motives of his accusers. A corrupted and unjust court, however, who had predetermined his death, listened not to the truth; and Socrates was condemned to be poisoned by hemlock.

The friends of Socrates endeavoured to persuade him to make his escape, or at least to allow them to carry him off from his enemies. He rejected, however, the proposal as a violation of the law, and resolved to submit himself to its decrees.

His friends and disciples repaired to his prison, to hear the last words of their great master, and on this occasion the conversation turned principally on the immortality of the soul. Socrates condemned the practice of suicide, and assured his friends that his chief support was the expectation, not free from doubts, of a happy existence after death. "It would," he said, "be inexcusable to despise death, were I not persuaded that it would lead me into the presence of the gods, who are the most righteous governors, and into the society of just and good men; but I confide in the hope that something of men remains after death, and that the condition of good men will then be better than that of the bad." When Crito asked him how he wished to be buried, Socrates replied with a smile, "According to your pleasure, provided I do not escape out of your hands." Then addressing himself to the rest of the party, he said, "Is it not strange, after all that I have said to convince you, that I am going to the society of the happy, that Crito still thinks this body, which will soon be a lifeless corpse, to be Socrates? Let him dispose of my body as he pleases; but let him not at its interment mourn over it as if it were Socrates."

After retiring to an adjoining apartment to bathe, he took his last leave of his friends, and then having prayed for a prosperous passage into the invisible world, he drank the fatal poison without the least change of countenance or apparent discomposure. His friends around him burst into tears. Socrates alone was unmoved. He upbraided their weakness, and implored them to exercise a manly fortitude worthy of the friends of virtue. He continued walking till the influence of the hemlock forced him to lie down upon his bed. After remaining silent for a short time, he requested Crito not to neglect the offering of a cock, which he had vowed to Esculapius. Then covering himself with his cloak he expired. This event, the account of which Cicero assures us he never read without tears, took place in the year 399 B. C.

The Athenians were roused to a sense of their shame, in having destroyed one of the greatest of their citizens. Melitus was condemned to death, and Anyles escaped the same fate only by voluntary exile. The Athenians recalled the friends of Socrates from exile, decreed a general mourning, and erected a statue to his memory. See *Pausanias* 1, cap. 42. Plutarch, *De Op. Phil.* &c. Cicero, &c. Cret. 1, c. 24. Tusc. Quest. 1, c. 41, *Valerius Maximus*, 3, c. 4, and Brucher's *History of Philosophy*, by *Enfield*, vol. i. See also our articles Athens, and Greece.

SODA. See Alkalies, and Chemistry.

SODALITE. See Mineralogy Index.

SODANE. See Chemistry.

SODIUM. See Chemistry.

SOGDIANA, a county of Asia, between the rivers Iaxartes and Oxus. It was bounded on the north by Scythia, on the west by Morgiana, on the south by Bactriana, and on the east by the Sacæ. Maracanda was the capital of the country. It is now called Sogd, and is part of the country of Great Bucharia.

SOHAM, or Monks Soham, a town of England, in the county of Cambridge, situated on the east side of the Cam. It is large and irregularly built, and has a spacious church, with a tower at the west end. Its principal street is three-fourths of a mile long. There is here a large charity school, and three alms-houses. Cheese of excellent quality is the principal produce of the place. Population of the town in 1821, 2856. Houses 537. Families 691. Do. in trade 107.

SOIL. See Agriculture Index.

SOISSONS, the *Noviodunum* of Cæsar, a town of France, in the department of the Aisne. It stands in a fine valley, traversed by the Aisne. The public buildings are the cathedral, with a library and a collection of manuscripts, the church of Notre Dame, the academy established in 1679, a lyceum, and a theatre. Its manufactures are leather, coarse linen, ropes, stockings, and thread. Corn is exported in considerable quantities. Its haricots are celebrated. Near Soissons is St. Gobin, celebrated for its glass manufactory. Population 8189.

SOLDER is the name of a metallic compound, used to join together other metals. The following are some of the most important of the solders, it being a general principle that some of the metals to be soldered should be mixed with some higher and finer metals.

1. *Solder for gold* consists of fine *gold*, with one-fourth or one-half its weight of fine silver, mixed by fusion, and beat out into leaves thinner than card paper, and rendered soft by annealing. A portion is then laid on the fracture, or ends to be united, and it is sprinkled with pulverized borax. The flame of a blow-pipe is then used to melt the whole. The borax is removed by boiling water, or a little dilute sulphuric or muriatic acid; and the paler colour of the solder may be deepened, by melting on its surface a mixture of two parts of nitre, and one of burnt alum, and washing it off with hot water. Silver after soldering, may be cleansed by boiling it in alum water, and gold by urine and salammoniac.

Solder for gold may also be made with gold and a little copper.

2. *Solder for Steel and Iron.*—Gold with a slight alloy of copper is a good solder for uniting the finer kinds of steel instruments. For larger articles in iron and steel, an alloy of equal parts of tin and iron is used.

3. *Solder for Plumbers.*—This solder consists of *two* parts of *lead*, and *one* of *block tin.* It is known to be good when small bright shining stars rise in a small piece of it poured out of the crucible in which it is melted. Equal parts of lead and tin are used when it is wished to be hard; and when it is wanted to be very fusible, bismuth is added in various proportions.

4. *Solder for Silver.*—The *hard* kind is composed of equal parts of silver and fine brass, and the *soft* is made by fusing the hard solder with one-sixteenth its weight of pure zinc.

A *second* solder for silver is made of two parts of fine silver, and one of brass, which must not be kept long in a state of fusion. lest the brass be oxidated.

A *third* solder for coarser silver is made of four parts of fine silver, three of brass, with a little borax, and it must be poured out when melted.

5. *Solder for copper.* This is made of copper and tin; but for fine work silver is substituted for tin.

6. *Solder for copper, brass, and the hard alloys of copper.* The best hard solder for these purposes is made of brass and zinc, from eight to sixteen parts of brass to one of zinc, according to the hardness required. The soft solder consists of three parts zinc and one lead, and is applied by a common red hot soldering iron.

7. *Solder for organ pipes.* This is made of three parts pewter and one bismuth.

8. *Soft pewterer's solder*, is composed of two parts tin and one bismuth, which is very easily melted.

9. *Spelter solder.* This is made of two-parts of spelter, (the commercial name for zinc.) and one of brass. It is used by braziers and coppersmiths for brass, copper, and iron. A dwt. of silver to each oz. improves it greatly.

SOLEURE, in German, *Solothurn*, is the name of a canton of Switzerland. It lies between the Aar and the Jura, partly occupying the plain and partly the face of the ridge. Its surface is about 275 square miles. The land is partly arable and partly devoted to pasturage, which is greatly improved by an excellent system of irrigation. The cattle thus reared are deemed the best in Switzerland. The manufactures are woollen, linen, and cotton goods. Soleure and Olten are the principal towns. Olten is beautifully situated on the banks of the Aar, with the finely wooded peaks of Jura rising behind it. The Aar is here crossed by a wooden bridge of six arches roofed in with wood. Olten has a new church with two small towers, a gate with a high square turret and another small tower. The population is 1300. The inhabitants are chiefly catholics, and amount to 50,000.

SOLEURE, the *Solodurum* of the ancients, and the capital of the above canton, is finely situated on the Aar, which divides it into two parts. It is fortified with walls and bastions, the walls inclosing about fifty acres. It is tolerably well built, and the houses are generally neat. The principal buildings are the Hotel de Ville, the public jail, the Jesuits' church, the church of St. Urse, the mint, and the public library, containing above 11,000 volumes, and the great square Roman tower. The church of St. Urse, begun in 1762, and finished in 1772, is a noble edifice of whitish grey stone, the lower part being of the Corinthian, and the upper of the Composite order. The façade, which consists of a portico surmounted by an elegant tower, faces the extremity of the principal street. The expense is said to have been L.80,000. The vicinity of the town is beautiful; and the traveller should ascend to the Chalets and farm of Weissenstein. From this is the finest view in Switzerland, embracing the immense valley which separates Jura from the high chain of the Alps, together with the snowy mountains. At sunset this scene baffles all description. See *Dict. de la Suisse*, Art. Soleure. Coxe's *Travels in Switzerland*, vol. i. and Ebel's *Manual*, &c. vol. iv.

SOLFATARA, Lake of. See Campagna.

SOLID of Greatest attraction. See Attraction.

SOLIDS, Attraction of. See Attraction.

SOLIDS, Mensuration of. See Mensuration.

SOLON. See Athens.

SOLWAY Moss, a tract of land in Cumberland, celebrated for an eruption of a very remarkable kind, which is thus described by Mr. Gilpin.

"Solway Moss is a flat area about seven miles in circumference. The substance of it is a gross fluid, composed of mud and the putrid fibres of heath, diluted by internal springs, which arise in every part. The surface is a dry crust, covered with moss and rushes, offering a fair appearance over an unsound bottom, shaking with the least pressure. Cattle, by instinct, know and avoid it. Where rushes grow the bottom is soundest. The adventurous passenger, therefore, who sometimes, in dry seasons, traverses this perilous waste, to save a few miles, picks his cautious way over the rushy tussocks as they appear before him. If his foot slips, or if he ventures to desert this mark of security, it is possible he may never more be heard of. On the south, Solway Moss is bounded by a cultivated plain, which declines gently through the space of a mile to the river Esk. This plain is lower than the moss, being separated from it by a breast-work, formed by digging peat, which makes an irregular though perpendicular line of low black boundary. It was the bursting of the moss through this peat breast-work, over the plains between it and the Esk, that occasioned the dreadful inundations that destroyed so large a district. The more remarkable circumstances relating to this calamitous event were these:—

On the 13th of November 1771, in a dark tempestuous night,* the inhabitants of the plain were alarmed with a dreadful crash, which they could no way account for, many of them were then in the fields watching their cattle, lest the Esk, which was then rising violently in the storm, should carry them off. In the meantime, the enormous mass of fluid substance, which had burst from the moss, moved slowly on, spreading itself more and more as it got possession of the plain. Some of the inhabitants, through the terror of the night, could plainly discover it advancing like a moving hill. This was, in fact, the case; for the gush of mud carried before it, through the first two or three hundred yards of its course, a part of the breast-work, which though low, was yet several feet in perpendicular height; but it soon deposited this solid mass, and became a heavy fluid. One house after another it spread round, filled, and crushed into ruins, just giving time to the terrified inhabitants to escape. Scarcely any thing was saved except their lives; nothing of their furniture, few of their cattle. Some people were even surprised in their beds, and had the additional distress of flying naked from the ruins. The morning light explained the cause of this amazing scene of terror, and showed the calamity in its full extent; and yet, among all the conjectures of that dreadful night, the mischief that really happened had never been supposed. Lands which in the evening would have let for twenty shillings an acre, in the morning were not worth sixpence. On this well-cultivated plain twenty-eight families had their dwellings and little farms; every one of which, except perhaps a few who lived near the skirts of it, had the world totally to begin again. Who could have imagined that a breast-work, which had stood for ages, should at length give way? or that these subterraneous floods, which had been bedded in darkness since the memory of man, should ever have burst from their black abode? This dreadful inundation, though the first shock of it was most tremendous, continued still spreading for many weeks, till it covered the whole plain, an area of 500 acres, and like molten lead poured into a mould, filled all the hollows of it, lying in some parts thirty or forty feet deep, reducing the whole to one level surface." Gilpin's *Observations on the Mountains and Lakes of Cumberland*.

In order to clear the arable and pasture land of this accumulation of moss, Mr. Wilson from Yorkshire, adopted a very ingenious plan. He formed, in the higher grounds, two large reservoirs, which he filled with water, the whole force of which he directed against a large knoll in front of Netherby House, and afterwards against the accumulated masses, which he succeeded in washing away into the channel of the Esk. Dr. Graham of Netherby had sent for a person to survey the ground, and estimate the expense of removing the moss in the ordinary way. The estimate was L.1300; but while the matter was under consideration Wilson suggested that it might be done cheaper, and by the method which we have mentioned he effected it for less than L.20!

Another account of the eruption of this moss, by Mr. J. Walker of Moffat, will be found in the *Philosophical Transactions* for 1772, vol. lxii. p. 123. According to Mr. Walker, the mossy ridge was reduced no less than twenty-five feet; but what is not easily explained, he makes the eruption take place on the 16th December 1772, whereas Gilpin places it on the

* Three days rain of unusual violence preceded the eruption. Ed.

13th November 1771. Mr. Walker mentions the remarkable case of a cow, the only one out of eight in the same byre that was saved. It had stood *sixty hours* up to the neck in mud and water; and when it was taken out it did not refuse to eat, but it would not taste water, nor even look at it, without manifest signs of horror. It was soon, however, reconciled to it, and was then likely to recover.

SOMERSETSHIRE, a maritime county of England, is bounded on the north by Gloucestershire and the Bristol Channel, on the east by Wiltshire, on the south-west by Devonshire, and on the south-east by Dorsetshire. It is one of the largest counties in England, its greatest length from east to west being about 68 miles, and its breadth from north to south 47 miles; it is 240 miles in circumference, and it is computed to contain 1,050,880 English acres.

This county is divided into two civil divisions, the eastern and the western; in the first there are 20 hundreds and seven liberties, in the second 22 hundreds. Somersetshire possesses two cities, Bath and Wells, and a part of Bristol, seven boroughs, and 29 market towns. The ecclesiastical divisions are one bishopric, three arch-deaconries, 13 deaneries, and 482 parishes. The county is in the province of Canterbury, and the diocese of Bath and Wells. Bath contains two deaneries, Wells seven, and Taunton four.

Few counties present a more diversified aspect or a greater variety of soil, changing from the highly cultivated valley to the barren and stony heath, and to the bleak and lofty hills so seldom to be met with in other parts of England. In the north-east corner are the lofty Mendip Hills, which are chiefly remarkable for the quantity of coals and lead they produce. The other hills of note are Quantock, on the western side of the county, Brendon, near Quantock; Poulden, near Bridgewater, Broadfield-Down, between Bristol and Wrington; Leigh-Down, in the hundred of Portherry; Dundry, near Bristol; Lansdown, near Bath; White-Down, near Chard; and Black-Down, on the confines of Devonshire. Near the Quantock hills is a dreary heath called Exmoor Forest, a part of which, called Dunkeny, is 1668 feet above the level of the sea, and from which there is a fine view of the adjacent country, extending as far as the Bristol channel on one side, and the English channel on the other. The bleakness and sterility of these hills, however, is amply compensated by the luxuriance of the meadows and the fertility of the arable lands, which produce such abundant crops as are sufficient not only for the consumption of the inhabitants, but even for supplying other markets. The general appearance of the country is rich, rather than picturesque, owing, in a great degree, to the scarcity of woods and the sluggishness of the streams, which in summer become nearly stagnant, and thereby greatly diminish the beauty of the landscape.

The chief rivers are the lower Avon, the Ax, the Brue or Brent, the Parret, the Yow, the Cale, Chew, Tone, Frome, Ivel, Ex, and Barl. The lower Avon is a navigable river, and rising in the north of Wiltshire, near Wootton Basset, becomes navigable at Bath, and running on with a circuitous course, it passes Bristol, and empties itself into the Severn, forming the Bristol channel at Kingsroad by its conjunction with that river. The Ax rises in the Mendip hills, and has its chief source in a natural excavation called Wookey Hole, which bears some resemblance to the caves of Derbyshire. This river is not navigable. The Brue or Brent has its origin in Wiltshire, and enters the Bristol channel at Bridgewater Bay; it is navigable for about two miles from its mouth. The Parret rises near the village of south Parret in Dorsetshire, and after its junction with the Tone, runs into Bridgewater Bay through the marsh of Sedgemore. It is navigable from Stert point to Langport, a distance of about 20 miles. These rivers all abound with trout, salmon, perch, pike, carp, tench, and other smaller fish. The only canal that Somersetshire can boast of is the Kennet and Avon, which joins the Thames with the Severn.

As this county has long been famous for the richness of its meadow lands and the abundance of its grass, the fattening of cattle and the management of the dairy has, of necessity, become the most important branch of its rural economy. The oxen bred in the less favoured pasturages of Devonshire afford excellent beef when fattened in this district; and supply not only the neighbouring markets, but even those of London. The sheep natural to the county are of the Mendip breed, but of late years almost every improved variety has been introduced. The dairies are not less remarkable for the superior excellence of their butter and cheese, the cheese of Cheddar having long enjoyed the reputation of being equal to any in England, and is often sold at Gloucester; the butter made in the vicinity of Crewkerne is sent to the London dealers, who sell it under the name of Dorsetshire butter. Among the agricultural products, the cider, which is reckoned superior in strength and purity to that either of Herefordshire or Devonshire, is not the least important, as it is the principal drink of the lower orders throughout the whole county. The natural grass is so plentiful, that it has almost entirely superseded the use of clover or other artificial grasses. Barley is not much grown, but wheat, oats, and bear, together with flax, teazels, and woad, are cultivated very extensively in most parts of the county. The hundred of Taunton Dean is reckoned to produce the best crops of wheat. Elm trees thrive best in the rich loamy soils, which are also particularly well adapted to the growth of flax, most of which is used in the manufactures of the county. Geese feathers formerly yielded a considerable profit, but as many of the marshes were drained and inclosed a few years ago, and as many are now undergoing the same process, the supply of feathers is not nearly so great as it was when the county abounded with marshes, which are necessary for the subsistence of the geese, and which, in their present state, afford much more profit to their owners than before.

Somersetshire is by no means deficient in mineral products; the Mendip Hills abound with lead, coal, and calamine. The lead is chiefly exported for the purpose of making bullets and shot, and the calamine is used by the brass manufacturers of Bristol. The coals supply the cities of Bath and Wells, and the towns of Frome and Shepton Mallet. Lead is also raised on the Cheddar Hills of a finer quality than that of Derbyshire. Manganese, bole, and red ochre, are found on the Mendip Hills, and copper near Stowey. Limestone, fuller's earth, and marl, are procured in other parts of the county.

Somersetshire is almost entirely a manufacturing county. At Frome, Shepton Mallet, and their neighbourhood, there are extensive manufactories of cloths of Spanish and Saxon wool. Ilminster, Chard, Taunton, and Wellington, produce woollen cloths of a middle quality, while others of an inferior description are made at Wevesleombe, Milvarton, and Watchel. Linen goods, such as dowlas, bedtickings, and sail cloths, are manufactured at Yeovil, Crewkerne, Montacute, and Martock. There are silk mills at Bruton and Taunton; and gloves are made at Yeovil. Chard and Wells both possess manufactories, one for wove lace, the other for fine paper; a quantity of valuable articles are made at the glass houses near Bristol. At Bridgewater, there is a foundry and a braziery, which give employment to a number of people.

The foreign commerce of this county is chiefly carried on at Bristol, which is the place from which such goods as are eligible for the foreign market are generally exported, with the exception of the woollen articles made at Taunton and Wellington, which are exported from Exeter. Bridgewater enjoys a trade with Ireland, and many of the smaller sea-coast towns, a coasting trade which they turn to a considerable account. The greatest part of the productions of the county, both agricultural and manufactured, which are not destined for home consumption, find a ready sale at the markets of the adjacent counties. The cattle, butter, and cheese, are sent to the metropolis. Wales and the western counties are supplied with the linen and woollen manufactures.

The parliamentary representatives are two for the county, and two for each of the undermentioned towns, viz: Bath, Wells, Taunton, Bridgewater, Ilchester, Minehead, and Milborn Port, and two for Bristol, which is partly in this county, and partly in Gloucestershire.

Ilchester is considered the county town, as the elections are held there, and as it contains the gaol and county court, although the assizes are held at Taunton in spring, and in the summer season at Bridgewater and Wells alternately.

The population in 1821, was 355,314, of whom there were 152,447 males, and 165,357 females. The inhabited houses were 61,852, the uninhabited 1974, and houses building 850. The number of the families was 73,537, of whom 31,448 were employed in agriculture, 27,132 in trade, and 14,957 in neither of the above classes. See Bellingsley's *Account of the Agriculture of Somersetshire*, and the *Beauties of England and Wales*, vol. xiii.

SOMERSET, county of the United States in Maine. It would be not merely useless, but deceptive to give a description of this county, with its present extent, as the advance of settlement must superinduce perhaps 8, 10, or more counties from its limits. When the census of 1820 was taken, Somerset county extended from Kennebec northward to the extremity of the state, stretching 180 miles in length, with a breadth exceeding 50, and embracing between 7000 and 8000 square miles. But of this great extent, only the southern part was inhabited, and sustained a population of 21,187. The inhabited tract, traversed by the Kennebec river, is a fine, it might be said, beautiful country, and in a state of rapid improvement. Seat of justice Norridgewock. N. Lat. 45° and Long. 7° E. from Washington City, intersect near the Kennebec river in this county, and about 30 miles a little W. of N. from Norridgewock.

SOMERSET, county of the United States in New Jersey, bounded by Middlesex SE., Hunterdon W., Morris N., and Essex North-east. Length 30, mean width 12, and area 360 square miles. This county extends lengthwise from N. to S. and is drained by the various confluents of Rariton river. The face of the country agreeably diversified by hill, dale, and even mountain scenery, render Somerset county of New Jersey one of the most pleasant to the eye of the inland counties of the United States. In 1820, the population amounted to 16,506, or within a very small fraction of 46 to the square mile. The agricultural products are various and valuable, and occupying a nearly central position between New York and Philadelphia, the farmers find a ready market. Somerset divides the city of New Brunswick with Middlesex, and besides the seat of justice, Somerville, has the villages of Boundbrook and Middleburg, with part of Princeton. Central Lat. 40° 35′ N. Long. from Washington City 2° 25′ E.

SOMERSET, county of the United States in Pennsylvania, bounded by Alleghany county in Maryland S., by Fayette county in Pennsylvania SW., Westmoreland NW., Cambria NE. and Bedford E. Length from south to north 35, mean width 26, and area 910 square miles. Embracing a large part of an extensive valley between that particular ridge of the Appalachian system of mountains called the Alleghany, and another lateral ridge, the Laurel hill, the surface of Somerset county of Pennsylvania is a true mountain table land, elevated at a mean of at least 1500 feet above the tides of the Atlantic coast, and upwards of six hundred and sixty feet above the level of the Monongahela at Brownsville. This relative height gives to Somerset a climate near, if not altogether, four degrees of Fahrenheit more severe than that of similar latitude on the eastern coast of New Jersey. The 40th degree of North Lat. and two degrees of Long. W. from Washington City, intersect near the centre of Somerset. The middle parts of New Jersey, will therefore contrast with the southern mountain valleys of Pennsylvania. The comparative tropical climate of the former is usually ascribed to proximity and absence of an open ocean, a cause perhaps of a share of the effect, but difference of level is the far more efficient agent.

A very small angle of the south-east part of Somerset is drained by Wills creek branch of Potomac: Youghioghany river, rising in Virginia and Maryland, flows north into Pennsylvania, forming for 8 or 9 miles part of the boundary between Fayette and Somerset counties, receiving from the latter a large confluent, Castleman's river. The northern section towards Cambria is drained by the south-eastern sources of Conemaugh river. Though bounded by two mountain ridges, Somerset is rather level than even hilly. The soil is various, and generally well adapted to grain and meadow grasses.

The intended Chesapeake and Ohio canal is projected to pass over the southern part of Somerset by the valley of Castleman's river.

Somerset, the seat of justice, is situated near the centre of the county, N. Lat. 40°. Long. W. from

Washington City 2° 05′ Population of the county, 1820, 13,374, or 15 to the square mile nearly.

SOMERSET, county of the United States, on the eastern shore of Maryland, bounded by Worcester county in the same state E., Chesapeake bay S. and W., Nanticoke river, or Dorchester county, Maryland, NW., and Sussex county, Delaware, N. This county lies between the Pocomoke and Nanticoke rivers, and is cut into three peninsulas by the Wicomico and Monokin rivers. The surface is flat and sandy, though generally productive. From the indentings of the bays or river mouths, the area is estimated with some difficulty; the length from the Pocomoke inlet to the Delaware line 30, and mean width 15, with an area, exclusive of water, of about 450 square miles. Central Lat. 38° 16′. Long. E. from Washington City 1° 18′. Seat of justice, Princess Anne.

DARBY.

SOMME, the name of one of the departments in the north of France, is bounded on the north by the Straits of Calais, on the west by the sea and the department of the Lower Seine, on the south by that of the Oire, and on the east by that of the Aisne. In point of agriculture and manufactures this is one of the most flourishing departments in France. Tillage and the feeding of cattle are carried on as in Flanders. The surface contains 604,456 hectares. The principal river is the Somme, whence it derives its name. The chief towns are

	Population.
Amiens	40,289
Abbeville	18,052
Doullens	2,946
Montdidier	4,049
Perrone	3,706

The forests occupy 57,000 hectares, and the contributions in 1803 amounted to 5,630,664 francs. The population in 1822, was 508,910, and in 1827 526,282; there being 860 inhabitants to every 1000 hectares. See ABBEVILLE and AMIENS.

SOMNAMBULISM is that state of the body in which it *walks* during *sleep*, and performs many voluntary actions without any consciousness of performing them, or any recollection of their having been performed.

In this state of the body the patient rises from bed, opens doors, windows, or drawers, walks into the fields, sits down to write, crosses hedges, walks along the tops of houses, ascends precipices, climbs to rooks' nests, and performs feats from which he would shrink in his waking moments. To these we may add the delivery of sermons and prayers during sleep, a power possessed, and for many years exercised, by an American lady. Dr. Park is of opinion that "the physical cause of this singular affection appears to be an irregular distribution of blood in the sensorium, or some local congestion that impedes the uniform and simultaneous restoration of the corporeal and mental faculties." Those who wish to study the subject may consult Hoffmann's *Dissertatio de Somnambulismo*, in the Suppl. to his works, vol. iii. Art. *Somnambulism* in the Encyclopedie. Cleghorn, *De Somno*, Edin. 1783, Darwin's *Zoonomia*, vol. i. Sect. 19. in Dugald Stewart's *Philosophy of the Human Mind*, chap. v. and Dr. Park in the *Quarterly Journal*, vol. vii. p. 258. See also our article DREAMS.

SONORA and SINALOA, (*Sonora y Sinaloa*,) nominally a state of the Republic of Mexico, but in fact an immense, and towards the northern part, but imperfectly known section of North America, exceeding in extent the whole Atlantic section of the United States. As laid down and coloured on Tanner's map of Mexico, Sonora and Sinaloa extends from N. Lat. 21° 40′ to 39° 40′, or through 18 degrees of latitude, and limited on the north-west by the Red river of the Gulf of California, (*Rio Colorado*,) and W. by the Gulf of California. It touches the states of Jalisco and Durango on the south-east, with Chihuahua and New Mexico stretching along the eastern border. Thus restricted, this country reaches from South to North over 1250 miles with a mean width of at least 200, and embraces an area of 250,000 square miles.

Restricting Sonora y Sinaloa to the Colorado river, however, leaves an unnamed region of Mexico south from N. Lat. 42°, which if included would give the state under review a superficies of at least 300,000 square miles. The following will be confined to the region between the Gulf of Bayona, and the Rio Gila.

According to Humboldt, the Intendancy of Sonora comprehended the three provinces of Cinaloa, or Sinaloa, Ostimury, and Sonora Proper. Sinaloa reached from the Rio del Rosario to the Rio del Fuerte. Ostimury occupied the narrow space between the Rio del Fuerte and the Rio Mayo. Sonora, more anciently New Navarre, included all the northern extremity of the Intendancy.

Sonora and Sinaloa is a hilly rather than mountainous country, and from either the meagre description of Humboldt or its representation on our maps, is in a great degree devoid of large navigable rivers. The Rio Gila rises in the Sierra de los Mimbres, between N. Lat. 32° and 34°, 31° W. from Washington City, and flowing westerly about four hundred miles, falls into the estuary of the Rio Colorado, N. Lat. 32° 50′. At a long interval of upwards of four hundred miles, flowing the coast SSE. with the small river Ascension excepted, there is no stream worthy notice from the mouth of the Rio Gila to that of the Hiaqui.

The Rio Hiaqui has its remote sources in the same chain with those of the Gila, but the former pursues a course of SW., four hundred miles, into the Gulf of California, which it enters opposite Cape St. Miguel, N. Lat. 27° 40′. It is probable that as a navigable entrance the Hiaqui is of little importance, as no city or extensive settlement has risen on its banks. From the outlet of Hiaqui to the Gulf of Bayona, in a distance of five hundred miles, several petty rivers flow from the interior, but are of minor value regarded commercially.

The Gulf of California, the American *Red Sea*, is, in geographical strictness, the continuation of the Rio Colorado, and stretches along Sonora and Sinaloa, 800 miles from the mouth of the Rio Gila, to a line from Cape Palmas to the port of Mazatlan, where it terminates in the Pacific Ocean, N. Lat. 23° 15′. The Californian Gulf is narrow and much chequered with islands, and represented as of difficult and dangerous navigation. Between Cape Palmas, the south-eastern point of the peninsula of California, to the opposing shore of Sinaloa, the Gulf is 120 miles wide, but at Cape St. Miguel, and at the Tiburon islands, not above 40, and may, in all its length, average a mean breadth of 60 miles, or an area of 48,000 square miles.

If the mental eye is turned to a map of North America, and the courses of the Colorado and its recipient. the Gulf of California, are taken in connexion, with the great western confluents of the Mississippi, the conclusion follows, that in the advance of population and improvement, the greatest facility to an inland communication between the United States and the Pacific ocean, is offered by the route of Sonora and Sinaloa. If the view of the map of America is extended to that of the world, it will be seen, that a commercial chain extended from St. Louis on the Mississippi, over the Colorado basin stretches towards China, India, and Polynesia, and merges into the Pacific Ocean twenty-three degrees of latitude more southwardly than by the Columbia.

The population of this region is stated by Humboldt (1803-5) at 121,400; in Tanner's map of Mexico the inhabitants of Sonora and Sinaloa are given in a subjoined table at 188,636. Neither adduce their authority or inform us whether the independent Indians are included, or whether the estimate is restricted to the whites and subject tribes of natives. If, however, only the latter are included, the distributive population must be very thin. Humboldt (1803) our only authority for the condition of this remote country, has passed the mental state of the whites in silence, but observes that "the Indians who live on the plains adjoining the Cases Grande of the Rio Gila, and who have never had the smallest communication with the inhabitants of Sonora, deserve by no means the appellation of savages. (*Indias bravos.*) Their social civilization forms a singular contrast with the state of the savages who wander along the banks of the Missouri." The Spanish missionaries who have been able to reach this interesting region, represent the inhabitants as civilized, and social, residing in villages formed of good houses and environed by well cultivated fields. More, these Indians were found clothed in cotton fabrics of their own manufacture. These favourable accounts have been recently confirmed by some travellers from the United States.

This domestic and advanced civilization cannot be of recent origin. "Father Francisco Garces, accompanied by Father Font," says Humboldt, "who was intrusted with the observations of latitude, set out from the Presidio d' Horcasitas, on the 20th of April, 1773. After a journey of eleven days, they arrived at a vast and beautiful plain, one league's distance from the southern bank of the Rio Gila. They there discovered the ruins of an ancient Aztec city, in the midst of which is the edifice called *la Casa grande.* These ruins occupy a space of ground of more than a square league, ($7\frac{1}{4}$ *square miles nearly.*) The Casa grande is exactly laid down according to the four cardinal points, having from north to south 445 English feet, and from east to west 276 feet. The walls are of clay, constructed in *Pisé* 3 feet 11 inches thick. The edifice had three stories and a terrace. The same kind of construction is still to be found in all the villages of the Independent Indians of the Moqui west from New Mexico. A wall, interrupted by large towers, surrounds the principal edifice, and appears to have served to defend it. Father Garces discovered the vestiges of an artificial canal, which brought the water of the Rio Gila to the town. The whole surrounding plain is covered with broken earthen pitchers and pots, prettily painted in white, red, and blue. We also find amongst these, fragments of Mexican stone ware, pieces of obsidian, (itztli,) a very curious phenomenon, because it proves that the Aztecs passed through some unknown northern country which contains this volcanic substance, and that it was not the abundance of obsidian in New Spain which suggested the idea of razors and arms of itztli.

"We must not," continues Humboldt, "confound, however, the ruins of this city of the Gila, the centre of an ancient civilization of the Americans, with the Casas grandes of New Biscay, situated between the presidio of Yanos and that of San Buenaventura." Between these points are spread plains and mountains in a distance of upwards of one thousand miles.

Gold is amongst the productions of Sonora and Sinaloa. The hilly country of Pimeria alta is the Choco of North America. All the ravins and even plains contain gold scattered up and down the alluvious land. Fragments are discovered weighing from five to eight pounds Troy.

The most remarkable places of Sonora are Arispé, the former capital of the state, N. Lat. 30° 36′, Long. W. from Washington City 31° 38′, upwards of one thousand miles NNW. from the city of Mexico. Population 8,000.

Sonora the present capital of Sonora proper is situated about 50 miles south from Arispé. Population 6,400.

Hostimury, or Ostimury, is a mining town and capital of the province of the same name, situated on the Pacific ocean, N. Lat. 27°.

Sinaloa, or Cinaloa, otherwise known by its ecclesiastical name of *Villa de san Felipe y Santiago*, is now the capital city of the state of Sonora and Sinaloa, containing a population of 13,000; and is situated at N. Lat. 26° 58′, and Long. W. from Washington City 30° 57′, upwards of five hundred miles NW. from the city of Mexico.

About one hundred and twenty miles SE. from the city of Sinaloa, stands Culiacan, the Aztec Hueicolhuican, on a small river of the same name. It is still a place of some consequence as the population was stated by Humboldt at 10,800.

On the small river del Fuerte, 70 or 80 miles NW. from the city of Sinaloa, is situated a considerable town, Montesclaros, or Villa del Fuerte, with a population of 8,000; and 70 miles still farther NW. is Alamos, sustaining 8,000 inhabitants.

A Rosario, near the rich mine of Copala, and approaching the southern extremity Sinaloa and about 200 miles SE. from the city of Sinaloa, contains a population of 6,000.

DARBY.

SOPHOCLES, a celebrated tragic poet, was born at Athens, 497 B. C. In his twenty-eighth year he entered the lists with Æschylus and gained the theatrical prize, and in the opinion of the best critics both of Greece and Rome, he has been placed above all the ancient writers of tragedy. Sophocles was distinguished also as a general. He commanded the Athenian armies, and in several battles he held the supreme command along with Pericles. He exercised also the office of Archon. He is said to have died of joy at the advanced age of ninety, in consequence of having obtained a poetical prize at the Olympic games. Of the one hundred and twenty tragedies which he composed only *seven* are extant, viz. *Ajax, Electra, Oedipus, Tyrannus, Antigone, the Trachiniæ, Philoctetes*, and *Oedipus at Colonos.* The best editions of this author are those of Capperonier, 2 vols. 4to. Paris, 1720; Johnson's, in 3 vols. 8vo. Oxon. and Lond.; Bruncks, 4vols. 8vo. and Musgrave's, Oxon. 2 vols. 8vo.

SOREL, river of Lower Canada. This stream, the outlet of Lake Champlain, is known by several local names; towards Lake Champlain it is called Richelieu river, near Lake St. Joseph the Chambly, and near its entrance into St. Lawrence the Sorel. From Windmill Point in Vermont, where the current from Lake Champlain begins, to the mouth at the town of William Henry in Lower Canada, the course of the Sorel river is a little east of North, 72 miles, and with but few partial inflections. The valley of the Sorel is indeed only a part of that very remarkable glen or chasm in the earth's surface, occupied by the Hudson river, Lake Champlain and Sorel. The stream is ample and rendered less subject to fluctuation from the seasons than rivers which are formed without lakes, but is much impeded from shoals and rapids. It serves, however, as a channel for a very considerable down stream navigation.

DARBY.

SORRENTO, a town of Naples, delightfully situated in the middle of gardens, on the south side of the Gulf of Naples, between the mountains of Massa and Vico. It was the birth place of Tasso. The number of ancient marbles, and the ruins of temples attest its former reputation and importance. Population, 4200.

SOVEREIGNTY. See GOVERNMENT.

SOUND. See ACOUSTICS, HARMONY and MUSIC. See also SCIENCE, *Curiosities in*.

SOUTHAMPTON, an ancient town and burgh of England, and capital of the county of Hampshire, is pleasantly situated on a tongue of land bounded on the south and west by the large estuary called Southampton water, and on the east by the river Itchin. The town contains many handsome streets, which are built of bricks, instead of timber, which was formerly the custom. The High Street, which runs northward from the quay, is upwards of half a mile in length, and is no less remarkable for its elegance and spaciousness, than for the resemblance it bears to the High Street of Oxford. Owing to the circumstance of the town being built upon a slightly elevated ridge, and the soil being of a gravelly nature, the streets are kept remarkably clean and dry. They have also the advantages of being well paved, and regularly lighted and watched. The public buildings are five parish churches, St. Michael's All-Saints', Holyrood, St. Lawrence, and St. Mary. There were formerly six churches; but the parishes of St. John and St. Lawrence being united in the reign of Charles II. it was deemed expedient to pull down the church of the former at the same time. St. Michael's is the oldest of the five, and is ornamented by a lofty octagonal spire, which was erected about sixty years ago for the purpose of guiding ships entering the harbour. On the north aisle of the chancel, a handsome monument has been raised to the memory of the Lord Chancellor Wriothesley; and in the opposite aisle on the south, there is a very curious antique font. It is in this church that the ceremony of the mayor being sworn into office takes place. All-Saints' church is a handsome modern building in the Grecian style. The remains of Captain Carteret, the well known circumnavigator, and of Bryan Edwards, the celebrated historian of the West Indies, are interred here. Holyrood church is a spacious edifice, with a tower at the south-west angle, and a colonnade in front, generally called the Proclamation, where the hustings is erected, and the poll taken at elections. In the interior of the church, there are several monuments, and a fine organ. The churches of St. Mary and St. Lawrence are no way remarkable. There was formerly a house of Grey Friars, instituted in 1240, of which hardly a trace now remains. At the north end of the High Street, there is a curious old gatehouse called the Bar gate. On its north front are delineated two gigantic figures, one on each side of the gateway, which, according to tradition, were intended for the giant Ascupart, and Sir Bevois of Southampton, who slew him in combat. Southampton being much frequented during the summer months by visiters, for the purpose of enjoying the sea-bathing, and drinking the chalybeate water, a spring of which, highly esteemed for its medicinal qualities, rises about a hundred yards to the west of Bar gate, is enabled to support a theatre, and assembly and ball rooms, which are beautifully situated, and elegantly fitted up. The Audit house is a handsome edifice, in which the sessions are held; it is also the repository of the records and regalia of the corporation. There is a free grammar school, which was instituted so long ago as the reign of Edward the Sixth. There is likewise a charity school for ten boys, founded by Alderman Taunton of this town; and Sunday schools, and a school of industry, were established in 1786, and are still continued. Near the entrance of the town on the right, is a neat range of alms-houses, built about fifteen years ago, to accommodate eighteen poor widows, who each receive two shillings per week from a legacy left by Robert Thorner, Esq. of Baddesley, who died in July 1690. There is an hospital, called Domus Dei, or God's house, founded in the reign of Henry the Third, for four old men and as many women. The poor house is an extensive, modern, and convenient structure. Near the town, on the north, barracks have been lately built by government, for the reception of cavalry, which occupy nearly two acres of ground. The principal trade of this port is with Portugal, the Baltic, and the Islands of Jersey and Guernsey. Wine and fruit are imported from Portugal. Tar and pitch from Sweden; hemp, iron, and tallow from Russia. English iron is brought by the coast from Wales; and coals, lead, and glass, from Newcastle. Southampton is allowed to export 6000 tons of unwrought wool yearly to Jersey and Guernsey; the most part of which is returned, converted into coarse knit hose. The manufactures are inconsiderable, being chiefly silk and carpets. Frigates and sloops of war were formerly built here, but ships of smaller burden only are now constructed. Southampton is governed by a mayor, recorder, sheriff, two bailiffs, and a common council, (formed of all those who have filled the foregoing offices,) a town clerk, two coroners, and other inferior officers, and is a county of itself, being styled the town and county of the town of Southampton, a privilege bestowed on it by King John, and, as such, is independent of the lord lieutenant and sheriff of Hampshire, having its own clerk of the peace, which office was added by charter to that of the town clerk. It returns two members to parliament, who are elected by about 700 voters, consisting of the burgesses, and those inhabitants who pay scot and lot. The mayor is admiral of the liberties from Southsea Castle to Hurst Castle, and half sea over from Calshot to the Isle of Wight. It was in this town that the Earl of Cambridge, Lord Scrope of Masham, and Sir Thomas Grey, were executed, for conspiring against the life of King Henry the Fifth. The number of eminent men born at Southampton is not very great; the most remarkable are Nicholas Fuller, an eminent divine, born in 1557, who died in 1622-3; Dr. Isaac Watts, born in 1674, who died in 1748, and Richard Pococke, a celebrated traveller, and a bishop of Meath, born in 1704, who died in 1765. In Southampton four fairs are held annually, the principal of which is opened by the mayor and bailiffs with much ceremony; there is a market every Tuesday, Thursday, and Saturday, which is held in an area behind the Audit House, and is plentifully supplied with fish and provisions of every kind, and of the best description.

The population in 1821 was as follows:—

Houses	2,161
Families	2,960
Do. in trade	2,331
Males	5,931
Females	7,422
Total population	13,353

See the *Beauties of England and Wales*, vol. vi. p. 125.

SOUTHAMPTON, county of Virginia, bounded south by Northampton and Hertford counties of North Carolina, south-west by the Meherin river, or Greenville county of Virginia, on the north-west by Greenville, Sussex, and Surry counties, and on the east by Blackwater river, or Isle of Wight and Nansemond counties. Greatest length from south-west to north-east 40 miles, and the area being within a trifling fraction of 600 square miles, the mean width about 15 miles. The outlines are nearly triangular, with the base to the north-west, and opposite angle on North Carolina, near the junction of Nottoway and Blackwater rivers. Bounded north-east and east by Blackwater, south-west by Meherin, and traversed nearly centrally by Nottoway river, the navigable facilities of this county are remarkably abundant. The whole of the preceding rivers unite and form the Chowan 9 or 10 miles by water within North Carolina, and continuing their original course south-east, open into Albemarle Sound. Extending from N. lat. 36° 30′ to 36° 54′, Southampton comes into the region where cotton can be successfully cultivated, and lying below the falls of the river, the surface is but moderately elevated above tide water. The seat of justice and principal post-office is at Jerusalem, on the Nottoway, near the centre of the county, N. lat. 36° 39′, and only 6 minutes of longitude west of the meridian of Washington City. Population of the county in 1810 was: Whites, 3216; coloured persons, 908, and slaves, 3350; total 7474:—in 1820, whites 3369; free coloured persons 1013, and slaves 3323; total 7705.

SOUTH AMERICA.

South America, one of the great continental extensions of the earth, and to which has been given a very improper relative name, since though confounded under one general term, the two sections of the newly discovered continent stand much more detached from each other than do Asia and Africa, and beyond comparison more than Europe and Asia. In general features, and in vegetable and animal productions also, the two Americas stand very strongly contrasted.

South America reaches in a very nearly north and south direction from Cape Vela, N. lat. 12° 15′, to Cape Horn, S. lat. 56°, or through above 68 degrees of latitude, 4743 miles. The greatest breadth is almost exactly at right angles to the greatest length. From Cape San Roque to Cape Blanco on the Pacific is very near 44 degrees of longitude, on from 4° to 5° S. lat. giving to the continent a width of upwards of three thousand miles.

On even a cursory glance on its map, coloured to represent, not the political, but natural subdivisions, the mountains and rivers of South America present themselves as the most distinguishing features. We find the continent united to North America by a mere strip of land, and expanding rapidly to the south-east. The connecting isthmus is really or apparently continued southward in an immense system of mountains, to which the original Spanish discoverers bestowed in their just admiration the title of Cordilleras. In the first ages of Spanish discovery, the Andes, as they are now universally called, were considered as continuous from one continent to the other, but more recent and accurate observation has rendered the connexion doubtful between the mountains of North and South America. Without attempting to decide the problem, we may proceed to regard the Andes of South America as an immense system of mountains stretching along the western side of that continent in all its length, and dividing it into two very unequal inclined planes. Between the Andes and the Pacific Ocean, the slope of land does not average one hundred miles in width, though extending along an inflected line of upwards of sixty degrees of latitude.

Rising from this confined border, the system of the Andes extends in lateral ridges, with unequal intervening vallies; the system extending in width from 100 to 200 miles. Here occur many of those elevated, and, from their approach to the equator, habitable vallies, or rather plateaus, which vary the features of every continent, but which in South America deserve particular notice. This will appear from a comparative view. In Europe, the table land of Spain is about 1900 feet above the level of the ocean. The table land of the Alps rises to about from 1300 to 1900 feet, and that of Bohemia and Silesia perhaps at a mean of 1400 feet. The highest level in France* is Auvergne, which rises to 2360 feet above the ocean level. The central plateaus of Asia and Africa are not very accurately determined, but must be far more elevated than the high plains of Europe.

In South America,† the Cordilleras of the Andes exhibit at immense heights plains comparatively level. Such is the plain between the sources of the Meta and Magdalena, N. lat. 3° 5′, elevated 8413 feet, where on its surface stands the city Santa Fè de Bogotà. Some of the vallies and plateaus of Peru are equally, if not still more elevated. But the volcanic region of Pichincha, only 13 minutes south of the equator, sustains the city of Quito at the height of 9500 feet above the Pacific.

The enormous summits or peaks of this vast system may be said literally to pierce the heavens, and not only reach, but pass the region of perpetual snow. Though it is probable that the Andes of Chili are as high as those of Colombia, the latter part of the system has been scientifically measured, whilst the more southern chains have not been visited by travellers of adequate activity and science. The following tabular view contains the height of the most remarkable peaks of the Colombian Andes:—

Chimborazo	21,440 feet. ‡
Disca Casada	19,570
Cayamba Urcu	19,392
Antesana	19,152
Cotopaxi	18,864
Altair	17,472
Sangal	17,152
Tunguragua	16,579

From this congeries of chains, peaks, and ridges, are precipitated westward into the Pacific, innumerable small, but locally interesting rivers. Of the Pacific river system of South America, the Guayaquil & Patia, neither having a comparative course of 200 miles, are nevertheless the most considerable streams, but on the eastern slope, the lengthened volumes of the Magdalena, Orinoco, Amazon, Plate, St. Francis, Colorado, and Cusu Leuvu, compensate for the brevity of those westward from the Andes.

Without noticing the minor branches, which would swell this article to an inconvenient length, it will be sufficient to review the great basins, not in their order of extent, but in respect to their position, relatively advancing from north to south.

The basin of Magdalena is long and narrow, and extending from south to north, nearly along the 2d and 3d meridian E. of Washington City, is in effect only an extension of the great vallies of the Andes. From Popayan, near the head of the basin, at an elevation of 5900 feet, the valley sinks gradually, but renders the rivers very unnavigable, from the great general descent. The entire basin stretches from N. lat. 2° to 11°, length 700; mean breadth about 120, area 84,000 square miles. Down this basin flow the various confluents of the two great constituent branches of the Magdalena, the Cauca and Magdalena proper. These streams unite at N. lat. 9°, and flowing thence one degree of latitude more northward, separate into two branches, which encircle the city of Carthagena, and enter the Caribbean sea 70 miles asunder.

The two minor basins of Atrato to the west, and Maracaibo to the east of that of Magdalena, belong to the Caribbean slope of South America, which is continued eastward to the gulf of Paria or Trinidad by a narrow strip.

From the sources of the Magdalena, a vast arm of the Andes extends north-eastward upwards of eight hundred miles, until imperceptibly merged in the plains of Coro. From this chain flow westward the confluents of the Magdalena, and to the eastward those of the Orinoco.

Entering the basin of Orinoco, introduces us to the most interesting river system of the earth. In this system, though only the third in extent, the basin of the Orinoco embraces an area of nearly four hundred thousand square miles, between N. lat. 2° and 10°, and from 2° to 17° long. E. from Washington City.

The particular confluents of this great river are too numerous to admit individual notice: it may suffice to observe, that the north-western branch, the Apure, draws its sources from the mountains of Merida and Paramo de la Rosa, and from the chain of Venezuela; some of its northern fountains rise within 40 miles of the Caribbean sea in the provinces of Maracaibo and Caracas.

The Meta, a longer, though perhaps in volume not so great a body of water, follows the Apure, and is again succeeded by the Guaviare. The latter rises in the main Cordilleras of the Andes, interlocking sources with the Rio Negro and the Magdalena.

The Orinoco properly so called, rises in the mountains of Guyana, N. lat. 5°, and long. 11° E. from Washington; flowing thence eastward, bends gradually to the south,

* Humboldt's New Spain, Black's translation, New-York, vol. i. page 37.

† Humboldt's New Spain, Black's translation, New-York, vol. i. page 41.

‡ Until recently, it was, as stated in the text, supposed that the first rank in height amongst American mountains was due to the Chimborazo, but it is now ascertained that it is more than rivalled by the peaks of Upper Peru. "In the eastern chain separating the valley of Desaguadero from the immense plains of Chiquitos and Moxos, are found the Nevado de Sorata, elevated 25,250 English feet above the ocean, and the Nevado de Illimani, of 23,000 English feet of similar relative elevation." The Sorata and Illimani were measured by Mr. Pentland. Vide Revue Encyclopédique, vol. 49, page 145—January, 1830. Paris.

south-west, and west, to where a stream flows from it into the Rio Negro. At the efflux of the Cassiquiari, the Orinoco has already flowed by comparative courses upwards of four hundred miles. The junction of the Amazon and Orinoco by the Cassiquiari and Rio Negro on an elevated plateau, is certainly the most singular and important fact in the natural history of rivers. This connexion, long denied after discovery, has been added to ascertained fact and science by Humboldt and Bompland, who actually passed from the Rio Negro by the Cassiquiari into the Orinoco.

With its great extent, variety of feature, and peculiar structure, the Orinoco is still an humble stream if compared to the Amazon. The latter basin sweeping from the Atlantic to the verge of the Pacific Ocean, embraces the central and southern equatorial regions of South America, and comprises the great superficies of two millions eight hundred thousand square miles. Similar to all very large rivers, there is an idle dispute respecting the source particularly deserving of the title given to the basin. Measured from the mouth, by the valley of the Negro, the length is about 1800 miles; by the Madeira, 2300 miles; but following the main volume and the Ucayale, it is 2900 miles. In a nearly western and eastern direction from the sources of the Tunguragua, the chord of the basin is about 2600 miles. If, therefore, we regard length of course as decisive of the question, the Ucayale is the main stream of the Amazon basin. The Ucayale and Madeira rise together from the Andes in the province of Cochabamba; but pursuing different directions, the former flows 2100 miles, and the latter 1800 miles before their union.

From the sources of the Ucayale, 17° S. lat., to the most northern branch of the Lauricocha, S. lat. 1°, the strip of land between the sources of the Amazon and the shore of the Pacific Ocean does not amount to an average of one hundred miles, and in many places is less than seventy miles wide.

To give a minute description of this wide spread and important basin would demand an extensive treatise; we must therefore be limited by a general view. If the windings are followed, by the most lengthened constituent branches, the Amazon flows from 3000 to 5000 miles. If we assume the Amazon proper, and Tunguragua, as the main stream, it receives from the north, beside innumerable branches of lesser note, the Pastaca, Piguena, Napo, Jupura, and Negro, advancing from head to mouth; on the contrary side, and proceeding in a similar direction, we find the Ucayale, Javari, Jutay, Jurua, Purus; the very lengthened Madeira, Tapajos, Xingua, and we may add the Tocantinas.

If the Amazon basin is compared with that of the Mississippi, the great extent of the former becomes more striking. The basin of the Mississippi is a trapezium of 1700 miles diagonal, with a mean breadth of 800 miles, area one million three hundred thousand square miles. The basin of the Amazon approaches a parallelogram of 2100 miles by 1400 miles, with an area of 2,940,000 square miles, forming by at least one half, the most extended basin on earth, having but one point of discharge, and affording much the most expansive navigable system of rivers, flowing towards a single recipient.

The great central valley of South America is continued southward from the basin of the Amazon, and between 13° and 36° S. lat. presents another very extended river basin, that of the Plate. The range of the Orinoco and Amazon basins are nearly at right angles to the chains of mountains, whilst on the contrary, the Plate basin ranges nearly parallel to the Andes and Brazilian systems of mountains.

The principal river of the Plate basin, the Paraguay, or as it is called in the latter part of its course, Parana, rises about S. lat. 13°, between the sources of the Madeira and Tocantinas, and flowing in an opposite direction from those of the Tapajos. Continuing a southern course through twenty degrees of latitude to its junction with the Uraguay, receiving in the intermediate distance, from the west, the Pilcomayo, Rio Grande, and Salado, and from the east, the great tributary branch the Parana, which latter name the united streams assume below their junction.

The whole of these vast arms with their minor branches, drain a navigable basin approaching the form of a square, with a mean of 1140 miles each side, area nearly one million three hundred thousand square miles. There is a remarkable equality of extent between the basins of the Mississippi and Plate, but what is more remarkable, they do not, when taken together, equal that of the Amazon. Again, if we add together the three great central basins of South America, we have a continuous valley sweeping over four million five hundred thousand square miles, and comprising within and contiguous to the torrid zone, more than the one ninth part of the land area of the earth.

The basin of the Plate, between S. lat. 20° and 24°, approaches to within fifty miles from the Pacific coast of Upper Peru; and on the opposing side of the continent, in the Brazilian province of St. Paul, the remote sources of the Parana rise but little more than thirty miles from the Atlantic Ocean. On S. lat. 24°, the continent of South America is 25 degrees of longitude, or 1575 statute miles wide, but the Plate basin has its greatest eastern and western extension on S. lat. 21°. Along the latter curve the basin itself is 25 degrees of long. wide, where the degree is 64.42 miles each, consequently it is upwards of sixteen hundred miles from the fountains of the Pilcomayo, in the Andes, to those of the Rio Grande branch of the Parana.

The breadth of the Plate basin varies less perhaps than does in that respect any other of the great river basins of the earth. From cape St. Antonio, the southern point of the bay of Rio de la Plate, to the sources of the Pilcomayo, in the vicinity of Potosi, is 1400 miles. A line drawn between these points is nearly the base of the basin, since it leaves the far greater part of the surface to the north-east. The breadth from the base contracts in advancing towards the Brazilian provinces, but will average at least 950 miles.

From so great a surface in temperate latitudes issue the various constituent streams which ultimately unite and form the wide estuary known as the bay of Rio de la Plata. This inlet opens to the Atlantic Ocean between S. lat. 35° and 36°, and long. 21° E. from Washington City, and is from the confluence of the Paraguay and Uraguay to the Atlantic 200, with a width varying from 30 to 150 miles wide.

In their general characters, the eastern and western confluents of the Plate vary essentially; the Parana and its branches are rather rapid currents, but the flow is gentle, or indeed sluggish, of the Paraguay and all its western tributaries. Such distinction of feature arises from the general structure of the continent of South

America. Rising as has been observed, by a rapid acclivity from the Pacific Ocean to the table land of the Andes, the short rivers flowing from so great an elevation westward, are brief in their courses, but rapid torrents until near their recipient. The streams again, which are discharged eastward, also are poured down the steeps with great velocity and frequent cataracts, until reaching the eastern verge of the Andes they enter on a plain, over which their channels are excessively winding and deeply cut, but currents necessarily sluggish.

The central plain of South America stretches with variant breadth, from the north-western sources of the Orinoco, to Patagonia, some places wooded, but in others presenting on the basin of Orinoco, the grassy tracts of Casanare, and Llanos of Cundinamarca and Pilcomayo; and again the wide spread Pampas of Buenos Ayres.

Crossing the central plain, the continent eastward from the basins of the Amazon and Plate, rises into a table land less elevated and less extensive than the Andes, but distinct, and from which the river currents fall with considerable force. The Amazon, flowing from the Andes, may be said to pierce the eastern plateau, and enter the Atlantic by a wide ravine between the Brazilian system of mountains and that of Guyana; but the tributary waters of the Plate issuing from the eastern and western plateaus, flow towards each other, unite in the heart of the continent, and continue over the central plain to the Atlantic.

Considering the Parana as the principal stream, a Spanish author observes, that " one of the peculiarities which most interests the curiosity of the observer, is the nature of its periodical inundations, very much resembling those of the Nile. In fact, we believe that there is not on the globe two other rivers, the qualities of which are more analogous to each other. Both have their sources in the torrid zone; and nearly equidistant from the equator, although in different hemispheres. Both disembogue themselves almost on the same latitude, directing their course towards their respective poles. Both are navigable for many leagues, and possess each their cataracts. Each of them has its periods of increase in the respective seasons, which cause it to rise in its channel, and inundate an immense tract of country."

With the preceding points of resemblance, it may be observed that the contrasts between the Nile and Rio de la Plata are equally striking. The Nile enters the final recipient by an extensive Delta, the Plate by a wide bay, and whilst the African river is environed in all the lower part of its basin by arid sandy plains, the Plate and Parana, with their confluents, drain an almost invariable fertile tract.

As a basin of navigation, that of the Plate possesses advantages fully commensurate, in a comparative view, with its relative extent. At the lowest depth, there is 15 or 16 English feet of water in the mouth of the Parana, and a much greater depth below in the bay, or above in the river. Vessels of 300 tons burthen are built above the junction of the Paraguay and Pilcomayo, and navigated to Europe and elsewhere. The Parana proper, the Salado, Rio Grande, Uraguay, Paraguay, and many others, present navigable channels from 200, to near 2000 miles, following the sinuosities of the rivers.

Beyond the basin of the Plate spreads a triangular slope from S. lat. 36° to 52°, being a continuation southward of the great plain of the Andes. The latter section is least known, and in the existing state of settlement and civilization in South America, the least important of the Atlantic portion of that continent. The Saladillo, Colorado, Cusu Leuvu, Camarones, and some other rivers, traverse the slope south from Buenos Ayres, but are mostly yet inhabited by savages, and as far as known not generally well calculated for civilized settlement. This tract is succeeded to the southward by another equally savage, and much more naturally rugged and inclement, and Patagonia, with the adjacent island of Tierra del Fuego, closes South America, by the most Austral continental protrusion of the earth.

Returning to more genial climes, and passing the ample estuary of the Rio de la Plata, we discover, skirting the Atlantic Ocean, a narrow extended but very interesting slope. The Brazilian table land, inclining a very little from the meridian towards N. E. and S. W. extends in broken fragments from the outlet of the Plate basin to that of the Amazon, giving existence and course to numerous rivers. If not on the same continent, and contrasted with the Orinoco, Amazon, and Plate, a respectable rank would be due to such rivers as Rio Grande, St. Francis, and Parnaiba.

Much confusion has arisen in Spanish American geography, by a multiplication of the same names. Several rivers are known by the title of Rio Grande, one of which, a very remarkable stream, is disembogued into the Atlantic Ocean, almost on S. lat. 32°. What is called here Rio Grande, is however only the mere discharge of a basin of about 500 miles from S. W. to N. E. and with a mean width of 140, area 70,000 square miles.

Two large lakes, the Laguna Patos, 150 by 50 miles, and the Laguna Merin, something less in length and breadth, lie parallel to the opposing coast, the latter discharging its water into the former, and both fed by numerous rivers flowing from the interior table land.

Between S. lat. 20° and 28°, and north-eastward from the basin of Rio Grande, extends a narrow zone, varying from about 150, to less than 50 miles wide, and 900 in length; having the Atlantic Ocean S. E. and the sources of the Parana N. W. Besides many smaller streams traversing this well watered tract, are the Ribeira and St. James, of considerable length of course. With S. lat. 20°, the Brazil slope of South America widens rapidly, the table land inclining west of north, and stretching towards the mouth of the Tocantinas. The rivers entering the Atlantic between S. lat. 11 and 20°, are excessively numerous, though of abridged course. The limited length of those rivers, as produced by one of those singular phenomena, which render the geography of South America peculiar. The St. Francis derives its highest sources interlocking with those of the Parana, within 200 miles from the Atlantic coast, and as far south as lat. 21°. Pursuing a northern course of 400 miles, the St. Francis inflects gradually to the north-east, east, and south-east, enters the Atlantic Ocean at S. lat. 11°, after an entire comparative course of upwards of 1100 miles, and in this long course overheading the intermediate Atlantic rivers.

On the same slope, and nearly due west from the mouth of the St. Francis, and interlocking sources with that river, and with the Tocantinas, rises the Parnaiba. The latter inclining to N. N. E. and after a comparative course of six hundred miles is lost in the Atlantic Ocean, at S. lat. 2° 40′.

Sweeping round the extreme eastern protrusion of South America, forming politically the Brazilian provinces of Pernambuco and Ceara, in a distance of 900 miles from the mouth of St. Francis to that of Parnaiba, the rivers are found still more confined in their courses than on any other part of the oceanic margin of South America; but from the estuary of the Parnaiba to that of the Amazon, or rather to that of the Tocantinas, the Pinare, Gurupy, Capim, and some others, flow from two to three hundred miles, before their exit into the Atlantic.

Passing the estuary of the Amazon, we discover between that outlet and the Delta of the Orinoco, another detached slope extending from south-east to north-west about one thousand miles, with a mean width of 150 miles; superficies 150,000 square miles. This region, to which, by a rare felicity, a general and elegant name has been given, Guyana, is nearly commensurate with the natural section we are describing, and from extended European colonization is a very interesting portion of maritime South America. Similar to the other parts of the oceanic border of that continent, the sea coast of Guyana is much indented by rivers, though only three, the Essequibo, Surinam, and Marowine, are of magnitude worthy notice.

The most considerable of these rivers, the Essequibo, is formed by two branches, the Cuyuni from the north-west, of 300 miles comparative course, and the Essequibo proper from the south, of 400 miles comparative course. Uniting at the town of Essequibo, the confluent waters open in a wide bay, which terminate in the Atlantic Ocean at N. lat. 7°.

The Surinam or Surimaca, rises in the same mountainous ridge as the Essequibo, but the former flowing eastward about 100 miles on N. lat. 4°, turns abruptly to the north, and continuing that direction, is finally lost in the Atlantic Ocean at N. lat. 6°.

The Marowine rises at N. lat. 1° 30′, and flowing thence northward, has a course of about 4 degrees of latitude, and is merged in the Atlantic Ocean one hundred miles east of the mouth of the Surinam.

The rocky, bold, but narrow slope skirting the Caribbean Sea from the Delta of Orinoco, to the Gulf and Bay of Maracaibo, completes our general survey of South America. From the Gulf of Paria, westward to the strait between the Gulf and Lake of Maracaibo, is 600 miles, but the mean width is probably less than 50 miles. The northern abutment of Colombia is continued westward of the Gulf of Maracaibo, by the provinces of Rio de la Hacha and Santa Marta. The extreme northern extension of South America is found in that peninsula jutting to the N. E. from the Delta of the Magdalena; Cape Falso, N. lat. 12° 12′, long. 5° 08′ E. from Washington, is, by Tanner's map of Colombia, the utmost northern cape of that continent, and forms part of a detached slope of about two hundred miles by one hundred. This peninsular declivity takes its name from a small river which falls into the Caribbean Sea at a city of the same name. The mountain torrent Rio de la Hacha, after a comparative course of little more than one hundred miles, forms the harbour of the city of Rio de la Hacha, N. lat. 11° 32′, long. 3° 48′ E. from Washington City.

We have completed a cursory survey of the natural features of South America, and proceed to a delineation of the political subdivisions of that continent.

Viewed as a whole, South America presents on its northern extremity the great Republic of Colombia. Excluding the savage regions towards the straits of Magellan, the southern part is occupied by the Argentine Republic, or as it is usually called, the United Provinces of Rio de la Plata; and on the Pacific Ocean, Chili. In the central Pacific part, spreads Peru and Bolivia. The vast eastern cape terminated by St. Roque, and great part of the basin of the Amazon, are occupied by the Empire of Brazil.

The Republic of Colombia extends from S. lat. 6° 40′ to N. lat. 12° 21′, and in long. from 4° 20′ W. to 21° 13′ E. from Washington City. The outlines, according to Tanner's map of that republic, commence in North America, at the Bay del Dragon of the Caribbean Sea, and from thence follows the coast of that sea, and of the Atlantic Ocean, about two thousand miles. Across the peninsula from the Bay del Dragon to that of Dulce is about 100 miles. At the latter indenting of the Pacific Ocean begins a second line of sea coast stretching 1400 miles, and terminating at the mouth of the little river Tumbez, S. lat. 3° 50′. The land boundary, if we begin the survey on the Pacific, will extend up the Tumbez river 30 miles, from whence inflecting to S. S. E. along a ridge of the Andes 160 miles to the head of the small river Chotu, and down that stream 50 miles to its influx into the Amazon. Thence up the Amazon 50 miles to the village of Balzas. At the latter place abruptly turning to nearly E. crosses the main ridges of the Andes, 250 miles to the right bank of the Ucayale river, and down that stream 100 miles. Thence inflecting to nearly N. E. 300 miles again reaches the Amazon at S. lat. 4° and 7° E. from Washington. This great river forms the boundary 400 miles, to the inundated tract formed by its junction with a north-western branch the Jupura. Now leaving the Amazon, and following the Jupura 100 miles, turns to nearly north 120 miles to the Rio Negro, which crossing and thence following the windings of the small river Calaburis 150 miles, reaches an interior chain, the Sierra Turaguaca. Following the dividing ridge of the waters flowing into the Amazon from those entering the Orinoco and Essequibo 800 miles, reaches the extreme eastern extension of the republic. Turning by an acute angle to the north-west, 300 miles, intersects the Essequibo near its junction with the Repumunuri, and again down the former to the influx of the Cuyuni 150 miles. Following the Cuyuni, about 20, and thence by a curve of 100 miles in a northerly direction, reaches the Atlantic Ocean at the mouth of the Poumaron river.

Within the lengthened outline of 6580 miles is included an area of 1,180.000 square miles, including the entire basins of the Orinoco and Magdalena, and 412,000 in the north-western part of that of the Amazon, with the narrow but very important slopes along the Pacific, Carribbean, and Atlantic coast.

The whole territory of Colombia is divided into twelve departments: Istmo, Magdalena, Zulia, Venezuela, Maturin, Cauca, Cundinamarca, Boyaca, Orinoco, Guyaquil, Equador, and Assuay.

Istmo is the north-western department, and lies in North America, along the narrowest part of the isthmus, uniting the two continents, whence its name. It extends in nearly an east and west direction, from the meridian of Washington to 6° W. Central lat. 8½° N. Including the two provinces of Veraguas and Panama, Istmo embraces a superficies of 24,300 square miles; length from west to east 400, and mean breadth a small fraction above 80 miles, population 100,085. The capital Panama, containing a population of 9000, stands at 9° 01′ N. lat., long. 2° 31′ W. from Washington City.

Magdalena, comprising an area of 53,400 square miles, and subdivided into the provinces of Carthagena, Mompox, Santa Marta, and Rio Hacha, lies along the Caribbean Sea, from the mouth of the Atrato, to the Gulf of Maracaibo, deriving its name from the Magdalena river, which disembogues itself into the Caribbean Sea near the middle of the department. Cape Falsa, in the province of Rio de la Hacha, is the extreme northern point of the continent of South America, at N. lat. 12° 21′, from whence the department stretches inland to the south-west, and up the Cauca branch of Magdalena to N. lat. 7°, having a length from north-east to south-east of about 500 miles, and mean breadth of 107 nearly; population 176,983. The capital, Cartagena, at N. lat. 10° 24′, long. 1° 26′ E. from Washington City, is situated on an island formed by the two main outels of Magdalena river, and contains 15,000 inhabitants.

Zulia is subdivided into the four provinces of Maracaibo, Coro, Merida, and Truxillo, encircling the Lake of Maracaibo. The length of this department, following the periphery of the circle, is a little above 500 miles, having an area of 29,100 square miles, the mean breadth is a small fraction above 58 miles; lying between 8° 21′ and 12° N. and in long. from 4° to 8° 30′ E. The department of Zulia is formed from the opposing slopes of a valley between the Sierra de Perija, and the mountain chain called Paramo de la Rosa, with the Lake of Maracaibo occupying the lower part of the valley; and having the department of Magdalena west, and that of Venezuela east. Population 43,700.

Venezuela, containing the provinces of Carabobo and Caracas, with a superficial extent of 43,700 square miles, and a population of 326,840, is perhaps the most important section of the Republic of Colombia. Having the department of Zulia west, and Cumana east, fronting on the Caribbean Sea, and extending inland to the Orinoco river, the department of Venezuela is favourably situated for foreign and domestic commerce. As a natural section this department is remarkable, since though stretching along the Caribbean Sea upwards of 220 miles, the slope is inwards towards the Orinoco. The city of Caracas, distant only 8 direct miles from the sea coast, is elevated above its surface 2860 feet, and the sources of the confluents of Orinoco rise within forty miles of the waters of the Atlantic. This department extends from 7° 30′ to 10° 40′ N. lat. and in long. from 7° 05′ to 11° 35′ E. from Washington City. The capital city, Caracas, situated in a mountain valley, at 10° 31′ N., long. 9° 51′ E. from Washington, contains a population of 28,000.

Maturin comprises the three provinces of Margarita, Barcelona, and Cumana, having the Caribbean Sea north, the Atlantic Ocean north-east and east, the Orinoco river south, and Venezuela west; greatest length along the Orinoco 400 miles, and embracing a superficial area of 48,600 square miles; the mean breadth is a small fraction above 121 miles. Extending from 7° 45′ to 11° 10′ N. lat. and in long. from 11° to 16° 45′ E. from Washington City, Maturin contains the great Delta of the Orinoco, a river border along that stream of 400 miles, and an oceanic front of 700 miles. Though the original discovery of Columbus, the region contiguous to the lower Orinoco is yet very thinly peopled. Maturin on 48,600 square miles, contains but 86,017 inhabitants, or not two to the square mile; and of this moderate population, the three capitals, Asuncion of Margarita, Barcelona of the province of the same name, and Cumana of Cumana comprise 14,500. The city of Cumana is the capital of the department, and stands on the Gulf of Cariaco at N. lat. 10° 25′, long. 12° 47′ E. from Washington City; population 7000.

Cauca is the department which unites the two continents of North and South America, and stretching along the Pacific coast from the mouth of the Atrato 500 miles, comprises the four provinces of Choco, Popayan, Buenaventura, and Pasto. Having a superficial extent of 53,600 square miles, the mean breadth is about 107, with a population of 149,324. The very remarkable river Atrato, flowing into the Gulf of Darien, has its source and entire course in the province of Choco of this department, and affording a navigable channel, connected with the small river St. Juan of the Pacific, by a short canal, goes far to demonstrate that there exists no real connexion between the mountains of the two continents. The city of Popayan, N. lat. 2° 26′, and in long. 0° 19′ E. from Washington City, is elevated above the oceanic level 5,825 feet; and the city of Pasto, at N. lat. 1° 13′, and in long. 0° 22′ W. from Washington City, is elevated 8575 feet above the Pacific Ocean. Far above the region of epidemic fevers, and elevated to that of European grains and fruits, the provinces of Popayan and Pasto have a climate of mildness and uniformity highly favourable to health. Pasto contains 4500, and Popayan 2500 inhabitants. These high tropical vallies of the Andes are amongst the most desirable parts of the habitable earth, where the soil admits cultivation; but the arable land being of small extent when compared with the entire superficies, comparative population will be always restricted. There does not any where else exist a greater difference in the atmospheric phenomena than does between the two provinces of Buenaventura and Choco, and the contiguous provinces of Popayan and Pasto. The former in particular is a narrow slope along the Pacific falling rapidly from the Cordillera de Sindagua, between 1° and 4° north, with a climate of unequalled heat, humidity, tempest, and noxious insects.

Cundinamarca, east from Cauca, and stretching in a direction of nearly north and south between 8° 35′ N. and 0° 40′ S. comprises the four provinces of Antioquia, Mariquita, Bogotà, and Neiva, or Neyva. With a superficial extent of 76,600 square miles, and length of 650, the mean breadth is about 118 miles. This lengthened department unites the basins of the Magdalena and Amazon; the southern province of Neyva being in great part drained by the sources of the rivers Negro and Jupura, whilst the provinces of Bogotà, Mariquita, and Antioquia, are watered by the Cauca and Magdalena. The city of Medellin in Antioquia, 6° 13′ N. lat., long. 1° 15′ E. from Washington City, stands upon a site elevated above the ocean 4847 feet; the city of Neiva, capital of the province of that name, at 3° 07′ N., long. 1° 31′ E. from Washington City, is elevated 1310; La Honda, the capital of Mariquita, at 5° 10′ N., long. 2° 04′ E. the lowest of the four capitals of the department, is elevated 640 feet above the ocean level, whilst Bogotà, the capital of the whole department, at lat. 4° 36′ N., long. 2° 44′ E. from Washington City, rises to 8413 feet above the Pacific. Neiva and la Honda are both on the banks of the Magdalena, the former lower down the stream, 143 minutes of latitude, and by the intermediate fall of 660 feet, showing the very rapid descent of the country. Here, as in many other parts of tropical America, near the Pacific coast, the extremes of climate and vegetable production exhibit the most rapid transition: the burning sea coast, covered with a tropical vegetation, is bordered inland by mountain plains covered with wheat and other Cereal gramina; and palms are succeeded by the apple. These contrasts are peculiarly striking between the sea borders of Buenaventura and Choco, and the plain of Bogotà. The latter expanse, furrowed by the Magdalena, spreads between the Sierra de Quilidio, and the bleak mountain plateau, Paramo del Chigasa, with a breadth of 100 miles, having a remarkable resemblance to the valley of Mexico, with the exception that the lakes of Bogotà have disappeared. This valley is again rendered interesting from containing near the capital, the great cataract of Tequendama, and the natural bridge of Icononza. The population of Cundinamarca amounts to 391,426, of which 188,695 are in the province of Bogota.

Boyaca, extending from 1° 40′ S. to 8° 40′ N. lat. and in long. from 2° 35′ to 9° 10′ E. of Washington City, comprising 195,000 square miles, occupies part of an immense inclined plane, falling by a very slow declivity eastward from the Andes, and the three provinces of Pamplona, Socorro, and Tunja in the basin of Magdalena. Indeed, the extreme northern angle of the department and of the province of Pamplona, is drained by the river Zulia of lake Maricaibo. Stretching thence to the river Caqueta beyond the equator, this extensive department is traversed by the Apure, Casanare, Meta, and Guaviare, branches of the Orinoco; and by the Negro, Guapes, Apuapures, and Caqueta, confluents of the Amazon. The three north-western provinces, Pamplono, Socorro, and Tunja, lying between the eastern chain of the Andes and the river Magdalena, comprise a territory of 250 miles from S. W. to N. E. with a mean breadth of 100 miles, or 20,000 square miles, is a continuation of the great plain of Bogotà, and differs in every physical feature from the much more extended region east from the Andes. Of the entire population of 409.921, there exists 390,839, on the 20,000 square miles we have designated. If the extent of the province and the tabular numbers on Tanner's map are correct, Tunja, with a superficies of 6000 square miles and 189,632 inhabitants, is one of the best peopled parts of the republic of Colombia. From this productive and cultivated tract we pass the Andes, and enter on the almost interminable plains and deserts of Casanare, where on 175,000 square miles we find only 19 082 inhabitants. Over much of this waste spreads a plain, where rises not a hill or rock; the earth at unequal distances exposes shattered horizontal strata, something more elevated than the adjacent country. The appearance of these plains change with the seasons. After the periodical rains, one wide spreading verdant turf appears like an ocean; but with the dry season vegetable life languishes and dies, and leaves the face of Casanare a Lybian desert. Advancing towards the central parts of the basin of the Amazon, the steppes, Llanos (*plains*) are followed by forests still more desolate and dreary. At long intervals on the Llanos, human and civilized habitations have been made, but in the deep woods of the Amazon, the most loathsome reptiles hold sway. Tunja is the capital.

Orinoco, sweeping over 332,000 square miles, fills the space between the departments of Zulia and Boyaca, and the Atlantic Ocean, and is subdivided into the three provinces of Varinas, Apure, and Goyana. Bounded by the Orinoco to the south-east, the plains of Casanare south, the Sierra de Merida, or provinces of Pamplona, Merida, and Truxillo north-west, and the provinces of Carabobo and Caracas north-east; and embracing an extent of about 30,000 square miles, the two provinces of Varinas and Apure, contain 109,512, out of an entire population in the department of 125,822, leaving 16,310 inhabitants on upwards of 300,000 square miles, or above 18 square miles to a human being. The uninhabited part of Orinoco, between the Orinoco river and the Sierra Paracaina, and an extension on both banks of the Rio Negro, and stretching to the Jupura, nearly to two degrees of south latitude, is a desolate but very interesting portion of the habitable earth. It is in this region at N. lat. 3° 8′, long. 10° 38′ E. that the inland communication between the Orinoco and Rio Negro offers an interior natural channel, connecting two rivers of the first order, upwards of 600 miles from the nearest ocean. This great uninhabited tract gains a certain degree of importance also from its vastness, and from the reflection that a civilized population is slowly penetrating and removing its solitudes. Angostura the capital, otherwise called St. Tomas, is situated on the right bank of the Orinoco, at N. lat. 8° 8′, long. 13° 1′ E. from Washington City; population 4000.

Guayaquil, to survey this comparatively small but more cultivated department, leads us again to the shores of the Pacific. With an extent of 14,200 square miles, the department of Guayaquil is subdivided into two provinces, Marribi and Guayaquil proper, with an aggregate population of 73,488. Though fronting on the great ocean 450 miles, except Guayaquil river there is no great commercial entrance into this department. Compared with the adjacent provinces of Chimborazo and Pichincha, Guayaquil is depressed to almost the ocean level, and lying between 4° 21′ S. and 1° N. lat. is exposed to a burning sun twice annually. The river of Guayaquil rises near the equator, and flowing south to 2° 12′ passes the port and city to which it gives name, and opens into a wide gulf round the island of Puna. The eastern recesses of this gulf are about 30 miles from the sources of the Rio Santiago branch of the Amazon, a fact in physical geography demonstrating the very rapid acclivity of the Pacific slope of South America. The city of Cuenza on the eastern slope of the Andes, at a distance of scarce 30 miles, rises above the level of the gulf of Guayaquil 8632 feet; or almost 288 feet per mile. The city of Guayaquil, the capital of the department, stands on the right bank of the river of the same name, at 2° 12′ S. lat., long. 3° 2′ W. from Washington City. The environs, according to Humboldt, are highly majestic, from the variety and magnitude of its vegetable products.

Equador, or the Department of the Equator, is amongst the most elevated habitable regions of this planet. Extending from 3° 5′ S. to 1° 15′ N. lat. and in long. from 1° 30′ E. to 2° 40′ W. this department is subdivided into three provinces, Pichincha, Ymbabura, and Chimborazo. Nature has here not sported, but exerted a strength at the effects of which the human mind shrinks with dread, whilst enchained by admiration. The Andes, divided into three separate chains in Cauca and Cundinamarca, gradually approach in the province of Pasto, and apparently merge in that of Ymbabura. But though apparently confounded, two chains remain distinct, with a very elevated intervening valley raised above the ocean from 8800 to 9500 feet. Colossal volcanic summits rise in symmetrical opposing lines, which covered with eternal snows, served as signal points to the French mathematicians in the measurement of an equatorial degree. Cotapaxi, Antisana, and Cayambe Urcu, range along the eastern, whilst Chimborazo and Pichincha crown the western chain. On the great table land between these gigantic mountains, where the barometer stands at 21.3, we find Quito, 0° 13′ S. lat. with 52,000 inhabitants, standing 9540 feet above the level of the Pacific; Ibarra, 0° 20′ N. lat. at 7591 feet of elevation, and 12,000 inhabitants; Riobamba, 1° 41′ S. lat. at 8441 feet, and 16,000 inhabitants; Loxa, 3° 58′ S. lat. at the height of 6765 feet, and 10,000 inhabitants; and Cuenca, 2° 55′ S. lat. at 8632 feet, and 25,000 inhabitants. The habitable plateau in the provinces of Chimborazo, Pichincha, and Imbabura, is 240 miles in length, with a mean breadth of 30, or 7200 square miles; on which area there is already a population of nearly 300,000 inhabitants, upwards of 41 to the square mile. It is on this aerial plain that the traveller and inhabitant, under and contiguous to the equator, range amid the mingled vegetation of the most distant climes. The lama is seen sporting in the same pastures with the sheep of Asia and Europe. The human being feels invigorated in an atmosphere, nearly four times more elevated than the chains of the Appalachian system. When we read, however, of mountains rising above the ocean to a height from 15,000 to 21,000 feet, the effect on our minds is very different from what a view of the same summits would produce when actually seen from the equatorial plateau. Already elevated to 8000 feet, such a system of mountains as that of the Pyrenees, would be merged in the plain of vision, and even Chimborazo is depressed more than one-third of its absolute height.

The province of Ymbabura, confined to the central plain, is more than semicircled by that of Pichincha, which latter rising from the sand and rocks of the Pacific, sweeps over the summit and plain of the Andes, far down the Isa, Napo, Piguena, and other branches of the Amazon combining in a length of 280 miles, all the climates, and admitting a large portion of all the vegetables of the earth. Quito, the capital of the province of Pichincha, and of the whole department of the Equator, stands on a site too uneven to admit, says Malte Brun, of the use of carriages. The latitude and height of this city have already been noticed. Though so near the equator, Fahrenheit's thermometer ranges between 40 & 61, but contrary to what might be expected, the seasons of different years vary greatly in mean and relative temperature The whole adjacent country is very subject to earthquakes; one of which, attended with peculiar destructive effects, occurred February 4th, 1797. But amid the revolutions of their turbulent atmosphere, and treading on ground so liable to convulsion, the people of Quito are admired by every traveller for urbane, kind, lively, and hospitable manners.

Assuay, the extreme southern, or rather south-western department of Colombia, sweeps eastward from the highest summits of the Andes, from within 20 miles from the Pacific Ocean, and 3° 10′ W. from Washington, to the alluvial junction of the Amazon and Jupura, 11° 40′ E. from Washington. Extending from west to east through nearly fifteen degrees of longitude, between latitude 6° 35′ S. and 0° 50′ N., this extensive region embraces an area of 251,700 square miles, with, however, only 127,900 inhabitants, or about one human being to two square miles. It is subdivided into three provinces of very unequal extent; Cuenca, 170 by 70 miles, and with an area of 11,900 square miles, containing 76,423 inhabitants; Loxa, 100 by 60 miles, and on 6000 square miles, contains 34,471 inhabitants. The residue of the population, 16,000, is seated on the western border of the immense province of Jaen de Bracamores. Indeed, the inhabited part of Assuay is in great part confined to the elevated table land of the Andes; Cuenca, capital of the province of the same name, rises above the Pacific 8,632 feet, with 25,000 inhabitants, and Loxa, capital of the province of Loxa, contains a population of 10,000, who exist 6765 feet above the oceanic level. From this temperate region, Assuay falls in a lengthened inclined plane of 1000 miles. The rivers Amazon, Gualaga, Ucayale, and Javari, pour their great volumes from the south-west into Assuay, which is again furnished by the minor, though still large streams, of Santiago, Pastaca, Piguena or Tigre, Napo, Putumayo or Isa, and is limited north-east by the Jupura. The latter rivers have their sources on the table land of the Andes, but traverse the great plain which spreads along the eastern border of that system of mountains. The white or Spanish inhabitants occupy the plateau of the Andes, whilst the alluvial plains are yet in possession of the aboriginal Indians.

We have now taken a survey of the widely extended Republic of Colombia, as much in detail as the nature of our work would admit. The subjoined summary will give the reader a condensed view of the extent and relative position of this large section of South America.

Summary Table of the departmental Subdivisions of the Republic of Colombia.

Departments.	Area in Square Miles.	Population.	Capitals.	Population.	Latitude.	Longitude.	Altitude in feet.
Istmo, - -	24,300	100,085	Panama,	9,000	9° 01′ N.	2° 31′ W.	
Magdalena, -	53,400	176,983	Carthagena,	15,000	10 24 N.	1 26 E.	
Zulia, - -	29,100	120,960	Maracaibo,	20,000	10 41 N.	5 35 E.	
Venezuela, -	43,700	326,840	Caracas,	28,000	10 31 N.	9 51 E.	2,860
Maturin, -	48,600	86,017	Cumana,	7,000	10 25 N.	12 47 E.	
Cauca, - -	53,600	149,374	Popayan,	8,000	2 26 N.	0 19 E.	5,825
Cundinamarca,	76,600	391,426	Bogota,	38,000	4 36 N.	2 44 E.	8,818
Boyaca, - -	195,000	409,921	Tunja,	16,000	5 16 N.	3 10 E.	
Orinoco, -	332,000	125,822	Angostura,	4,000	8 08 N.	13 01 E.	
Guayaquil, -	14,200	73,488	Guayaquil,	20,000	2 12 S.	3 02 W.	
Equador, -	58,700	307,614	Quito,	52,000	0 13 S.	1 45 W.	9,540
Assuay, - -	251,700	127,894	Cuenca,	25,000	2 55 S.	2 16 W.	8,632
Total,	1,180,900	2,396,404					

In relative position, and in the accuracy of information in regard to the local subdivisions, the Empire of Brasil, or Brazil, follows Colombia. After Russia and China, the Empire of Brasil is the most extensive political subdivision of the earth, and the most extensive continuous body of productive soil ever united under one sovereignty. Excluding the Banda Oriental, Brazil stretches along the Atlantic Ocean from Cape Orange, N. lat. 4°, to near the mouth of Rio Grande, S. lat. 32°; and from east to west, from Cape San Roque, long. from Washington 44° E. to the mouth of the Javari river, long. 7° E. from Washington. Extending through 36 degrees of latitude, and 37 degrees of longitude, forming a trapezium, approaching to a square of 2500 miles each side. Within this expanded perimeter, is included between three and four millions of square miles. Having an ocean border of 3900 miles, indented by small but convenient bays, and by the unequalled Amazon, and many other rivers. It would not, it is probable, be infringing the truth to say, that every 20 miles of the whole of the Brazilian coast would average a river.

The eastern part, where the civilized settlements are chiefly made, is broken and even mountainous, but advancing into the interior, over the basin of the Amazon, the surface is comparatively level. Much is low, alluvial, and periodically overflowed. It is deceptive, however, to attempt to give any general character to regions, exceeding the superficies of all Europe, and whose secondary provinces are individually more extensive than Germany, France, or Spain. Brazil is nevertheless naturally divided into two unequal physical sections. A not very well defined, nor elevated system of mountains stretches southward from the estuary of the Amazon, until merged in the Atlantic Ocean, S. lat. 28°. Eastward from this system, spreads a triangular slope of 2000 miles base and 1000 perpendicular, containing about 1,000,000 square miles. This slope sustains, with the exception of some settlements along the Amazon, and other interior streams, the improved part of the empire, but not more than one third part of its territory. Passing from the Atlantic slope of Brazil, an almost interminable interior opens. In our general view of South America, the great interior valley was noticed. The central parts of this valley are included in Brazil. Without any apparent regular elevation that could influence the courses of the rivers, the waters of the Brazilian valley are discharged northward, towards the Amazon, or southward into the basin of the Rio de la Plata. The Tocantin, Xingu, Tapajos, Madeira, Purùs, and Jutay, are only the principal tributaries of the Amazon, which traverse Brazil. The southern provinces, Rio Grande, and St. Paul's, and much of Minas Geraes, Goias, and Matto Grosso, are drained by the innumerable branches of the Parana and Paraguay.

The Atlantic slope of Brazil has been examined by several scientific travellers, but the central regions on both sides of the Amazon have been but imperfectly explored. The connexion between the Orinoco and Amazon basins, by the Rio Negro, noticed in our survey of Colombia, was only recently determined. Sufficient is known, however, to enable us to complete the general sketch of Brazil by including a territory north of the Amazon, comprising the lower part of the valley of the Rio Negro, and an additional tract of 800 miles in length, reaching from the mouth of the latter stream to the Atlantic Ocean.

The civil divisions of Brazil, perplexing to the natives, are inexplicable to strangers. In the Spanish and Portuguese American colonies, there were civil and military provinces, with different names, and sometimes conflicting limits. The subdivision of Brazil into captain generalships, is best known, and is as follows:

Rio Janeiro, containing the capital of the empire, lies along the Atlantic Ocean, from the river Doce, to the Baua Canressu. It is four hundred miles in length along the ocean, but in no place much exceeds one hundred inland, and does not average above 80 miles in width. This province, when under Portugal, was entitled and ruled as a viceroyalty, is traversed from south-west to north-east by a chain of secondary mountains, and is a high, broken, fertile, and healthy country. Rio Janeiro, the capital of the province, and of the empire, stands on a fine bay of the Atlantic Ocean, at S. lat. 23°, and long. 33° 14′ E. from Washington City. The population in 1817, was by Malte Brun computed at 110,000; the amount at present (1829) is no doubt considerably augmented.

Minas Geraes has a front on the Atlantic Ocean from the mouth of the Doce to that of the Pardo river, 450 miles, and spreads inland, nearly semicircling Rio Janeiro; having Bahia north, Goias west, and St. Paul's south-west; lying between S. lat. 15° and 22° 40′; length 600 miles, and mean breadth about 300; superficies 180,000 square miles. The south-western part of Minas Geraes, is drained by the eastern sources of the Parana; the western by the St. Francis; and the eastern by the Doce and other minor streams. It is a hilly, in many parts a mountainous country, with a population perhaps amounting to 500,000, amongst whom mining has superceded or retarded agriculture in a soil and climate where vegetation demands slight labour, and where the range of vegetable products is indefinable. This province is divided for civil purposes into the *Comarcas*, or districts of St. Joao del Rey, Sabara, and Cerro del Frio.

St. Paul's, or San Paulo, is the south-west captain generalship of Brazil, and follows Rio Janeiro, and Minas Geraes, and lying between the Atlantic Ocean and river Parana, having a front on the Atlantic Ocean of 400 miles; greatest length from north-east to south-west 560 miles, with a mean breadth of 300; area 168,000 square miles. With the exception of a narrow strip on the Atlantic Ocean, St. Paul's is an inclined plane sloping to the north-west, and down which numerous confluents of the Parana are precipitated, and flow, not towards the contiguous ocean, but directly towards the central parts of the continent. The dividing ridge between the short Atlantic rivers and the sources of the Parana, is part of the Brazilian system of mountains, already noticed, and which, in St. Paul's, rise from the margin of the Atlantic. The city of St. Paul's, though not in a direct line, 40 miles from the ocean, is drained by a tributary of the Parana. The mountains rise abruptly from the ocean to about 6000 feet, and slope by gentle ascent inland. The city of St. Paul's, connected with its port Santos by a paved road formed with great labour and expense over the mountain gorges, contains a population of 30,000 souls. Its elevated position, and latitude almost exactly under the southern tropic, give to this city a peculiarly temperate climate.

The whole of the province of St. Paul's, lying between S. lat. 19° and 25° 40′, contains a population of about 220,000 souls, engaged in agriculture and mining. Such a population, however, when viewed comparatively, shows a country where civilized settlement is only commenced, though, perhaps of all the original establishments in America, the first settlers of St. Paul's were amongst the most active and intelligent.

Rio Grande, deriving its name from one of the numerous rivers of South America bearing that title, is the southern province of Brazil, having the Atlantic Ocean south-east, St. Paul's north, Banda Oriental south, and Uruguay west, with a front of upwards of five hundred miles on the Atlantic Ocean. The south-western boundary of Rio Grande is of great political consequence, as it is the limit between the empire of Brazil, and Banda Oriental. On the map published in London in 1825, and which forms the frontispiece to the "Account, Historical, Political, and Statistical, of the United Provinces of Rio de la Plata, the limit between the Banda Oriental and Rio Grande is thus traced: commencing on the Uruguay river, at its junction with the Ubicui, and following the latter to its source; thence, by a line south-eastward about sixty miles to the source of the Yaguaron river, and thence down the latter to its entrance into the Laguna Merin. From thence to the Atlantic Ocean, a distance of about 40 miles in a direct course, the boundary is not either etched or coloured, but most probably was intended to follow the Laguna Merin, its outlet, into the Laguna Patos, and thence to the Atlantic, by the mouth of the Rio Grande river. The boundary thus traced deserves particular attention, as the original of the map was drawn at Buenos Ayres, and of course acknowledged by the authorities of the United Provinces of Rio de la Plata. On Tanner's map of South America, the limit is drawn across the peninsula, between the Laguna Merin and the Atlantic Ocean, reaching the ocean about 20 miles north of a place named on the map, Marco del Limite.

The physical features of the province of Rio Grande are in a peculiar manner varied and interesting. The southern part is composed of that remarkable basin from which the province derives its name, and which has already been noticed in our general view of South America. The western and north-western sections slope towards the Uruguay and Parana rivers, whilst the north-eastern are composed of a very narrow mountainous slope along the Atlantic Ocean. The whole province extends from the river Iguacu, flowing into the Parana, 25° 20′, to the river Yaguaron, S. lat. 32° 40′; long. 25° E. from Washington City, dividing the province into two very nearly equal sections. Its extent in square miles is about one hundred thousand, having a length from north to south of upwards of five hundred, with a mean breadth of two hundred miles. Rio Grande, the capital, stands on the very singular outlet of the river of that name. It is a seaport, but the shallowness of the water on the entrance, the violence of the currents, and quicksands, render the entrance dangerous for vessels drawing more than ten feet, though within the bar there is a safe anchorage, and depth of water for any ship, of whatever draught. It is along the Rio Grande that the population is chiefly distributed. "A circuit," says Malte Brun, "of twenty leagues, is supposed to contain a hundred thousand inhabitants."

The small island of St. Catherine, opposite the north-eastern coast of this province, and the adjacent shores around the city of Rosario, have been much celebrated for fertility of soil and picturesque scenery. The centre of the island is in S. lat. 27° 30′, but the mountainous elevation of the coast lowers the temperature so much, as to give to the seasons a mean heat suitable to a much higher latitude.

Bahia lies between the Atlantic Ocean and the river St. Francisco, and has Minas Geraes south, Maranham west, and Pernambuco north. It derives its name from that of the great Bay of Todos os Santos, or All Saints Bay, on which, or rather on a peninsula between it and the Atlantic Ocean, stands the capital, San Salvador do Bahia, with a population, it is probable, of one hundred thousand people. The peninsula is narrow, but receding from the southern point northward, rises to about six hundred feet above the ocean and bay. The city ranges nearly four miles along this neck. The point or ship entrance is at S. lat. 12° 50′.

Under the name of Bahia, are included some comarcas or districts not directly connected with its administration. The district of Sergipe del Rey lies between the river St. Francis and Rio Real, and north-east from Bahia. Ilheos extends along the Atlantic Ocean from the Rio dos Contas to the Pardo, and of course between Bahia and Minas Geraes. However, for the purposes of general and physical geography, the bounds of Bahia may be viewed as follows: along the Atlantic Ocean, four hundred miles, from S. lat. 11° to 15°. The river St. Francis curves round this province on two sides, and forms a natural boundary upwards of seven hundred miles. On the south it is bounded by the Pardo, and a line, perhaps imaginary, thence to the right bank of St. Francis. Length from south-west to north-east about five hundred, and mean breadth two hundred miles, with an area of one hundred thousand square miles. Situated entirely within the torrid zone, and greatly diversified in surface, the productions of Bahia are numerous and valuable. Indigo, tobacco, rice, sugar, &c. are, with Brazil wood, its most common staple. Coffee is also cultivated, as are innumerable fruits and grains.

Pernambuco is remarkable as forming the most eastern part of the continent of America. It is bounded south-east, east, and north-east by the Atlantic Ocean; south by the river St. Francis, and west by a chain of mountains called the Sierra de Pianhi. Extending from south latitude 3° to 11°, and along the Atlantic Ocean by an immense sweep, from the village of Santa Cruz, on the small bay of Camosin, upwards of one thousand miles to the mouth of the St. Francis. It approaches to a square of four hundred miles each side, and comprises an area exceeding one hundred and sixty thousand square miles. A part of the coast only, however, is inhabited, but that contains the capital. This singular city is composed of two towns, Recif, or Pernambuco proper, and Olinda. The former is built on two islands, and the latter, three miles distance, on an eminence. Joint population sixty-five thousand. Lat. 7° 20′ S., long. from Washington City, 37° 10′ E. The interior of Pernambuco is singular as a physical section of South America, from the character of its rivers. Those flowing into the Atlantic are extremely limited in their length of course, whilst the interior appears a wide desert, entirely devoid of streams of any kind, giving to its map an appearance similar to that of Arabia. From the first establishment of the Portuguese on this part of America, the principal staples of Pernambuco have been cotton, sugar, and Brazil wood.

Ceara or Seara, and Paraiba, are districts included within Pernambuco, and dependent on the military governor thereof, but are independent as respects their civil jurisdiction.

Maranham follows Pernambuco, to the north-west, and includes the district of Pianhy. Taken in its most extended limits, this province stretches from the estuary of the Turuiassu river, S. lat. 1° 10′, to the northern boundary of Minas Geraes, S. lat. 14° 25′, or through upwards of thirteen degrees of latitude; having the Atlantic Ocean north; Pernambuco east; the river St. Francisco, or Bahia, south-east; Goias south-west, and Para north-west. Length from north to south above nine hundred miles, with a mean width of at least two hundred and eighty miles, and an area, at the lowest estimate, of two hundred and fifty thousand square miles. In regard to actual settlement by a civilized people, the extended region under the general name of Maranham, is nominal in great part. The comarca, or district particularly called by the title of Maranham, from the name of the capital, is small, but important from its staple productions, which to many more, may be named annati, capsicum, ginger, and pepper. The city of Maranham, with a population of thirty thousand souls, stands on an island at the mouth of the Pinare river, S. lat. 2° 28′, long. Washington City, 32° 56′ E.

The seven provinces, or captain generalships we have surveyed, stretching from the vicinity of the equator to S. lat. 32°, and containing an aggregate superficies of nine hundred and ninety thousand square miles, do not contain, when thus taken together, the one-third part of the Brazillian territory, and we now proceed to notice the still more extended, but less known tracts of South America.

Goias, as delineated on Tanner's map of South America, stretches from the confluence of the Tocantin and Araguay rivers, S. lat. 6°, to the junction of a small river named Pardo, with the Parana, S. lat. 21° 40′; having Matto Grosso west; Para north-west and north; Maranham north-east; Minas Geraes south-east; and St. Paul's south. Length one thousand and eighty miles, and mean width exceeding two hundred miles, with an area of at least two hundred and twenty thousand square miles. This very extensive province is bounded on the west by the Araguay in the entire length of that river, and contains nearly the whole valley of the Tocantin. The southern part is drained by the extreme northern tributary of the Parana, the Paranaiba, which has interlocking sources with those of the Tocantin and Araguay. The province of Goias, is obviously from the courses of its rivers, composed of two unequal inclined planes, sloping north and south from a table land between 16° and 18° S. lat. This plateau must be of considerable elevation, as a chain of mountains called the Cordillera Grande, is drawn from it on Tanner's map, and extends to the junction of the Araguay and Tocantin, through eleven degrees of latitude.

Goias is as yet thinly peopled, and but very imperfectly explored. The settlements are principally on the higher branches of the Tocantin and Paranaiba. Villa Boa, the capital, stands in a mountain valley on the source of a branch of the Vermelho river, at S. lat. 16° 12′, long. 28° 56′ E. from Washington City, about 700 miles N.W. and directly inland from Rio Janeiro. The population of Goias is too much scattered, to be sufficiently well ascertained in regard to number, to admit even an approximate enumeration.

Matto Grosso, still more extensive and still worse explored, lies west and south-west from Goias, and extends from S. lat. 9°, to the tropic of Capricorn, S. lat. 23° 50′. On the southern boundary, this province fills the space, about 250 miles, between the Parana and Paraguay; and on the northern limit sweeps upwards of one thousand miles from the Araguay to the Madeira. At the broadest part, S. lat. 10°, this province extends about 1100 miles from east to west; its greatest length from the angle on the Paragnay, to that on the Madeira, above twelve hundred miles. The area falls little, if any short of 600,000 square miles, or between nine and ten times the extent of Virginia. With our imperfect knowledge of its local features, it would be mere idle presumption to give a general character of Matto Grosso. It may be sufficient to observe, that the central part is decidedly a table land of considerable elevation, as from it flow, north-westward, the eastern sources of the Madeira; to the north are discharged the higher branches of the Tapajos and Xingu; the waters of the Rio das Mortes, a branch of the Araguay, flow eastward, whilst the numerous and most northerly confluents of the Paraguay fall to the south down the higher rim of the basin of Rio de la Plata. The table land of Matto Grosso is, in fact, a continuation of that of Goias.

Villa do Cuibabu, the capital of Matto Grosso, is situated on a river of the same name, at S. lat. 15° 20′, and long. 21° E. from Washington, about 1100 miles north-west by west from Rio Janeiro, and 1200 a little east of north from Buenos Ayres.

If we add the combined extent of Goias and Matto Grosso, 820,000 square miles, to that of the Atlantic provinces previously noticed, 990,000 square miles, we have an area of *one million eight hundred and ten thousand square miles*, a superficies exceeding that of the Roman empire under Trajan and the Antonines, and far exceeding China proper, or European Russia, and yet we have not included perhaps one half the Brazilian territories. We have now to launch into the central regions of Amazonia.

Para reaches from the sources of the Branco branch of Rio Negro, in the mountains of Guyana, N. lat. 4°, to Fort Principe de Beira, on the Madeira, S. lat. 12°. In longitude this province extends from the mouth of the river Juriassu, 32° E. from Washington City, to the sources of the Javari, 5° E. from the same meridian. Length from east to west, 1830 miles. The mean width must exceed one thousand, with an area of 1,830,000 square miles. The main volume of the Amazon reaches Para at the mouth of the Javari, and separates Lower Peru from the dominions of Brazil to Fort St. Fernando, at the mouth of the Ica. Below the latter point, the already great stream of the Amazon enters and continues its entire course of upwards of one thousand four hundred miles in Para. Immense as is the mass of water already accumulated in the Amazon above Para, it receives in that province, beside innumerable smaller streams, the Jupura and Negro from the north-west, and from the south-west, the Jutay, Jurua, Tefte, Purùs, Madeira, Tapajos, Xingu, and Tocantin. We have already waived the attempt to give general characters to regions so immense—we may here merely observe, that it would be no hazard to pronounce Para, if all its natural advantages of tropical climate, fertility of soil, and abundance and navigable facilities of its rivers are taken into view, as the most favoured tract of comparative continuous extent on the whole habitable earth.

When we turn, however, from the features of nature to the improvements of man, we find Para, with a few detached settlements, a waste. The immense Llanos, Pampas, or grassy plains devoid of timber, so extensive along the eastern slope of the Andes, in the entire length of South America, have but a limited existence on the lower part of the basin of the Amazon. Entangled forests, with all the variety and luxuriance of a tropical clime aided by a soil exuberantly fertile, spread over Para. The hand of man can be hardly said to have attacked this world of wood. Para, or Grand Para, sometimes called Belem, a city on the right bank of the Tocantin, at its mouth, and which contains 20,000 inhabitants, is the capital, and gives political name to the province. This city stands at S. lat. 1° 30′, and long. 28° 27′ E. from Washington City.

The government or district of Rio Negro, is a comarca of Para, but the former, dependent on the military, is free from the civil jurisdiction of the latter. In Rio Negro, there has not yet risen a town deserving the name of city.

We have, as far as our materials admitted, sketched the outlines of the ten captain generalships of Brazil, and by that means given the general extent and relative situation of the subdivisions of that empire. But, for civil jurisdiction, that sovereignty is divided into comarcas or districts, in each of which there is an *ouvidor* or judge. These comarcas, where their position is actually and accurately laid down, enable us to fix real settlement much more correctly than can be done by the great military provinces. Malte Brun names twenty-four comarcas, which, as may be seen, in part follow, and in part are different from the provincial subdivisions: of these, Bahia, Porto Seguro, Sergipe del Rey, and Ilheos, are included in Bahia. The comarca and captain generalship of Rio Janeiro are commensurate, with the exception of Espirito Santo, which occupies the north-east part of the province from the river St. John. The comarcas of Ceara, Paraiba, and Pernambuco, are included in the province of the latter name. Piahu and Maranhao, are comarcas of Maranhao, or Maranham. San Paulo, Santa Catarina, and Paranagua, are comarcas of St. Paul's. Porto Seguro, Sabara, Serro do Frio, and Villa Rica, are comarcas of Minas Geraes. Rio do Frio is a comarca of Matto Grosso, on the head of the Araguay. Some other comarcas are named from the province in which they are placed, but from increase of population these judicial districts must be subject to frequent change.

The population of Brazil has been a subject of much and mere conjecture. It has been estimated from three to four millions, and may probably, if all castes are included, exceed even the latter amount. If the position of the comarcas is carefully examined on a map, it will be seen how very detached are the settlements. Brazil, separated from Portugal, has become a nation of America, with an unequalled extent of dominion, and must, under an even tolerable administration, advance to great power and prosperity.

The United Provinces of Rio de la Plata follow the empire of Brazil in relative position. We may remark as a curious coincidence, that in North America, the United States sweep over the great basin of the Mississippi; and in South America, the republic of Colombia embraces the Orinoco, Brazil the greater part of the basin of the Amazon, whilst the United Provinces of the Rio de la Plata are, with but partial exceptions, commensurate with the basin of the great river from which their title is derived. Thus in America, those wide natural basins, with streams flowing to single points, have already influenced the artificial outlines of new nations, and will contribute physically to unite communities morally and politically connected.

Similar to other parts of the Spanish dominions in America, the administration of the parent state gave rise to murmurs long previous to actual revolt. These murmurs rose to a storm in 1810 at Buenos Ayres, and the Platane provinces ceased to be Spanish. The revolution in that country is in fact not yet terminated, but the aspect of the provinces is sufficiently fixed to admit a geographical view; which we are enabled to take with some clearness, from the Historical, Political, and Statistical Account already noticed.

Before, however, entering on the detailed provincial survey, we may pause to examine the great confluents of the Rio de la Plata. The basin of the Plate extends from the sources of Paraguay, S. lat. 13°, to Cape St. Antonio, S. lat. 36° 40′, and what is peculiarly remarkable, its greatest breadth about S. lat. 22°, equal to 26 degrees of longitude, reaches from less than one hundred miles from the Pacific Ocean, to a still nearer approach to the waters of the Atlantic. The Pilcomayo on the west, and the Parana on the east, flow respectively towards the central parts of the continent. It is generally known that the Andes range nearly parallel to, and at no great distance from the Pacific, but it is by no means equally well known, that the corresponding Atlantic slope from S. lat. 20° to the mouth of the Rio de la Plata, is still more restricted in breadth. The latter, immediately under the southern tropic, in the vicinity of St. Paul's, is not thirty miles wide, from the shore of the Atlantic to the sources of the Tieté; and again, at S. lat. 28°, the higher branches of the Uruguay flow within 50 miles of the Atlantic waters.

The name of Rio de la Plata is only given to the bay below the junction of the Parana and Uruguay. By a misnomer, similar to what has occurred in North America with the Mississippi and Missouri, the Parana has superseded the main stream of the Paraguay. The latter rises at S. lat. 13°, interlocking sources with the Tapajos and Xingu. Augmented by numerous confluents, this river flows almost directly south to S. lat. 21° 20′, at the city of Assumption, where it receives from the north-west a very large branch, the Pilcomayo, and also from the same side, 100 miles lower, another of great magnitude, the Rio Grande, and again 50 miles still lower, loses its name by receiving the Parana. The latter takes its source in the long range of mountains situated to the north-west of Rio Janeiro, in S. lat. 21°. It is increased by uniting with the Parancuba, the Tiesse, the Paranapane, and the Curitaba. Winding to the north-west, to S. lat. 19° it receives from the north the Paranaiba, and turns to S. S. W., and continues that direction to S. lat. 27° 30′, into the Missiones de las Guarames. From this place, it begins to display its peculiar character: forming an archipelago, of an infinite number of islands, and turning west, joins the Paraguay at the city of Las Siete Corrientes. Here the Parana and Paraguay have conjointly drained at least 800,000 square miles, and the united waters under the former name, but continuing the general course of the latter, assume the grand and majestic appearance which it retains, and descending, like a fresh water sea, with a mean course south, but curving to the west, to S. lat. 34° 20′, where it receives from the N. N. E. the Uruguay, and opening into a wide estuary loses its name in that of Rio de la Plata. Without regarding partial bends, the Parana flows from Corrientes to its mouth 560 miles, receiving from the west numerous minor confluents. The Parana admits the entrance of vessels of 15 feet draught, and is navigable for those of 300 tons burthen above the city of Assumption. The various confluents are navigable to near their sources, rendering the basin of the Rio de la Plata, like that of the Mississippi, a vast expanse capable of indefinite intercommunication by water.

The Parana is subject to annual inundation. The rise begins about the end of December, some time after the commencement of the rainy season in the countries between the tropic of Capricorn and the equator; and it continues to rise, without interruption, to the beginning of April. Then, decreasing till July, with a little more rapidity than it rose, it again returns to its natural bed. The inundations are not invariable as to elevation. The average rising is about twelve feet.

The local features of soil and climate will be best seen by reference to the subjoined description of the provinces.

Buenos Ayres, from which the whole republic is often named, is the most southern and important province, and lies south-west from the great bay of Rio de la Plata and the Parana river. It is in form of a triangle, with the base from Cape St. Antonio north-west to Rosario on the Parana, and stretching inland to a rather indefinite extent. The surface to which settlements have been extended may amount to 20,000 square miles. The capital of the province and of the whole republic, the important city of Buenos Ayres, is situated on the south-western or right bank of Rio de la Plata, about 30 miles below the junction of Parana and Uruguay rivers, and at S. lat. 34° 36′ 29″, long. 18° 32′ E. from Washington City, and 58° 23′ W. from London; at an elevation above high tide in the adjacent bay of 35 Castillian, or 33⅓ English feet. As this city occupies a favourable position in the southern temperate zone of America, and as we have element derived from respectable observers on the spot, it may be well to dwell something at large on the climate and seasons of Buenos Ayres.

To the west and south the territory of Buenos Ayres is flat, forming a continued plain, which extends to the confines of the provinces of Cordova and Mendoza. These pampas, or open plains, sweep upwards of five hundred miles to the south-west from Buenos Ayres, which is in fact seated on their margin. They spread from the Atlantic Ocean to the Andes, and are parts of the same species of soil which at broken intervals skirt the eastern slope of the Andes from the Llanos of Cundinamarca inclusive, to the recesses of Patagonia. The quality of the soil is generally chalk and productive mould to the depth of three feet. Neither on the surface, nor on excavating, are stones of any kind met with. It is only at the depth of seventy-five or eighty feet that a hardened clay containing lime, and called *tosca*, is encountered. Directly north from the city is the inundated valley of the Uruguay, which rising in the Brazilian province of Rio Grande, flows first nearly west, gradually curving to south, which latter course, with a slight inclination west, it pursues from south lat. 30° to its junction with the Parana, at 34°. To the north-west, again spreads the still more extensive delta of the Parana, the whole covered with immense forests. To the north-east, beyond the bay, the surface of the Banda Oriental is high and dry, and finally to the east and south-east, opens the great bay of La Plata. From these local features, and the great difference of surface over which the various winds sweep, it is obvious that the seasons of Buenos Ayres must be liable to great and sudden revolution; and that health must be most essentially influenced by prevalent winds. This is the case, and the wind most dreaded at Buenos Ayres is that from the north. This wind is humid, at all seasons, and often attended by excessive rains. It produces laxity of the whole frame, but in a particular manner affects the head. A fact attends the north wind at Buenos Ayres, which almost uniformly precedes copious rain; objects become visible at an immense distance. La Colonia, on the opposite side of the bay, 25 miles distant, is seen under the influence of the north wind. The north-east wind, though in a diminished ratio, participates in the preceding phenomena. The south-west (*pampero*) is by far the most wholesome wind at Buenos Ayres. Its elasticity, purity, and vigour, make it desirable in all seasons, as it counteracts the humidity too prevalent in the houses. The effects produced by the *pamperos* are at once deducible to the cause, by reference to the physical geography of that part of South America, south-west from the estuary of the Plate. In summer, a breeze from the river, or from the east, is produced every evening, with the same regularity as attends those currents of air called trade-winds within the tropics. It has been observed in winter at Buenos Ayres, that often when the air in the streets is warm and bracing, it is cold, moist, and distressing in the houses. This is occasioned by the want of fires. The author, from whom these observations are extracted, observes, "Our fathers have handed down to us an absurd prejudice against fire; and the anti-philosophical and hurtful manner in which they made use of it, in open brasiers, was sufficient, by its effects, to sanction the prejudice. It is but lately, that foreigners have overcome that aversion in us to artificial heat; and their example, their good state of health, and their not suffering more than others from the commencement of cold weather, but on the contrary less, have made converts of many of the natives, who already begin to have chimneys in their habitations."

Taking a series of seasons, the general weather is found pleasant and salubrious; the aspect of the sky beautiful; the air bracing, and exciting in the human mind a confidence of health.

The barometer has risen to thirty inches, and was never lower than twenty-nine. The thermometer seldom falls even to the freezing point of Fahrenheit. A series of years, from 1817 to 1821 inclusive, give for the greatest heat, 83, 85, 85, 86, and 81, and for the greatest cold, in 1817, 28°, or four degrees below the freezing point, a very uncommon occurrence in that country.

Such is the territory and productive facilities of the province of Buenos Ayres, that under a free and liberal administration its prosperity must advance rapidly. In 1825, the city contained a population of 81,136, the country 82,080; aggregate 163,216.

The list of staples for exportation, shows, however, the very low state of agriculture. These staples are hides of horses, cows, and vicunna; sheep's and vicunna wool; horse hair and ostrich feathers; lamb, otter, chinchilla, wolf, lion, and tiger skins; tallow, beef, and last of all, wheat.

Entre Rios, or *Between Rivers*, is a real Mesopotamia, having the Parana south and west, the Uruguay east, a line from one river to the other, nearly along S. lat. 30°, of one hundred and fifty miles. From the northern boundary it extends in the form of a parallelogram of about one hundred and forty miles wide, to the confluence of the Parana and Uruguay, in S. lat. 34°. The length of its course is equal to four degrees of latitude, or 280 miles, in round numbers; superficies 39,200 square miles. No spot of all South America is more advantageously situated for agriculture and commerce, bounded as it is by two of the finest rivers of that continent. In its natural state Entre Rios was a dense forest, and so in a great measure it remains; as in 1825, the inhabitants amounted to only about thirty thousand.

Corrientes lies above Entre Rios, and remarkable as is the river perimiter of the latter, that of the former is not less so; having the Parana on the north and west, and the Uruguay east. At the north-east angle of the province the two rivers approach to within thirty miles of each other, and then recede, the Parana westward, and the Uruguay south-west. Spreading thus between those rivers, the province of Corrientes fills the space from the Parana above its junction with the Paraguay, or from S. lat. 27° 20′, to the northern boundary of Entre Rios, S. lat. 30°, forming nearly a square of two hundred miles each way; area about forty thousand square miles. This province, but little known, was one of the most early Spanish settlements on the basin of the Plate. The city of Corrientes is situated on the east, or left bank of the Parana, immediately below the mouth of the Paraguay, S. lat. 27° 26′, and almost exactly due north from Buenos Ayres; difference of lat. 7° 10′, or five hundred English statute miles.

With much resemblance to Entre Rios, the surface of Corrientes is more diversified. In the interior are many lakes, and in particular one called Ypicu, or Ybera, boasted of for the beauty of its shores. The inhabitants of Corrientes, similar to those of all other countries where the climate is mild, the soil fertile, and the population thin, are disinclined to labour. The situation of the capital is admirable for commerce, and the dense forests would be as favourable for steam-vessels, but hitherto, pastoral pursuits have been preferred. Agriculture has not been altogether neglected; sugar, cotton, and indigo have been exported, but in moderate quantities. Coffee has likewise been cultivated with good success—but nature has done too much in Corrientes.

The river Uruguay separates on their eastern sides both the preceding provinces from Banda Oriental.

Paraguay is the next province to Corrientes, with the Parana intervening. Here again, the courses of the rivers give compactness and a defined natural outline to a political section. The Parana, after having been swelled by innumerable streams from the mountains of Brazil, crosses the southern tropic, and flows southward with a very slight inclination to the west, to below S. lat. 27°, when abruptly turning to west, one hundred and fifty miles, unites with the Paraguay, and encloses the province of the latter name on two sides; which province is again washed on the west by the great river from which its name is derived. On the north Paraguay bounds on the Brazilian province of Matto Grosso. The whole forming an oblong 280 by 200 miles; area 56,000. Such is Paraguay on our maps, but the following extract shows how imperfectly the physical or political features of this remote region is known even at Buenos Ayres.

"It is undoubtedly one of the provinces which has always been held in most estimation, on account of the abundance, variety, and value of its productions. For the last 15 years, however, (from 1825) which goes back to the time when, with Buenos Ayres, it separated itself from the Spanish domination, it occupies an obscure place in the politics of that country, and maintains no social or mercantile relation with any other part of the world; for which state of seclusion it is favoured by its detached local situation. Without knowing whether this circumstance ought to be attributed to the rustic character of the only person who has governed Paraguay, during the greatest part of that time, or to the constitutional apathy and ignorance of the persons governed, the fact is, that notwithstanding it followed the sentiment of the whole territory, as regards its separation from Spain, that province has not only taken no part in the war of independence, but also, since that moment, has cut off all communication with the contiguous and united provinces, and thus continued to the present time to prevent the exportation of its interesting productions, and to prohibit the return of all foreigners or natives, with very few exceptions, who came for the purpose of introducing ultramarine merchandise into Paraguay. *Hence, nothing is known of that province which is not of an old date; and that information, of course, is liable to all the inaccuracies with which such communications were constantly divulged in those times.*"*

The author of the preceding goes on to state what important facts are known of Paraguay. It abounds in mountain forests of the finest ship timber, and though so far inland, the construction of vessels has always been one of its principal branches of commerce. Most of the small vessels employed in the trade of all the internal rivers, have been constructed there. In Paraguay some ships have been built, which have been navigated to Buenos Ayres, a distance of 1200 miles. In the year 1824, one of those ships sailed to Lima, after having made several voyages to Europe.

This province seems to produce in highest perfection that remarkable herb, (yerba mate, or the *chenopodium ambrosioides* of Linnæus) the tea of South America. It has been noted for the excellence of its tobacco, cotton, and many other vegetables. It has also gained a shameful notoriety by the forcible detention of M. Bompland, who was so long and usefully the companion of Baron Humboldt, and who was sent as a naturalist by the government of Buenos Ayres, to explore those recesses situated between the Missiones of Corrientes and Paraguay.

The three provinces we have surveyed constitute the territory of the republic of the United Provinces of la Plata to the east, or along the right bank of Parana; extending through upwards of ten degrees of latitude, and comprising an aggregate of 135,000 square miles, most advantageously situated for every pursuit necessary to human prosperity, happiness, and improvement. In general character, the face of the country to the east and west of the Parana and Paraguay differs essentially. The dense forests of Entre Rios, Corrientes, and Paraguay, are followed, advancing towards the Andes, by the Llanos de Manso, and other interminable grassy plains, which occupy the far greater part of the regions from the Parana and Paraguay to the mountains of Chile.

Santa Fe gives name to a province north-west from that of Buenos Ayres. This city is the first on the road from Buenos Ayres to Paraguay, at a distance of 300 miles above the capital, and at S. lat. 31° 32′. It stands on the Salado, at its entrance into the Parana. The province of Sta. Fe is bounded by Buenos Ayres south, Cordova north, and the barbarian frontiers south-west. The population is very scanty, and the number of its inhabitants unknown; supposed to be from 15,000 to 20,000. With all the advantages of position and soil, agriculture is neglected. The inhabitants are devoted to rearing horses and vicunnas. Its productions are conveyed to Buenos Ayres by land, as well as by water.

Cordova is the capital of the province of that name, and the first city to which the traveller comes after leaving Buenos Ayres, in following the western road, which is commonly called the road of Peru. It was founded in July 1573, and is situated at S. lat. 31° 15′, about 400 miles N. W. from Buenos Ayres. Its situation is picturesque, amid mountains. The city alone contains a population of from 12 to 16.000 souls, and that of the whole province may amount to from 70 to 80,000. The territory of Cordova remains but vaguely defined, but is usually considered about 330 miles square; which would give nearly one hundred and nine thousand square miles; but such estimates without adequate data are of little value. Many circumstances of interest respecting this province are, however, known. The city contains a university tolerably well endowed. In the territory there are many towns and places of whites and Indians; such as Concepcion, Carlota, Tutumba, San Xavier, Rio Seco, Frayle Muesto, Soto, Pichano, Quilino, Yschitin, La Toma, San Marcos, Cruz Alta, and several others, with a very scanty population in each. The greater part of the inhabitants being spread about the country, on the *Haciendas* or *Estanias*, establishments for grazing.

Agriculture is neglected, though wheat and other grains succeed well; but the people are pastoral, mild, and happy. If the pursuits of the people of Cordova did not assimilate to those of the banks of the Parana, we might ascribe the pastoral character of the former to the nature of their rivers: no navigable stream flows from Cordova. But on the Parana, Paraguay, and Uruguay, and even at Buenos Ayres, the people are pastoral. This general similarity in the habits of society in places so very remote, and in places so physically distinct, must have for causes something which writers have not sufficiently explained. The effects every traveller must observe. Most of the rivers of Cordova are lost in the intermediate plains before reaching the Parana. One is an exception, which reaches the Parana at Rosario, but it is unnavigable. In 1804, and 1810, attempts were made to remove the obstructions to the navigation of this river, but proved abortive. In fact, to complete such works demands a more dense and enterprising population than exists on Cordova.

St. Louis, or San Luis de la Puntz, still more remote from Buenos Ayres than is Cordova, and still more deprived also of the benefits of navigable rivers. This city lies on the road to Mendoza, at S. lat. 33° 22′ about 500 miles a little north of west from Buenos Ayres, and 300 miles east from Santiago de Chile. Though founded as early as 1565, it yet contains only 1500 inhabitants. The province is about 300 miles by 180, and contains on an area of 54,000 square miles a population of 25,000 souls. The temperature of the air is good; and yet, the lack of population in the towns, and culture in the country, greatly diminish its importance. It is well calculated for breeding cattle, and the rearing of horses and vicunnas,

* Historical, Political, and Statistical Account of the United Provinces of Rio de la Plata, page 251. London, 1825.

the chief employment of the people. Occupying a point on the great road from Buenos Ayres to Mendoza, Santiago de Chile, and other places, San Louis, may with a more numerous and more industrious popula'ion, become a city of great importance.

San Juan, a city at S. lat. 29° 20′, 60 miles north from the termination of the jurisdiction of Mendoza, remained until recently almost unknown, though founded 270 years, and contains a population of upwards of 20,000 souls; and 35,000, if the adjacent villages of Las Lagunas, Pueble Viejo, Jacha, Valle Fertil, &c. are included. It stands 700 miles N. W. from Buenos Ayres. The province is about 300 miles square, terminating like Mendoza, on the summit of the Andes.

In all the provinces of the republic of Rio de la Plata, hitherto noticed, we have found pastoral life prevailing, but approaching San Juan and Mendoza, we perceive a favourable change. The former city, is now considered as that which most closely follows Buenos Ayres in the march of social reform. In particular, the people of San Juan have made astonishing progress in ecclesiastical reform. They have incorporated the regular with the secular clergy, and suppressed the convents. In regard to agriculture, this city and territory competes with Mendoza. The inhabitants cultivate the vine to great extent, and export wines and brandies to Potosi, Buenos Ayres, Santa Fe and other places. The fertility of the soil is so great that wheat produces a hundred fold. The olive tree is also much cultivated, and the fruit and oil are great objects of commerce. In the northern part of the province gold mines abound; and from one, that of Tacha, an average of 80,000 dollars is drawn annually.

Mendoza, a city containing a population of 15,000 souls, was founded on the eastern side of the Andes in 1560. It stands at S. lat. 35° 50′, on the direct road from Buenos Ayres to Santiago de Chile, 650 miles westward from the former, and 150 eastward from the latter city. The ground on which Mendoza stands is elevated 4656 feet above the ocean. The provincial jurisdiction of Mendoza is bounded west by the Andes, south by the river Diamante; on the north and east it touches San Juan and San Luis, and on the south-east borders on the savage or barbarian frontier. The whole province is about 400 miles from north to south, with a breadth of 300 east and west. This would give an aggregate of 120,000 square miles, but the far greater part is merely nominally connected with the capital, and much spread into the pampas, and is uninhabitable.

The really cultivated section adjacent to Mendoza, is, however, amongst the best improved parts of Spanish America. Beside the capital there are several towns of considerable note, such as San Carlos, towards the south in the valley of Uco, Coriconto, towards the east, and another, Los Barriales, in the same direction. Towards the north, at the very extremity of the jurisdiction, lies a town, the name of which sufficiently expresses its favourable locality—*Las Grandes Lagunas de Guanacache*.* Towards the N. E. six miles from Mendoza, stands San Vincente, a town of considerable importance. Entire population 35,000 souls.

The inhabitants of the city and province of Mendoza, are amongst the most enlightened of the republic, as is proved by the facility with which religious and political fanaticism have yielded to more liberal opinion. The character of the inhabitants of both sexes is amiable and hospitable. This city was rendered remarkable in the annals of the revolutionary war, because in it was organized the army which carried independence to the republic of Chile, and which also opened the road to that of Peru. The province is the most agricultural of the republic to which it belongs, and its people most devoted to labour. Their chief employment consists in the cultivation of vines, clover, and other productions usually met with in a fertile soil abundantly irrigated. They also carry on an extensive traffic in wine, brandy, and dry fruits, with the neighbouring provinces, particularly Buenos Ayres, Santa Fe, and Paraguay, managing even to export dry fruits as far as Brazil. The country produces Indian corn and wheat adequate to the internal consumption. The people of Mendoza are also actively and very extensively engaged in the transport trade, from Buenos Ayres to Chile.

Rioja, a small city situated on one of the highest branches of the river of Mendoza, at S. lat. 28° 25′, and 870 miles to the north-westward of Buenos Ayres, and 400 miles to the northward of Mendoza, though containing only 2 or 3000 inhabitants, is the capital of a province of considerable extent, and with a population of 20,000 souls. The province has the Andes of Chile west, the province of Tucuman north and east, and San Juan south. It is about 400 miles in length from north to south, with a mean breadth of 300, or with an area of 120,000 square miles; but of this great superficies little is cultivated or inhabited by a civilized people. The deficiency of population is not owing to a defect of soil or climate, since both are admirable. Wheat and the vine are cultivated, but pastoral pursuits and mining are preferred to agriculture. Famatina, one of the most productive mines of America, lies in the Andes, about 100 miles west from the city of Rioja. This province is subdivided into four departments, Los Llanos, (*the Plains*) Aranco, Famatina, and Guandacol.

Santiago del Estero, (*Santiago of the lake*) stands on the right bank of the river Dulce, 600 miles N. N. W. from Buenos Ayres, and almost exactly equidistant, 350 miles, and directly between Rioja and Corrientes on the Parana. It may be noted as a very remarkable and important feature in the physical features of that section of South America comprising the provinces of Cordova, Mendoza, San Juan, San Luis, Rioja, and Santiago del Estero, though embracing a surface upwards of 500 miles square, or 250,000 square miles, have no navigable outlet. The most remote northern sources of the Colorado, which flowing S. E. enters the Atlantic Ocean at S. lat. 40°, are found above Rioja at S. lat. 27°; but though flowing through the provinces upwards of 600 miles, it affords no navigable facilities worthy of notice. Leaving the civilized settlements, this stream crosses the pampas and reaches its point of discharge far south from any white establishment. From the Colorado, in the southern part of Mendoza, to the river of Santiago or Dulce inclusive, in a distance from S. W. to N. E. of 500 miles, only one river, that of Cordova, reaches any outlet. The river which passes Santiago del Estero, called

* Guana, is a species of American palm tree, and this town must have been named from the Lagunes or lakes where that vegetable abounds. Guanacache, on Tanner's map, is at S. lat 31° 10′, 200 miles N. N. E. from Mendoza.

the Dulce, rises in the mountains of Tucuman, flows south-eastward about five hundred miles, and is lost in an interior lake; and such is also the case with numerous other rivers which issue from the Andes and pursue their courses towards, but never reach the Parana.

The city of Santiago del Estero was founded about 1551, at S. lat. 27° 28′. The city is thinly peopled, but the number of inhabitants under its jurisdiction may be computed at 50,000, whose principal occupation is agriculture. It is a country well adapted to grain, of which sufficient is produced for home consumption. The provincial extent of Santiago is too undefined to admit an estimate of its superficies.

Tucuman, a city containing 10 or 12,000 souls, follows advancing northward, Santiago del Estero, at the distance of one hundred miles. The former is at S. lat. 27°, about 650 miles north-westward from Buenos Ayres, on the road from that city to Upper Peru. The population of Tucuman does not exceed 12,000 souls, but the whole province, it is probable, contains an aggregate of 40,000. The territorial extent is small, being only about 150 miles from east to west, by 180 miles from north to south; area 27,000 square miles. It is a country well adapted to agriculture and grazing, and both are followed by the inhabitants; wheat, rice, Indian corn, and tobacco are produced. Esculent roots abound, particularly potatoes of extraordinary size and flavour. Cotton and woollen stuffs are made here of cheap but good quality, for home use and exportation. Though bordering on the Llanos or plains, the higher part of Tucuman abound in forests of very large timber. The city itself is environed in one of those woods, in which upwards of fifty species of trees have been enumerated.

In the war of independence Tucuman acted a very distinguished part. In 1812, a splendid victory over the royalists was gained in its vicinity, and in this city, in 1816, was drawn up by the general Congress the Declaration of Independence, as well of Spain, as of every other foreign power, which had only been the case, *de facto*, since the 25th of May, 1810. The inhabitants, are affable, amiable, hospitable, and honourable in their dealings, as well as industrious in their habits.

Catamarca, the territory of which lies east from that of Tucuman, and south-east from Salta, was founded about 1680, and contains a population of 4500 souls. The whole province is inhabited by 35,000, including with those of the city, the towns of Piedra Blanca, Sierra del Alto, Sierra de Ancasti, Tinogasta, Santa Maria, and Belen. The territory is not well defined, but in the 26th degree of south latitude, the climate is mild and the soil productive. Though grazing has been more attended to than agriculture, grain and cotton are made for domestic use and for exportation. Reaching the Bermejo river, the unnavigable character of the streams begins to change for the better. The Bermejo, by numerous sources, flows from the Andes of Salta and Jujuy, and crossing these provinces, unite above Catamarca, and turning to south-east, reaches the Paraguay after a course of 700 miles. With all this great length of course, this fine stream cannot be navigated to its mouth. We have already noticed abortive projects to remove the obstructions in its bed. In the actual state of things, the produce of Catamarca, like that of all the neighbouring provinces, must find a market by land carriage.

Salta, situated at S. lat. 24° 50′, on the road from Buenos Ayres to Upper Peru, 950 miles north-north-westward of the former. This city was founded in April, 1582, and has for its territorial boundaries, those of Jujuy, Tucuman, Attacama, and the great Chaco of Potosi. The population of the city and suburbs amount to about 10,000, but the whole country 40,000, including the inhabitants of Caldera, Rosario de la Frontera, Rosario de Serrillos, Chicoana, Auta, Sumalas, Goachipas, Serrillos, Campo-Santa, Zoras, Corras, Valle de San Carlos, Valle de Calley, Rio del Valle, Balvuena, Mira-Flores, and Macapillo. The province of Salta, though under the southern tropic, or but little advanced into the southern temperate zone, enjoys a mild climate. Many branches of the Andes extend themselves into its recesses, and approach the Bermejo river. The country abounds in forest timber, and though unprovided with navigable channels, no country can be more abundantly supplied with pure and wholesome water. The mines of gold, silver, and copper, are much celebrated, and the province produces also iron, sulphur, and alum. The principal article of exportation is mules, which to the amount of from 60 to 80,000 head have been sent in one year to Peru. Salta possesses the first materials of the three kingdoms, animal, vegetable, and mineral, and it is already peopled by inhabitants worthy of their advantages. Measures are there adopting to render the Bermejo navigable; and a company is forming for that purpose in Buenos Ayres.

Jujuy, a small city about 100 miles north from Salta, stands on a river of the same name, a branch of the Bermejo, at S. lat. 23° 50′, and 13° 05′ long. E. from Washington City. It was founded in 1591; its territorial jurisdiction about 120 miles from east to west, and 210 from north to south; bordering to the north-west on Potosi, to the south on Salta, and to the north and east on Oran and Great Chaco; population of the province 30,000 souls. Wheat, barley, maize, and different kinds of pulse, potatoes, sugar, honey, and brandy are exported, but the principal employment of the people is in breeding sheep, vicunnas, horses, and mules. The mules are here, as they are to an immense extent in Spanish America, the means of transportation, and are themselves again the most valuable article of commerce. Jujuy would be most signally benefited by the opening of the Bermejo to navigation.

Upper Peru includes all that territory belonging to the Republic of Rio de la Plata, which begins where the jurisdiction of Jujuy finishes, and ends at the river Desaguadero; on the opposite bank of which begins the Republic of Peru. Limiting Upper Peru, however, by the Desaguadero, a small river, flowing north-west into the lake Titicaca, or Chicuita, must mean its termination in that direction, since to the northward this country stretches down the higher branches of the Madeira and Ucayale rivers, 6 degrees of latitude beyond the mouth of the Desaguadero, and reaches S. lat. 12°.

The author we have followed in our view of the provinces of Rio de la Plata, under the head of Upper Peru, observes that, "On account of the occupation of this province by the Spaniards, it has been impossible to obtain any statistical account posterior to the revolution. All that is known for certainty is prior to that event; and with the idea of giving preference to what has been published within the country itself, the following accounts are extracted from a book printed in Buenos Ayres, in the year 1803, under the title of *A Guide to* FOREIGNERS, *in the Viceroyalty of Buenos Ayres.* This authority informs us, that under the Spanish government, Upper Peru was subdivided into the four provinces of Potosi, Cochabamba, Charcas, and La Paz.

POTOSI, the city, which contains a population of about 20,000 souls, was founded in 1545. It stands at S. lat. 19° 28′, on one of the higher branches of the Pilcomayo river, upwards of 1200 miles, following the nearest road, N. N. W. from Buenos Ayres. The province, as near as we are able to define its boundaries, extends from the river Jujuy in S. lat. 24°, to the Desaguadero, S. lat. 18° 50′; and from the river Tarija to the Andes east and west. Length 350, mean breadth 170, area about 60,000 square miles. It is drained by the Vermejo and Pilcomayo rivers. The name and celebrity of this province and city were derived from the great mine mountain in the vicinity of the city. The mine was opened on the 21st of April, 1545, and the city increased so very rapidly, that in 1611 it contained 160,000 persons, but subsequently declined to about 30,000. It is supposed, on good authority, that in 255 years, from 1545 to 1800, that the mines of Potosi yielded upwards of *one thousand six hundred and forty-seven millions, nine hundred thousand dollars*, or above 6,462,000 dollars annually. One consequence of this abundant and continued production of the precious metals has been, that Potosi as a country remains poor, thinly peopled, and uncultivated.

CHARCAS follows Potosi, from which it is separated by the river Paspaya, a confluent of the Pilcomayo, and extends north to the river Guapey, a branch of the Madeira, and which separates it from Cochabamba. This province, known by the various names Charcas, Chuquisica, and La Plata, lies between 18½° and 21° S. lat.; is about 400 miles long from west to east, with a mean width of 100 miles, or 40,000 square miles. This province occupies a table land from which the waters of the Madeira flow northward towards the Amazon, and those of the Pilcomayo descend south-eastward towards the Paraguay. The climate has been the admiration of all travellers, and to this many incidental advantages recommend it; for instance, its university, the superior education of its inhabitants, with their polished manners, and the rich productions of its fields and pastures.

La Plata, or Chuquisaca, the capital, stands on a branch of the Pilcomayo, at S. lat. 19° 27′, about 65 miles N. E. from Potosi. It was founded by Pedro Azures, and made a bishopric in 1551, and in 1608 raised to a metropolitan city. Before the late revolution, it was the seat of a royal audience, and contained 15,000 inhabitants; whole province 30,000.

COCHABAMBA is the first province which we have reached amongst those appertaining to Buenos Ayres, which lies entirely in the basin of the Amazon. This province was founded in 1572, and from the following account, taken from a manuscript document preserved in the public library of Buenos Ayres, containing the observations of Don Thadeus Haenke, it is very erroneously laid down in our maps.

"The territory of the province of Cochabamba forms a long and narrow strip of land, which, with but little variation, runs from west to east. Its length is about 130 geographical leagues, (20 to a degree, we may presume, or about 3⅓ English miles) more or less, supposing it a straight line; and its diameter, under the same supposition of a straight line, does not exceed the space of 20 or 30 leagues. Its direction is almost from north to south." From these observations, the province of Cochabamba contains an area of about 43,000 square miles, and although in its territory gold and silver mines are not found as they are in most parts of Upper Peru, it is a country of the first importance. Its soil is proverbially fertile, and the elevation and variety of its surface give it almost every variety of climate. The population amounts to upwards of 100,000 souls, and it is one of the best peopled provinces of the whole republic to which it belongs. The pursuits of the people may be seen from their productions for export, which are indigo, cacao, cochineal, wools of the vicunna and of alpaca (*cavia paca* of Linnæus) grains, &c.

LA PAZ terminates the republic of the United Provinces of Rio de la Plata. It was founded in 1548, at S. lat. 17° 20′, in a ravine on one of the extreme higher sources of the Ucayale, and by any road upwards of 1500 miles N. N. W. from Buenos Ayres, and 700 S. S. E. from Lima. The provincial territory of La Paz lies in one of the great vallies of the Andes, and is drained by the Beni, a confluent of the Ucayale. It extends from S. lat. 13° to 18½°, leaving the remarkable lake Chicuito or Titicaca to the westward. On the high parts the climate is cold and variable. Some of the mountains rise above the region of perpetual snow; but the vallies are warm and very productive.

We close our account of the United Provinces of Rio de la Plata by the subjoined tabular summary of the extent of the provinces and their population in 1825. The reader must be aware, nevertheless, that the estimates are too much founded on defective data to deserve entire confidence, but we trust with all its imperfections it may serve to give a general view of this interesting country.

Provinces.	Sq. miles.	Population.
Buenos Ayres,	20,000	163,316
Entre Rios,	39,200	30,000
Corrientes,	40,000	50,000
Paraguay,	56,000	30,000?
Santa Fé,	30,000	20,000
Cordova,	109,000	80,000
San Luis,	54,000	25,000
San Juan,	90,000	35,000
Mendoza,	120,000	35,000
Rioja,	120,000	20,000
Santiago del Estero,	250,000	50,000
Tucuman,	27,000	40,000
Catamarca,	25,000	35,000
Salta,	25,000	40,000
Jujuy,	25,200	30,000
Potosi,	60,000	60,000
Charcas,	40,000	30,000
Cochabamba,	43,000	100,000
La Paz,	40,000	35,000
	1,213,000	908,316

The physical extent north and south of the Republic of the United Provinces of Rio de la Plata, may in general terms be considered as reaching from S. lat. 13° to 40°, or through 27 degrees of latitude: in longitude from the western border of La Paz to the eastern angle of Corrientes, from 7° to 21° E. from Washington City, or through 14 degrees of longitude. Having the Andes west, Lower Peru north, the Brazillian provinces north-cast and east, the Atlantic Ocean south-east, and the wide and almost unexplored regions of Patagonia south.

Rigidly measured, there would be a larger superficies enclosed within the outlines, than is shown in the preceding table, but as a habitable section of the earth, the table yields a more conclusive result than would an aggregate including extensive tracts upon which a dense population could not subsist. In its actual state, if we suppose the inhabitants to have augmented to a million, there are only 82 on 100 square miles. In fact, the great error committed by the Spaniards in colonizing America, was that of spreading their physical force over too wide a surface; therefore, the actual settlements, after a lapse of three centuries, are detached from each other, and individually weak, if we except Mexico and a part of Colombia and of Peru.

On one million of square miles of the Republic of Rio de la Plata, 200 persons to the square mile could be amply supported, or that country might sustain a population of two hundred millions, which would be nearly equal to that of Europe at the present time.

To the south from the basin of the Rio de la Plata, again spreads a vast region in the temperate latitudes, which in the course of events must receive a civilized population from the contiguous provinces; it is therefore no risk to say that there is a continuous surface of one million and a half of square miles on which the population of the republic of the Plate may expand, and it is as safe to say, that the population of these regions will double in each 30 years.

In treating of the three great divisions of Colombia, Brazil, and the United Provinces of the Rio de la Plata, though the data was far from being in either case ample or perfect, yet the elements for the residue of South America, are still more deficient; but we hope to make the view correct, as far as our means will admit.

In regard to geographical connexion, the republic of Chili, or more correctly Chile, follows that of the Rio de la Plata, having the great system of the Andes intervening.

Chile extends along the Pacific Ocean from S. lat. 24° 20′ to S. lat. 44° or through 1180 minutes of latitude, equal to a fraction above 1356 miles; but the breadth inland from the Andes does not exceed, if it amounts to 100 miles: the area is about 135,000 square miles. This extent is, however, very much restricted in regard to civilized settlement. The river Biobia at S. lat 36° 50′, separates the white from the Araucanian territory, consequently the population of Chile, exclusive of independent Indians, exists on the $12\frac{1}{2}$ degrees of latitude north from the Biobia river, or on 86,250 square miles. Beyond the Indian country, the republic holds the archipelago of Chiloe, with about 26,000 inhabitants. The main island is about 140 miles long from north to south, with a mean breadth of perhaps 30, and 4200 square miles. The whole surface of Chile, upon which resides a civilized people, a little exceeds ninety thousand square miles. By a census taken about 1812 the provinces of northern Chile contained a white population of 1,200,000, and the Chile islands 26,000; the whole 1,226,000; yielding a distributive population of $13\frac{6}{10}$ths to the square mile. The provinces are, advancing from north to south, Copiapo, Huasco, Coquimbo, Cuscos, Petorca, Aconcagua, Quillota, Santa Rosa, Mellipilla, Mapocho, Rancagua, Colchagua, Curico, Maule, Canquenes, Isla de Maule, Chilan, Puchacay, Chillan, Rere, Conception, and Isla de Laxa.

Santiago, the capital of Chile, at S. lat. 33° 20′, was founded in 1541, by Pedro de Valdivia, under the provincial name of Nueva Estramadura. It stands about 90 miles from the ocean, and 21 from the foot of the Andes, about 100 miles north-westward from Mendoza, and nearly an equal distance S. E. by E. from the port of Valparaiso. It is a fine city, containing a population of 50,000 souls; is well built, paved, and admirably supplied with pure fountain water. Standing on the thoroughfare from Buenos Ayres to Valparaiso, it is an entrepot for an immense merchandize. The inhabitants have been noted for their lively and hospitable character. The climate of Santiago is much influenced by its height, which is $2347\frac{3}{4}$ feet above the level of the Pacific Ocean.

Valparaiso, the port of St. Jago, is built on a rocky peninsula, forming a crescent, within which is the harbour. Population 6500. S. lat. 33° 2′. This is the most commercial port, perhaps in America on the Pacific Ocean.

Conception is the second largest city, and the outpost of Chile towards Araucania. It stands at S. lat. 36° 40′, on a bay made by the Biobia river, and on the north side of the river, 3 miles above Talcahuana the port; 350 miles S. S. W. from St. Jago. The harbour of Biobia is safe, and admits the largest vessels.

The other important seaports of Chile, are Copiapo, S. lat. 27° 15′, Coquimbo, or La Serano 29° 54′ S., and Valdivia. The latter is, however, in Araucania, at 39° 50′ S., and though one of the most capacious and safe harbours of America, is commercially of no moment.

In regard to climate, that of Chile is peculiar in America. South from the Maule, or about S. lat. 35°, the seasons are variable. Proceeding north along the Pacific coast, from the Maule, rains become more and more rare, until in the provinces of Coquimbo, Huasco, and Copiapo, it ceases entirely. The air is from November to May cloudless: dews are light, and throughout the year an unequalled serenity prevails. The temperature fluctuates between 70° & 80° of Fahrenheit, and very seldom rises to 85°. Thunder storms are extremely rare in this region of atmospheric tranquillity.

Mines of gold, siver, copper, iron, lead and tin, abound in the northern provinces of Chile. The precious metals are in particular produced in great plenty. Wheat and hemp are named amongst the exports, but agriculture is not in an advanced state.

The revolutionary movements in other Spanish American colonies, extended to Chile, in 1809, and from that period until 1818, the country alternately submitted to the Spanish royalists, or declared themselves independent. In 1817, general San Martin led an army from Buenos Ayres, by Mendoza, into Chile, and after many previous successes, secured Chilean independence by the splendid victory of Maypo, April 5th, 1818. A constitution of government was subsequently formed, and Chile ranks amongst the nations of the earth.

Our survey of Colombia, Brazil, the United Provinces of la Plata, and Chile, has brought us round to the highly interesting country of Peru.

Peru, if taken in the utmost extent, includes, as we have seen, the four north-western provinces of the republic of Rio de la Plata, but what has been called Upper Peru will, it is probable, be soon antiquated, and leave the term to designate that great section of South

America, having the Pacific Ocean west and south-west, Colombia north, and Brazil east, and the United Provinces of Rio de la Plata and Chili south-east. Extending along the Pacific Ocean from the river of Tumbez, S. lat. 3° 47′, to the Desert of Atacama, 21° 30′ S. and in long. from 12° E. to 4° W. from Washington city. Within these limits is included an aggregate area of something above five hundred and thirty thousand square miles; physically divided into two unequal inclined planes. The western or Pacific plain, narrow and steep, is in no place 80 miles wide, in some not 30, and does not average above 50 if so much, but stretches the whole oceanic border of Peru, 1500 miles. The Andes of Peru have never, it is probable, been well defined on any map. Their range is, however, known with more precision than the collateral ridges or chains. The whole system of the Andes follows the general course of the opposing coast, and consequently, between S. lat. 5° and 16°, the Andes extend from north-west to south-east.

The middle branches of the Amazon, rising from 3° to 5° S., flow eastward from Loxa and Jaen of Colombia, crossing the mountain vallies nearly at right angles. On the contrary, the southern confluents of the Amazon rising in the mountain vallies from 10° to 18° S., pursue the course of those vallies to the northwest, as is the case with the Ucayale and its numerous confluents; the Gualaga and its branches, and also the Lauricocha. Thus the higher tributaries of the Maranon or Amazon drain an inclined plane, having its descent along, and not from the system of the Andes. It is from this singular physical structure, that the relative terms have arisen of Upper and Lower Peru. The two extremes of the eastern Peruvian plain, the province of Cuzco, and the eastern part of Truxillo, occupy the higher and lower part of this slope, though both are at about an equal distance from the Pacific Ocean.

Under the head of Colombia, we have taken some pains to describe the very elevated vallies of the Andes. We have found those high arable plains from one thousand to ten thousand feet, in the provinces of Popayan, Pasto, Ymbabura, Pichincha, Chimborazo, Cuenca, Loxa, and Jaen; and we find neither their extent nor height diminished in Truxillo, Tarma, Guancavelica, Guamango, and Cuzco in Peru. In Peru, as in the mountain regions of Colombia, all the climates of the earth approximate, but the excess of heat is in no part of either as high as the latitude would seem to indicate. By the meteorological tables of Lima, published by Dr. Unanue, in his admirable work on the climate of that capital, which were made out for the years 1799 and 1800, it is found that the greatest degree of heat in Lima is $20\frac{2}{3}$° of Reaumer, or 77° of Fahrenheit, and the lowest 13° of Reaumer, or 61° of Fahrenheit. On the mountain table lands there is scarce any change of temperature. The woods and fields are always verdant, and the grains and fruits of Europe flourish amid the vegetation of the torrid zone—Fahrenheit's thermometer standing at about 65° or 66°, a little below the mean of Lima. Amid this perennial summer on the east and table lands, eternal snow lies on the higher Andes, and the human frame may be reposed on a couch surrounded with an unvarying, mild, and salubrious air, with the eye fixed on the region of never relaxing frost.

The narrow slope along the Pacific has been called the country of *valles;* here rain, thunder, and lightning are rare, indeed scarcely known; but the want of moisture gives barrenness to the soil, except where proximity to rivers permits artificial irrigation. Wine, oil, and sugar are produced on the valles; the high plains abound in grain, Peruvian bark, and cacao. The mountains are productive of mineral wealth. In 1791 the mines of gold, silver, quicksilver, copper, and lead, yielded under a very defective management, an annual amount of 4,500,000 dollars, of which seven-eighths was silver.

The most important difference, however, between the *valles* and high plains regards health. On the latter, intermittent, malignant, and catarrhal fevers are prevalent; on the former salubrity prevails, with as little interruption as in any part of the earth.

Under the Spanish government, Peru, like Mexico, was subdivided into intendancies; and since the emancipation of the Spanish colonies few provincial changes have been made, it will suffice, for a general view, to give the political sections as they stood in 1795. At the latter epoch Peru was divided, advancing from north to south, into the intendancies or provinces of Truxillo, Tarma, Lima, Guancavelica, Guamanga, Cuzco, and Arequipa.

Truxillo is bounded north by Colombia, west and north-west by the Pacific Ocean, south by Tarma, and east by the uninhabited regions between the Gualaga and Ucayale rivers. In latitude it stretches from 3° 25′ to 8° 50′ S.; and in long. from 4° 05′ W. to 2° E. from the meridian of Washington City. Length along the Pacific Ocean 400 miles, mean width about 180, area 72,000 square miles. The north-western part of this province, sometimes distinctively called Piura, is the most western part of South America, a part of a burning and barren slope, but thinly peopled; the eastern section, between the Tunguragua and Gualaga rivers, is also in great part uninhabited, leaving for the civilized and cultivated tracts in Truxillo, the mountain valley of the Andes, watered by the Lauricocha river. In 1795 the whole province contained an aggregate population of 230,176, which was composed of whites 19,098, Indians 115,647, Mestizoes 76,949, Mulattoes 13,757, and African slaves 4725.

Truxillo, a city and seaport of the province of the same name, stands on the Pacific, S lat. 8° 01′. It was founded in 1535, by Francis Pizarro: present population uncertain. Caxamarca, on the Tunguragua, is about 100 miles inland, and north east by east from Truxillo; S. lat. 7° 40′ This is no doubt one of the most ancient cities of America. It was one of the great capitals of Peru under the Incas, and the ruins of palaces and temples yet exist. Population 12,000.

Tarma, between S. lat. 8° 15′ and 12°, follows Truxillo, having the Pacific Ocean south-west, Lima south, the uninhabited regions towards the Ucayale east, and Truxillo north. The outlines of Tarma are very irregular, but the area may be estimated at about 26,000 square miles; on which, in 1795, existed a population 200,928, of whom were whites 15,939, Indians 105,187, Mestizoes 78,682, Mulattoes 884, and African slaves 236.

The south-east part of Tarma must be amongst the elevated table lands of South America. The rivers Lauricocha and Gualaga there interlock sources with the Apurimac; the two former flowing to the north-west, and the latter to the south-eastward. The Indian town of Tarma, with about 6000 inhabitants, stands on this elevated plateau, at S. lat. 11° 20′, and about 85 miles north-east by east from Lima.

Lima, containing the capital of Peru, stretches from S. lat. 10° 18′ to 15° 30′, bounded by the Pacific Ocean on the south-west, by Tarma north and north-east, Guancavelica east, and Guamanga and Arequipa south-east. It is about 400 miles in length along the Pacific Ocean, with a mean breadth of 80 miles inland; area 32,000 square miles. Being comprised in great part of the valles of the Pacific coast, though containing the capital, Lima is not so well peopled as are the provinces spreading along the table land of the Andes. In 1795, there were in Lima 22,370 whites, 63,180 Indians, 13,747 Mestizoes, 17,864 Mulattoes, and 29,763 slaves, forming an aggregate of 146,924.

Lima, the capital, stands on the high plain of Rimac, from which by a curious corruption the permanent name of the city was derived. Called in the first instance Ciudad de los Reyes, Lima was founded, January 15th, 1535, by Francis Pizarro, and with many other of his works, evinces the keen sagacity of that ferocious conqueror. The city is six miles from Callao its port, and though the intermediate space is level, it is nevertheless an inclined plane, rising from the ocean upwards of five hundred feet. This gradual but comparatively great elevation gives to Lima its admired command of view, and also enables the inhabitants to drain their streets by constant running water, from the small river, the mouth of which forms the harbour of Callao. The houses, public and private, are many of them as splendid and solid as the frequent occurrence of earthquakes will admit. The churches are numerous, but the most important edifice is that of the University, founded in 1576. The number of inhabitants has been stated variously, but generally supposed about 54,000, of whom one third are whites. Having been for nearly three centuries the centre of commerce and political power, Lima is a city of much wealth and luxury, and is beyond any dispute the finest city of America on the Pacific coast.

Callao, though six miles from Lima, cannot be regarded as more than a suburb, though containing a population of 6000 souls. The inhabitants of both cities have been admired for urbanity of manners, and a lively active genius. The adjacent country is in a peculiar manner delightful, but the pleasure of viewing this beautiful picture is damped by the reflection that it is the outside of a region liable to frequent and most destructive earthquakes. In 1786, Lima was shaken and upwards of a thousand of its inhabitants destroyed; and at the same moment Callao was ingulfed, and only two hundred out of four thousand lives were saved. This was only one of many similar visitations recorded in the history of the two cities.

Guancavelica, containing an area of about 10,000 square miles, and lying east from Lima, with Tarma north and Guamanga south-east, is a mountainous region, which has been rendered remarkable from one of the most extensive mines of quicksilver yet discovered in America. Though lying between S. lat. 11° 40′ and 14° 30′, it is a cold, and in many places a frozen region. The city of Guancavelica from which the province is named, is perhaps the most elevated town ever inhabited by man. It is upwards of 12,300 feet above the ocean level, and the quicksilver mines of Santa Barbara, in the vicinity, are 2200 feet still higher. The population of this aerial city, though greatly diminished in number, still exceeds five thousand souls. The valley and plains composing the province of Guancavelica, are drained by the Jauja, Bangara, and other rivers forming the higher north-western branches of the Apurimac. The whole province is about 200 miles by 40 miles; area 8000 square miles, with a collective population of 30,917, of whom only 2341 were whites.

Guamanga has Guancavelica and the southern part of Lima west, Arequipa south, Cuzco east, and the plains of the Apurimac north and north-east. The central and civilized settlements of this province are contiguous to Guamanga the capital. The whole province contained in 1795, 111,256 inhabitants, of whom only 5378 were whites, and the residue 75,284 Indians, 29,621 Mestizoes, 943 Mulattoes, and 30 slaves. This province is about 300 miles by 60 miles; area 18,000 square miles.

The name of the principal river flowing from Guamanga explains the nature of the country; it is called the Pampas, or river of the plains. The capital containing 26,000 souls, occupies an unhealthy situation on a confluent of the Bangara river, at S. lat. 13° 8′, and 250 miles S. E. by E. from Lima.

Cuzco, a city containing about 40,000 inhabitants, the ancient seat of the Incas of Peru, is situated at the foot of a ridge of the Andes, at S. lat. 13° 41′, and by the road of Guamanga, 550 miles S. E. by E. from Lima. Similar to other Peruvian provinces, that of Cuzco is far from being easily defined, but as laid down on our maps, it is bounded west by Guamanga and Arequipa, south-east by the United provinces of Rio de la Plata, and the lake of Chucuito, and north by a country yet in the possession of native Indian tribes. It is about 350 miles long from north to south, being between S. lat. 12° 50′ and 17° 50′, with a mean width of 135, and area 47,250 square miles. Aggregate population in 1795, 216,382, of whom 31,828 were whites.

The province of Cuzco is one of the most diversified, not only of Peru, but of the earth. High and precipitous chains of mountains are separated by deep vallies or by elevated plains, from which the Jambari, Vilcabamba, Apurimac and other rivers flow to the north, and many brief but rapid currents rush into the lake of Chucuito. The latter is a Caspian on a small scale, of about 180 miles from south-east to north west, and with a very irregular outline. It is in fact a mountain basin, similar to to Bohemia in Europe, and Mexico in North America, with the exception, that the two latter have their outlets broken, and the former has no issue for its imprisoned waters. Between lake Chucuito, and the Pacific Ocean at S. lat. 16° are the extreme sources of the Lauricocha, or main stream of the Amazon.

Arequipa closes the Peruvian provinces to the south, having the Pacific Ocean south west, Lima north-west, Guamanga north, Cuzco north-east, the United Provinces of Rio de la Plata south east, and the Chilean desert of Atacamas south. This province is a long and narrow strip along the Pacific Ocean between S. lat. 15° and 21° 27′, but extending from south-east to north-west, the actual length exceeds 600 miles; breadth inland not exceeding a mean of 40 miles; the area 24,000 square miles.

Arequipa, the capital, is an inland town of considerable note, containing a population of 24,000 souls, situated at the western foot of the Andes, at S. lat 16° 20′. The commercial capital is Arica on the Pacific, through which, a trade is maintained with the inland provinces. It stands at S. lat. 18° 20′. The slope of Arequipa entire, partakes so much of the general character already given of the whole Pacific coast of Peru, as not to need much farther description. It may suffice to observe, that along the streams agriculture is more skilfully and extensively pursued, than it is on the plateau of the Andes, where the soil is more productive, but where mines of the precious metals supersede the far more useful and really more enriching labours of the field.

In 1794, there were in the intendancy of Arequipa, an aggregate population of 136,024, of whom 39,357 were whites, 66,609 Indians, 17,797 Mestizoes, 7003 Mulattoes, and 5258 slaves.

Summary table of the population and relative provincial extent of Peru in square miles.

Provinces.	Agg'te Pop'n.	Extent in sqr. mls.
Truxillo	72,000	230,176
Tarma	26,000	200,928
Lima	32,000	146,924
Guancavelica	8,000	30,917
Guamanga	18,000	111,256
Cuzco	47,250	216,382
Arequipa	24,000	136,024
	227,000	1,072,607

How or in what manner the population of Peru has been affected by recent revolutionary movements we are unable to state, but according to Baron Humboldt, the inhabitants of that country amounted to 1,400,000, about 1820. In 1794, when the estimates were made from which the preceding summary was formed, the components of the people of Peru were, whites 136,311, Indians 608,911, and the residue Mestizoes, Mulattoes and slaves. The proportions given by Humboldt, are nearly the same, and it is probable, have not varied materially in the last 34 years.

Since 1821, Peru has been definitively separated from Spain, but the political condition of the former is far from fixed, nor have we document for its actual condition.

When we read florid descriptions of the tropical mountain vallies and plains of America, we are seduced from a consideration of their great disadvantages. In the table lands of Mexico, Central America, Colombia, and Peru, a perpetual summer may be said to reign, but these gardens are separated from the continent and each other, by steep and excessively lofty mountains, and by deep and precipitous vallies. Here, nature seems to have opposed equal barriers against water or land intercommunication. To construct roads over the chains and vallies of the Andes, or the Anahuac, demands a labour almost beyond all human power, and to open the channels of the rivers to navigation is a task still more appalling. If we turn our attention to a map of Peru, and the south-western provinces of Colombia, we see the great fountains of the Amazon rising near the very shore of the Pacific, through 16 degrees of latitude, and gradually uniting, trace a direct channel to the Atlantic Ocean. But when we learn, that to reach the navigable bosoms of these rivers, we must fall from 2000, to 12,000 feet, we also learn the painful truth, that ages must elapse before united wealth and physical force can render those flowing masses of water available to the inhabitants of the elevated plains of the Andes.

Since the discovery of America, the commerce of these peculiar regions has been conducted by package transportation on the backs of animals, with but little exception, and the features of the earth indicate the perpetuity of this caravan mode of conveyance.

Thus far we have surveyed the vast provinces of Colombia, Brazil, the United Provinces of Rio de la Plata, Chile, and Peru, and to complete the view of civilized settlements on South America, we return to the shores of the Atlantic Ocean.

Guiana—Guyana, taken in the utmost extent, designates a space in South America, stretching south-eastward from the Orinoco, to the Oyapok river, having the Atlantic Ocean north-east, the Orinoco river north-west, and the Brazillian provinces west, south-west, and south. Thus extended, Guyana would extend upwards of one thousand miles from east to west, with a mean breadth of at least three hundred miles, but under the head of Colombia, the extensive country between the Orinoco, Atlantic Ocean, and the Pomaron and Essequibo rivers, has been already noticed. Therefore, under the present article, we have to review the region particularly called Dutch, French, and English Guyana, comprising a tract of 450 miles by 300; area 135,000 square miles.

Of the foregoing superficies, the inland, and far greater part is not only unsettled by civilized colonies, but remains unexplored. The coasts are low, and the river banks in many places liable to inundation, and the very gradual acclivity of the country from the ocean, permits the flow of the tides far inland. From every description of the ocean border of Guyana, it bears a very striking similitude to that of Louisiana; on both, sand hills parallel to the shore, and of no great, if any elevation above high tides, seem to indicate accretion from the alluvion of the ocean. The great current of rotation from Africa, washes along the coast of Guyana, and no doubt contributes to the deposit of sand. The general range of Guyana is from east to west, as is that of the mountains which separate it from the rivers flowing into the Amazon. The principal rivers of Guyana are thus determined in their course, and the Essequibo, Demerara, Berbice, Corentin, Surinam, Maroni, and Oyapok, flow in nearly a northwardly direction.

The elevation of the interior mountain chain of Guyana has been stated at 2000 feet, from which the rivers have a direct and rather precipitous course, until they fall over numerous ledges of rock, and reach the level of the ocean. The country is consequently divided into three physical sections; first, the interior, mountainous; secondly, a hilly and broken tract between the mountains and the falls; and thirdly, the sea and river sand alluvial border. This structure is essentially the same in character with that of the Atlantic slope of the United States, and proves that the far finest part of Guyana, is yet an uncultivated wilderness. In latitude, this part of South America lies between N. lat. 1° 20′ and 7° 20′, and in long. between 18° and 24° 40′ E. from Washington City.

Along the flat and in part marshy shores, the European colonies have been established. The Dutch settlements of Essequibo, Demerara, and Berbice form what is now called British Guyana. These settlements containing 10,000 whites and 80,000 negroes, line the coast from the mouth of Essequibo river to that of Berbice, inclusive, and do not extend above 100 miles along the coast. Starbrock, at the mouth of the Demerara, is the capital, and contains a population of 10,000, amid the most flourishing part of British Guyana. The town and settlements of Essequibo, and Poumaron are of inferior importance. The settlers generally reside on their farms, and are many of them excessively wealthy. Whole population 3151 whites, 3220 people of colour, and 96,349 slaves.

Surinam follows the Dutch British settlement of Berbice, and including the whole of what is yet Dutch Guyana, stretches in an east and west direction from the settlements of Berbice 240 miles to the Marowine river. This flourishing colony is a monument of active industry; "none of the Antilles," says Malte Brun, "are so extensively or so well cultivated." Parmaribo, or Paramaribo, the capital, is built on the western bank of the Surinam. The streets are lined with orange, shaddock, tamarind, and lemon trees, bearing mingled bloom and fruit perennially. In 1815, the whole number of inhabitants in Dutch Guyana amounted to 2029 whites, 3075 people of colour, and 51,937 slaves; the whole 57,041.

Cayenne, or French Guyana, is of very inferior consequence to either the British or Dutch part. Nominally reaching from the south-east to north-west 200 miles, from the Oyapok to the Marowine river, the actual settlements are restricted to the banks of the small river Cauron. The whole number of inhabitants has been estimated at 2000 whites, and 16,000 negroes, mulattoes, and mestizoes.

We thus find in the three sections of Guyana only 7180 whites, and 170,581 people of colour and slaves; in all 177,761.

If the whole region from the mouth of the Oyapok to that of the Poumaron is viewed on a map, it will be perceived that the extremes differ about three degrees of latitude, and lying so far within the tropics as to approach within 5 degrees from the equator, that but little difference of climate or season could exist between the parts, but such uniformity of temperature does not exist. The dry season lasts at Surinam from the end of July to November, and the rainy season corresponds to the winter months of Europe; but the summer and winter, or rainy and dry seasons, begin at Cayenne about two months earlier than at Surinam. At Cayenne, Fahrenheit's thermometer does not at any time rise above 82.3°, and in the rainy or winter season ranges below 75.2°. The climate of Surinam is still milder. Mr. Stedman, however, represents the seasons as variable as in any part of Europe. The influence of northern winds during the rainy season, and of the east and south-easterly breezes in the dry months, are felt along the whole coast of Guyana. The effect on health of such a country is obvious; malignant and intermittent fevers must prevail, and extend their influence more or less from local circumstances; and from what has been stated, it is rendered certain that the fine hilly tract of Guyana above the falls of its rivers, must in the progress of settlement constitute the most healthy, agreeable, and best populated part.

The vegetable productions of Guyana are such as are superinduced by the soil and climate. Sugar, coffee, and indigo are staples of commerce. The fruits of Europe, except the grape, fig, and pomegranate, do not flourish: the orange, lemon, sapota, guava, amiona, and others, abound. The forests of Guyana are proverbially dense and specifically numerous.

From those parts of this great continent where civilization has at least commenced, we now turn to that lengthened peninsula and insular group, which protrudes far into the southern temperate zone This extensive region, bounded north by Chile and the province of Rio de la Plata, stretches from the river Colorado, S. lat. 40°, to Cape Horn, S. lat. 56°. or through upwards of one thousand one hundred miles north and south. The width varies from 400 miles on the north to a point to the south, but will average a breadth of 400 miles, with an area exceeding 440,000 square miles. Even the coasts are not very accurately known, and the interior has been but defectively explored. The ignorance, or the indifference of geographers, has designated these southern regions under the names of Patagonia, Terra Magellanica, and Araucania, each applied vaguely. The latter term, however, admits of some precision when applied to the country south-east from Chile, and south-west from the provinces of Rio de la Plata.

When the Spaniards, early in the sixteenth century, entered Peru, their sanguinary career swept with unequalled rapidity over Peru and over northern Chile. They advanced without fear of successful opposition until they crossed the river Maule, when they at once encountered an enemy not only their equals, but superiors in the art of war, and though nearly three centuries have elapsed since the Spaniards penetrated into southern Chile, their posterity have rather retrograded than advanced in Araucania. Under the head of Chile, we have found the provinces of that republic bounded by the Biobia river, with the exception of the detached achipelago of Chiloe. On the Atlantic side of the continent, the civilized settlements do not extend beyond lat. 38°. The intermediate country, therefore, between southern Chile and the extreme southern settlements of Buenos Ayres and Mendoza, and all beyond to Cape Horn, is in possession of the native Indians. These hordes, few in number, but fierce and warlike, are inimical to the Spaniards, and interrupt the communication between Buenos Ayres and Patagonia. In April, 1822, a commissioner was sent by the provincial government of Buenos Ayres, in order to negotiate a purchase of a large part of the Indian territory. A conference was had with the caziques, but the high price demanded defeated the negotiation. The following extract shows the relative situation of the Indians and whites, and the ultimate views of the latter at Buenos Ayres. "The Indians who belong to these chiefs, (the caziques who met the commissioner) are seven feet in height, naked half way down the body, and painted, wearing leather hats with a plume of feathers. Most of them agreed to sell lands, but demanded for them silver to an immense amount. Owing to this, and to the opposition made by the Indians called Rangueles, who belong to Chile, and are constantly inimical to peaceful measures, influencing, by their courage, all the other Indians; that Congress, or *Parlimento*, as they call it, produced no advantageous result, as to the laudable idea of *buying* those countries, and not taking them away by *force*. In consequence of this failure, no choice is now left to the government of the United States, but to resort to *violence;* which Buenos Ayres will the more easily carry into execution, as the number of all these barbarians does not exceed 8000 men, armed with slings and lances, with no other advantage than the rapidity of their evolutions, which they derive from their dexterity on horseback."*

It would be useless to swell our necessarily brief notice of Araucania and Patagonia with barbarous names which time and civilization must obliterate. This most protruded continental section of the earth terminates in a broken, barren, and desolate group of islands. separated from the main land by the celebrated straits of Magellan. They were discovered, passed, and named in 1519, by

* Account, Historical, &c. of the United Provinces of Rio de la Plata, page 185.

Magelhaenes, a Portuguese navigator. The tortuous length of these straits is about 450 miles, and their navigation difficult and dangerous. The cold sterility and desolation of these Magellanic regions have been no doubt too greatly exaggerated. More recent and correct information has removed much of the terrific from the face of nature along its shores, and has shown the navigation much less difficult than was formerly supposed. No permanent civilized establishment has yet been made on the straits of Magellan, though perhaps no other colonial settlement could be made more beneficial to the commercial interests of mankind. In the present state of human affairs, the imperfectly known seas and islands which environ southern Patagonia are regarded as the terror of seamen, and the sources of prolific fable in physical geography.

We have reserved to close this account of the colonized parts of the continent of South America, a notice of the province recently contended for by Brazil and the United Provinces of Rio de la Plata.

Banda Oriental, so called relatively to Buenos Ayres and Entre Rios, is bounded by the Rio de la Plata south, the Uruguay river west, the river Ybicui north, the Rio Yaguaron and the Laguna Merin north-east, and the Atlantic Ocean south east. It extends from S. lat. 29° 30′ at the entrance of the Ybicui river into the Uruguay to Punta del Este, S. lat. 34° 59′, or through 329 minutes of latitude, equal to 380 miles nearly; the mean breadth from east to west about 200 miles; area 76,000 square miles. If a temperate latitude, a fruitful soil, and commercial facilities by ocean and rivers are taken into view, no other equal section of the earth can exceed the Banda Oriental. Without regarding minute bends, it is bounded 350 miles by the most navigable part of the Uruguay; by the great Bay of Rio de la Plata, in all its length from Punta Gorda at the mouth of the Uruguay to Cape Maldonado, 215 miles. Along the Atlantic Ocean, from Cape Maldonado to Fort de Santa Teresa, 100 miles, and thence with but a short land interval, by the Laguna Merin, and the Yguaron and Ybicui rivers, to the entrance of the latter into the Uruguay.

The central part of this fine country is a table land from which flow several rivers of considerable magnitude. The Laguna Merin is the estuary of the St. Luis, Cebullati, Olinar, and Yguaron, the waters of which, collected in the Merin, are discharged by the strait of Sangradero in the Laguna de los Patos, and reach the Atlantic by the Rio Grande. Beside the Uruguay, and many rivulets, the bay of Rio de la Plata receives at Punta Espinello, seven miles N. W. from Monte Viedo, Rio Santa Lucia, from the interior settlement of Minas. The most considerable stream, however, of the Banda Oriental, the course of which is entirely within the country, is the Rio Negro. This stream heads with the Yguaron, and Ybicui, and by its most considerable southern branch the Rio Yic, with the Santa Lucia and Cebullati. By a comparative course of three hundred miles to the south-eastward, it falls into the Uruguay, 80 miles directly north from the city of Buenos Ayres. Above the Rio Negro, again issue from Banda Oriental, the Guegissay or Quequay, Rio Diamon, and Arapey rivers.

Without any assistance from art, the streams of the Uruguay, Negro, Cebollati, Ybicui, and Santa Lucia, are navigable far into the interior. A ridge of high land, winds through the whole length of the Banda Oriental, called the *Cuchillo Grande*, (*Large Knife*) from which the rivers have their sources.

As in all other Spanish and Portuguese American colonies, the settlements in Banda Oriental are detached, and in many instances distant from each other. The principal inhabited places are Monte Video, Colonia, Santa Lucia, Camelones, San Jose, San Carlos, Soriano, and Cerro Largo; which are all towns: and the villages are, Toledo, Pando, Rocha, Penarol, Piedra, San Salvador, Minas, Florida, Porongos, Colla, Bacas, Vivoras, Espinilla, Mercedes, Piasandu, and Hervidera.

The climate of the Banda Oriental is temperate and humid in general. The winds from the ocean, which are those from south-west to north-east inclusive, are productive of rain, those from the western side of the meridian are dry. In particular, the N. W. called *passageros*, are invariably dry land winds. The salubrity of this country has been the boast of its inhabitants and of strangers.

In the year 1810, the population of Banda Oriental was between 60 and 70,000 souls, and at present, 1829, it is probable, exceeds 70,000. Monte Video, the capital, stands on the north side of the Bay of Rio de la Plata, at S. lat. 34° 55′, two degrees of long. and diagonally 132 miles, a little S. of E. from Buenos Ayres, and 80 miles almost directly west from the mouth of the Bay at Punta del Este. The width of the bay from Monte Video S. W. to Punta de la Memoria, is 60 miles. The city stands on a small open bay, and is generally represented as containing about 20,000 inhabitants. The original settlement of the capital and province is disputed between Spain and Portugal, but the general and particular names being Spanish, afford an almost conclusive evidence in favour of the former. The dispute was national and of long standing, and when Brazil became an empire under the eldest son of the king of Portugal, that monarch risked a war with Buenos Ayres, in preference to yielding the claims of his parent country to the Banda Oriental. This war terminated by a treaty signed at Buenos Ayres, August 27th, 1828, and the following articles of the treaty show the disposition made by the parties of the object of contention.

"Art. 1.—His majesty the emperor of Brazil, declares the province of Monte Video, at present called the Cisplatane, separated from the territory of the empire of Brazil, in order that it may constitute itself into a state free and independent of any nation whatever, under the form of government which it may deem most suitable to its interests, wants, and resources.

"Art. 2.—The government of the Republic of the United Provinces concurs in declaring, on its part, the independence of the Province of Monte Video, at present called the Cisplatane, and in its being constituted into a free and independent state, in the foregoing article."

The 4th article provides for the formation of a representative convention Congress, by deputies elected from the Banda Oriental and by the city of Monte Video; and the 5th, 6th, and 7th articles provide for the formation of a provisional government, and constitute the Congress a Convention to form a permanent Constitution. The remaining 12 articles regulate the various details relating to the troops, rights of removal, and of property, delivery of prisoners, &c.

With the ultimate proceedings under the treaty, we are unacquainted; but are enabled to regard the Cisplatane province, or Banda Oriental, as at least nominally an independent republic of South America.

We have, as far as material has been collected, and with due regard to our restricted limits, taken a general survey of the continent of South America, and close the article by a notice of the islands, contiguous to and usually regarded as appertaining to that continent.

Tierra del Fuego, already briefly noticed under the head of Patagonia, is a large but desolate irregular island, separated from the continent by the Straits of Magellan. It is three hundred miles in length from the Straits of Le Maire, to Black Cape. The surface is mountainous and contains one or more active volcanoes, whence the name, Tierra del Fuego, or Land of Fire. The main island is environed with many smaller ones of similar mountainous and desert character.

It is a common error to suppose that Cape Horn, the *Ultima Thule* of South America, is a part of the island of Terra del Fuego: on the contrary, Cape Horn, almost exactly on S. lat. 56°, is the extreme southern point of Hermit Island.

Between the western outlet of the straits of Magellan, in S. lat. 53°, and Maulin Bay, separating Chiloe Island from Chile, in S. lat. 41° 40′, through upwards of eleven degrees of latitude, the western coast of South America is much broken by islands and small peninsulas; amongst the former, the most worthy of notice are Ancon, Madre de Dios, and St. Martin's, between S. lat. 49° 20′, and 52°, and between the Gulf of Santissima Trinidad, and Cape St. Isabella. Cape Corsa separates the Gulf of Santissima Trinidada from Campana Island, extending to S. lat. 48°. The gulfs of Chonos, Guytecas, and Chiloe, form in fact one lengthened bay from the peninsula of Three Mountains to Maullin Bay, or for about 250 miles. This labyrinth is filled with numerous islands, the principal of which, Chiloe, was noticed under the head of Chile.

Immediately to the north of the western entrance of the straits of Magellan is the peninsula of Lobos, terminating to the north-west in the Cape of Santa Isabella, and again between S. lat. 45° 22′ and 46° 41′, extends the true peninsula of Three Mountains, attached to the continent by a very narrow neck of land.

It is very remarkable, that leaving the Bay of Maullin, and advancing northward, that there is not along the coast of South America a single island worthy of notice, or a peninsula from Chiloe to the Pearl Islands in the Gulf of Panama, in a distance, following the coast, of four thousand miles.

The islands of the Pacific, Juan Fernandez, Ambrosio, St. Felice, and the Gallapagos, have been by geographers attached to South America, but the relative distance renders the connexion doubtful. A similar remark might also be made with respect to the Malouine or Falkland's Islands in the southern Atlantic, but we may notice the former from their historical notoriety. The group crossed by S. lat. 52°, lies about 110 miles a little north of east from the straits of Magellan. There are several smaller, but only two of any considerable size are relatively called East Island and West Island, separated by a strait, the San Carlos of the Spaniards, or Falkland's Channel of the English. No wood, and but a scanty vegetation of any kind grows on these islands, except grass, which is luxuriant. They are in reality, though long contended for between Spain and Great Britain, mere barren rocks or marshes, the residence of Phoci and wild fowl.

Though the Atlantic coast of South America is lined in many places by islands, they are mostly very narrow and separated from the main shore by very confined channels. From the straits of Magellan to the equator, the only island of considerable extent is that of Joanes, between the mouth of the Amazon and Tocantin; lying between the equator and 1° 30′ S. Length from N. E. to S. W. 180 miles. Its form is oval, and comprises an area of about 9000 square miles. There are several villages on its shores.

Trinidad, off the mouth of the Orinoco, is perhaps the far most important island of South America, to which with Tobago it certainly belongs. The ranges of mountains, and the longitudinal position of Tobago and Trinidad, connect them with the Sierra de Paria. The latter lies between N. lat. 10° 06′ and 10° 51′; and excepting four sharp and narrow capes, the form is nearly a square of 40 miles each side. The outlines of Trinidad are peculiar; from each angle of the square protrudes a point, to the south-east Point Galeota, to the south-west Point Yeacas, north-west Point Coroval, and north-east Point Galera.

The two western points of Trinidad, Punta de la Pena, Cumana, and the Delta of the Orinoco, nearly enclose the gulf of Paria, a sheet of water, of one hundred miles from east to west, with a mean breadth of sixty miles. This gulf opens to the north, between Trinidad and Cumana, by the channel of the Dragon's Mouth, and towards the Orinoco by the Serpent's Mouth. It was through the Dragon's Mouth, that Columbus, in 1498, entered the gulf of Paria, and gave the island the name of Santissima Trinidad. It was first colonized by the Spaniards, and with casual interruptions from the English and French, continued a Spanish colony to 1797, when it was invaded and taken by the English, and by the treaty of Amiens, March 27th, 1801, it was finally ceded to Great Britain.

The products of Trinidad are cotton, sugar, coffee, indigo, and ginger, with a great variety of tropical fruits, and maize. The climate is moderately healthy, with a soil of boasted fertility. Existing population uncertain.

Tobago, lying 23 miles north-eastward from Punta de Galera, is evidently a continuation of the Sierra de Paria, and of the northern ridge of Trinidad, is a small island thirty miles from south-west to north-east, with a mean breadth of seven miles. On this confined spot, a few years since, resided 2574 whites, and 15,426 negroes. Tobago was one of the discoveries of Columbus, in 1498, and underwent perhaps, more changes of masters, than any other American island. Finally, in 1814, it was ceded to Great Britain. Commercial staples nearly similar to those of Trinidad.

Margarita, island and province of Colombia, cut into two nearly equal parts by N. lat. 11°, is separated from the coast of Cumana by a channel of 12 miles width. Its greatest length from east to west is 40 miles. The very irregular outline renders an estimate of the surface difficult, but may be stated at 350 square miles. In 1827, it contained a population of 14,690, of whom 3000 were contained in Asuncion, the capital.

Curaçoa, Buenaire, and Oruba, are three islands lying off the province of Coro in Colombia, but belong to the kingdom of the Netherlands. Curaçoa, the principal island, is situated at from N. lat. 12°, to 12° 18′, long. 8° E. from Washington city. Buenaire lies 60 miles easterly, and Oruba an equal distance westerly from Curaçoa. The whole three may amount to a length of 70 miles, with a breadth of seven or eight, with an area of 500 square miles, and of which nearly one half would be in Curaçoa. It was perhaps only the Dutch, of all the European nations, who attempted colonies in America, who could have succeeded in Curaçoa. The land is arid and sterile; the soil, what little does exist, thin. Yet on this ungrateful tract, there were in 1815, whites 2781, free coloured persons 4033, and 6026 slaves, in all 12,840.

Williamstadt, the capital, is represented as one of the most magnificent, clean, neat, and convenient towns in the whole West Indies. Sugar and cotton have been successfully cultivated on Curaçoa, but on Buenaire and Oruba, the rearing of stock has been preferred to agriculture by the inhabitants.

Summary Table of South America.

The political sections taken in the order of the preceding description.

Political Section.	Sq. miles.	Population.
Republic of Colombia,	1,180,000	2,396,404
Empire of Brazil,	3,000,000	4,000,000
Republic of Rio de la Plata,	*1,100,000	1,000,000
Chile,	90,000	1,226,000
Peru,	227,000	1,072,607
Guyana,	135,000	177,761
Patagonia and Araucania,	440,000	500,000?
Banda Oriental,	76,000	70,000
Islands,	44,000	87,690?
	6,292,000	10,530,462

We have completed our brief survey of the most interesting, because the most fruitful and healthy peninsula of the earth, and we find at its conclusion the striking moral phenomenon, that on much more than one seventh part of the productive soil of this planet, there exists only ten and a half millions of human beings. On a surface where the whole existing human species could be subsisted, there is a little fraction above 1½ human beings to each square mile; or about 16 to each 100 square miles.

If we compare South America to Europe, and take the respective climates into the contrast, it is safe to say that the former could support a population double to that of the latter. Europe, on about three millions of square miles, has an existing population of two hundred millions; therefore, if South America was peopled equal to Europe, it would contain four hundred millions of souls.

The actually inhabited part of the United States of North America, amounts to about 600,000 square miles, on which there is an aggregate of, say thirteen millions of persons: the surface peopled nearly equal to one tenth part of South America, consequently, if the latter had a population even equivalent to the former, it would then have ONE HUNDRED AND THIRTY MILLIONS OF SOULS.

For a more full account of the the Provinces, Cities, and Islands of South America, see our articles AMERICA, Vol. I. p. 578; ARAUCANIA, Vol. II. p. 285; AREQUIPA, 321; BRASIL, Vol. IV. p. 404; BUENOS AYRES, p. 778, and Vol. V. p. 1; CARACCAS, Vol. V. p. 318; CHILI, Vol. VI. p. 19; CUENCA, Vol. VII. p. 324; CURACOA, p. 349; CUSCO, 372; TIERRA DEL FUEGO, Vol. IX. p. 492; NEW GRANADA, Vol. X. p. 54; GUAMANCA, p. 139; GUAYAQUIL, p. 141; GUIANA, 144; LIMA, Vol. XII. p. 66, PATAGONIA, Vol. XV. p. 398; PERU, p. 504; QUITO, Vol. XVI. p. 296. See also SURINAM, in this volume, and TOBAGO and TRINIDAD, in Vol XVIII. DARBY.

SOUTH CAROLINA, one of the original thirteen United States of America, bounded south-east by the Atlantic Ocean, south-west by Georgia, and north and north-east by North Carolina. It has an ocean border from Little Inlet to the mouth of Savannah river, 185 miles;—along Savannah, Tugaloo, and Chatuga rivers, in common with Georgia, 270 miles;—along the southern boundary of North Carolina, 300 miles;—entire outline 755 miles.

The greatest length of this state is from the eastern angle on the Atlantic Ocean, at Little River Inlet, by a line extending N. W. by a westerly direction to the western angle of Picken's district on the Chatuga river, 275 miles. The area of South Carolina has been generally and greatly underrated. Measured carefully, on the recent and excellent state map by the rhumbs, it gives a result of very near 33,000 square miles. The mean width is 120 miles. The state lies between N. lat. 32° 01′ and 35° 10′, and in long. from 1° 44′, to 6° 20′ W. from the meridian of Washington City.

Immediately south-west from the Susquehanna river, the physical geography of the Atlantic slope gradually assumes a separation into three zones, indeterminate in separating lines, but fully apparent in Maryland, more distinct in Virginia, and completely developed in North Carolina, South Carolina, and Georgia. These three zones are, first, from the ocean extends a level sea sand strip about 60 miles wide, and stretching along the whole front of South Carolina, 180 miles; second, a hilly and higher, but parallel and contiguous band of nearly equal breadth; and lastly, a still more broken and elevated tract, comprising the residue of the state. These three zones may be specifically designated, the south-east or sea-sand border; the middle, sandy and hilly section; and lastly, the north-western or mountainous portion.

The zone near the Atlantic rises very gradually from the Ocean level, near which it is marshy, and is intersected by a net-work of interlocking streams, receiving the tide, though none are sufficiently deep to admit the navigation of large vessels. Receding inland, the surface seems to emerge from the swamps, and hills of moderate, but increasing elevation, appear. The interlocking of the river channels ceases before reaching the middle zone. In a state of nature, the Ocean zone of South Carolina was covered with a most dense forest, in which the gigantic Palm *Arec oleracea*, raises its majestic stem. The tide in the principal rivers passes over the first to the middle zone.

Great part of the middle or central zone of South Carolina has been called "*the Sand Hills.*" Here pine forests abound, the productive soil lying mostly along the rivers. This central belt passes the tides and reaches the falls of the rivers. In a geological view, the two outer zones have been considered alluvial. The exterior one on the Ocean is truly so, and much of the alluvion recent, but the second must, in regard to formation, be referred to a very remote period, though below the falls of the rivers, the whole surface exhibits full evidence of submersion. The great ledge of rock over which the rivers of the Atlantic slope of the United States are precipitated, and which in every case arrests the tide south-west from the Hudson, crosses the Great Pedee near Sneadsborough, and almost on the line between North and South Carolina. Continuing south-westerly, the rock ledge is passed by the Wateree near Camden, the Congaree at Columbia, immediately below the junction of the Saluda and Broad rivers, and by the Savannah at Augusta, where it quits South Carolina.

Above this ledge and the river falls, commences the high hilly or mountainous zone, and though the change is not in many places very rapid, yet a few miles to the north-west exhibits the salutary transition. Below the falls the aspect of nature is more or less monotonous, and near the outer border vies with the ocean in depression and level: but above, receding towards the Appalla-

* We have taken the superficies and population of the Provinces of Rio de la Plata in round numbers.

chian chain, hills meet the eye, in a succession of form and elevation, round, bold, and swelling in their contour. The rivers wind through vales, variegated and gently undulating, and where under the hand of culture, smiling in all the gaiety of field, garden, orchard, and meadow.

Agriculture in South Carolina has been controlled effectually by soil and climate, and the latter regulated as much or more from relative elevation of surface as by mere parallels of latitude. The extremes of the state, from the marshy surface of Beaufort, Colleton, and Charleston districts, to the mountainous tract embraced by Spartanburg, Greenville, and Picken's districts, differ three degrees of latitude, and at least 1000 feet in relative level. The difference of height is more than equal to two degrees of latitude in effect on aerial temperature; therefore, the upper and lower section, or what in South Carolina is the same in position, the northern and southern part, differ in temperature equivalent to five degrees of latitude.

Below lat. 33°, the orange, lime, and lemon come to perfection; the fig is reared in great part of the state. Apples and peaches abound in the more northern and higher parts. As staples, rice and cotton have been long the principal objects of agriculture in that state. The former is limited by climate, and the necessity of irrigation, to the sea border, but the latter has a range commensurate with the entire superficies of the state. The cotton of South Carolina presents, however, two distinct varieties. "*The Sea Island, or black seed*," is limited as its name imports; but the green seed, or common cotton, is cultivated in other parts.

Rice and cotton do not preclude the cultivation of grain. Indian corn is reared in every part, and wheat, rye, oats and barley in the interior, and particularly on the high mountainous section. Sugar cane has also been cultivated to advantage in Beaufort district.

Taken as a whole, South Carolina is a fruitful and prosperous state. The natural vegetation combines the pines and palms with the oaks and hickory, and in cultivated plants, the sugar cane and orange to the wheat and apple. Though the sea coast offers to commerce no harbours of the first class, it abounds with those which admit commercial, and exclude large vessels of war. Similar to many other sections of the Atlantic slope, the rivers of South Carolina are more navigable for boats at a distance from, than near the sea coast; and to aid internal navigation, two very important and several smaller canals have been completed.

The Santee Canal, made to effect a direct water communication between Charleston harbour and Santee river, leaves the latter at Black Oak Island, or rather opposite that island, and crossing the intermediate swamp in a direction of south south-easterly, enters the western branch of Cooper river about thirty miles, in a direct line, almost due north from Charleston. Length of the canal 21 miles. This is the most extensive artificial water channel yet executed in the United States south of Virginia.

Before entering the Atlantic ocean, and 15 miles inland, Santee river divides into two great arms, called locally and relatively, North Santee, and South Santee. From the former to Winyaw bay, or the estuary of Pedee river, there is an intermediate marshy peninsula of 12 miles wide. To connect the two rivers, and obviate the danger of the open ocean, a canal called Winyaw Canal, 6 miles in length, has been opened across the peninsula, from Winyaw bay to Kinlock's creek of Santee river.

Above the river falls, side cuts have been made to meliorate the navigation of the Saluda, Broad, and other rivers. A rail road from Charleston to Augusta in Georgia has been commenced, and other similar works projected.

The natural channels are numerous and extensively navigable. Great Pedee river rising on the line between Virginia and North Carolina, and traversing the latter, is a river of upwards of two hundred miles comparative course, and of considerable volume where it enters South Carolina, and within which it receives from the west Lynche's and Black rivers, and from the east Waccaman river. The Pedee also, by its northern and main tributary the Catawba, rises in North Carolina, and is a fine navigable stream at its entrance into South Carolina. Between Charleston and Columbia, the Congaree joins the Pedee with an equal if not superior body of water. The former drains the far greater part of the north western section of tho state, and is navigable far above Columbia in both its constituents, the Saluda and Broad rivers. The Savannah, forming the south-western boundary of the state, is navigable to the entrance of the Tugaloo.

Along the marshy sea border, though none of the channels are deep, they are numerous, and amongst the principal entrances may be named, advancing from N. E. to S. W.: Georgetown entrance or Winyaw bay, North Santee, and South Santee; CHARLESTON HARBOUR, Stone River, North Edisto, and South Edisto; St. Helena Sound, Port Royal entrance, and Savannah river.

History and Progressive Population.—The name of Carolina is derived from that of Charles IX. king of France, and was imposed from an abortive attempt made during the reign of that monarch, by the French to colonize that part of America. The first actual settlement by an English colony in the territory now included in South Carolina, was formed in 1680, though partial attempts had been made as early as 1670. At the former epoch a few settlers fixed on Oyster Point, between Ashley and Cooper rivers, and laid the foundation of Charleston. Conflicting grants were made by the English crown to the country, and contributed to retard settlement. In 1662, Charles II. granted to Lord Clarendon and others, all that zone of North America from N. lat. 31° to 36°, and two years afterwards the boundaries were extended to 36° 30′. Locke's scheme of government made the previous confusion a chaos, which was in part reduced to order in 1719, by the permanent separation of the colony into two parts, which were called relatively North Carolina and South Carolina. South Carolina now advanced slowly but steadily. The cultivation of useful vegetables was encouraged. Rice was first introduced into the colony about the year 1695. Indigo followed, (cotton. now the great staple of the country, was introduced at a later period) and South Carolina, though frequently harassed by Indian warfare, flourished until checked by the Revolutionary war. In that great moral contest this state was an illustrious actor and a deep sufferer. Her fields and waters were made classic by being the theatre of many of the most remarkable events of that war. Many of her sons distinguished themselves as patriots and heroes, and some were made martyrs to the cause. To mention no others, the names of Hayne, Marion, Sumpter, and Lee, threw a halo of glory over the state. The character and actions of Marion, give indeed to the history of the southern campaigns the richness of the epic, with the solid grandeur of reality.

In 1790, the population of South Carolina amounted to 240,073; in 1800 to 345,591; in 1810 to 415,115; and in 1820, to 501,154. This gives an increase of 209 per cent. very nearly, in 40 years. In our review of the natural subdivisions of the state, three zones were noticed, and it is very remarkable, how much the relative castes depend upon natural features of soil. With a view to render this important statistical fact obvious, the subjoined table was calculated.

Natural Section	Area in Square Miles.	Whites.	Free col'd Perso	Slaves.	Aggregate.	Pop'n to the Square Mile.
Alluvial,	9,000	43,241	4,451	132,637	180,329	20
Hilly,	13,000	101,537	1,801	89,013	192,351	14½
Mountainous,	11,270	93,114	553	34,807	128,474	11½
Amount,	33,270	237,892	6,805	256,457	501,154	15

This table exhibits the comparative density on the different zones, and the respective numbers of each caste, and is the only instance in the United States where, in any state, the Africao race preponderates.

Education.—For the higher branches of education, the principal institutions of this state are the Charleston College at Charleston, and the South Carolina College at Columbia. This latter institution has been established and sustained by legislative bounty. The building, library, and philosophical apparatus, including some necessary repairs, have absorbed 200,000 dollars, and to this may be added an annual appropriation of 15,000 dollars.

Free schools are also supported at the expense of the state. In 1828 the commissioners of free schools reported the establishment of 840 schools, in which were taught 9036 scholars, the cost of which was 39,716 dollars; and in 1829 the appropriation to this object was 37,200 dollars.

Government.—The existing Constitution of South Carolina was adopted June 3d, 1790, and under the authority of the 11th article, was amended by the Legislature, December 17th, 1808, and on December 19th, 1816.

The Legislature consists of two houses, under the title of General Assembly. The senators are chosen for four years, and are divided into two classes, one of which is elected biennially. No person is eligible to a seat in the Senate, unless he is a free white man of the age of 30 years, and hath been a citizen or resident in the state five years previous to his election; he may be elected whether resident in or out of the district for which he is chosen; but if a resident of the district, he must be legally seised and possessed in his own right, of a settled freehold estate of the value of three hundred pounds sterling, clear of debt, and if a non-resident in the district, he must be in like manner possessed of a settled freehold estate, in the district, of the value of one thousand pounds sterling.

The House of Representatives is chosen biennially, the qualifications for membership in which require the individual to be a free white man twenty-one years of age, a citizen and resident of the state three years previous to his election; if a resident in the election district, he must possess a settled freehold estate of five hundred acres of land and ten negroes, or a real estate of one hundred and fifty pounds sterling, clear of debt: if a non-resident of the district, he must be legally possessed of a settled freehold estate therein of the value of five hundred pounds sterling, clear of debt.

The Governor is chosen by joint ballot of both houses of the Legislature, for a term of two years, and at the end of that term, is ineligible for the four succeeding years. He must have attained the age of 30 years, and have resided within the state and been a citizen thereof ten years previous to his election, and when elected must be seised and possessed of a settled estate within the same in his own right, of 1500 pounds sterling, clear of debt. The Lieutenant Governor is elected at the same time, continued in office for the same period, and must be possessed of the same qualifications as the Governor.

The Governor has the power of pardon after conviction, except in cases of impeachment.

The executive power is vested in superior and inferior courts directed and established by the Legislature: the judges hold their offices during good behaviour, and are only removable by impeachment.

To exercise the elective franchise in the choice of members of the Legislature of either branch, it is requisite, that the person be a free white man citizen of the state, and have attained to the age of 21 years; paupers, and non-commissioned officers and privates of the United States army excepted; must have resided in the state two years previous to the day of election; have a freehold of fifty acres of land or a town lot, of which he must be seised and possessed at least six months before such election: or not having such freehold or town lot, hath been a resident in the election district in which he offers to give his vote, six months before the said election.

By the 11th Article of the Constitution of South Carolina, it is provided that: "No convention of the people shall be called, unless by the concurrence of two thirds of both branches of the whole representation." But, the Constitution may be amended by the Legislature, when "a bill to alter the same shall have been read three times in the House of Representatives, and three times in the Senate, and agreed to by two thirds of both branches of the whole representation; neither shall any alteration take place until the bill so agreed to, be published three months previous to a new election for members of the House of Representatives; and if the alteration proposed by the Legislature shall be agreed to in their first session, by two thirds of the whole representation in both branches of the Legislature, after the same shall have been read three times, on three several days in each house, then, and not otherwise, the same shall become a part of the Constitution.

Under all these restrictions, the Constitution of South Carolina has been, as we have shown, twice amended.

For political and judicial purposes, this state, in place of counties, is subdivided into districts. In the subjoined table, the italic letters annexed to each district, show their relative situation, *e*, *w*, *n*, *s*, and *m*, stand for *eastward*, *westward*, *northard*, *southard*, or *middle*.

Districts.	*Chief Towns.*	Popul'n. 1820.
Anderson, *s. w.** - -	Andersonville, - -	18,090
Abbeville, *n. w.* - -	Abbeville, - -	23,189
Barnwell, *s. w.* - -	Barnwell, - - -	14,750
Beaufort, extreme *s.* -	Beaufort, - -	32,199
Charleston, *s.* - -	CHARLESTON, -	80,212
Chester, *n.* - - -	Chesterville, - -	14,379
Chesterfield, *n.* - -	Cheraw and Chesterfield,	6,615
Colleton, *s.* - - -	Waterboro', - -	26,373
Darlington, *n. e.* - -	Darlington, - -	10,949
Edgefield, middle of *s. w.*	Edgefield, - - -	24,309
Fairfield, middle, *n.* -	Winnsboro', - -	17,174
Georgetown, *e.* - -	Georgetown, - -	17,603
Greenville, *n. w.* - -	Greenville, - -	14,530
Horry, extreme *e.* - -	Conwaysboro' - -	5,025
Kershaw, *n.* - -	Camden, - - -	12,442
Lancaster, *n.* - - -	Lawcasterville, - -	8,746
Lawrens, *w.* - -	Laurensville, - -	17,682
Lexington, nearly central,	Granby, - - -	8,083
Marion, *n. e.* - - -	Marion, - - -	10,201
Marlborough, extreme *n. e.*	Bennettville, - -	6,425
Newbury, middle *w.* -	Newbury, - -	16,104
Orangeburg, middle, -	Orangeburg, - -	15,653
Pickens, extreme *w.**	Pickensville, - -	9,022
Richland, central, - -	COLUMBIA, - -	12,321
Spartanburg, *n. w.* -	Spartanburg, - -	16,989
Sumpter, middle, - -	Sumpterville, - -	25,369
Union, *n. w.* - -	Union, - - -	14,126
Williamsburg, *e.* - -	Kingstree, - - -	8,716
York, middle, *n.* -	Yorkville, - -	14,936
		501,154

See our article Carolina, South, Vol. V. p. 376—384.

Darby.

SOUTH MOLTON. See Molton, South.

SOUTHWARK. See London, Vol. XII. p. 208 and 217, and Philadelphia, Vol. XV. p. 514 and 520.

SOUTHWELL, or Suell, a market town of England, in Nottinghamshire, situated in a fertile and well-wooded country, on the banks of the river Greet. It consists principally of one large street, on the ro. from Newark to Mansfield; and this street is intersected by two smaller ones. The church is celebrated for the beauty and variety of its architecture. It consists of a nave with two aisles, two towers at the west end, a transept, a choir with aisles, and a chapter. It is 306 feet long. One part of the town is under civil, and the other under ecclesiastical government. The first, called the burgage, is governed by justices appointed by the Archbishop of York, and the second, called the prebendage, by prebends. The chapter exercises a peculiar jurisdiction over 28 parishes. A silk and cotton manufactory have been established here, and added to the population of the place. In 1821 the population was 573 houses, 610 families, 279 families in trade, and the number of inhabitants 3051. See Dickinson's *History of Antiquities of Southwell*, 4to. 1787.

SPA, a town of the kingdom of the Netherlands, and in the province of Liege, and celebrated for its mineral waters. It stands on a small river, at the extremity of a deep valley, and in the middle of all the romantic scenery, which occurs among wild and precipitous mountains. Its streets, which have the form of a cross, are four in number, and are regular and spacious. The accommodation afforded by the hotels and private lodging houses are, in general, good. There is a theatre and a good ball-room, and the public walks are grand though not extensive.

The springs, which are six or seven in number, are all acidulous chalybeates, an analysis of which we have already given in our article Mineral Waters. Population about 3000.

SPAIN.

PART I.—HISTORY.

In giving a short sketch of Spanish history, it cannot be expected that we should enter into any minute details. Our limits would scarcely contain a simple enumeration, in chronological order, of the many important events which have contributed, at various periods, to influence the face of this country. We shall content ourselves, therefore, with a brief statement of the different revolutions through which it has passed, with occasional observations upon its agricultural, commercial, and political state. With this view, the history of Spain may be divided into six periods.

I. Its state prior to the irruption of the northern nations.

II. While under the dominion of the Goths.

III. While subject to the Moors.

IV. While under the dynasty of Austria; and

V. While governed by the Bourbons.

Chap. I. *State of Spain prior to the irruption of the Northern nations.*

With respect to the first period, we shall pass over the fabulous legends of Berosus, who traces the origin of its inhabitants to Tubal, the fifth son of Japhet, and gives a long line of descendants, who reigned in Spain for several centuries. But whoever were the aborigines of this country, they are generally known in ancient history under the name of Iberians; and it is also ascertained

* In 1820, when the last census was taken, that part of South Carolina west of Saluda river, and N. W. from Abbeville district, composed Pendleton district; but subsequently, the latter was abolished, and out of its former limits Anderson and Pickens districts were formed.

that the Celts or Gauls, at a very early period, had formed numerous settlements to the west of the Ebro, and had become so blended with the inhabitants by intermarrying and living together, that they obtained the designation of Celtiberians.

The Greeks and Phœnicians had also planted colonies in the maritime districts, but neither of these nations penetrated into the interior, contenting themselves with the command of the sea, for the purpose of commerce, which they were allowed to hold without molestation from the inhabitants, who were glad to benefit by their trade, while they enjoyed in peace and tranquillity the produce of their own lands. This state of amity was at last interrupted by the Phœnicians, who having built the city of Gades, now Cadiz, were desirous of extending their authority over the neighbouring territory. The Spaniards, alarmed at the growing prosperity of the new city, collected their forces, and would soon have driven out the intruders, had not the Phœnicians invited the Carthaginians to their assistance, who, furnishing them with powerful succours, not only repulsed the Spaniards, but obtained the greater part of the province.

This expedition formed the commencement of the Carthaginian power in Spain. Elated with their success, and delighted with the richness of the country, and the valuable mines of gold and silver which it contained, they contemplated the conquest of the whole peninsula. For a time, however, their arms made very little progress against its warlike inhabitants, who defended themselves with great bravery and resolution, till the whole power of Carthage was directed to their subjugation. During nine years of incessant hostility, the Carthaginians penetrated into the very heart of the country, when their general, Hamilcar, was killed in a general engagement with the Vettones. His successor, Asdrubal, carried his victorious arms as far as the Ebro; and, in order to secure his conquests, built the city of New Carthage, which afterwards became one of the most considerable cities in the world.

These successes excited the jealousy of the Romans, who could not behold without alarm the rapid advance of their rivals to the entire dominion of such a country as Spain. They, therefore, willingly listened to the request of the Saguntines, who had implored their protection, and interposing in their behalf, prevailed upon the Carthaginian general to enter into a treaty, in which it was stipulated that the Carthaginians should not pass the Ebro, and that the Saguntines and other Grecian colonies should enjoy their ancient rights and privileges. No violation of this treaty occurred during the life of Asdrubal; but extending his conquests in other directions, he, either by force or persuasion, established the dominion of Carthage over the finest provinces of Spain. A few years after, however, he fell by the hands of an assassin; and no sooner had Hannibal succeeded to the command of the Carthaginian army, than he made preparations for the siege of Saguntum. Though this city was situated within the Carthaginian territory, it was expressly excepted by treaty from all hostilities; but Hannibal promised himself many advantages from its reduction. It was a key by which the Roman army could easily enter into Spain; and its possession would serve as a barrier against their future encroachments. This colony also was immensely rich, and he expected to find in it treasure sufficient to defray the expenses of a premeditated war against that rival power. The Saguntines, however, bravely defended themselves for eight months; and every inch of ground was disputed with undaunted resolution. Being at last reduced to great extremity by the scarcity of provisions, and having no prospect of assistance from the Romans, the principal senators collected in the market place their richest effects, and the contents of the public treasury, and having set fire to the pile, threw themselves into the midst of it, and perished in the flames. Many of the inhabitants soon after followed their example; and the rest, making a sally on the besiegers, were all put to the sword.

The siege, one of the most memorable in ancient history, produced a lengthened and bloody war betwixt the Romans and Carthaginians, of which Spain, for several years, continued to be the theatre. The Romans, taking advantage of Hannibal's absence in Italy, sent an army into that country. After a long contest between these rival nations, and attended with various success, the Carthaginians were driven out of Spain, and the Roman standard planted on the walls of Cadiz, which, as it was the first, was also the last stronghold which the Carthaginians held in that country. But though the Roman power was thus in a manner extended over Spain, they found it no easy matter to maintain their authority. Many of the native princes had remained calm spectators during the struggle between their invaders, while others had alternately sided with the forces of Carthage and Rome. But when they saw their country reduced to the state of a Roman province by the appointment of pretors to its government, they evinced a general disposition to throw off the yoke. The avarice, extortion, and oppression of the Roman magistrates, gave occasion to frequent revolts; but their undisciplined troops were as yet unable to cope with the legions of Rome, and every attempt to recover their liberty, served only to rivet their chains the more closely. Among these attempts, the most successful and worthy of record, was that of the Celtiberians in Lusitania, under the brave Variathus. This person, during the distracted state of his country, had been a captain of a banditti, and afterwards became one of the principal leaders of the Lusitanians. In two successive engagements he defeated the Romans with great slaughter, compelled them to shut themselves up in their strong cities, and laid the whole country under contribution. By the dexterity of his movements, he, for six years, put to flight every army that appeared in the field against him, and had drawn off many nations from their alliance with Rome. A consular army for a time checked the career of Variathus; but, soon recovering from his reverses, he defeated the consul Servilianus with the loss of three thousand legionaries, and afterwards, by a most skilful manœuvre, so hemmed in the whole Roman army, that they had no way of escape but by submission. Instead, however, of seizing this opportunity of avenging his country by their destruction, he offered peace, with this single condition, that he should keep possession of the territories now in his power without molestation from the Romans. This generous offer was joyfully accepted, and the terms were soon after ratified by the Roman Senate. Variathus thus laid the foundation of a new kingdom, which, had it not been for the treachery of his enemies, would have set bounds to the conquests of Rome in that quarter, and counterbalanced their power. But instead of the generous rivalry of arms, Rome now employed the basest of means for the accomplishment of her ambitious projects. The laws of nations, the faith of treaties, and humanity itself, were set at defiance during the subjugation of this devoted country.

She could not brook a rival within the bounds of the peninsula; and after repeated attempts to exasperate Variathus, and force him to commence hostilities, he was declared an enemy to Rome, and was soon after, at the instigation of the Roman consul, and by the promise of great rewards, treacherously murdered by his own attendants. Spain thus lost one of her noblest defenders; but she found in the citizens of Numantia heroes worthy of the liberty which they sought, but which they were not destined to enjoy.

Numantia had maintained its independence during the struggle between Rome and Carthage; and its inhabitants had resisted every attempt at its subjugation, with such daring courage, that the bravest troops of Rome trembled at the very idea of a Numantine war. The first army that sat down before its walls was completely routed and dispersed. In the following campaign 4000 Numantines pursued an army of 30,000 Romans, seized and plundered the camp which they had abandoned, killed 20,000 in the pursuit, and shut up the remainder in a rough and mountainous country. In this situation the Roman commander, seeing no way of escape, was compelled to sue for peace. This was generously granted by the Numantines, who, for the lives of 10,000 Romans, merely stipulated that they should be allowed to maintain their independence, and be reckoned among the friends of the Roman people. But, in return for this noble and disinterested conduct, the senate of Rome refused to ratify the treaty; and, lost to all sense of honour and of justice, they basely resolved, in opposition to the remonstrances of all the officers who had served in Spain, to extirpate that brave and generous people. Scipio, one of their most experienced generals, and the conqueror of Carthage, was chosen for this dangerous expedition. Unwilling to expose his men, by hazarding an engagement with the Numantines, he enclosed the city with 60,000 troops, who were protected by a wall and ditch, being resolved to reduce the inhabitants not by force but by famine. The besieged, after several brave attempts to break through the enemy's lines and obtain succours, seeing their ruin inevitable, entreated the Roman commander that he would either allow them to die like brave men in a general action, or preserve their liberty by an honourable capitulation. Scipio, however, would listen to no proposals, and insisted upon an unconditional surrender. This drove the Numantines to despair, who were now reduced to such straits that they were destroying and devouring each other; but preferring death to slavery, they set fire to their city, and either killed one another, or perished in the flames. The fall of this city was considered of such consequence that Scipio was honoured with a triumph, and had the surname of Numantinus added to that of Africanus. It consummated the subjection of Spain; for though that noble love of liberty, for which this nation was so justly famed, frequently led them to attempt their emancipation, yet they were never afterwards able to make any head against the Romans; but were at last compelled to receive the religion, the laws and the customs of their conquerors. The last who submitted were the Cantabrians, who were almost exterminated by Agrippa; and from that time Spain continued incorporated with the Roman empire until the irruption of the northern nations.

Remarks.—Before the invasion of the Carthaginians Spain was divided into a multiplicity of petty kingdoms and commonwealths, who being entirely detached, and having little communication with each other, fell one by one under the power of their conquerors. Had the Spaniards been united as one state, or mutually assisted each other, it is not probable that so brave and virtuous a people would ever have been brought under a foreign yoke. Few nations have performed such great and heroic exploits, or exhibited so many noble examples of self-devotion to the cause of liberty as the ancient Spaniards. They were trained from their infancy to martial deeds, and were early inspired with a love of liberty and a contempt of death—being taught to esteem nothing so glorious as to die fighting in defence of their country. Thus naturally brave, and capable of enduring great labour and fatigue, no reverses could shake their courage. They yielded only inch by inch to the whole power of the Roman empire. Armies, sufficiently numerous to conquer kingdoms, were slaughtered among their mountains; and their subjugation was completed only after a struggle of nearly 200 years. Spain, however, received in exchange for her independence wise laws and an equitable government; and soon became the richest, the happiest, and the most powerful province in the empire. Many Roman families of distinction settled in the country, and five and twenty colonies were distributed in the most fertile districts, who, intermarrying with the natives, consolidated the two nations as one people. The executive government was, in general, milder here than in any other of the Roman provinces. It was administered in towns by magistrates named by the citizens; and the different districts were under the superintendence of pretors or deputies, who had the charge of the public works, and the collection of the revenue. Many magnificent ruins, still existing, testify the opulence and civilization of Roman Spain; and several of her cities, as Merida, Seville, Cordova, and Tarragona, were numbered with the most illustrious of the world. During her long tranquillity agriculture and the arts were encouraged and protected by the emperors; her commerce was extensive and profitable; and her vegetable and mineral riches were improved and manufactured by the skill of an industrious and happy people. But as Spain had shared in the grandeur and civilization of Rome, she also participated in her decline. Under the last emperors, her population had considerably diminished, her commerce had become languid, and her agriculture had suffered by the accumulation of estates in the hands of a few. The peace and repose of four centuries had enfeebled the national character, and almost eradicated their love of glory: and the Spaniards, whom the Romans conquered, was as another race from those who submitted to the northern barbarians.

Chap. II. *Spain under the dominion of the Goths.*

The Suevi, Alani, and Vandals, in their progress southward, broke into Spain about the beginning of the fifth century; and, in a few years had reduced and partitioned among them that beautiful country. The native militia, for a time, successfully repelled the inroads of barbarians; but when these were supplanted by the mercenary guards, the gates of the Pyrenees were betrayed to the enemy, whose progress was marked by rapine and carnage. They exercised their cruelty indiscriminately upon the Romans and Spaniards; and ravaged with equal fury the cities and the open country. Famine, and its inseparable attendant, pestilence, swept away a large proportion of the inhabitants; and the barbarians were not satiated till they began to feel the destructive effects of those calamities which they themselves had occasioned. The majority of the nation submitted to the yoke of their conquerors; while a few maintained their independence in the mountains of Galicia. These barbarians, however, were not allowed long to enjoy their conquests. The Goths had become the allies of Rome by the marriage of their king with the daughter of the Emperor Theodosius; and were induced to draw their swords for the recovery of Spain. During three years the contest was obstinately supported with desperate valour and various success, when the superior achievements of the Gothic king at length prevailed, and Spain was once more restored to the authority of the empire. The Roman power was again overthrown by the Vandals; and after the passage of that people to Africa, the Suevi aspired to the conquest of the country, and threatened to extinguish the Roman dominion. But Theodoric the Goth, by one decisive victory, laid the foundation of the Gothic monarchy in Spain. Rechiarius, king of the Suevi, was taken prisoner and put to death, when the remains of his army retired to Galicia, and for more than a century his successors held a precarious authority in that province. Euric, the son of Theodoric, consolidated the Gothic power; and, in addition to his territories in Spain, his dominion extended from the Pyrenees to the Rhone. His son Alaric, however, was stript of his Gallic possessions by the victories of Clovis; but the Goths were amply compensated for their loss by the secure enjoyment of the provinces of Spain. They fixed the royal seat at Toledo; and the Suevic kingdom of Galicia was soon after added to the monarchy. The Romans, who had continued masters of the whole coast from the straits of Gibraltar to the confines of Valentia, and also held considerable possessions on the ocean, were confined within the small territory of Algarve, and this they held, by the moderation of the Gothic monarch, for nearly ten years, when king Suintilla became the first absolute master of the whole Peninsula.

The history of the Gothic dominion in this country, from the accession of Euric to that of Roderic, afford few materials of any interest. Their princes were frequently engaged in civil or religious wars; and long adhered to the wandering and warlike manners of their fathers. The dissolute and cruel reign of Witiza the predecessor of Roderic, had lost him the confidence and esteem of his subjects, and had occasioned a general defection throughout the kingdom. A civil war was the consequence, which ended only with the death or deposition of Witiza, and the accession of Roderic to the Spanish throne. The sons of the deposed monarch, however, could not brook their degradation from the rank of princes, and endeavoured to wrest the sceptre from the hands of their rival. They were still supported by a considerable party in the state; but unable to accomplish their object by their own strength, they began to intrigue with the Saracens, which paved the way for the speedy subjugation of their country by that ambitious people.

The followers of Mahomet had overrun the whole of Mauritania and reduced it to the obedience of their master, except the castle of Ceuta, which resisted for a time all their efforts. This fort, with a small district around it, was the only territory south of the straits belonging to Spain, and was entrusted to Count Julian, who defended it with such skill and intrepidity, that Musa, the Moslem commander, was compelled to retire with disgrace from before its walls. This nobleman, it is supposed, was married to a sister of king Witiza, and, being consequently involved in the downfall of the deposed family, his resentment was excited against the usurper of their rights. Besides his command in Africa, he possessed extensive estates and numerous followers in Andalusia, and thus held in his hands the keys of the Spanish monarchy. These, in an evil hour, he betrayed to the enemy; and this Christian commander, who had so nobly repulsed that very enemy from the gates of Cueta, forgetting the highest claims of religion and of country, sacrificed all in revenge of a private wrong. When the first intimation of his purpose was conveyed to Musa, the wily Moslem hesitated to trust an army of the faithful to the traitors of a foreign land: but having ascertained what might be expected from the intrigues and influence of the count, and having been well informed of the dissensions among the Spaniards, he despatched an army under Tarik to the easy conquest of a populous and wealthy kingdom. On the descent of the Saracens, Roderic hastily collected a small army to oppose their progress, and to check the devastations which they committed upon the unarmed inhabitants. He, at the same time, endeavoured to heal the divisons which were so fatal to his country, and was so far successful that the sons of Witiza, with a seeming devotion to the common cause, joined his standard with their dependants. The bishops also, and the flower of the nobility assembled with their followers at the royal summons; and his army amounted to nearly one hundred thousand men; but they were without discipline, and their fidelity was suspected. The troops of Tarik were composed of twelve thousand veteran Saracens, and a crowd of Moors who were eager to share in the expected plunder. The two armies met on the plain of Xeres, and after three days of hard skirmishing they joined in a general engagement. The issue was long doubtful. Sixteen thousand Moslems had fallen under the swords of the Goths; and they would soon have been overwhelmed by the numbers of the Christians, had they not been saved by the defection of the sons and brother of Witiza, who held the most important post in the army of Roderic. The ranks of the Christians being thus broken and thrown into disorder, opened a way for the action of the Moorish cavalry, which made prodigious havock; and during the three succeeding days of flight and pursuit, the remains of the Gothic army were scattered or destroyed. This decisive and fatal battle sealed the ruin of the Gothic monarchy in Spain: and in the course of a few years, the victorious Moslems had subjected the finest provinces of the peninsula to the obedience of the caliph. The vanquished were allowed to retain their laws, religion, and language, upon the payment of an annual tribute; but many who preferred a life of poverty with the unrestrained exercise of their religion, to the precarious possession of their properties, retired under Pelagius, a prince of the blood, into the mountains of Asturias, where, forgetting every other care, sought only to provide for their safety and freedom. Here the vital spark of national independence was cherished and kept alive; and it was thence that the successors of these warriors emerged in after times, and by degrees recovered their country from the Moorish yoke.

Remarks. During this period, Spain presents to us a compact monarchy, concentrated within its natural limits, whose laws, manners, and religion, have in a great measure remained unaltered for fourteen centuries. The crown was elective in a council of bishops and nobility, styled *palatines*, who, while they swore allegiance, bound the monarch by a reciprocal oath that he would execute faithfully his important trust. The only indispensable requisite in the king was his being descended from the illustrious blood of the Goths. But though he derived his title from election, his power was almost absolute. He had the sole command of the army, bestowed all places of trust and profit, assembled and dissolved the national councils, exercised an ecclesiastical supremacy, and further had the power of making laws, which were revised, confirmed, and published by the assemblies of the states.

The administration of justice was strictly exercised throughout the kingdom, and the greatest reverence was everywhere paid to the laws. Before the reign of Euric, the Goths had no written jurisprudence; but this prince employed some of the most learned and eminent men in the kingdom in composing a body of laws, called the Theodorictan code, which he imposed upon all his subjects both in Gaul and in Spain. His successor Alaric, however, abrogated these, and restored the Roman laws, which continued in use until a new code of civil and criminal jurisprudence was examined and ratified by a legislative council at Toledo. This code contained the edicts of a succession of kings from Euric to Ejica, and, uniting a part of the Roman law with the Christian morality, formed a body of laws superior to all others then in existence. The native Spaniards, who were long separated from the Goths by the irreconcilable difference of religion, were at length raised to a participation of the same privileges with their conquerors; and all insensibly submitted to the restraint of an equitable rule.

The Goths, on their first entrance into Spain, were Arians; and for more than a century continued devotedly attached to that persuasion, till the conversion of king Recared, who, with the principal nobility, publicly renounced the errors of Arius, and embraced the catholic faith. The Spanish church at this time, though oppressed and persecuted, had retained much of its primitive purity; and even after its doctrines became the established faith of the kingdom, it still maintained its integrity and respectability. It was in a great measure free from those gross superstitions which then prevailed in the church of Rome. The Roman pontiffs were never able to obtain any right of interference in its concerns; and in one of the last councils held at Toledo, his claims of jurisdiction in Spain were rejected with contempt, and treated as an usurpation. The pious and temperate lives of its bishops were often conducive to the order and stability of the state, and the influence of the clergy in general was uniformly directed to the support of the best interests of the king and the people. It was indeed greatly owing to the predominance of episcopal policy in the national councils that the Gothic dominion in Spain was rendered friendly to the vanquished at home, and formidable to its foreign enemies, maintaining the authority and vigour of the laws, securing the privileges of every class of the community, and protecting all in the enjoyment of their property.

In the earlier ages of the Gothic rule in this country, industry and the useful arts were greatly neglected; and the warlike barbarians regarded with indifference all those accomplishments which can only be appreciated in a more refined and civilized state of society. But during a long peace, and a succession of wise administrations, agriculture and commerce had rapidly advanced, and had introduced a state of prosperity and refinement, which corrupted both prince and people. The favourite exercise of arms had been long abandoned by the Spanish youth. The floodgates of luxury were opened, and a love of ease and pleasure pervaded all ranks. The walls of their cities were mouldering into dust; and the descendants of those hardy bands who had humbled the pride of Rome were slumbering in security, ready to become a prey to the first invaders.

Chap. III. *Spain in subjection to the Moors.*

The first Moorish invaders under Tarik, consisting of various tribes, asserted, by assuming the name of Spaniards, their original claim of conquest; and though they were afterwards joined by numerous bands of Arabs of different countries, who were allowed to share in the fruits of this important enterprise, they appropriated to themselves the most fertile districts of the country. "The royal legion of Damascus was planted at Cordova; that of Emesa at Seville; that of Kinnisrin or Calchis at Jaen; and that of Palestine at Algezire and Medina Sidonia. The natives of Yemen and Persia were scattered around Toledo and the inland country; those of Egypt were established at Murcia and Lisbon; and the fertile seats of Granada were bestowed on the ten thousand horsemen of Syria and Irak, the children of the purest and most noble of the Arabian tribes." A spirit of emulation and jealousy existed among these different tribes, which gave rise to frequent disputes, and which, being nourished by a factious and hereditary pride, scattered those seeds of division, which afterwards ripened into a full harvest of intestine broils, and which led to their final expulsion from the peninsula.

The Moorish conquests in Spain continued to be governed by a lieutenant of the Caliph of Damascus until the deposition and destruction of the Ommiades in Arabia, when Abdalrahman, a royal youth, who alone had escaped the massacre of his house, fled into Spain, where he was hailed with joy by the party attached to his family. After a short and successful struggle with the lieutenant and forces of the rival family of the Abbassides, he established the throne of Cordova, and became the first Caliph of the west. The dynasty of the Ommiades continued to reign in this country with great splendour for nearly two centuries and a half, when the Spanish Caliphate expired. Their dominions were split into several petty states by the rebellion of the Moorish governors, who usurped the sovereignty of the provinces over which they presided, and assumed the royal style in Cordova, Seville, Valentia, and Granada. This dismemberment occasioned constant wars, which were sometimes prosecuted with all the rancour of hereditary feuds; and during which the monarchs, as well as the boundaries of the different kingdoms, were continually changing. Their limits were also greatly circumscribed by the conquests of the Christians, who were gradually extending their territories, and threatened the complete recovery of their native possessions.

The Goths, who had retired with Pelagius to the mountains of Asturias, had chosen that prince as their monarch: and his territories were at first confined to the small province of Liebana with the hamlet of Cangas for its capital. This district was so fortified by nature, that, with a few defenders, it was capable of resisting almost any number of invaders. Here Pelagius laid the foundation of the kingdom of Leon, and of the Spanish monarchy; and defied the whole power of the Moors, who twice attempted with numerous armies to dislodge his little band of patriots; but were as often overthrown with dreadful slaughter. By these victories he became master of all the Asturias, and soon after extended his dominion over the best part of Biscay. His little territory afforded an asylum to the oppressed Christians, who, retiring privately from the Moorish provinces, repaired in great numbers to his standard, and by thus recruiting his forces, enabled him and his immediate successors, to descend with more confidence into the lower and more fertile parts of the country, and to push their conquests, on the one hand, as far as Castile; and, on the other, to the confines of Portugal. The kingdom of Leon increased rapidly in extent and resources during the reigns of Alphonso III, who subdued Galicia, and spread his dominion as far as Coimbra, and of Ramirus II, who penetrated to Madrid, which he took by storm, and even threatened Toledo, at that time one of the strongest cities in the hands of the Moors. Encouraged by the successes of the Christians in Leon, other provinces began to establish themselves as independent states, and by similar means, rose to power and distinction. The independence of Navarre commenced about the middle of the ninth century; that of Castile thirty years later; and Aragon was erected into a kingdom in the beginning of the eleventh century. The wars and events which led to the formation of these kingdoms, were signalized by many heroic achievements; and no history records a succession of kings so remarkable as those who shone in those different states. Several of the name of Alphonso were distinguished and able princes, one of whom invented the Alphonsine tables, and superintended the digesting of a code of laws, which likewise bears his name. By the establishment of these states the Moors were driven from the finest provinces of the Peninsula, and confined within the kingdom of Granada. In a series of years, however, by the usual events of intermarriages, or succession, or conquest, all these were united under Ferdinand and Isabella, the former the hereditary monarch of Aragon, and the latter, the heiress of Castile and Leon.

As our limits will not admit of any detail of these transactions, we shall content ourselves with presenting here a chronological table of the different kingdoms, with the periods of their formation, and the sovereigns by whom they were governed.

Leon and Asturias.	Barcelona Counts.	Navarre.	Castile.	Aragon.
718. Pelagius.	801. Bera.	831. Aznar, Count.	1035. Ferdinand I.	1035. Ramirus I.
737. Favila.	820. Bernard.	836. Sancho.	In 1037, the kings of Castile became kings of Leon and Asturias.	1070. Sancho I.
739. Alphonso I. the Catholic.	844. Alderan.	853. Garcias.	1065. Alphonso VI. and I. of Castile	1094. Peter I.
757. Froila I.	858. Wifred.	857. Garcias-Ximenes.	1070. Sancho II.	1104. Alphonso I.
768. Aurelio.	872. Salamon.	880. Fortunio I. the first king.	1072. Alphonso VII.	1134. Ramirus II.
774. Silo	880. Wifred II. the Warlike.	905. Sancho I.	1109. Urraca and Alphonso VIII.	1137. Pelonille and Raymond-Berenger.
783. Mauregat, an usurper.	911. Miran.	926. Garcias I.	1157. Sancho III.	1162. Raymond, surnamed Alphonso II.
788. Bermudus I.	928. Seniofred.	978. Sancho II.	1158. Ferdinand II.	1196. Peter II.
791. Alphonso II. the Chaste.	967. Borellus.	994. Garcias II.	1188. Alphonso IX.	1213. James the Victorious.
842. Ramirus I.	993. Raymond I.	1000. Sancho III. the Great.	1214. Henry I.	1276. Peter III. deposed.
850. Ordogno I.	1017. Berenger I.	1035. Garcias III.	1217. Ferdinand III.	1285. Alphonso III.
886. Alphonso III. the Great.	1035. Raymond II.	1054. Sancho IV.	1252. Alphonso X. the Wise.	1291. James II.
911. Garcias.	1067. Raymond III.	1076. Sancho V.	1284. Sancho IV.	1327. Alphonso IV.
914. Ordogno II.	1081. Raymond-Berenger IV.	1094. Peter I.	1295. Ferdinand IV.	1336. Peter IV.
923. Froila II.	1131. Raymond-Berenger V. who died in 1162, when the county of Barcelona passed to the king of Aragon.	1104. Alphonso.	1312. Alphonso XI.	1387. John I.
924. Alphonso IV.		1134. Garcias IV.	1350. Peter the Cruel.	1395. Martin.
927. Ramirus II.		1150. Sancho VI.	1369. Henry II.	Interregnum.
950. Ordogno III.		1194. Sancho VII.	1379. John I.	1412. Ferdinand.
955. Ordonio, an usurper.		1234. Thibaut I.	1390. Henry III.	1416. Alphonso V.
955. Sancho the Big.		1253. Thibaut II.	1406. John II.	1458. John II.
967. Ramirus III.		1270. Henry.	1454. Henry IV.	1479. Ferdinand II. married Isabella of Castile.
982. Bermudus II.		1274. Joanna I. and Philip, king of France.	1474. Isabella and Ferdinand V. king of Aragon.	1516. Charles I. who inherited from his mother Joanna the monarchy of Spain
999. Alphonso V.		1305. Louis Hutin, king of France. Interregnum.	1504. Joanna and Philip.	
1027. Bermudus III.		1316. John I.		
		1316. Philip the Long, king of France.		
		1322. Charles, king of France.		
		1328. Joanna II.		
		1349. Charles II. the Bad.		
		1387. Charles III.		
		1424. John II.		
		1479. Eleonora.		
		1479. Gaston-Phœbus of Foix.		
		1481. Interregnum.		
		1483. Catherine. John d'Albert.		
		It became subject to Castile in 1512		

The first care of Ferdinand and Isabella, after having wisely settled the interior affairs of their dominions, was the recovery of Granada. An opportunity was soon found for breaking the peace with the Moors; and after a protracted and bloody war, this wealthy kingdom, which had occupied a large proportion of the south of the Peninsula, having under its jurisdiction thirty-two cities and ninety-seven walled towns, was reduced within the small compass of the city of Granada. Being now invested by the Spaniards, and all communication with the surrounding country cut off, the inhabitants were reduced to the utmost extremity. The Moors, however, made a gallant defence; and received an honourable capitulation, in which it was stipulated that the inhabitants should retain the undisturbed possession of their property, the use of their laws, and the free exercise of their religion. Thus this last strong-hold of the Arabs in Spain submitted to the Christian arms, after an almost uninterrupted war of eight centuries, and during which, according to the Spanish historians, three thousand seven hundred battles were fought. Shortly after the battle of Xeres in 712, the Moors had overrun the whole Peninsula, except a small district in the mountains of the Asturias; but the tide of victory was not long in setting in from an opposite direction; and they were gradually driven by the arms of the Christians from all their possessions in Spain: from the Asturias in 716; from Salvarba in 750; from Catalonia in 820; from Leon in 923; from Castile in 1073; from Aragon 1118; from Cordova and Jaen in 1236; from Seville in 1248; from Valentia in 1264; from Murcia 1265; and from Granada in 1492.

The important conquest of Granada was, in the same year, followed by the more important discovery of America by Christopher Columbus; which, with its subsequent conquest, redounded more to the glory and fame of Isabella than any other act of her reign; and as she consented to defray the whole expense of the expedition, without the concurrence of Ferdinand, she reserved for her subjects of Castile exclusively all the advantages resulting from such an undertaking.

Upon the death of Isabella, the archduke Philip, king of the Netherlands, who had married her daughter Joanna, a princess of very slender capacity, claimed the crown of Castile in right of his wife. Ferdinand, who, by the will of his queen, had been appointed regent of the kingdom till her grandson Don Carlos should attain the age of twenty, found it prudent to resign the regency and retire to his own dominions of Aragon. The reign of Philip, however, was short and turbulent. He disgusted the nobility by his great partiality to his Flemish favourites, upon whom he bestowed all places of trust and emolument; and also by his cruelty to his queen, whom he wished to deprive of the government, and to confine as a deranged person. This conduct spread universal discontent, the consequences of which were averted only by his death, which happened about seven months after his arrival in Spain. The affairs of Castile were thus thrown into great confusion, and the states, in order to maintain the tranquillity of the kingdom, invited Ferdinand to resume the regency, which he held until his death in 1515.

This monarch was one of the greatest princes that ever ruled in Spain, and possessed in a very high degree the love and affection of his people, who lamented his loss with unfeigned sorrow; and called him with great justice, their father and deliverer. He bequeathed his hereditary dominions, and also the kingdoms of Naples and Navarre, which he obtained by conquest, to Joanna queen of Castile, and after her to his grandson Don Carlos. He appointed Cardinal Ximenes, archbishop of Toledo, regent of Castile; and bestowed the regency of Aragon and its dependencies upon his natural son Don Alonzo, archbishop of Saragossa.

Remarks.—It could scarcely have been expected that during this period, when the Peninsula was divided into small kingdoms without frontiers and guaranty; and governed by sovereigns of different nations and religions, who were almost continually at war with each other, much attention would be devoted to its agricultural and commercial interests. Yet that portion of it which was subject to the Moors, enjoyed a degree of prosperity and civilization, unexampled in Spain during any other period of its history. This people were particularly skilled in agriculture, and carried every branch of public and private economy to a high degree of perfection. They paid the most minute attention to the analysis, classification, and manure of the different soils, to rustic buildings, plantations, and agricultural implements, and to the care of animals. They divided their lands into small fields, which were kept constantly under tillage, and by their reservoirs and canals, they conveyed water to the highest and driest spots. They were the first who introduced into this country the cultivation of rice, sugar, cotton, and silk; and the general appearance of their estates formed a striking contrast to the domains of the crown, and the immense wastes of the Gothic lords. They were also expert in all the mechanical arts; and in almost every city were established looms, forges, mills, glass-houses, &c. The invention of paper is due to this people; and many kinds of manufactures, particularly silk and cotton stuffs, morocco leather, &c. were brought by them to so great perfection, that, in the twelfth century, the tissues of Granada and Andalusia were highly prized at Constantinople and throughout the Eastern empire. Their skill in architecture was equally conspicuous; and the *Alhambra* of Granada, still in existence, is an evidence of the fine taste, studied elegance, and ability of their artists. To this improved state of industry the Moors added the love of science and learning. These they introduced into Europe at a time when it was immersed in darkness; and they possessed many luxuries unknown to the neighbouring nations. "The successers of Abdalrahman had formed a library of 600,000 volumes, 44 of which were employed in the mere catalogue. Their capital of Cordova, with the adjacent towns of Malaga, Almeria, and Murcia, had given birth to more than 300 writers; and above 70 public libraries were opened in the cities of the Andalusian kingdom." The Arab historians describe the reign of the Ommiades as the most splendid and prosperous era of Moorish Spain. "The third of the Abdalrahmans derived from this kingdom the annual tribute of 12,045,000 dinars or pieces of gold, about six millions Sterling, his royal seat at Cordova contained 640 mosques, 900 baths, 200,000 houses; he gave laws to 80 cities of the first, to 300 of the second and third order; and the fertile banks of the Guadalquivir were adorned with 12,000 villages and hamlets, The inmates of his seraglio, comprehending his wives, concubines, and black eunuchs, amounted to 6300 persons; and he was attended to the field by a guard of 12,000 horse, whose belts and scimitars were studded with gold." To this extraordinary concurrence of industry, wealth, talents, and learning, this people united that romantic gallantry which so eminently prevailed in the ages of chivalry; and their noble conduct in many instances, inspired with confidence in their honour, even the enemies of their kingdom and of their faith.

This high state of prosperity and refinement, however, was confined chiefly to the Moorish dominions. The descendants of the Goths were entirely occupied in the pursuit of independence and military glory. They were forward to imitate, and often surpassed their rivals in the noble qualities of generosity and honour, and in all those deeds which spring from a romantic and chivalrous spirit, but they disdained to follow them in the pursuits of industry and science. Preferring the wandering and martial life of their fathers, they never could be induced to relinquish their ancient habits and manners for the advantages of agriculture and the mechanical arts. The care of flocks and herds, which from time immemorial had enriched the kingdoms of Castile and Leon, appeared to them a securer source of wealth, and as they were involved in continual wars, was more easily removed from the inroads of an enemy. In those times all the inhabitants capable of bearing arms followed the standard of their lords. Their flocks and herds were entrusted to the care of the old men, women and children, who were totally unfit for the laborious duties of an extended agriculture; and as the quantity of corn which they raised was insufficient for their consumption, they were under the necessity of exchanging their wool, hides, iron, and oil, for the grain and manufactures of their neighbours. Their aversion to rural employments and the arts was thus the consequence of their situation and the circumstances in which they were placed; and during peace the enthusiasm of war and chivalry degenerated into a spirit of pride and of idleness incompatible with an industrious application to mechanical labour. This spirit was almost universal among the Spaniards, except in the Moorish cities, where the Christians by their constant intercourse with them, had learned their arts and continued to cultivate them. While the Moors, though a vanquished people, continued in the peninsula, the country was greatly benefited by their industry and their genius; but after the expulsion of a great proportion of them, in consequence of frequent revolts, Spain was never able to supply the demands of her inhabitants, and so became a constant tributary to the industry of other nations. The establishment of the inquisition by Ferdinand and Isabella also tended in no small degree to deprive this country of its most industrious population. The Jews who, after the Moors, had engrossed almost all the wealth and commerce of Spain, were so exposed to its merciless rage, that they were compelled to leave the kingdom or to embrace Christianity; and it is calculated, that within four years after the appointment of Torquemada, the first inquisitor-general, 6000 persons, chiefly of this unfortunate race, were burned by order of this sanguinary tribunal, and that upwards of 100,000 felt its fury.

With respect to the political institutions of the Gothic Spaniards during this period, they still adhered to their ancient laws, not only from attachment to them, but out of antipathy to the Moors, who held very different notions concerning property and government. These, however, were considerably changed by a variety of concurring causes. As the different kingdoms were wrested from the Moors gradually and with difficulty, the nobles who followed the standard of their chief conquered not for him alone, but for themselves. "They claimed a share in the lands which their valour had won from the enemy; and their prosperity and power increased in proportion as the territory of the prince extended." The sovereign being thus obliged to conciliate their good will by successive grants of new honours and privileges, before he could establish his dominion in a conquered province, the greater part of the territory was parcelled out by him among his barons, with such jurisdictions and immunities as raised them almost to sovereign powers. The monarch was thus but a little elevated above his nobles; and they, feeling their independence, often acted as his equals. The cities of Spain had also obtained very considerable power during this struggle. As the open country was perpetually exposed to the depredations of the enemy, with whom no peace or truce was permanent, persons of all ranks were obliged, for self preservation, to fix their residence in the cities. These at length became the only places of safety; and as many of them were, during a longer or shorter period, the capitals of little states, they enjoyed all the advantages which accelerate the increase of inhabitants in every place which is the seat of government. Their number at the beginning of the fifteenth century was very considerable, and were peopled far beyond the proportion which was common in other parts of Europe; and as their assistance was frequently required in prosecuting the war against the Moors, their monarchs found it necessary to gain their favour by ample concessions, which not only extended their immunities, but added to their wealth and power. By the exorbitant privileges of the nobility, and the unusual power of the cities, the royal prerogative was hemmed in on every side, and reduced within very narrow limits, and when the Castilian nobles combined against Henry IV. they arrogated, as one of the privileges belonging to their order, the right of trying and passing sentence upon their sovereign, which they carried into effect by deposing him from the throne. Several monarchs, impatient of such restraint, endeavoured at various junctures, and by different means, to enlarge their authority, but it was left for Ferdinand to accomplish in some degree the extension of the sovereign's prerogative, which his predecessors had so long and so frequently attempted in vain.

Owing to the restricted power of the monarch and the feebleness of the government, the different Spanish states presented, during the greater part of this period, a scene of the utmost disorder and insubordination. The bonds of civil society seemed to have been burst asunder. The administration of the laws was so extremely weak, that it afforded no protection to the subject; and robbery and murder became so common, as not only to intercept the internal commerce of the kingdom, but in a great measure to suspend all intercourse between its cities. The feudal barons who were sufficiently forward to assist their prince in repelling foreign aggressions, or in extending his dominions, were equally ready in resisting any encroachments upon their privileges, which were alike inimical to the stability of the throne and the welfare of the people. They claimed and exercised a sovereign jurisdiction within their own territories; and this, with their frequent private wars, the want of discipline among the troops, and the incessant depredations of the infidels, filled the provinces of Spain with confusion and tumult. The inhabitants of the cities were the greatest sufferers; and as a measure of self defence, the cities of the kingdom of Aragon, and after their example those of Castile, formed themselves into an association, distinguished by the name of the *Hermandad*, or "Holy Brotherhood." They exacted a certain contribution from each of the associated towns; they levied a considerable body of troops, in order to protect travellers and to pursue criminals; they appointed judges, who opened their courts in various parts of the kingdom. Whoever was guilty of murder or robbery, or of any act that violated the public peace, and was seized by the troops of the Brotherhood, was carried before judges of their nomination, who without paying any regard to the exclusive and sovereign jurisdiction which the lord of the place might claim, tried and condemned the criminals. By the establishment of this fraternity, the prompt and impartial administration of justice was restored; and together with it internal tranquillity and order began to return. The nobles alone murmured at this salutary institution. They complained of it as an encroachment on one of their most valuable privileges. They remonstrated against it in a high tone: and, on some occasions, refused to grant any aid to the crown unless it were abolished." Ferdinand, however, was too sensible of the good effects of such an institution to listen to any proposal for abridging its powers. He supported it on all occasions with the whole force of royal authority; for to limit and abolish the independent jurisdiction of the nobility was one of the great objects of his policy; and this he in a great measure accomplished by his perseverance and the assistance of the Hermandad. When the deputies from the states of Aragon, who had refused him supplies in his war with France, offered to accede to his demands upon condition of his restoring the territorial jurisdiction, he ordered them from his presence, declaring that "he would not purchase a supply at the expense of the liberties of his subjects; that before his reign the vassals of the nobility were their slaves; that he had made them free, and would keep them so." Notwithstanding, however, the exertions of this able and wise prince, the spirit of liberty was so vigorous among the people, and the spirit of independence so high among the nobility, that the kingly prerogative was less extensive in Spain than in any other of the great monarchies of Europe.

Chap. IV. *Spain while under the dominion of the Austrian dynasty.*

The affairs of Spain, until the arrival of Charles, were conducted by the aged Cardinal Ximenes with such wisdom, integrity, and firmness, that the kingdom felt not the loss of the powerful mind of Ferdinand. Many of the nobles who, supposing that the reins of government would be relaxed under the delegated power of a regent, had taken up arms to prosecute their private quarrels and pretensions, were compelled to repress their hostilities and to submit to the terms of the Cardinal. The decision and vigour of his administration, and the high authority which he assumed, excited the fears of the nobility for the safety of their peculiar privileges; and when they sent a deputation to question his power, and demand by what right he held the regency of the kingdom, he showed them the will of Ferdinand, ratified by Charles. This, however, not seeming to produce the acquiescence which he wished, he led them to a balcony, and pointing to a body of troops and a train of artillery stationed before the palace, said, "These are the powers by which I mean to govern Spain until the arrival of his majesty." But the exertions of this able minister, who, during his short regency, did so much for the security of the kingdom, and the extension of the royal prerogative, were rewarded with neglect and disgrace. On the arrival of Charles at St. Andero, Ximenes hastened to meet him, but was seized during the journey with a violent disorder, supposed to be the effects of poison. This accident obliged him to stop at Aranda, from whence he wrote to the king, earnestly desiring an interview, and at the same time advising him to dismiss all the strangers in his train, whose numbers and influence already gave great offence to the Spaniards, and who would ere long alienate the affections of the whole people. This advice was disregarded; and the Flemish courtiers, jealous of the power of the Cardinal, industriously kept the king at a distance from Aranda, and at length prevailed with him to dismiss this faithful minister and supporter of his throne. Ximenes died a few hours after receiving this communication, leaving behind him a reputation for wisdom and sanctity, prudence and boldness, which no monarch or minister had ever enjoyed in that country.

After the death of Ximenes, Charles found great difficulty in establishing his authority in Spain. His Flemish favourites, by their exactions and avarice, had become odious throughout the kingdom; and several cities of the first rank in Castile entered into a confederacy for the maintenance of their rights and privileges. This confederacy assumed the name of the Holy Junta, and bound themselves by a solemn oath to live and die in the service of the king, and in defence of the privileges of their order. As Charles was now absent in Flanders, they appointed a deputation to wait upon his majesty, and drew up a remonstrance, which contained not only an enumeration of their grievances, but also many new regulations for the security of their liberties; and which show that the Spaniards of that day had acquired more liberal ideas, with respect to their own rights and privileges, and had formed more bold and generous sentiments concerning government, than other people in Europe. The nobles, while they supposed that the demands of the Junta were confined to the redress of such grievances as had arisen from the inexperience of the monarch, or the rapacity of his courtiers, connived at, and even favoured their proceedings: but when they perceived that their own peculiar privileges were in some danger, they immediately joined the forces of the regent. After a contest of nearly eight months, which was prosecuted with a rage and fury peculiar to civil insurrections, and which was attended with many fruitless negotiations the army of the Junta, under Don Juan Padilla, was completely routed near Villelar, when three of their chiefs were taken prisoners, and immediately executed. After this defeat, the city of Toleda alone maintained the struggle, being animated by the presence and courage of Donna Maria Pacheco, Padilla's widow, a woman of rank, abilities, and boundless ambition. When driven to the citadel, she defended it for four months with amazing fortitude; but being at last reduced to great extremities, she made her escape into Portugal. Similar troubles prevailed in Valencia, where the commons assumed the name of *Germanada*, and also in Aragon and Majorca; but the spirit of disaffection was completely crushed before the arival of the king in 1522.

Charles, who had now obtained the imperial crown, proceeded with great prudence and moderation to heal the unhappy divisions which had distracted Spain during his absence. He proclaimed a general pardon for all crimes committed during the insurrection, with the exception of about eighty persons, of whom, however, very few suffered; and many who were of rank had their outlawry reversed, and were restored to their honours and estates. This act of clemency was condemned by his council, who strongly solicited him to make some more examples; but he answered that "enough of blood had been already shed;" and when one of his courtiers, in expectation of a reward, officiously informed him where one of the proscribed party was concealed, he sharply replied, "You had done better in advising Ferdinand de Avalos to be gone, than in putting me in the way to apprehend him." By this magnanimous conduct, and by "his address in assuming the manners, and speaking the language of the Castilians, he acquired an ascendency over the people which hardly any of their native princes had ever attained, and brought them to support him in all his enterprises, with a zeal and valour to which he owed much of his success and grandeur."

It would be foreign to our purpose to follow this prince in his campaigns in the Milanese, and his wars with France, which continued with little interruption during the whole of his reign. These belong more properly to his history as Emperor of Germany, and a succinct account of which will be found in the article FRANCE. Spain was but as one of the provinces of his extensive dominions; and however much his successes in these wars might redound to his own glory, and throw a gleam of splendour around his name as a warrior and a politician, they were fatal to the internal improvement of this kingdom. The produce of its soil, the treasures of its colonies, and the flower of its population, were dissipated in foreign lands in the prosecution of his ambitious schemes. His demands for subsidies were repeatedly refused by the cortes; and his impoverished subjects were frequently upon the eve of a rebellion, which was prevented only by his foresight and prudence.

After the treaty of Cambray in 1529, which gave a short repose to Europe, Charles meditated an expedition against the piratical states of Africa. The famed Horne Barbarossa, who from a private corsair had raised himself by his singular valour and address to be king of Algiers and Tunis, had become terrible by his depredations from the Straits of the Dardanelles to the rock of Gibraltar. Daily complaints were made to the emperor by his subjects, both in Italy and Spain; and all Christendom seemed to look to him for deliverance from this new and odious species of oppression. For this enterprise, which was very popular among all classes, he obtained abundant supplies; and having embarked with the flower of the Spanish nobility for Cagliari, which was the general place of rendezvous, he from thence sailed for Tunis with a fleet of 500 sail, having on board 30,000 regular troops. Barbarossa was prepared for the attack. He had strongly fortified the fortress of Goletta, which is situated on a neck of land, and commands the bay of Tunis, and in the strength of which he placed his chief confidence. Charles on his landing laid siege to this fortress, and after a month of daily skirmishing, took it by storm on the 25th of July 1535, when the whole piratical fleet fell into his hands. He then proceeded to Tunis, but was met upon the march by the army of Barbarossa, which he completely routed, when his troops, flushed with victory, and eager for plunder, rushed into the city, and, in spite of all his exertions to restrain them, committed every species of excess and cruelty. Thirty thousand innocent inhabitants perished on that occasion, and ten thousand were carried away as slaves. Having restored Muley Hassan, the former monarch, and bound him by treaty to hold the kingdom of Tunis as a vassal of the crown of Spain, he garrisoned the Goletta with Spanish troops, and returned to Europe.

The expedition of Charles against Algiers, however, about six years afterwards, was not so fortunate. He disembarked his army on the coast of Africa at too advanced a season of the year; and before the provisions and warlike stores could be landed, his fleet was dispersed by a tempest, in which 15 ships of war, and 140 transports, with 8000 men perished. Such of his vessels as had escaped, received his dispirited troops, but being overtaken by another storm, the emperor with difficulty reached Carthagena, extremely mortified at the failure of his favourite scheme.

On his return, Charles found himself embroiled in new wars. Having committed the government of Spain to his son Don Philip, who, as heir apparent, had received the oath of fidelity from the cortes, he passed over to Flanders, and the remainder of his reign was spent in his contest with France and the protestants of Germany. At the same time, however, that he was prosecuting his plans of conquest and of aggrandizement on the continent, he formed the ambitious project of adding England to the dominions of his family. He succeeded in accomplishing a treaty of marriage between his son and Mary of England, by which it was stipulated that their heirs should, together with the crown of England, inherit the duchy of Burgundy and the Netherlands; and if Don Carlos, Philip's son by a former marriage, should die without issue, they should succeed also to the crown of Spain, with the emperor's hereditary dominions.

Worn out at length by his arduous duties and the ravages of the gout, and conscious of his inability much longer to direct with vigour the multiplicity of affairs which called for his attention throughout his extensive dominions, he resolved to resign his hereditary states to his son Philip, who had now attained his 28th year, and having been early accustomed to business, had discovered both inclination and capacity sufficient to sustain the weighty burden which was about to devolve upon him. For this purpose he recalled Philip from England, and having assembled the states of the low countries and of Brussels, Charles seated on a chair of state, and surrounded by a splendid retinue of the princes of the empire and grandees of Spain, with great solemnity surrendered to his son all his territories, jurisdiction, and authority in the low countries. A few weeks afterwards, he resigned with great solemnity, and in an assembly no less splendid, the crown of Spain, "reserving, of all his vast possessions, nothing for himself but an annual pension of one hundred thousand crowns to defray the charges of his family, and to afford him a small sum for acts of beneficence and charity." In the following year he returned to Spain, and retired to the monastery of St. Justus, near Placentia. Here in a mean retreat, he forgot the ambitious thoughts and projects which had so long engrossed his mind, and which for half a century, had filled with terror all the kingdoms of Europe, and devoting the evening of life to innocent amusements and religious exercises, died on the 21st of September 1558.

Philip II., though his father, with all his power and influence, was unable to obtain for him the imperial crown, succeeded to a sceptre more powerful perhaps than that of any monarch of the age. Besides his dominions in Europe, including Spain, Naples, the duchy of Milan, and the Netherlands, he possessed in the new world territories of such vast extent, abounding in inexhaustible veins of wealth, and opening such boundless prospects of every kind, as must have roused into action a mind much less ambitious and enterprising than that of Philip. He inherited with his crown a war with France and the pope, but this was but of short duration; and the treaty of Chateau Cambresis left him without an enemy. In memory of the battle of St. Quintin, fought in this war, "on the day consecrated to St. Laurence, he built the splendid and magnificent palace of the Escurial, in honour of that saint and martyr, and so formed the plan of the work as to resemble a gridiron, which, according to the legendary tale, had been the instrument of St. Laurence's martyrdom." This prince, however, was not of a disposition to remain long inactive; and though he was not desirous of military glory, yet in other respects, he was not inferior to his father either in ambition or abilities; and during a long reign, he gave more disturbance to his enemies by his political intrigues, than the emperor had ever done by his arms.

The severity of Charles's government in the Netherlands, with respect to religious matters, had estranged from him the affections of his subjects in that country; and the violent and bigoted principles of Philip's administration, under the Duke of Alva, exasperated them into open rebellion. This afforded employment to the arms of Spain for nearly half a century, and at last lost to that crown one half of its most valuable possessions in the low countries. (See Netherlands.)

The same spirit of intolerance which raised such a flame in the Netherlands, stirred up the Moors in Spain to a similar resistance. This industrious people, since their subjection, had lived as quiet subjects. But it had been insinuated to the court of Rome, that though nominally Christians, they still adhered to the Mahometan faith, which induced the pope to press upon Philip the necessity of bringing them by force within the pale of the Catholic church. The king ever ready to listen to the instigations of monkish zeal, sent express orders into the kingdom of Granada, to oblige the Moors to change at once their habits, manners, and language; and the clergy were enjoined to require the registration of all Moorish children between five and fifteen years of age, that they might be taught the Castilian tongue, and be instructed in the Catholic faith. Notwithstanding the humble representations of loyalty and attachment from this unfortunate race, and the louder remonstrances of the governor and principal officers of the province, against so impolitic and impracticable a measure, Philip remained inflexible. The Moors were driven to despair, and having taken up arms, renounced their allegiance to the king of Spain, and proclaimed one of their chiefs king of Granada and Cordova. The struggle was prosecuted on the part of the Moors with all the fury of religious frenzy, committing every where the most outrageous excesses, and inflicting inexcusable cruelties upon the innocent inhabitants, particularly ecclesiastics: while the Spanish commanders acted with great moderation, treating their prisoners with lenity, and receiving many to mercy. This war lasted between two and three years, cost the lives of 20,000 Castilian soldiers, of about 100,000 Moors, and depopulated and destroyed some of the finest countries in Spain.

About this time was formed what is called the Holy League against the Turks, and in favour of the Venetians, one half of the expense of which was to be defrayed by the king of Spain. The command of the armament, consisting of 200 gallies, with 50,000 foot, and 4000 horse, was given to Don John of Austria, the king's half-brother, who obtained a signal victory over the Ottoman fleet, in which 30,000 Turks were killed, 10,000 taken prisoners, and 15,000 Christian slaves set at liberty. But the fruits of this victory were lost from want of unanimity among the leaders of the league: and from the same cause, in the following year, another Turkish fleet was saved from destruction. The consequence of this was, that the Turks made a descent upon the coast of Africa, reduced Tunis and the Goletta, which the Spaniards were never after able to recover.

These losses, however, were amply overbalanced by the seizure of the crown of Portugal. The young king Sebastian, who, with most of his nobles, fell in the battle of Alcaçar-quivir, was succeeded by his uncle Cardinal Henry, who, after an uneasy reign of two years, died without naming a successor. Philip, who was one of the competitors for the throne, and had an army ready to act upon the first intelligence of Henry's death, immediately seized upon the kingdom, which submitted without a struggle. This accession to his dominions, however, afforded him little satisfaction. Portugal had been drained of its wealth and population by the unfortunate expedition of Sebastian: and though Philip went in person to Lisbon, where he resided for some time, and conferred many powers upon the nobility, yet finding that all his efforts to gain the affections of his new subjects were fruitless and ineffectual, he returned home in displeasure, leaving the management of the kingdom to a regent and council.

The attention of Philip was now directed to a more formidable enemy, the queen of England. Having, in the early part of his reign lost his consort queen Mary, he offered his hand to her successor; but that prudent princess, who wished not to make an enemy of so powerful a monarch in the commencement of her career, returned a respectful but evasive answer. The measures of her government, however, soon convinced him that he had nothing to hope for on that head; and he soon after married the sister of the king of France. No open rupture occurred between the two courts before 1569; and this was followed by no material consequences until about fifteen years afterwards, when the Spanish monarch, enraged at the assistance afforded by Elizabeth to his rebellious subjects in the low countries, and at the depredations committed by her fleets, not only on his settlements in America, but even on his own coasts, where Sir Francis Drake destroyed about a hundred vessels in the road of Cadiz, and captured an East Indiaman of great value, bent the whole force of his empire to revenge these repeated insults. Great preparations were consequently made for this purpose; and the invincible Armada was sent forth with the confident hope of crushing at one blow these presumptuous islanders and their heretical queen. The fate of this armament is well known, (See Armada;) and Philip now found his attention sufficiently employed as protector of the Catholic league, which opposed the accession of Henry IV. of France; and with his own ambitious schemes for the exaltation of his own daughter, the infanta Isabella, to the throne of that kingdom. But the conversion of Henry to the Catholic faith destroyed all his views in that quarter.

During this period the English had not been inactive in retaliating by deeds the threats of Spain. Corunna was sacked, Lisbon endangered, and saved only through a misunderstanding between the English commanders, and the outward-bound India fleet in the port of Cadiz plundered and destroyed. These losses and insults instigated Philip to another attempt upon England, which, however, was similarly unfortunate as the former, the elements seeming to combine with his enemies in discomfiting his best laid and most confident plans. This was the expiring effort of his reign. He died in the following year, leaving Spain drained of her wealth and her populatiou; for it happened with this prince that while he meditated the destruction of other kingdoms, the very means which he employed exhausted his own.

Philip III. had neither the ambition nor the abilities of his father; and both from his education and dispositions, was altogether incompetent to manage the weighty concerns of an extended empire. He consequently gave himself up entirely to the direction of his favourite the duke of Lerma, who, though not endowed with splendid talents, possessed great prudence, mildness, and moderation. His accession to the throne was immediately followed by the ratification of a peace with France, and in a few years afterwards with England. The contest in the low countries, which occasioned such a waste of troops and treasure, as was gradually wearing out the strength of the monarchy, became also the subject of consideration; and a truce for twelve years was concluded, in which the Dutch republic was acknowledged as a free state. This disposition, on the part of the king's advisers to adopt moderate and pacific measures, promised that tranquillity to Spain of which she stood so much in need for recruiting her resources and restoring vigour to her government. But unfortunately the spirit of intolerance still predominated in her councils, which was encouraged by the bigotry of the priesthood, and the superstitious fears of her monarch; and which led, in spite of the vigorous opposition of the barons and landholders, to the expulsion of the Moors, a measure both impolitic and inhuman, and which lost to the state 600,000 of its most industrious and wealthy population.

Spain still maintained her superiority in Italy, but with difficulty and at great expense; and the intrigues and ambition of her governors in that country rendered her authority odious and insupportable to the Italians.

The disgrace of the duke of Lerma, through the intrigues of his own son, who succeeded him in the affections of the king, produced little change in the foreign policy of the kingdom; but the death of Philip soon after threw the administration of affairs into other hands, who, disdaining the pacific measures of their predecessors, were eager in the prosecution of plans of aggrandizement.

The same system of favouritism still prevailed, and Philip IV. entrusted all to the Count d'Olivares, a man of considerable talent, but boundless ambition. The political horizon of Europe had continued tolerably serene during the last reign; but it now began to be overcast; and the eventful contest of the thirty years war had already commenced. Dissensions in Germany and Italy called for the interference of Spain; and the renewal of the war with the Dutch republic, notwithstanding that power evinced a strong disposition to prolong the truce, or even to convert it into a solid peace, demanded exertions which the diminished resources of the government were little able to support. The policy of Olivares was ruinous to his country. It excited the resentment of all her neighbours, who, without the ceremony of a general alliance, concerted to attack her on every side; and although she suffered little from their hostility, yet being compelled to exert herself beyond her strength, she was shaken to the foundation. New exactions from the people already overburdened, and disorders abroad, increased the general discontent, which, being accompanied by the revolt of the Catalans, the revolution in Portugal, and a series of ill-fortune in the Netherlands, brought her to the very brink of ruin. The removal of Olivares led to the adoption of more moderate measures. Peace was concluded with the Dutch; and though the war was continued with France, she was greatly relieved by the civil discords which arose in that country during the minority of Louis XIV. The Catalans, who had been treated with greater severity, had thrown themselves into the arms of that power, by which a foreign enemy was admitted into the heart of the kingdom. This unnatural contest was prosecuted with various success until 1652, when Don John of Austria, a natural son of the king's, compelled the surrender of Barcelona, when the whole country, except Rosas, followed the fate of the capital.

The great efforts made for the recovery of Portugal and the constant supplies required in other quarters had completely exhausted the treasury, which occasioned considerable embarrassment in the affairs of government. Most of the revenues were anticipated, the people impoverished, and, what added to her misfortunes, the Spanish galleons were burnt by the English fleet under Admiral Blake. In such circumstances peace became absolutely necessary, and accordingly the treaty of the Pyrenees was concluded in the beginning of 1660, in which it was stipulated that the French king should receive the hand of Maria Theresa, the eldest daughter of Philip; but under the express condition that she should, for herself and issue, renounce all right to her paternal inheritance.

The remainder of Philip's reign was employed in an ineffectual attempt to recover Portugal, and at his death he left the kingdom in a most critical situation. His ministers were in absolute disgrace with the people; his successor, Charles II., a sickly infant in the fourth year of his age, and the queen-mother, whom he had appointed regent, inordinately fond of power, but without talents requisite to govern a great and turbulent nation. This princess was the sister of the reigning emperor, and consequently entirely devoted to the interests of the court of Vienna. The first act of her authority was to place at the head of her council her confessor, father Nitard, a jesuit of low birth, of very moderate talents, and totally unacquainted with public affairs. At a juncture when the greatest circumspection and fortitude was necessary to uphold a sinking kingdom, the incapacity of the minister, and the unsteadiness of his mistress, soon excited general discontent, and the nation looked to Don John of Austria as the only person capable of relieving them in their difficulties. This prince possessed great abilities both as a statesman and a soldier, and was besides respected by the nobles and beloved by the people. But the queen-regent, jealous of his superior talents, had prevailed upon her late husband to exclude him from any share in the administration, and now formed the design of sending him from the kingdom, by appointing him to the government of the Netherlands.

In this distracted state of affairs, the government was somewhat relieved by a peace with Portugal, the acquisition of which, from the aversion of the inhabitants to a Spanish yoke, had all along been an embarrassment rather than an advantage to the nation, whereby the independence of that kingdom was acknowledged. But Louis XIV. who had now begun his career of ambition and injustice, in defiance of the treaty of the Pyrenees, claimed the Netherlands in right of his queen, and without waiting to negotiate, made a sudden irruption into Franche Compte, and would soon have overrun the whole of that province, had not the triple alliance between Britain, Sweden, and the Dutch republic, one of the boldest political measures of that age, commanded the peace of Aix-la-Chapelle. By this treaty, however, Spain was compelled to cede some of her strongest fortresses between the Channel and the Scheldt, which so roused the popular indignation, that Don John found little difficulty in driving father Nitard from the national councils and from Spain. The queen-regent, however, resisted every attempt to admit the prince to a share of the government; and in order to remove him from court appointed him viceroy of Aragon.

The loss of father Nitard was soon supplied by another favourite Don Fernando de Valenzuela, equally inexperienced and unqualified for the situation of a minister, and whose vanity and presumption led to the expulsion of his mistress from the helm of the state. The king having attained his fifteenth year, the term of his minority, threw himself into the arms of Don John, who was received by the people as the preserver of his country. The perplexed state of affairs, however, made it no easy matter for the new minister to maintain his popularity. The country had entered into another contest with France in support of the Dutch, which was attended with disappointment and disasters, and the peace of Nimeguen in 1678 added only to their losses in the Netherlands. This was followed by the marriage of the king with a French princess, a measure highly objectionable to the nation, whose principles and feelings were at all times hostile to the name of France, and this circumstance was employed by the enemies of the minister to ruin him both with the king and the people. Their intrigues were too successful. Don John oppressed with chagrin and disappointment, fell sick and died of a broken heart, and with him the sun of Austria set for ever in Spain. The death of this prince, whose abilities, disinterestedness, and noble nature, rendered him the only hope of the monarchy, threw the government into great confusion. The king overcome by a hypochondriac malady, bordering on insanity, was totally incapable of business, and the new minister, the duke of Medina Cœli, though possessed of a good capacity and the best intentions, was unable to remedy so many evils. "The misery of the court was so great, that many of the king's menial servants left the palace for want of subsistence; and the king, with the advice of his council, was not able to find money for the annual journey to Aranjuez. The navy sunk to nothing, the funds destined for its support being diverted by those whose duty it was to supply them. The soldiers deserted on the frontiers for want of pay, and at last the governors quitted the fortresses, to come and represent at Madrid, in person, what they had often represented by letter to little or no purpose."

In this distracted and powerless condition, the king of France, whom no treaty could bind, commenced again his plan of spoliation. Spain having in vain endeavoured to engage the other powers in her defence, submitted to a truce for twenty years, with a farther loss of part of her territories. The queen-mother, who had been imprisoned in a convent in Toledo, and had returned to court upon the death of Don John, again assumed the ascendency in the councils of her son; and upon the death of the queen hastened the marriage of the king with an Austrian princess.

The violent encroachments, and shameless perfidy of the French monarch at last called for the league of Augsburgh, and plunged Europe into a general war, which raged for nearly ten years; and the peace of Ryswick found Spain distracted by internal intrigues respecting the succession of the crown. Charles, with a constitution naturally weak, was fast declining, and there was no hope of a lineal heir to the throne. In the event of his dying without issue, the principal competitors were the Dauphin of France, in right of his mother Maria Theresa, the daughter of Philip IV. though that princess upon her marriage had renounced all claim to the succession: The archduke Charles, second son of the Emperor Leopold, who was the son of Maria Anne, daughter of Philip III., and the Prince of Bavaria, whose mother was the only child of the infanta Margaret Theresa, daughter of Philip IV. France and Austria had both ministers at the court of Madrid, who were instructed to employ every method to induce Charles to make a will in favour of their respective families. But Louis, who at first had little hope of success, and was perfectly aware of the injustice of his pretensions, formed the design of securing a portion of the Spanish dominions to his own family, whatever might be their destination by Charles. For this purpose was negotiated the famous partition treaty between France, Great Britain and Holland, which, when known in Spain, excited universal indignation. By this treaty, Spain and the Indies, with the Netherlands, were assigned to the prince of Bavaria, Naples and Sicily, with some smaller dependencies, to the Dauphin, and Milan to the archduke. But the death of the prince of Bavaria rendered a new arrangement necessary, which substituted the archduke for the Bavarian prince, and Lorraine was added to the share of the Dauphin, Milan being given in exchange to the prince of that duchy. The emperor, who had remonstrated against both treaties, conceiving himself the sole and indubitable heir to the whole Spanish monarchy, was allowed three months to declare his acquiescence. While these schemes of spoliation, however, were in contemplation, the struggle between the contending parties at the court of Madrid continued to be prosecuted with great keenness. The Cardinal Portocarrero, whose personal influence with the king was of the greatest importance at this crisis, was gained over to the French interest. At his instigation, and by the advice of the pope, Charles, worn out by disease and chagrin, was induced to make a will in favour of Philip, duke of Anjou, the second son of the Dauphin of France, the signing of which he survived only one month.

Remarks.—At the commencement of this period, Spain possessed within herself all the sources of agricultural and commercial wealth. Separated by a natural barrier from the other continental powers, and at peace with the world, she had little interest on account of her situation, in augmenting her empire; and it required only a period of repose, and the fostering care of her rulers, by encouraging industry and consolidating an economical system, to render her formidable and respected among the nations of Europe. But the ambitious schemes of Charles I. and Philip II., whose names have been blazoned in the annals of the world, were most injurious to the peace and prosperity of their country. Instead of employing its population and its wealth in improving industry and in spreading cultivation to the deserted portions of its lands, its sons were sent to perish in making fruitless conquests, and its resources exhausted for the interest of their other dominions. And the only return which it received for this sacrifice of blood and treasure, was the ruin of its commerce and manufactures.

The impulse given to industry by the regulations of Ferdinand respecting the admission of foreign cloths, continued for a time to give life and vigour to the national manufactures, and while the Moors remained in the country, Spain could still boast of the excellence of her fabrics. But even then there was little exportation; and during the boasted reigns of the first monarchs of the house of Austria, the Spaniards were still tributaries to the industry of other nations. The whole trade of the Castiles consisted in the exportation of wool, iron, wine, oil, and other raw materials; and in the list of duties paid by the company of Burgos merchants, it does not appear that they exported a single manufactured article. In the middle of the sixteenth century, the quantity of wool sent to Bruges amounted annually to between thirty-six and forty thousand bales, which, after being manufactured, was sent back and distributed over Spain. Besides these cloths, Spain received from the Low Countries, linens, cambrics, cotton and muslin stuffs, Oudenarde and Brussels' carpets, &c. and an immense quantity of hardware. The importation at the same period, of silks, velvets, and brocades from Italy, and hardware, glass, and gold and silver articles from Lombardy and Germany, was very considerable; and also muskets and other military weapons. In 1534, on the eve of a war, it was necessary to import from Flanders gunpowder and even timber for artillery carriages; and to bring carpenters from Italy to make them. Exportation was then confined to articles of the first necessity, a little dressed leather and cloth in inconsiderable quantities. "All the demands of the Cortes," says Laborde, "from the commencement of the sixteenth century, tend to the prohibition of all those commodities which, they said, robbed the country of the treasures which they sent for to the new world." "Lombardy had another kind of traffic no less injurious, that of lending its money at exorbitant interest. Spain was thus tributary to the Lombards on the one hand, and to the Flemings on the other, though the mother country of both. It is evident how irksome this state of things became to the Spaniards by the repeated rebellions that took place under Charles I. and by the opposition made to granting him the subsidies he demanded for his foreign wars, while he could easily have obtained them by an amelioration of the country. The deputies of Castile spoke openly on the subject in 1527, and refused every grant; the petition of the Cortes of Valladolid in 1542 runs thus: "Your majesty's enterprises in Germany and in Italy have drawn into this country an enormous number of foreigners, who, not satisfied with the exchanges, commissions, and profits they make, and that your majesty allows them, have monopolized every kind of commerce by which your subjects gained their livelihood. They do not confine to themselves farming the estates annexed to bishoprics, lordships, official revenues, &c. and to making a profit of landed property; they even go so far as to buy up wholesale, wool, silk, iron, and other raw materials; thus cutting off all the means of existence from the greater part of your subjects, who see with grief what belongs to them go into the hands of those covetous people." The Spanish merchants, discouraged by the advantages which the foreigners possessed over them, and by the capitals of which those persons had the disposal, resigned all business to them. Damien de Olivares says, that in 1610 there were 160,000 foreigners in the Castiles, and among these 10,000 Genoese, who filled almost all the lucrative places, and transacted all the business of the country. The representations of the Cortes, however, and of many of the principal cities of the monarchy; and even the prohibition of the sovereign, were rendered of little effect from the low state of the finances, which made it necessary to augment the public revenue by custom-houses, and to permit importations.

In this wretched state of the kingdom, the principal aim of the government seemed to be, the devising of means to procure money; and while its demands were most exorbitant, the system of taxation was most oppressive and vexatious. The whole revenue of the state was inadequate to defray even the interest of the debt contracted by Charles in his ruinous wars; the rebellion in the Low Countries cost his son Philip above twenty millions Sterling; and this monarch, who had given assignments upon the revenue for sums borrowed from foreign bankers and his own subjects, was under the necessity of superseding these assignments, and thus in a manner becoming bankrupt. The constant influx of specie from the American colonies kept up for a time the apparent prosperity of the kingdom, but this was also absorbed in fruitless and expensive expeditions; and the galleons were as anxiously looked for as if the safety of the monarchy depended on their arrival. This disastrous state grew much worse under the last sovereigns of the house of Austria. In the reign of Charles II. the settled revenue of the kingdom was anticipated for several years; and what was still worse, the officers of the crown did not bring into the treasury above one-tenth of what they levied from the people. Following the steps of their predecessors without possessing their abilities, they completed the ruin of the kingdom; and such was the state of apathy into which the country had sunk, that the potentates of Europe had signed a treaty of partition, and impatiently waited for its spoliation.

While manufactures and commerce were thus suffering from the baleful policy of the government, agriculture was equally neglected. One great obstacle to its improvement was the want of labourers to till the soil. The plague, which made such dreadful ravages in Spain during the fifteenth and sixteenth centuries, left extensive districts without an inhabitant; and we learn from the account of Miguel Martines de Leyva, "that, for a century after, the lands were seen lying waste, and the villages empty; nor have the disasters then sustained been repaired since that period." That little attention was then paid to cultivation appears from a rescript of Philip II. in 1594, which begins thus: "We have been informed that the husbandmen are in want of seed to sow their lands, and of cattle to plough them; that the earth being badly cultivated does not return what it ought, and that persons possessing farms reap no advantage from them." But though this prince granted the title of nobility, and exemption from military service to such as would devote themselves to the study of agriculture, yet this law was never put in execution, for the agriculturists obtained no honourable distinctions, and upon them also principally fell the weight of military service.

With respect to its political state, Spain lost her own liberties while attempting to enslave other nations. At the commencement of the sixteenth century, her institutions were more favourable to freedom than those of any other of the great European kingdoms. The royal prerogative was greatly circumscribed by the privileges of the nobility and by the pretensions of the commons. The military power was lodged in the hands of the nobles, who appeared in the field at the head of their vassals, and without whose assistance the authority of the monarch was feeble and precarious. The inhabitants of the cities also possessed valuable immunities, and were admitted to a considerable share in the legislature. They had acquired the arts of industry, and had accumulated wealth by engaging in commerce. Free and independent themselves, they were ever ready to act as the guardians of public freedom and independence. "Their representatives in the Cortes were accustomed with equal spirit to check the encroachments of the king, and the oppression of the nobles. They endeavoured to extend the privileges of their own order; they laboured to shake off the remaining incumbrances with which the spirit of feudal policy, favourable only to the nobles, had burdened them; and conscious of being one of the most considerable orders in the state, were ambitious of becoming the most powerful." These orders, with the clergy, constituted the Cortes, and in this assembly alone resided the power of making laws, granting subsidies, &c. When Charles, therefore, came to the throne in the lifetime of his mother Joanna, and assumed the title of king, he found great difficulty in prevailing upon this body to acknowledge him in this capacity. The Aragonese looked upon him only as the son of their queen, and opposed the assembling of the Cortes in his name. They at last, however, acknowledged him under the title of king in conjunction with his mother, but bound him by a solemn oath, which they exacted from all their kings, never to violate any of their rights or liberties. The Cortes of Castile proposed that, before acknowledging him as their sovereign, he should promise to observe the laws made at Burgos seven years before; viz. that no foreigner should be capable of any dignity or employment in church or state in Castile, and that no money should be sent out of the kingdom. But this was overruled, and a free gift of 600,000 ducats granted him, after which he promised to observe the laws, and more especially those on which they most insisted. The promises of Charles, however, were given without any intention of fulfilling them; and during the greater part of his reign there was a constant struggle between him and the Cortes; the one demanding subsidies, and the other a redress of grievances; and often separating without agreeing to either. Had the different orders of the Cortes been true to each other, they must have at last prevailed; and might have prevented those unhappy foreign wars which brought the kingdom to such poverty and weakness. For while the cities were forward in stating their grievances, and demanding redress with that boldness which is natural to a free people, the nobles, instigated by a mean jealousy of that spirit of independence which they saw rising among the commons, stood by in silence, and discovered neither the public spirit nor resolution which became their station. When Charles summoned the Cortes of Castile to meet at Compostella instead of Valladolid, the commons remonstrated against the legality of the assembly in that place, and resisted all the arts of the courtiers to influence their vote. But the nobility, who were now desirous of court favour, in opposition to the voice of the nation, granted every demand, without obtaining the redress of any one of the many grievances of which the people complained. The consequences of this was a civil war, which not long after threw the kingdom into such violent convulsions as shook the throne, and almost overturned the constitution. On this occasion the confederated cities put forth a remonstrance, containing a long list of grievances, and some regulations which they thought necessary for their own safety and that of the constitution. Among other things, they demanded that the king shall reside within the kingdom, or appoint a native regent; that no foreign troops shall on any pretence whatever be introduced into the kingdom; that none but natives shall hold any office or benefice in church or state; that no member of the Cortes shall receive an office or pension from the king, either for himself or for any of his family; that each city or community shall pay a competent salary to its representative during his attendance on the Cortes; that the Cortes shall assemble once in the year at least, whether summoned by the king or not; that neither gold, silver, nor jewels, shall be sent out of the kingdom; that the lands of the nobility shall be taxed equally with those of the commons; that all the privileges of the nobles, prejudicial to the commons, shall be revoked; and that no man shall be compelled to purchase papal indulgences.

In this contest the government, assisted by the nobles, was victorious; and this "bold attempt of the Commons," says Dr. Robertson, "like all unsuccessful insurrections, contributed to confirm and extend the power of the crown, which it was intended to moderate and abridge. The Cortes still continued to make a part of the Castilian constitution, and was summoned to meet whenever the king stood in need of money; but, instead of adhering to their ancient and cautious form of examining and redressing public grievances before they proceeded to grant any supplies, the more courtly custom of voting a donative in the first place was introduced, and the sovereign, having obtained all that he wanted, never allowed them to enter into any inquiry, or to attempt any reformation injurious to his authority. The privileges which the cities had enjoyed were gradually circumscribed or abolished; their commerce began from this period to decline, and becoming less wealthy and less populous, they lost that power and influence which they had acquired in the Cortes." The Cortes, however, were not always so submissive to the will of the monarch. On several occasions they peremptorily refused any supplies, and resisted all the solicitations and threatenings of the king. In 1539, when the exigencies of Charles were at the utmost, he proposed to establish a general excise upon commodities; but the nobles, who had now begun to see, with regret, the miseries which their acquiescence to the will of the monarch had entailed upon the country, that it was drained not only of its wealth, but of its inhabitants, in order to prosecute quarrels in which it was not interested, and to fight battles from which it could reap no benefit; and also to feel that the most valuable and distinguished privileges of their order—an exemption from all taxes—was about to be wrested from them, opposed the measure so steadily, by the persuasion of the constable of Castile, that the scheme miscarried, when Charles dismissed the assembly with indignation. This disappointment of Charles was accompanied by another still more mortifying to a prince of his temper. As he was returning from a tournament on the plain of Toledo, one of the harbingers, in clearing the way for the king, struck the Duke of Infantado's horse with his baton, when that proud noble drew his sword and cut him over the head. Such an outrage in the presence of the sovereign called for immediate punishment, and the provost of the household was ordered to arrest the duke; but the constable of Castile interposed, asserting that it belonged to his office to take cognizance of such offences, and conducted Infantado to his own house. The other nobles applauded the boldness of the constable, and retired with him and the duke, leaving the king unattended except by the Cardinal Tavera, with whom he was conversing at the time. Charles, however mortified, saw the danger of irritating a jealous and high-spirited body of men, and had the prudence to conceal his displeasure. He even sent next morning to Infantado, offering to punish the person who had affronted him; but the duke pardoned the officer, and gave him five hundred ducats as a compensation for his wound. Charles, however, by degrees broke the power of this formidable body, and left them nothing but the vain distinction of being covered in the presence of their sovereign. From that "period neither the nobles nor the prelates have been called to the Cortes, on pretence that such as pay no part of the public taxes should not claim any vote in laying them on. None have been admitted but the procurators or representatives of eighteen cities. These, to the number of thirty-six, being two from each community, formed an assembly which bore no resemblance to the ancient Cortes, and became rather a junto of the servants of the crown, than an assembly of the representatives of the people. Philip II. persevered in the same system. Taking advantage of an insurrection in Aragon, he curtailed many of their privileges, and abolished the office of Justiza, which extinguished the liberties of that kingdom; and so successful was he in extending the royal prerogative, that, during the reigns of his successors of the house of Austria, the will of the sovereign became the supreme law in all the kingdoms of the monarchy.

Chap. V. *Spain while subject to the Bourbons.*

Upon the death of Charles II., the junta of regency immediately assumed the functions of government; and communicated to the king of France the testament of their late sovereign. Louis, aware of the glaring violation of his most solemn engagements with respect to the treaty of partition, pretended to hesitate about accepting the will in favour of his grandson; but his scruples were easily overcome, and Philip was conducted to the frontiers to take possession of the Spanish crown. The reception of the young monarch was most cordial and joyful. He made his public entry into Madrid with all possible magnificence, surrounded by exulting and admiring crowds, who contrasted his youthful and prepossessing countenance with the decrepitude and gloomy melancholy of their former sovereign. His title was acknowledged not only by the distant provinces of the monarchy, but by the maritime powers who had been parties to the treaty of partition. But while Philip seemed in quiet possession of the throne, the Emperor of Germany issued a bold and vehement remonstrance against this act of usurpation on the part of France; and "questioned not only the authenticity of Charles' will, but the right of that sovereign to make such a disposition, which was contrary to the acknowledged claims of his family, and the solemn obligation of treaties." This was immediately followed by vigorous preparations for war; and before the conclusion of the year, the emperor was joined by England and Holland, and sometime after by Portugal, who formed what was called the grand alliance, the object of which was, to secure satisfaction for the claims of Austria upon the Spanish monarchy, and to prevent the union of the crowns of France and Spain under one government. Louis had foreseen the issue, and was prepared for it; but the deplorable state of Spain—her revenue exhausted, her fortifications in ruins, without garrisons, or magazines, and her naval and military establishments almost annihilated,—precluded any hope of efficient support from that quarter; and convinced him that the preservation of the crown of Spain for his grandson, must depend chiefly upon his own exertions. He had commenced the war in Italy with considerable success, but was checked on the side of Flanders by the talents of Marlborough. The war was at first confined to the distant provinces; but the internal tranquillity of the Peninsula, began soon to be disturbed by the impolicy and imprudence of the Spanish rulers.

Portocarrero, thinking no reward too high for his services to the house of Bourbon, had absorbed all the influence of the crown, and directed every measure of the state. A thorough reform was indeed requisite in every department, particularly in the finances; but the attempts of the minister, which were confined chiefly to the suppression of various offices and places under government, and the withdrawing of pensions, which the piety of former sovereigns had granted for the subsistence of poor widows, and the maintenance of charitable institutions, produced a very trifling saving, while it involved numerous families in embarrassment and ruin. The Spaniards had formed very extravagant notions of the wisdom and energy of the new government, and flattered themselves that their country would resume all its pristine splendour, without sweeping away those abuses and encumbrances which had been accumulating for ages. This impolitic parsimony therefore tended only to excite discontent among the people; and the attachment of Philip to French customs and manners, and the admission of the peers of France to the same rank and honours as were enjoyed by the grandees of Castile, disgusted and alienated the high-spirited nobles. The spirit of disaffection to the new dynasty was aggravated by the destruction of a French squadron and the Spanish galleons, in the harbour of Vigo, by the Duke of Ormond; and by the defection of some of the principal grandees, among whom was the Duke of Medina de Rio Seco, admiral of Castile, "whose vast possessions, splendid talents, and high descent, rendered him one of the most powerful and distinguished members of the nobility." At the same time the Spanish cabinet was torn by personal feuds and petty cabals. The princess Orsini, camarera mayor to the queen, was a woman of superior talents and attractions, and had gained such an ascendency over both their majesties, that no affair of importance was transacted without her knowledge and advice. Though devoted to the court of Versailles, both from self-interest and gratitude, yet she soon perceived the evil effects of that despotic control which the French monarch was labouring to acquire in the councils of his grandson. She therefore resolved to employ all her influence in organizing an administration entirely Spanish, "to level all the distinctions of Austrian and Bourbon partisans, and to admit into all places of trust persons of known talents and capacity." Such a plan was well calculated to promote the welfare and the independence of Spain. But the French ambassador, who wished to arrogate to himself the whole direction of affairs, represented to his master that the interference of the princess was most hurtful to the French influence, and that the king was completely under her control. This gave occasion to endless wrangling and recrimination. Nor was this confined to one or two. "The whole court seemed to be involved in one common dispute, each individual striving who should most thwart, or calumniate the others." The public interest was thus sacrificed to personal antipathy and private ambition; and, while in this distracted state, the nation was totally unprovided with the means of defence against a powerful enemy.

The allies, by the persuasion of the admiral of Castile, had resolved to carry the war into Spain, and to set up a competitor to Philip in the very heart of his kingdom. The Archduke Charles was consequently proclaimed king of Spain and the Indies at Vienna, and soon after arrived at Lisbon accompanied by 14,000 British and Dutch troops. This threatened invasion excited a spirit of alacrity and decision in the Spanish government which had been long absent from its councils. An army was hastily embodied and organized, and 12,000 French troops entered Spain under the Duke of Berwick. The allies wasted their time in disputes and inaction, and the events of the first campaign were favourable to the Spanish arms. But this was counterbalanced by the loss of Gibraltar, which was captured by the British, and by the battle of Blenheim, which was hailed by the Austrian party as a prelude to the downfal of the Bourbons.

The feuds in the cabinent continued with greater violence than ever; and at the moment when prompt and vigorous exertions were necessary to resist the increasing force of the allies, a total suspension of business ensued; and the most trifling as well as the most important measures were equally thwarted. This was occasioned chiefly by the recall of the Princess Orsini by the king of France, which so afflicted and irritated the queen, that she secretly obstructed every measure of the French ambassador, and encouraged the cabinet to oppose the exercise of foreign influence, and to demand restoration of the ancient forms. The unpromising state of affairs, however, forced her to yield to the demands of Louis, and a new council was appointed under the auspices of France. But she still resisted all reconciliation, and ceased not to exert all her power for the return of her favourite, which she at length accomplished to the great joy of herself and her husband; and the princess was allowed to new model at pleasure the government and administration of Spain.

The affairs of the allies in the peninsula began to assume a more imposing attitude. Charles had landed in Catalonia with a small body of troops under the

Earl of Peterborough; the citadel of Montjuich was taken by assault in a most gallant style by their general; and was soon after followed by the surrender of Barcelona and the submission of the whole province except Rosas. Valencia and Murcia followed the example of Catalonia; and in these provinces nothing remained to Philip but the fortresses of Alicant and Peniscola. The recovery of Barcelona was now the great object of Philip's exertions. There his rival had established his court, and the fate of Spain seemed to depend upon the issue of this enterprise. Philip advanced into Catalonia with 20,000 troops commanded by Marshal Tessé, and was joined under the walls of Barcelona by the Duke of Noailles with a considerable reinforcement from France. A French fleet also blockaded the port, and prevented all communication by sea. The allies, dazzled with their first success, had neglected the requisite preparations for a siege. They had dispersed their troops in the different fortresses of the province; and 3000 regulars constituted the principal strength of Barcelona. The inhabitants, however, were animated by the presence of Charles, and all ranks vied in devotion to his cause. The Earl of Peterborough also, with a flying camp, kept the besieging army in constant alarm. An extensive city so weakly garrisoned could not have long resisted the efforts of so powerful a force. After a month's operations, during which the citadel had been abandoned, practical breaches were formed in the rampart, and the last decisive assault was about to be made, when the allied fleet appeared in sight. The French squadron immediately withdrew; and Philip was compelled to raise the siege, with the loss of his magazines and artillery, and retreat into Roussillon. There he left the remains of his army, and returning to Madrid, where, notwithstanding his disasters, he was received with sincere affection, he removed the court to Burgos. Saragossa opened its gates to Charles, and the whole kingdom of Aragon submitted without a struggle.

While these disastrous events were occurring in the north, the Duke of Berwick, who commanded on the frontiers of Portugal, was obliged to retire before a superior force, under the Earl of Galway, into the heart of the kingdom, and leave the way open to the capital. The allied army, consisting of 30,000 troops, entered Madrid; but instead of taking advantage of the general consternation, and pushing their conquests into old Castile, which would probably have secured the reduction of the whole peninsula, they wasted their time in waiting for the archduke, who had been loitering in Barcelona and Saragossa, and preparing for a magnificent entry into the capital. The Duke of Berwick, however, was not slow in profiting by these delays. His army, reduced to 9000 men, was stationed behind the Henares, and had been joined by the troops which had retreated from Barcelona, and increased by numerous new levies. With this increase of force, he pushed a detachment to recover Madrid, and having shut up the communication with Portugal, forced the allies to retreat towards Valencia, and by a vigorous and active pursuit, rendered their loss scarcely less decisive than an absolute defeat. The distresses and fortitude of Philip having endeared him to his subjects, he was received at Madrid with an universal burst of joy, far more impressive than the acclamations which had hailed his first accession. During this campaign, while Philip was upon the eve of being driven from his throne, the Netherlands was severed from the monarchy by the battle of Ramilies, and Naples was soon after conquered by the emperor.

Both parties prepared, with increased exertions, to renew the struggle in the peninsula. The Duke of Orleans was despatched from France, with a considerable force, to take the command of the Spanish army; and the allied army in Portugal was reinforced by 12,000 men. But before the arrival of these succours, the fate of the campaign was decided by the battle of Almanza. The Earl of Galway, anxious to anticipate the expected supplies, attacked the Duke of Berwick in his quarters with 30,000 men; but that general, having hastily united his forces, took post in the plain of Almanza; and after a long and well-contested action, the allies were routed with great slaughter, insomuch, that on their arrival at Tortosa, their forces scarcely amounted to 5000, of whom only 800 were infantry. The Duke of Orleans joined the army on the following day, and made such a rapid improvement of the victory, that in less than a month he recovered all Aragon and Valencia, and closed the campaign with the capture of Lerida in Catalonia. The joy for these successes at the court of Philip was heightened by the birth of a prince, who was named Louis Ferdinand, *Prince of Asturias.*

The kingdoms of Aragon and Valencia, which had always been forward in embracing the cause of Charles, were made to atone, in some measure, for their rebellion. In Aragon, the city of Saragossa alone was obliged to pay 45,000 pistoles, and the rest of the kingdom 90,000. The ancient rights and privileges of both kingdoms were abolished, and they were in future to be ruled by the same laws and customs as Castile.

The allies, notwithstanding their severe reverses, were no way backward in prosecuting the contest. The army in Catalonia was strengthened by the arrival of Count Staremberg with a body of imperial troops, and by additional reinforcements from England. But even these would not admit of any offensive operations. They were barely sufficient to fill the vacancies occasioned by the late disasters; and, after detaching a corps to the northern frontier, the Count found them too weak to cope with the victorious army of Philip. On the other hand, however, the plans of conquest formed by the Duke of Orleans were thwarted by the exhausted state of the Spanish treasury. France was able to afford but a scanty supply; and the arrival of the American fleet was anxiously looked for to make up the deficiency. But while in this emergency, intelligence arrived that seventeen galleons had been intercepted by the British squadron off Carthagena, when three of the richest were taken or destroyed, and the rest dispersed. The only fruit of the campaign, therefore, was the capture of Tortosa. The duke then returned to Madrid; but owing to some suspicions of his having a design upon the crown of Spain, he was recalled to Paris.

The repeated reverses of the French monarch constrained him to think seriously of putting an end to the war. The battle of Oudenarde, and the consequent capture of Lisle, had opened a road to the very gates of his capital; and the alarms and discontents of his subjects were heightened by the pressure of famine and pestilence. In these circumstances, peace seemed to be the only alternative; but the demands of the allies were so degrading and dictatorial, that he rejected them with indignation. They insisted, as the basis of a treaty, that the whole Spanish monarchy should be restored to the house of Austria, and that Louis should assist in compelling his grandson to abandon his crown. He, therefore, appealed to the loyalty and honour of his people to preserve him from such an unnatural and degrading condition. Hostilities were continued, but he intimated to Philip his inability, from the distressed state of his own kingdom, to furnish the requisite assistance for maintaining him upon the throne.

In this trying situation, Philip, at the instigation of the Princess Orsini, convened the chief ministers and grandees; and having stated to them the exorbitant pretensions of the allies, the withdrawing of the French troops, and his firm resolution to die in defence of his crown, he appealed to their zeal and affection, and demanded from them assistance and counsel. A burst of enthusiasm broke from the assembly, and they protested, "that duty and affection, no less than allegiance, bound them to maintain the sovereign on his throne." They, however, recommended the immediate dismission of all the French, and the establishment of an administration entirely Spanish, at the head of which was placed the Duke of Medina Celi, who had always been strenuous in his opposition to foreign influence. The enthusiasm of the nobles spread through the nation. Levies of men, and contributions of money and plate, were poured in from all quarters; the clergy also lavished their treasures in the cause, and the people every where flocked to the royal standard. Spain, however, when left to herself, notwithstanding the reviving loyalty of her inhabitants, was too much exhausted to furnish adequate resources for the impending struggle. Philip was still directed by the court of Versailles; for although he avowed his determination of throwing himself into the arms of his Spanish subjects, he never gave his confidence to his Spanish ministers, who soon began to discover that the pretended separation from France was merely an affected expedient to stimulate the zeal of the nation. The preparations for the ensuing campaign were not therefore made with that vigour which the emergency required. The system of finance, which had been planned and rendered efficient under the vigorous control of the French ambassador, became unproductive and even injurious under the unskilful and negligent management of the new ministers; and it soon appeared, that the affairs of the government could not be conducted by them with that energy which was necessary. Some suspicions also falling upon the Duke of Medina Celi, he was suddenly arrested and committed to the castle of Segovia; but his offence was never publicly investigated, and his death, which happened soon after, left this transaction involved in mystery. His successor Ronquillo, upon coming into office, engaged to supply the deficiency of the treasury and the wants of the army.

The following campaign commenced by the advance of Philip with 23,000 men, under the Marquis of Villadarias, to the siege of Belaguer in Catalonia; but all his operations were thwarted by the skill of Count Staremberg; and being straitened for provisions, he was obliged to retire upon Lerida. The allied army having been strengthened by reinforcements from Italy, and joined by the Archduke, followed him across the Segra, and attempting to cut him off from his supplies, came to an engagement near Almenara, when the Spanish army was thrown into confusion, and would have been totally destroyed had not night favoured their escape. Although their loss in battle did not exceed 1500 men, yet a panic spread through the army, and it was with difficulty that they reached Saragossa. Here Philip transferred the command of his army to the Marquis of Bay, who had distinguished himself on the western frontier. But the allies had pressed close upon his rear, and before three days had elapsed, the battle of Saragossa drove Philip from his capital, and gave a temporary triumph to the arms of his rival. The Spanish commander, with a remnant of 8000 men, retreated to Soria, and the king hastened to Madrid. Though he returned a fugitive, without an army or resources, he still possessed the affections of his Castilian subjects; and when he removed the residence of the court to Valladolid, his departure was the signal of a general emigration. "He was accompanied by the greater part of the nobles; above 30,000 persons covered the road to Valladolid; even ladies of the first distinction followed on foot; and scarcely any remained in the capital except those whose age, infirmities, or poverty, did not permit them to remove." When Charles, therefore, entered Madrid, no cheers greeted his arrival, but solitude and silence reigned in the deserted streets, and he was compelled to exclaim, "Madrid is a desert."

The firmness and prudence of Philip seemed to rise with his misfortunes; the Castilian spirit was roused to maintain the national glory and independence; and his subjects vied with each other in lavishing their property and their lives to repair the losses of their sovereign. The arrival of the Duke of Vendome to take the command of the army infused additional energy into their councils. He collected the scattered remains of the Spanish forces, and by the middle of November had a well appointed army of 25,000 men. The troops of Charles had remained in the vicinity of the capital, exhausted by disease and intemperance, and exposed to the incessant attacks of the armed peasantry; and their departure was hastened by the intelligence that a French force, under Noailles, had entered Catalonia, and attacked Gerona. The Archduke hastened to Barcelona with an escort of 2000 horse; and his army immediately after began their retreat towards Aragon. Vendome followed, and by a rapid movement overtook their rear guard, consisting of 6,000 men, commanded by the British general Stanhope, who had taken up his cantonments in the small village of Brihuega. Stanhope, though surprised, prepared for a vigorous defence. He threw up entrenchments in the streets, which he defended with great bravery, and disputed every inch of ground in expectation of being relieved, but he was at last overpowered by numbers, and compelled to surrender prisoners of war. Staremberg being apprised of the attack, hastened, but too late to his rescue; and encountered the Spanish army at Villaviciosa. After a bloody and doubtful conflict, the two armies were separated by the darkness, and Staremberg kept possession of the field of battle; but he had suffered so much during the action, that he spiked both his own cannon and those of the Spaniards, and retreated during the night to Barcelona. Soon after this, Gerona having submitted to Noailles, the Spaniards gradually established themselves in the centre of Catalonia, and menaced Barcelona and Tarragona.

The distresses of France were now come to a crisis: and Louis, with all the energy of an absolute government, was scarcely able to prolong a defensive war. The only resource, therefore, from impending ruin, was peace almost upon any terms. The preceding campaign had been most favourable to the arms of the allies; and had they prosecuted the war during another year with similar success, they would have been able to dictate a peace at the gates of Paris. But the house of Bourbon was saved by the shameful defection of Britain from the principles of the grand alliance. A change of ministry in that country had led to a change of measures most favourable to France and Spain. The overtures of Louis were favourably received, although the resignation of the throne of Spain by his grandson, the great cause of the war, formed no part of them; and the British cabinet, selfishly grasping at the offer of commercial advantages, meanly submitted to commence negotiations without the consent of the other maritime powers, and continued these clandestine transactions, while they were amusing the Dutch with professions of cordiality and confidence. Louis, however, had some difficulty to bring Philip to accede to the proposed terms. The cession of the Netherlands was at first vehemently opposed by Count Bergueck, the minister of Philip; but Louis having gained over the Princess Orsini, his objections were silenced or overruled, and Philip granted full powers to his grandfather to negotiate in his name. The consent of the Dutch to the preliminary arrangements was extorted by the dread that Britain would conclude a separate peace; and Charles, who had been raised to the imperial throne, finding all remonstrances fruitless, did not refuse to take a share in the discussions. The deaths of the Dauphin and his son the Duke of Brittany, which left only the duke of Anjou, a sickly infant, between Philip and the throne of France, threw a new difficulty into the negotiations. Louis, though he tacitly acknowledged, yet was always solicitous to evade one of the preliminary articles respecting the separation of the two crowns. When their union, however, became so probable, the British cabinet demanded the immediate renunciation of Philip for himself and his heirs, of all claim to the crown of France, and a similar renunciation of the Duke of Orleans to the crown of Spain. The king of France at first resisted their demand, and declared that "No power on earth can alter the constitutional law of the kingdom, the prince next the crown necessarily succeeds." But when the allies, by their military preparations, gave undoubted indications of their determination to resume hostilities, Louis, afraid again to trust the fate of his crown to the fortune of war, was compelled to acquiesce, and Philip soon after signed his renunciation in a full council of state, which was ratified and confirmed by the Cortes. The great obstacle to peace being now removed, the negotiations proceeded, and at last led to a general peace, which was concluded at Utrecht, with all the contending parties except the Emperor and Philip. The principal articles with regard to Spain were, that Spain and the Indies should continue subject to the present sovereign: that Gibraltar and Minorca should be ceded to Britain; the Netherlands, Naples, and Milan, with the island of Sardinia to the house of Austria; and Sicily to the duke of Savoy, with the title of King. As the emperor refused to renounce his pretensions to Spain, the decision of the grand question relative to that monarchy between him and Philip, was left to future wars and negotiations.

The war still continued in Catalonia, but as the campaign on the side of Philip was merely defensive, the only event of importance was an unsuccessful attempt of Staremberg against Gerona. The emperor, however, in order to concentrate his whole force on the borders of the empire, entered into a treaty for the evacuation of that principality, in which he laboured to preserve for the Catalans their darling constitution. But Philip would admit of only one form of government in his dominions, and was resolved to abrogate their privileges. All, therefore, that could be attained for these faithful supporters of his cause, was a general amnesty and oblivion of past offences, and a tender of the constitution of Castile in lieu of their own. England also, who had twice pledged herself in the face of Europe to maintain their privileges as the price of their services, meanly shrunk from the fulfilment of their engagements: and the Catalans were left to their fate. Ardently attached to their native customs and laws, and holding in detestation those of Castile, the inhabitants of Barcelona resisted every offer of accommodation, short of the actual acknowledgment of their ancient privileges. Though abandoned by all, they prepared for a vigorous defence, determined to relinquish their liberty only with their lives. Villaroel, who had received the rank of general in the Austrian service, was entrusted with the military command. He had only 16,000 troops besides armed citizens, to oppose the whole army of Philip, supported by 20,000 French, under the renowned Duke of Berwick. But every expedient that skill or valour could suggest, was employed to ensure success in the approaching conflict. All who were unfit for service, the timid, the sickly, and the aged, were removed to the island of Majorca, which also held out against the authority of Philip, the fortifications were repaired and strengthened, the streets barricadoed, and every house converted into a citadel, by piercing the walls for the use of musketry; and, in order to excite the popular enthusiasm, and to strengthen their patriotism with the sanctions of religion, they deposited on the high altar of the cathedral the written promise of the queen of England to maintain their constitution, making a solemn appeal to heaven against the desertion of those, of whose selfish ambition and crooked policy they were about to become the victims.

The Spanish trenches were opened on the 12th of July; on the 30th a lodgement was made in the covert way; and by the 12th of August, breaches were effected in two of the bastions. After a struggle of three days, the assailants obtained a footing upon the rampart; and, while arrangements were making for a general assault, the Duke of Berwick, anxious to prevent a farther effusion of blood in this unnatural contest, and to save the city from the horrors of a storm, repeated the offers of a general amnesty. His compassionate efforts were treated with contumely, and served only to add fuel to their enthusiasm. The signal for the assault was given on the morning of the 11th of September, "Fifty battalions of grenadiers," says Coxe, "commenced the dreadful work, and were supported by forty others. The French attacked the eastern bastion, the Spaniards that of St. Clara and the new gate. The resistance was obstinate even to ferocity. Cannon loaded with grape made the most dreadful carnage in the breaches. Without being able to advance a single step, the assailants perished by hundreds. Fresh troops incessantly arriving, at length overpowered the weaker number of the besieged. The French and Spanish columns mounted the breaches at the same instant, and the French pushed forward into the town. But here the conflict really commenced. Every street was intersected with barricades; every inch of ground was purchased with the sacrifice of lives. Unprovided with means to force the barricades, or fill up the ditches, the assailants were swept away by an incessant fire from every house. At length all obstructions were overcome by torrents of blood. In the heat of the combat, the victors spared not; the Catalans, lavish of life, demanded no quarter. When they were driven into the great square, the assailants deemed the conflict at an end, and dispersed for pillage. But the insurgents, profiting by the moment, returned to the charge; the assailants were driven back to the breach, and would have been again precipitated into the ditch, had they not been rallied by the bravery and exertions of their officers. Again the combat raged with aggravated fury, for the Spanish column, which had penetrated by the other breach, was driven back as the French retreated. Numbers and bravery at length vanquished all resistance. The Spaniards turned their own cannon against them, and additional artillery was brought up to the breach. Yet, though thrown into disorder, they did not cease to combat. The assailants, galled with a continual and terrible fire, by a desperate effort forced the bastion of St. Peter, where the besieged made their principal stand, and turned its artillery against them. In this crisis, the chiefs led them to a new charge, but were repulsed, and Villaroel desperately wounded. Though discouraged by the misfortune of the commander, the besieged still maintained the struggle for twelve hours, in every quarter of the town; and there was scarcely an inhabitant of any age, sex, or condition, who did not share in the defence. The history of this century does not furnish an example of a siege so long and bloody. The women at length retired into the convents; the populace, vanquished and straitened on every side, and unable to defend themselves, did not demand quarter; and the French massacred all without distinction. At this moment, some individuals raised a white standard; and Berwick seized the opportunity to suspend the carnage, ordering the troops to maintain their posts, till he had heard the proposals of surrender. But a sudden cry of "kill and burn" bursting from the ranks, revived the fury of the troops; the streets were again deluged with blood, and the authority of Berwick himself scarcely sufficed to arrest the disorder. Night arrived, and with it new horrors; for in the short interval of suspense, the inhabitants resumed their arms, and again poured a destructive fire from the houses. Deputies at length advanced to the breach to parley with Marshal Berwick, but required a general pardon, and the restoration of their privileges. The marshal contemptuously rejected the demand, and threatened to give no quarter, if they did not surrender before morning. His answer inflamed the spirit of the insurgents; and the combat raged with redoubled fury, a storm of fire pouring upon the assailants from the houses, which, by order of the marshal, had been respited from destruction. This night was one of the most horrible that imagination can form. The marshal ordered the dead and wounded to be removed, kept the troops under arms, and prepared to reduce the town to ashes. Day broke, and notwithstanding the obstinacy of the insurgents, he granted a delay of six hours. This concession producing no effect, the houses were set on fire. Apprised of their danger by the burst of the flames, the insurgents once more hoisted a flag of truce. The fire was extinguished, the deputies of the magistracy yielded the town without condition, and the offers of Berwick procured the immediate surrender of Montjuich and Cardona.

The lives and property of the inhabitants were spared; but twenty of the chiefs, among whom were Villaroel, Armengol, the Marquis of Peral, and Nebot, were consigned to perpetual imprisonment in the castle of Alicante; and the bishop of Albaracin, with two hundred ecclesiastics, banished to Italy. Of the rest, the inferior officers were dismissed on taking the oath of allegiance. The standards of the town were publicly burnt, the privileges of the province annulled, and a new government established, according to the constitution of Castile.

Thus ended a conflict which recalls to recollection the fate of the ancient Numantia and Saguntum, and in recent times finds a parallel in the immortal defence of Saragossa. The royalists purchased their victory with the loss of no less than 6,000 men in the siege, and 4,000 in the assault; and the besieged were equally sufferers.

The fate of Barcelona ensured the submission of Majorca; and Philip now reigned undisputed monarch of Spain. The death of the queen, and the marriage of Philip to Elizabeth Farnese, a princess of Parma, was followed by the disgrace of the Princess Orsini, and her French adherents; and the death of Louis XIV. to whose will Spain had hitherto been subservient, led to the removal of a foreign domination, which gave universal satisfaction to the Spanish people, and produced a temporary tranquillity in the court and kingdom which had long been unknown.

Philip, being now relieved from the control of his grandfather, directed his efforts to the improvement and welfare of his adopted country. The distant branches of the monarchy, which had always been supported at the expense of Spain, and in defence of which she had often lavished her treasure and her population, being lopt off, his attention was confined to the peninsula; and it required only a few years of peace to recruit his resources, and consolidate his power. A hypochondriac malady, however, had weakened his faculties, and had induced such indolent habits, as prevented him from prosecuting his purpose with any degree of consistency or firmness. He was consequently led by those who at any time were fortunate enough to gain his confidence. The new queen had succeeded to all the power possessed by her predecessor and the Princess Orsini, and by her talents and intrigues, governed her doting husband with such authority, that, without seeming to rule, she was, during the whole of his reign, the actual sovereign of Spain. Her chief guide and confidant in the science of politics was Alberoni, one of her own countrymen, and to whom she principally owed her own elevation. This person, by his talents and address, had raised himself from being the son of a poor gardener at Placentia, to the friendship and confidence of Vendome, and after the death of that general, became minister from Parma at the court of Madrid. By his discriminating and intriguing spirit, he soon obtained an ascendency over the sovereigns of Spain; and though he held no other public character than that of agent from Parma, he in fact held the reins of the Spanish government.

As the emperor still persisted in retaining the title and assuming the honours attached to the crown of Spain, Philip was anxious for an opportunity of humbling his rival, and wresting from him his Italian territories, which had been separated from Spain by the treaty of Utrecht. In the prosecution of this scheme, Alberoni endeavoured to obtain the co-operation of Britain. and for this purpose restored to that power all the commercial advantages which it had enjoyed under the former sovereigns of Spain. But professions of amity were all that he could obtain in return; and Britain soon after formed with the emperor and France the triple alliance, which had for its object the preservation of public tranquillity, and the confirmation of the possessions in the treaty of Utrecht, concerning the succession to the two crowns. When informed of this treaty, Philip was filled with indignation, and reproached Alberoni with betraying him; but the wily statesman soothed the irritation of his master with the hope of soon detaching Britain from the alliance; and laboured to protract a rupture until he was better prepared for hostilities. The allies immediately endeavoured to mediate an accommodation calculated to satisfy both parties. Philip, however, refused to renounce his pretensions in Italy, and hastened his hostile preparations. But, while Alberoni continued to temporize with the allies, the war was accelerated by the arrest of the Spanish ambassador at Rome on his return through Italy by the Austrian governor, who confined him in the castle of Milan, and having seized his papers, transmitted them to Vienna. This insult from such a quarter destroyed all hopes of a reconciliation; and Alberoni, having been raised to the dignity of cardinal, pressed the requisite preparations for an expedition against Sardinia, which was completely successful, and that island was again added to the crown of Spain. The war, once commenced, required great exertions, and called forth all the energy of Alberoni. The enthusiasm of the nation was awakened by the success of the Spanish arms; and contributions of money and troops were furnished by the different towns and provinces. By these means he was enabled to make a successful attack upon Sicily. Palermo submitted, and the restoration of the Spanish government was hailed both by the nobles and the people. But the further progress of the Spanish arms was stopt short by the defeat of the Spanish fleet by Admiral Byng in the bay of Naples. The allies still pressed upon Spain the necessity of an accommodation, and Britain even offered the restoration of Gibraltar provided that her sovereign would accede to the alliance. Philip, however, was inexorable, and declared that he would never lay down his arms until Sicily and Sardinia were ceded to Spain. Three months were allowed for the acceptance of their terms, accompanied with a threat, that any farther delay would be followed by a declaration of war.

In the meantime Alberoni had drawn Sweden and Russia into a treaty with Spain, the principal object of which was the invasion of Britain in support of the pretender. But the death of Charles XII. and the appearance of a British fleet in the Baltic, deprived him of all co-operation from these powers; and when an expedition, with 6,000 men, and 30,000 stand of arms, under the exiled Duke of Ormond, left Cadiz for the shores of Scotland, it was dispersed by a tempest off Cape Finisterre, and 300 men only, with a few officers, reached their destination. The other schemes of Alberoni were equally unsuccessful. He had fomented a conspiracy in France, which was encouraged by his master, with the view of removing the Duke of Orleans, and appointing Philip to the regency of that kingdom. The discovery of this plot was immediately followed by the invasion of Spain by a French army under the duke of Berwick, who destroyed the arsenal and stores of Port Passage, took possession of Fuenterrabia and Urgel, and then retired into Roussillon. These reverses compelled Philip to think of peace; but the allies would be satisfied with nothing less than the dismissal of his minister, which, having accomplished, Philip acceded to the quadruple alliance, by which he relinquished all claims to the dominions which had been severed from the Spanish monarchy. Sicily was restored to the emperor, Sardinia to the Duke of Savoy, with the title of king, and the eventual succession of Tuscany and Parma was entailed upon the issue of the queen of Spain. But, while these general arrangements were accepted by the contending powers, many minor claims on all sides were left unsettled as the germs of future disputes, and were referred to a congress to be held at Cambray. The bonds of amity between France and Spain were renewed by the marriage of the young king of France with the Infanta Mary-Anne in her fifth year, and of Louis, prince of Asturias, with a daughter of the Duke of Orleans; and this double connexion allayed the personal animosity which existed between Philip and the Regent, and suspended for a time all political rivalry between the two nations.

The removal of Alberoni deprived Philip of an able servant, whose vigorous intellect, and extent of information it was difficult to replace; and, when he affected to be his own minister, and to conduct the business of the state, he sunk under the weight, and gradually relapsed into his habitual melancholy. The reins of government were then alternately seized by various competitors for power, and had found no master hand to guide them, when Philip suddenly abdicated his crown in favour of his son Don Louis.

The young king was only in his seventeenth year when he ascended the throne. Attached by birth and habit to the Spanish manners, he was welcomed with universal exultation. But his youth and inexperience rendered him unfit to direct the helm of the state; and while he stood as the ostensible head of the government, he possessed no real authority. Philip, who with his queen had retired to the beautiful palace of St. Ildefonso, which he himself had constructed at great expense, enjoyed all the power without the trammels of royalty. He had retained the marquis of Grimaldi as his secretary, and through him regulated the affairs of his son's government. The passive disposition of Louis made him submit for a time to the orders from St. Ildefonso; but the intrigues of his cabinet were directed to his emancipation; and it is probable that he would soon have been induced to assert his right, and to unite the real to the nominal authority of his station, had he not been carried off by the small pox after a reign of only eight months.

The abdicated monarch, anxious to recover that authority which he had never altogether relinquished, hastened, in opposition to his solemn vow,—never to resume the crown, and also to the wishes of his subjects,—to prepare for his again ascending the throne; which, after some affected religious scruples, he was not long in accomplishing. The queen, overjoyed at recovering her crown, directed all her efforts to the accomplishment of her darling object, the reversion of Tuscany and Parma to her son Don Carlos. This subject, however, was received so coldly by the congress at Cambray, that she resolved to negotiate directly with the emperor. She accordingly despatched the duke de Ripperda on a secret mission to Vienna, which he fulfilled in such a way as secured her favour, and set aside for a time the favourite Grimaldi. Forgetting their former rivalry, the two monarchs entered into the closest bands of amity; and the first fruit of this new alliance was the demand from Britain of the immediate restitution of Gibraltar. In resisting this demand Britain was supported by France and Prussia; but their hostilities were confined to diplomatic warfare, until Philip became the aggressor by besieging that fortress. This was followed by lengthened negotiations among all the contending powers respecting a variety of points, which none were willing to concede.

The hypochondriac malady of the king had now increased to such an extent, that it occasionally gained the empire over his reason. In these seasons of distress his mind reverted to the happiness of retirement, and he expressed his determination again to resign the crown. The queen dreading such a measure, removed the residence of the court to Seville. But, eager in the prosecution of her favourite scheme, she continued the negotiations, and at last by her intrigues and perseverance effected her object. Don Carlos was put in possession of Parma aud Placentia, and acknowledged the successor to the Grand Duke of Tuscany.

The disputes respecting Poland raised Philip once more from his stupor, and returning to Madrid, he resumed the duties of government, and joined with France against Austria in support of Stanislaus to the throne of that kingdom. Their united arms were everywhere successful, but he was deserted by France in the midst of victories; and the only fruit of the war was the possession of Naples and Sicily by Don Carlos, in exchange for Parma and Tuscany. The administration of the government during these struggles had been ably conducted by Don Joseph Patino, who has been termed the Colbert of Spain, and was perhaps the most able minister, who since the accession of Philip, had directed the helm of the state. His death was a loss to his country which Philip, during the remainder of his reign, was never able to supply.

The long continued disputes with Britain respecting commercial rights, both in Europe and America, at last involved the two nations in war, the first fruits of which was the capture of 400 vessels, valued at one million sterling, by Spanish privateers. The attacks of the English were directed chiefly against the enemy's possessions in the new world; but they were repulsed with great loss before Carthagena, and also failed in an attempt upon Cuba; and their only reprisals were the taking of Porto-Bello, and the seizure of an Acapulco ship by Anson. Into this contest the other powers of Europe were drawn by the death of the emperor, and the accession of his daughter Maria Theresa. Though almost all of them had guaranteed the Pragmatic sanction, by which this princess was declared heir of all the Austrian dominions, yet few of them were found just enough to support it. Philip, among the rest, regardless of his solemn guarantee, appeared as one of the claimants of the Austrian inheritance, not with any hope of making good his pretensions but for the purpose of obtaining an establishment in Italy for the Infant Don Philip. After a long and expensive war, which was prosecuted with various success, Philip entered into the general negotiations for peace; but before they were brought to a close he was carried off by a fit of apoplexy.

His successor, Ferdinand VI., concluded the arrangements, by which Parma, Placentia, and Guastala were assigned to Don Philip: and the disputed points between Britain and Spain, which were too numerous and complicated to enter into a general treaty, were referred to a particular and separate negotiation. The pacific reign of this monarch was spent in cultivating a good understanding with Britain; and he found an able coadjutor in the upright Carjaval, while the interests of France were supported by the marquis Ensanada. The court of Madrid was the theatre where these contending powers maintained a constant rivalry, each being supported by a party in the government. The death of Carjaval, which threatened the annihilation of the British interests, was well supplied by the appointment of General Wall, who followed the politics of the deceased minister, and by the disgrace of Ensanada, became the sole arbiter of these contentions. This peaceful system, however, was overturned by the death of Ferdinand.

While the other powers of Europe were engaged in war, Ferdinand had maintained a strict neutrality; but Charles III., alarmed by the successes of Britain, and more attached to France than his predecessor, was drawn into an alliance with that power, which was called the "Family Compact." By this treaty, the Bourbon monarchs agreed to guarantee their respective dominions in all parts of the world, and to consider every power as an enemy, who might become the enemy of either. Spain was thus led to share in the misfortunes of her ally. The Havanna, the depository of her treasure, and the principal magazine of her naval and military establishments in the new world, submitted to the British arms, with a booty of three millions Sterling of public property, besides nine ships of the line, and an immense quantity of stores. Manilla surrendered about the same time, and was followed by the capture of the Santissima

Trinidada from that island, worth three millions of dollars.

Portugal, from her alliance with Britain, had also been forced into the war, and presented to the cupidity of Charles an easy and important conquest. But even here his arms were foiled, and his troops were obliged to retire within their own frontier. In this crisis the chivalry of the Spanish character was nobly displayed by the nobility of Aragon, and its ancient dependencies, rallying round the throne, and supplicating their sovereign to accept of their services in defence of their country. "We pray your majesty to accept the half of our forces to carry the war into hostile countries, instead of waiting for the enemy in our own; the other half will suffice to keep them far distant from our shores, should they have the temerity to approach us. We have little concern in regard to the quality of posts which your majesty may assign us, less for the climate whither we may be sent, and none for pay. Those who seek only to establish an incontestible title to the rank of gentlemen, need no reward but an open field to display their valour, and affection for their country." But repeated disasters having exhausted the resources of the Bourbon crowns, they became sincerely solicitous for peace; and the treaty of Paris again restored tranquillity to Europe. By the retirement of General Wall, and the appointment of Grimaldi, a partisan of France, the influence of that power gained the ascendency in the councils of Madrid; and the commercial disputes with Britain, which still remained undecided, occasioned a degree of irritation between the two courts, which required but a spark to kindle it into a war. But while Charles waited only until he could be assured of the co-operation of France, the internal affairs of his own kingdom called for his undivided attention.

Squilaci, the minister of finance, whom Charles had brought with him from Naples, had attempted, in his eagerness for reformation, to change the national dress. An edict was accordingly issued, prohibiting the use of flapped hats and long cloaks, which were supposed to favour assassination, a practice then very common in Spain. He had also established a monopoly for supplying Madrid with oil, bread and other articles of general consumption, which was immediately followed by a rise of price in these commodities. These measures roused the indignation of the populace, and excited an insurrection in the capital so sudden, violent, and powerful, that all attempts to restore tranquillity were unavailing, until Charles himself appeared in the balcony of the palace, and promised to dismiss the Neapolitan minister, to repeal the obnoxious edict, to suppress the monopoly for supplying the city with provisions, and to pardon the insurgents. The equable temper of the king was so ruffled by this tumult that he left the capital, and established his court at Aranjuez, where he resided for eight months.

As similar insurrections had occurred in different parts of the kingdom, Charles began to suspect that they arose from something else than a mere popular ferment; and upon a strict investigation into the circumstances of these disturbances, his suspicions fell upon the Jesuits. The spirit of intrigue and persevering ambition of this celebrated order had obtained for them great influence and power in every Catholic country. As the instructers of its youth, the confessors of its princes, and the spiritual guides of the nobility, they gained such an ascendency over the minds of men that they mingled in all affairs; and there was scarcely a public intrigue or revolution in which they were not actually implicated, or supposed to be engaged. Devotedly attached to the court of Rome, they endeavoured to exalt her dominion over all civil government, and acknowledged no authority that was any way opposed to the maxims of the order or the will of their general. They were thus dangerous as subjects, and by their number and wealth were formidable as enemies; and though they had become objects of fear and jealousy to many of the European governments, yet, until the middle of the sixteenth century, no monarch had been bold enough to set them at defiance. Portugal was the first who set the example, from whence they were expelled in 1759; France followed in 1764; and Spain in 1767; and the manner of their expulsion from this latter kingdom and its colonies, was as complete as it was unexpected. See Jesuits.

Internal tranquillity being completely restored, Charles, with the assistance of the Count D'Aranda, devoted his exertions to domestic reformation and the amelioration of the finances, while Grimaldi was at the same time concerting measures with the minister of France for again embroiling Europe in war. An unfortunate expedition against Algiers, however, drove Grimaldi from the helm, which was entrusted to Count Florida Blanca, who commenced his administration by a war with Portugal. This contest arose out of former disputes relative to their respective boundaries on the Rio de la Plata, and in consequence of these the two courts had been long engaged in angry discussions or actual hostilities. The first aggression was on the side of the Portuguese, who reduced several forts on the Rio Grande, and repulsed a Spanish detachment with the loss of 500 men. But Spain inflicted a severe retaliation by the capture of the isle of St. Catherine, and the colony of Sacramento; and when hostilities were stopt by the death of the king of Portugal, she obtained a very advantageous treaty, and retained Sacramento, which had long been a bane of contention between the two crowns.

Upon the breaking out of the revolution in British America, and the interference of France, Charles pretended to adopt a strict neutrality, and offered his services for the accommodation of their disputes. Partial however, to France, and anxious to crush the maritime power of Britain, which had long been the favourite policy of Spain, he used his mediation merely as a mask, and employed the long interval of the negotiation in maturing his naval and military preparations. He at the same time, in order to secure his object, had formed arrangements with almost every power either at enmity with Britain, or that was likely to be turned against her. Britain stood alone in this contest, and the first attempts of her united foes was the invasion of her territory. Fifty thousand troops were ready for a descent upon her coasts, and the combined fleets, consisting of 68 sail of the line, besides frigates, blockaded the channel, with the hope of intercepting the British fleet under Admiral Hardy. But the British admiral having eluded their vigilance, passed up the channel; and though they followed him above Plymouth, they declined an action in so narrow a sea, and returned to Brest mortified by their failure, and debilitated by hardship and disease. A greater reverse, however, was awaiting them upon their own shores. Gibraltar had ben invested by sea and land, and was reduced to such distress, that the Spanish court looked with confidence for its speedy surrender, when Admiral Rodney was despatched to its relief. Having captured on his passage a convoy of fifteen sail, with naval stores and provisions, he encountered the blockading squadron off Cape St. Vincent, which he defeated with great loss, and threw into the garrison whatever was necessary for its defence. These reverses, however, were in some measure counterbalanced on the side of Spain, by the reduction of the Floridas and the capture of the British East and West India fleets, valued at nearly two millions sterling. In the West Indies their operations were at first equally successful. They had secured almost the whole chain of the Antilles, and were preparing an immense armament, to consummate their enterprise by the reduction of Jamaica, when Rodney, as an evil genius, appeared in its defence, and having defeated the French fleet under De Grasse, saved that island, and in fact prevented the utter expulsion of the British from the Caribean Sea.

The capture of Minorca, after a brave defence, encouraged Charles to prosecute with vigour the siege of Gibraltar, which formed the most memorable feature of the war, and for a period of four years arrested the attention of Europe. All the skill and power of the Bourbon governments were exerted for the recovery of this important fortress: and they had made so sure of success, that two of the French princes repaired from Paris to witness its fall. But the gallant defence of General Elliot, and the admirable manœuvres of Lord Howe, who, in the face of a very superior force, passed the straits, and strengthened the garrison with a reinforcement of 1400 men, besides a supply of ammunition and provisions, rendered all their efforts unavailing, and the cessation of hostilities saved them from any farther disasters. After a long and fruitless negotiation for the cession of Gibraltar, Charles was under the necessity of acceding to other terms, by which he obtained the two Floridas; and kept possession of Minorca, which, next to Gibraltar, had been the great object of national ambition.

Charles had soon cause to regret his erroneous policy in encouraging the revolt of the American provinces. His own subjects in South America endeavoured to profit by the example of the northern states, and an insurrection, headed by a descendant of the ancient Incas, threatened to sever them for ever from the parent state. Tranquillity was at last restored, but the seeds of liberty were then sown, of which they are now reaping the harvest, and the maintenance of the royal authority required an establishment which absorbed the greater part of the American revenue.

The latter part of Charles's reign, under the wise direction of his favourite minister Florida Blanca, was spent in promoting the internal improvement of his kingdom; and the great object of his interference in the general system of European politics, was to secure public tranquillity, and prevent his country from being again involved in new troubles and commotions. He died in the 73d year of his age, and the 19th of his reign. This prince was the only Bourbon sovereign of Spain who was not led by those who happened to surround him. He was perhaps, in general, too pertinacious in adhering to his own opinions and resolutions; but his talents were respectable, his disposition benevolent, his morals irreproachable, and he possessed a manly firmness of temper, which was seldom elated by success or depressed by misfortune. He gave every encouragement to industry and the fine arts, and was a distinguished patron of literature and science. Respected and feared as a sovereign, he was beloved as a man; and those who attended on his infancy, grew grey, or died in his service. His most characteristic propensity was a love of shooting and the chase; and so high was the importance which he attached to his exploits as a sportsman, that he kept a regular account of the victims of his skill. It is said, that a little before his death he boasted to a foreign ambassador, that he had killed with his own hand 539 wolves, and 5323 foxes, adding with a smile, "you see my diversion is not useless to my country." His dress is thus ludicrously described by Swinburne: "It seldom varies from a large hat, grey Segovia frock, a buff waistcoat, a small dagger, black breeches, and worsted stockings; his pockets are always stuffed with knives, gloves, and shooting tackle. On gala-days, a fine suit is hung upon his shoulders; but as he has an eye to his afternoon's sport, and is a great economist of his time, the black breeches are worn to all coats. I believe there are but three days in the whole year that he spends without going out a-shooting, and these are noted with the blackest mark in the calendar. With all his peculiarities, however, he was greatly beloved by his people, and universally received the respected appellation of "the good old king."

Remarks.—When Philip V. took possession of the crown of Spain, he found a kingdom completely exhausted, without a marine or efficient army, without industry or manufactures, with scarcely a remnant of her ancient power, wealth, and grandeur. Owing to the neglect or incapacity of her former rulers, every department of her government was in the most deplorable disorder. Incapable of her own defence, it was only by the assistance of France that Philp was enabled to maintain himself upon the throne. When, by the treaty of Utrecht, the superfluous branches of the monarchy were lopt off, and the integrity of her territories in the Peninsula and America secured, she began to rise into her former importance, and to hold a high rank among the nations of Europe. The constant drain upon her resources required for the support of her dominions in Italy and Flanders, was now shut; and while her expenses were reduced, the revenue of Philip exceeded by one-third that of any of his predecessors. As the whole reign of this prince formed a series of inconsiderable projects, imperfect accommodations, and successive hostilities, he often experienced considerable difficulty in raising supplies. The money, however, which was expended in the war of the succession remained in the country, and the energy which that struggle produced, called forth a formidable army. Her disputes with Britain led also to the establishment of a powerful marine, and the strength of her navy once more awakened the attention of Europe. The revival of trade, industry and the arts, occupied the exertions of some of her ablest ministers. Alberoni laid the foundation of many important improvements, by surveying the different provinces, and ascertaining the state, productions, and resources of the kingdom. He greatly facilitated the interior communications and traffic, by removing most of the inland custom-houses to the frontier; and rooted out a contraband trade of great extent, which had been carried on by the people of Biscay, under the privilege which they enjoyed of trafficking with the manufactures and productions of their own province, free of duty. He diminished the introduction of foreign manufactures, which had hitherto filled the markets, to the detriment of those of Spain, by establishing a manufactory of woollens at Guadalaxara, under the royal patronage, and another of fine linens, in imitation of those of Holland, and by transmitting the strictest injunctions to the different intendants and governors to encourage the use of the native fabrics, and to have all the troops in future clothed with the manufactures of Spain. He also revived the foundry of artillery and small arms, which had fallen into total inactivity; and in the principal ports, he established docks, fabrics of rigging, and magazines. By these and other important regulations he emancipated Spain from her dependance upon foreign nations, not only for articles of almost universal consumption, but, what was of immense consequence in time of war, for the means of naval and military equipment. The short term of his ministry, however prevented him from giving consistency and effect to his various plans of internal policy; but his successors benefited by the valuable legacy, and, in the following reign, many of his projects were completed, and trade and industry greatly relieved from the trammels imposed upon them by interest and ignorance.

During the pacific reign of Ferdinand, the internal improvements of the kingdom were steady and progressive. The collection of the revenue was simplified by abolishing the farming system, which had been found to be both oppressive and inefficient, and by reducing the provincial taxes to a royal administration; and such order and economy was introduced into the finances by Ensenada, that the Spanish treasury had never been so well replenished since the accession of the Bourbons. Improvements in the marine, which had always been a favourite object of the government, were prosecuted with great vigour and success. Timber was collected from Naples and other parts of Europe; foreign shipbuilders and engineers were encouraged to settle in the country: and by fortifying and improving the arsenals of Ferrol, it was converted from a paltry village into one of the noblest ports of Europe. New discoveries and improvements in the arts and sciences were eagerly sought for in foreign countries, and transplanted into Spain. Strenuous efforts were made to revive the national agriculture, by the formation of patriotic societies, and by translating into the Castilian tongue a valuable Arabian manuscript, found in the library of the Escurial, which contained the excellent system of culture pursued by the Moors.

But these were merely preludes to the general system of reform which distinguished the reign of Charles III. and the administration of Florida Blanca, who, with the assistance of Campomanes and other able coadjutors, carried his schemes of amelioration far beyond any of his predecessors. The trade with America, which had been confined to Cadiz, was thrown open to all the Spanish ports, except those of Biscay, which spread industry and activity over all the kingdom, and so multiplied the connection with the colonies, that in a short time the imports and exports were tripled, and the produce of the customs and revenue in both dominions more than doubled. A new impulse was given to the native manufactures, by increasing the duties upon foreign fabrics; and the condition of the industrious classes was greatly meliorated by the abolition or modification of many oppressive taxes. Many charitable and patriotic institutions were established, for relieving the poor, and promoting industry and education among the lower orders; for the encouragement of agriculture and the useful arts; and for the cultivation of literature and science. Most efficient measures were also adopted for the prevention of idleness and mendicity; and the gypsies, a numerous and vagabond race in this country, who were lost in licentiousness, idleness, and vice, were converted into useful and industrious citizens. The difficulties of internal communication, which had always been a great obstacle to industry, and in a great measure prevented the transport of corn and other heavy commodities, were remedied by the formation of roads in the principal provinces, and by numerous canals, which served also for the purposes of irrigation. The labours of the minister were also directed to the administration of justice, both civil and ecclesiastical. By various regulations, he endeavoured to prevent the partiality or misconduct of the subordinate magistrates, and to check vexation, chicanery, and delay in the courts of law; and the formidable tribunal of the inquisition was so shackled and restricted in its operations, that it was allowed to give only such displays of its authority as to render it contemptible in the eyes of the nation, and to prepare the way for its final abolition. The naval and military system felt also the impulse of his beneficial regulation, and never was it marked by a more rapid amelioration than during his ministry. The improvements and changes introduced by this minister were, in fact, so numerous and varied that they extended to almost every department of foreign or domestic policy; and had his patriotic advice been followed, the burdens of the poor and industrious would have been still further diminished, and those odious impositions, the *alcavala* and *milliones*, which may be truly said to have cramped the industry, exhausted the wealth, and hastened the decline of Spain, would have been superseded by taxes less oppressive in their operation. But his dismissal from office in the following reign, by the intrigues of the queen, prevented the completion of many of his plans, and the breaking out of the French revolution turned the attention of the government to its own preservation.

Chap. VI.—*Bonaparte seizes the throne—Revolution in Spain—The French driven from the Peninsula.*

Charles III. upon his death-bed, charged his successor to retain Florida Blanca in his service, as an upright and faithful counsellor, to whose able and unwearied exertions the kingdom was indebted for many valuable improvements. Charles IV., however, held only the nominal sovereignty of Spain, the whole power and influence of the government resided virtually in the queen. This princess was a daughter of the Duke of Parma, and soon after her marriage with the Prince of Asturias, discovered a strong propensity to gallantry, which the severe and jealous temper of her father-in-law was scarcely able to check. But the death of the old king left her without an obstacle in the pursuit of her licentious pleasures, as her weak and good-natured husband seemed neither to feel nor to see her disgraceful conduct. Her favourite at this time was Don Manuel Godoy, a young officer in the horse guards, and descended of an ancient but decayed family in Estremadura. This person had obtained his present elevation by supplanting his brother in the affections of the queen; and he continued, in spite of his own imprudence and infidelities, which were well known to his royal mistress, to maintain his ascendency over her to the last. He had also ingratiated himself into the confidence of the monarch, and was rapidly advanced to the first ranks of the army, and the highest honours of the state. Having been raised to a grandeeship of the first class, he received a princely estate belonging to the crown, with the title of Duke de la Alcudia, and the faithful Florida Blanca was removed to make way for his appointment to the head of the government.

At this period the revolution in France had involved Spain also within the vortex of its influence; but her ill-conducted and disastrous efforts were of little avail to the general confederacy. The revolutionary forces overran the greater part of Navarre, and would soon have dictated their own terms at Madrid, had not the favourite minister concluded and ratified the peace of Basle, by which the French conquests were restored in exchange for the Spanish part of St. Domingo. The nation had been so alarmed at the successes of the republican army, that this peace was hailed with universal joy, and no reward was considered too extravagant for the person by whose management it had been accomplished. A new dignity was created for him alone, under the title of "Prince of the Peace," which placed him next in rank to the princes of the blood royal: and this was soon after followed by his marriage into the royal family, by receiving the hand of the eldest daughter of the king's late brother Don Louis.

The open and unguarded gallantries of the favourite, however, excited the jealousy of his royal mistress, and she frequently formed the design of accomplishing his disgrace, and driving him from the court; but her unextinguished, and ever reviving passion, yielded to the first offers of reconciliation; and all her attempts at revenge ended only in the ruin of those who were employed as the instruments of it. It was this which deprived Spain of the talents of the accomplished and patriotic Jovellanos, and consigned him to the fortress of Bellver in Majorca. The return of confidence was always followed by an accession of honour and influence. The antiquated dignity of high admiral, accompanied with great emoluments, and the title of highness, was revived and conferred upon Godoy, and a brigade of cavalry, composed of picked men from the whole army, was given him for a body guard. His power at length became so unlimited, that every department of the government was filled by his dependents; and it is said, that "the queen finding it impracticable to check his gallantries, had so perfectly conquered her jealousy as not only to live with him on the most amicable terms, but to emulate his love of variety in the most open and impudent manner."

It could not be expected that a country under such control could long maintain its respectability and independence. The incessant demands of the queen for the support of her pleasures, formed the most pressing and considerable item in the Spanish budget: and it is asserted that "Caballero, the minister for the home department, fearing the progress of all learning, which might disturb the peace of the court, sent a circular order to the universities, forbidding the study of moral philosophy. 'His majesty,' it was said in the order, 'was not in want of philosophers, but of good and obedient subjects.'" Spain consequently became the humble tool, first of the republic and then of the Emperor of France. Soon after the peace of Basle, she entered into an alliance with the republic, to which she furnished a fleet and large contributions in money; but in her contest with Britain, her fleet of twenty-seven sail of the line was defeated off Cape St. Vincent by a very inferior force, under Sir John Jarvis, when four line of battle ships remained with the victors.

Upon the renewal of hostilities after the peace of Amiens, Spain, as a vassal state, again attached herself to the fortunes of her more formidable neighbour,—but the battle of Trafalgar stripped her of her marine, and she continued to be the passive instrument of Bonaparte, till her population were roused to resistance by a system of perfidy and aggression, on the part of the French ruler, unexampled in the history of the world.

Not satisfied with having at his disposal the resources of the Spanish monarchy, Bonaparte meditated the total subjugation of the kingdom, and the conferring its sovereignty as a conquered province upon one of his own family. Having gained over Godoy to his interests, and sown dissensions among the royal family, he decoyed them, under the mask of friendship, to Bayonne, and there by threats compelled them to sign a renunciation of their rights to the crown of Spain and the Indies, and placed his brother Joseph upon the throne of that kingdom. This plan of oppression and aggrandisement, with the subsequent transactions of the Peninsula until the capture of Cividad Rodrigo by Lord Wellington in 1812, are circumstantially detailed in our article BRITAIN.

It will be seen from our last reference that the campaign of 1812, commenced on the east of the Peninsula, very unfavourably for the Spanish cause. The army under General Blake was annihilated by Suchet, who reduced almost the whole of Catalonia and Valencia. On the western frontier, however, the capture of Cividad Rodrigo secured the safety of Portugal, and at the same time opened a way into the centre of Spain. While Lord Wellington was prosecuting the siege of this city General Hill advanced upon Merida, which was evacuated on his approach, and by this movement the country between the Tagus and the Guadiana was completely cleared of the enemy, and the forces of Marmont and Soult effectually separated. Upon the fall of Cividad Rodrigo, Lord Wellington moved the greater part of his army towards Badajos, which, in the preceding year, had been surrendered, after a feeble defence by the Spaniards. This fortress was considered as an object of primary importance to his future operations, and he resolved to push the siege with the greatest vigour. By the middle of March the place was completely invested, and on the 29th, a sortee of the garrison was repelled with considerable loss. On the 31st the British fire opened from 26 pieces of cannon, which were strengthened by six more on the 4th of April; and by the 6th, three practicable breaches were effected, which determined his lordship to an immediate assault. About ten o'clock in the evening, the troops destined for this arduous duty advanced in four divisions. That, under Major General Picton, carried the castle of Badajos by escalade, and Major Wilson with 200 men established himself in the ravelin of St. Roque. The false attack committed to Lieutenant-General Leith, being converted into a real one, was completely successful. The division led by the Honourable Major-General Colville, and Lieutenant-Colonel Bernard, encountered more serious opposition. They advanced to the assault of the breaches with the utmost intrepidity, but such were the impediments raised by the enemy, that after repeated attempts, and the loss of many brave men, they were unable to accomplish their object. As the town and castle, however, were in possession of the British, all resistance ceased; and the French governor, who had retired with his staff into fort St. Christoval, surrendered at day-light in the following morning. This brilliant exploit was accompanied with the immense loss of 1,035 killed, and 3,789 wounded. During these operations of the allied army, Soult was rapidly advancing to the relief of Badajos; and Marmont had penetrated into the interior of Portugal, after an unsuccessful attempt upon Cividad Rodrigo. As soon, however, as they learned the result of the siege, they both retraced their steps, the one towards Salamanca, and the other towards Seville.

The British commander now meditated more extended operations; and, in order to prevent any communication between the French generals, he detached General Hill to destroy the bridge of Almarez, which formed the only passage below Toledo, by which a large army could cross the Tagus. This bridge was protected by two strong forts erected on each side of the river, and defended by 18 pieces of artillery; but this gallant officer, after a fatiguing march, in which he was obliged to leave his artillery behind, carried the one on the left bank at the point of the bayonet; which struck such a panic into the garrison of the other, that they abandoned the fort and fled in the greatest confusion.

Every preparation being made for the advance of the allied army, it crossed the Agueda; and reached Salamanca on the 16th of June. Marmont had constructed a strong line of forts in the neighbourhood of this city, with which he kept up a close communication, but by a masterly manœuvre of Lord Wellington, he was compelled to abandon them to their fate. Their reduction, however, proved a work of no small difficulty, and it was the end of June before the army was again in motion. The enemy had taken up a strong position on the Douro, which it was considered imprudent to attack. Lord Wellington, therefore, instead of advancing upon Valladolid, threatened the Spanish capital, but Marmont having received reinforcements from the army in the north, and thus become superior in numbers, by a skilful movement, turned the flanks of the allies, and re-established his own communication with Madrid. This was followed by a series of dexterous manœuvres in attempting to cut off the retreat of the British army, which, however, were met by evolutions not less brilliant on the part of Lord Wellington, who was anxiously waiting for an opportunity to come to an engagement. The over extension and weakening of the enemy's line pointed out the favourable moment, when General Pakenham commenced a furious assault on the flank of the French left, which was at the same time attacked in front by General Bradford's brigade, and the cavalry under Sir Stapleton Cotton, and, though well posted and defended by cannon, was completely overthrown. General Pack made a gallant attack upon the enemy's centre, on the Arapiles, which, however, did not succeed until supported on the right by General Leith, when they were driven from the hill with precipitation. The other wing of the enemy, reinforced by the fugitives from the left, still showed a determination to resist, but, after a sharp attack upon its right and front, the rout became general, and they were saved from destruction only by the darkness of the night. At daybreak the pursuit was renewed; and, coming up with the enemy's rear-guard, their cavalry was routed, and three battalions of infantry made prisoners. The fruits of this victory were eleven pieces of cannon, two eagles, six colours, and upwards of 7000 prisoners, which were bought by the British with the loss of 700 killed and above 4000 wounded. Marmont retreated with his broken army upon Burgos; and Joseph Bonaparte, who had been advancing with the army of the centre to join before the battle, was met by his flying squadrons, and retired to the capital. Lord Wellington, having left a force under General Paget to watch the motions of Marmont, proceeded to Madrid, which was immediately evacuated—the French retreating by Toledo and Aranjuez. The British troops entered on the 12th of August, and a French garrison, amounting to 2500 men, which had been left in the Retiro, surrendered prisoners of war.

The intelligence of the battle of Salamanca and the occupation of Madrid, determined Marshal Soult to withdraw the besieging army from before Cadiz, and to evacuate Andalusia, and, having joined his forces to those of Suchet and Joseph, to attempt the recovery of the Spanish capital. This movement enabled the allied forces under the Spanish General La Cruz and Col. Skerret, to advance upon Seville, which was taken by assault.

After remaining some time at Madrid, Lord Wellington advanced to the siege of Burgos, which was held by the enemy as the key of the north of Spain, and the castle of which they had rendered one of the strongest forts in the peninsula. He had been led to believe, from the magnificent promises of the Spanish government, that he would receive the support of the army of Galicia, which was represented as consisting of 30,000 troops, in the highest state of discipline and equipment, and led by officers of talent and experience; but discovered, to his great mortification, that this mighty army had dwindled into 10,000 raw levies, without equipments, and commanded by men who had yet to learn the rudiments of their profession. The rapidity of his march prevented the transportation of heavy artillery, which compelled him to abandon the ordinary method of attack, and to adopt the slower and more uncertain process of sapping the works. The fortifications on St. Michael's hill were successfully stormed, and in spite of the skilful and resolute defence of the garrison in the castle. the besiegers had established themselves within a hundred yards of the enemy's interior line. On the 11th of October a mine was sprung, when the breaches were instantly stormed, and a part of the British troops actually entered the works; but a heavy fire from the garrison compelled them to retire.

While the allies were engaged in these operations before Burgos, the beaten army of Marmont had been greatly reinforced under Souham, and was advancing to the relief of that important fortress; and at the same time Soult was hastening from the south for the purpose of forming a junction with the northern army. The intelligence of these movements determined Lord Wellington to raise the siege, and retire upon the Douro. Though pressed closely, and at different points by very superior numbers, he retreated in the finest order, without any other inconvenience than what arose from the badness of the roads, towards the frontiers of Portugal, where the troops were allowed to repose in their cantonments until the season of action again arrived.

At the opening of the campaign in 1813, the enemy occupied the centre of the peninsula, having their head quarters of the different armies at Madrid, Toledo, and Valladolid; while the line of the allies formed an extensive semicircle reaching from Galicia to the confines of Murcia and Valencia. Lord Wellington assembled his forces in the vicinity of Cividad Rodrigo, and having driven the French from Salamance, advanced upon the Douro, which he crossed with the main body of his army. He proceeded without opposition along the northern banks of that river to Valladolid, where the enemy had concentrated their armies. They did not, however, attempt to defend that city, or dispute the passage of the Pisuerga; but retreated at the approach of the allies without intermission, until they reached Burgos. Though occupying a strong position, and evincing a determination to stand, a charge of British cavalry turned both their flanks, and compelled them to withdraw and abandon that fortress, after destroying the works of the castle, which had cost them so great labour and expense in constructing. Lord Wellington, instead of following the route of the enemy, hastened to the Ebro, which he crossed on the 15th of June, and continued his March towards Vittoria, which the French had made their central depôt in the frontier provinces. Here he found the enemy strongly posted, and commanded by Joseph Bonaparte in person, having Marshal Jourdan as his major general. The allied army rested on the 20th, and on the following day, after a severe contest, obtained a most brilliant victory, driving the enemy from all his positions, and capturing 151 pieces of cannon, 415 waggons of ammunition, with all their baggage and stores, and a considerable number of prisoners. So complete was their defeat, that the enemy carried with them only one gun and one howitzer, and this solitary gun was afterwards captured. The fugitive army pursued its retreat, harassed at every point, until it crossed the Pyrenees, and the French were in a short time dislodged from all their posts in the north of Spain, except St. Sebastian and Pampluna, which it became necessary to reduce, before employing the allied army in more decisive operations.

Soult, who had been withdrawn from the Spanish war, to assist his master in Germany, was again appointed as the fittest person to restore the glory of the French arms in the Peninsula, and to relieve, if possible, the two principal strongholds which still acknowledged their dominion in that country. The beaten army, now stationed within the frontiers of France, having been greatly reinforced, and completely equipped, was joined on the 13th of July by the French marshal, who, when he assumed the command, boasted to his troops that he would drive the British beyond the Ebro, and celebrate the emperor's birth day in the town of Vittoria. The allied army occupied the passes of the Pyrenees, which afforded very strong positions, but the lofty chains of mountains which intervened, rendered the communication between the different divisions tedious and difficult. Soult, aware of the unfavourable situation of the allies in this respect, resolved to attack them separately; and, on the 24th, burst with an overwhelming force through the pass of Roncesvalles, which was defended by General Byng and Sir Lowry Cole, who maintained their post throughout the day, but found it necessary to retire in the night to the neighbourhood of Zubiri. In the afternoon of the same day, another division of the enemy attacked the position of Sir R. Hill, in the valley of Bastan, which was hardly contested for seven hours, when that officer, being apprised of the retreat of General Byng, by which his rear was threatened, fell back upon Irurita. Lord Wellington was not informed of these events till late in the following day, when he immediately adopted measures for concentrating his forces. Soult, on the 27th, arrived in sight of the walls of Pampluna, and after some severe fighting, by the 29th had occupied a formidable position in the mountains. The allies had also formed on a range of heights no less impregnable, but neither seemed willing to become the first aggressor. The enemy, however, trusting to the natural strength of his situation, withdrew a considerable body of troops from the front, with a view to strengthen his attack upon General Hill, when the British commander perceiving his line thus weakened, ordered Lord Dalhousie and General Picton to drive him from the heights on which his right and left rested, which being rapidly accomplished, the centre advanced to the attack and obliged him to abandon his position, which Lord Wellington in his despatches described as "the strongest and most difficult of access that he had ever seen occupied by troops." In his retreat he lost many prisoners and much baggage, and though he twice attempted to make a stand, he was at last compelled to retire within his own frontier.

While Lord Wellington was pursuing a brilliant career in the north, the operations of the allies on the eastern coast of Spain were attended with a less decisive result. The French held the numerous fortresses of Catalonia and Valencia, and Suchet with a large army occupied an advanced position at San Felippe on the line of the Xucar. The allies on the other hand, were stationed at Alicant under Sir John Murray, and consisted of several British and native regiments, which had been withdrawn from Sicily, and a considerable force collected from the neighbouring provinces, which had been organized in the Balearic islands under British officers: a Spanish army under General Elio also occupied the frontiers of Murcia. About the middle of April Sir John Murray advanced to Castella; and Elio, at the same time, took post at Villena. Suchet having driven back the Spanish force, pushed forward to Castella, where he encountered for the first time a British army; but he was met with such undaunted steadiness that he was repulsed with considerable loss, and retired with precipitation to his entrenched camp at San Felippe. The British general made no attempt to follow up his success; and his advance to Castella seems to have been intended chiefly to prevent Suchet from detaching any part of his force to the aid of the central army under Joseph Bonaparte. But when Lord Wellington moved from Salamanca, he directed General Murray to conduct an expedition of 1000 men by sea, to the attack of Tarragona, which it was supposed would induce Suchet to weaken his force in Valencia, and enable the Spanish generals to take possession of a great part, if not the whole of the open country in that province. This expedition having reached its destination, continued to prosecute the siege of Tarragona from the 3d to the 17th of July, when the approach of a superior force to its relief induced the British commander to embark his troops, leaving behind a considerable portion of his cannon and stores. The failure of this attempt, however, was not attended with any unfavourable results to the general cause. Lord William Bentinck having assumed the command, ordered the troops back to Alicant, and having there joined the Spanish armies, continued to maintain a war of posts, and to occupy the forces of Suchet, until the third Spanish army was detached to co-operate with Lord Wellington on the frontiers of France, when the remainder of the troops were called to act entirely on the defensive.

St. Sebastian capitulated on the 8th of September after a most gallant defence, and a severe loss to the besiegers, which, with the fall of Pampluna on the 31st of October, enabled Lord Wellington to become the invader in his turn. The French had formed two successive lines of defence, which they had been diligently employed in fortifying ever since the battle of Vittoria; the one along the course of the Nivelle, and the other immediately in front of Bayonne. The first of these was stormed on the 10th of November; and though disputed from day light till sun-set, the allies succeeded in carrying all the positions on the enemy's left and centre; and, by establishing themselves in the rear of the strong positions occupied by their right, obliged them to evacuate these also during the night. Soult now fell back upon his entrenched camp before Bayonne, of which the left occupied the peninsula formed by the confluence of the Adour and the Nive, and the right and centre extended from the left bank of the Nive to the Adour below the town, defended in front by an impassable morass. This position was so fortified by nature and art as rendered it impregnable against any direct attack, and it was therefore determined by a movement to the right to threaten his rear and interrupt his communication with France. For this purpose General Hill crossed the Nive on the ninth of December, and having driven the enemy from the right bank of the river, moved with his right towards the Adour. Soult, aware of the result of these operations, if not immediately checked, made a most desperate attack upon the left of the allies under Sir John Hope, which, however, was repulsed in a most gallant style. A similar attempt on the 12th proving equally unsuccessful, Soult passed, during the night, a large force to the left, and attacked General Hill with great fury, but was driven back with immense loss, and compelled to retire within his entrenchments. By these operations the allies firmly established themselves between the Nive and the Adour, and thus accomplished the liberation of Spain.

CHAP. VII.—*Spain under the Cortes—Ferdinand returns and again establishes an absolute government.*

When Bonaparte had decoyed within his power the royal family of Spain, and had raised his brother Joseph to the throne of that kingdom, the junta of government, which had been appointed by Ferdinand before his departure from Madrid, basely betrayed his cause by acknowledging the usurper, and the inquisitor-general, the highest religious authority in Spain, lent his aid in accomplishing the degradation and destruction of his country. The nation in general, however, were actuated by more patriotic feelings, and, as if by one instantaneous impulse, raised the standard of independence. Juntas were formed in every province, who adopted measures for the general defence, and for the recovery of the country; and in this struggle the lead was taken by the supreme junta of Seville. Many of the members of these bodies, however, though zealously devoted to the cause of their country, were still too much attached to its old abominations. Commissions and commands were bestowed not upon those who deserved them most, but upon their own friends and dependants; and even after the bitter experience of twelve months of disasters, no effectual measures were taken for improving the discipline of their armies, or supplying them in the field. The establishment of a central junta brought no remedy to those evils; and though among the members of this provincial government we find the names of the venerable Florida Blanca and the accomplished Jovellanos, yet they enjoyed neither the confidence nor the respect of the people. Their proclamations indeed were distinguished by a boldness and an energy worthy of the cause in which they were engaged; but never was language so belied by deeds. Their incapacity was so apparent, that a regency was loudly demanded, to whom they transferred all their authority, providing that it should be retained only until the meeting of the cortes. But no sooner were the central junta denuded of their power, than they became the victims of popular indignation. They were accused of having peculated the public money; and the regency, though convinced how false the charge was with respect to many of them, yet, yielding to the general clamour, and perhaps courting popularity, included them all in a general censure, by seizing their papers, and registering their effects. Even Jovellanos, whose patriotism and unsullied honour had never been suspected, was ordered to retire to his own province of Asturias, and placed under the inspection of the magistrates. The last act of the central junta consigned to the regency the charge of assembling the general and extraordinary cortes, according to a plan of representation which they had formed after much labour and research; but the meeting of this body was delayed for some time, and it was not until the month of June 1810 that a decree was issued ordering the elections to be completed with all possible speed. In this decree, however, the regency departed from the plan approved of by the junta, and convoked only one house. The privileged orders, the nobles and clergy, were not summoned at all, either to meet apart, or with the third estate, and were thus excluded entirely from the national representation.

The cortes commenced their proceedings on the 24th of September, and their first acts were to declare their own sovereignty, and to demand an acknowledgment of it from all the authorities, civil, military, or ecclesiastical, who were bound by oath to obey the decrees, laws, and constitution of the cortes. Their conduct, however, on this occasion, was marked with great precipitancy and intolerance. Almost at the instant that they decreed the separation of the legislative, judicial, and executive authorities, they confounded them in their own practice. Those who hesitated or refused to take the prescribed oath from conscientious scruples, as inconsistent with the fidelity which they had sworn to Ferdinand, were summarily punished with imprisonment or banishment, among whom were the bishop of Orense and the marquis del Palacio. Instead of infusing into the government, which continued to be held by a regency, that energy which the crisis required, they weakened and embarrassed its exertions by continually intermeddling with it; and, instead of directing their own attention to such measures as were necessary for the deliverance and security of the kingdom, they consumed their sittings in metaphysical discussions, and in framing a new constitution, a work which might well have been delayed to a fitter season.

This constitution was promulgated in 1812, and greatly resembled the French constitution of 1791. It was violently opposed in many parts of the kingdom; and even its fundamental doctrine, the sovereignty of the people, did not meet with that cordial reception from the nation which was anticipated. The sudden overthrow of the old system, and the extreme change from an absolute monarchy to a pure democracy, produced such revulsion of feeling in the hearts of many, as caused them to pause in the career which they had so gloriously begun. That burst of popular enthusiasm which arose in the peninsula, and was heard throughout Europe, was not the offspring of revolutionary principles, or even of discontent with their government, but it sprung from hatred of the usurper, and in defence of their rights, as an independent nation. The people had hailed the accession of Ferdinand to the throne, as releasing them from the tyranny of Godoy, who was held in almost universal detestation; and they still regarded him in adversity as their lawful and beloved monarch, whose return was the great object of all their exertions. Had the cortes then, as a provisional government, confined their attention to the administration of the affairs of the kingdom, and to the gradual adoption of measures for reforming the more glaring abuses of the old system, they would have carried with them the majority of the Spanish nation, and would have ensured at length a complete and thorough renovation of the government. But when they showed by their acts such a direct disregard of the feelings and prejudices of the people, invading, nay annihilating the rights of that prince, in whose behalf they had given such demonstrations of allegiance and affection, the nerve of patriotism was unstrung, and the national enthusiasm evaporated in a heartless cause. Not that their hatred of the usurper was lessened, but they had lost all confidence in their rulers; and hence that apathy exhibited by the majority of the Spaniards, and which was so much complained of by the allies at an advanced period of the war. Many of the better informed classes, though aware of the necessity of some reform, and perhaps considering this a favourable opportunity for making such alterations in the government as the circumstances of the country required, beheld with pain the conduct of the cortes, being convinced that their countrymen were totally unprepared for such an order of things, and that the adoption of the new constitution would tend only to retard the progress of rational liberty. Some even regarded the assembly itself as unconstitutional, and as resembling the ancient cortes only in name. It bore, indeed, some resemblance to the cortes of Charles V., after he had removed from its sittings the nobles and clergy, and which he then dissipated with a breath. These classes, whose interests and privileges were thus invaded, possessed great influence among the people: and their defection and opposition carried with them the great body of the nation. The promulgation of the new constitution consequently spread dissatisfaction and disunion throughout the peninsula; and so apprehensive were the new authorities of a popular commotion, that they refused arms to the inhabitants of Galicia, who had applied for them to defend their own province, at that time menaced by the enemy.

From this period, the exertions of the peasantry ceased, and all attempts to organize a popular force proved ineffectual. A plan for incorporating Spanish recruits in the allied army, under British officers, also failed; and had it not been for the desultory operations of the guerillas, who, under Empecinado, Mina, and other patriotic chiefs, continued to maintain an unwearied and destructive warfare against the invaders, the national cause was in danger of being forgotten amidst internal dissensions. It seemed to occupy but a small share of the attention or exertions of the Spanish rulers, and the majority of the people regarded with calm indifference the deliverance which Britain was accomplishing for their country. The British army, it is true, was every where received with *vivas*, but it was now no uncommon thing for Spanish patriotism to evaporate in these noisy ebullitions; and had it not been for the support of the British government, and the gallantry of her troops, Spain might have been at this moment an appendage of France. The unhappy division of the nation into constitutionalists and royalists, or, as they were afterwards called, *liberals* and *serviles*, completely neutralized the exertions of the people; and while the cortes were intent upon perfecting the new constitution, and, among many injudicious and even tyrannical acts, had passed some very important and beneficial measures, the press, and even the pulpits in many parts of the country, were employed in condemning their decrees, and in convincing the people that all exertions in favour of such a government, was rebelling against the authority of their lawful monarch.

Amidst these contentions, Ferdinand was restored to his kingdom. Of the two factions, the preponderance of talent and patriotism was on the side of the constitutionalists, but the royalists possessed greater wealth and influence; and it might easily have been foreseen which cause a prince of Ferdinand's temper and education would most readily espouse. Before his return, he had sworn to maintain the constitution; but he no sooner found himself surrounded by the nobles and clergy, whose rights and privileges that constitution had in a great measure swept away, than his royal oath yielded to the ambitious wish of reigning the absolute sovereign of Spain. He immediately annulled the constitution; and, in order to soothe its adherents, promised to convoke immediately the real cortes, and, with their aid, to frame a new system of government. But having escaped from the trammels of the constitution, his promise was forgotten; and seizing the reins of absolute power, he established in all their deformity the abominations of the old government. His will again became the law; and supported by a cabal of crafty and interested zealots, he stalked forth as the cruel persecutor of all who had in any degree lent their aid in accomplishing his own restoration, and the independence of their country. Sentences of imprisonment, exile, or personal servitude, were passed upon all the deputies of the cortes who had shown any zeal in the cause of freedom. Many distinguished leaders in the Spanish armies met with similar treatment, while others withdrew from persecution, by seeking an asylum in foreign countries. The yoke of despotism, however, was not borne without impatience. Occasional irruptions showed that the flame of liberty might be smothered, but was not extinguished. An attempt of Porlier at Corunna to accomplish a revolution upon the principles of the oppressed liberals, was followed by others in Valencia, Catalonia, and Galicia, but were all attended with similar results, and equally disastrous to their promoters. The unfortunate issue of these designs checked for a time the spirit of opposition, and Spain seemed to resign herself to her fate, presenting to a superficial observer an aspect of outward tranquillity, and quiet submission to the yoke of Ferdinand. The government reverted to its old principles, and if the term *absolute* can be applied to any monarch, the king of Spain at this period well deserved the appellation. The inquisition was restored with its ancient plenitude of authority; and among its first acts were, the publication of a long list of prohibited works, and a decree that all prints and pictures, as well as books, should be subjected to its previous censorship. One redeeming act of this government, however, which was passed in 1817, deserves our highest commendation. This was the abolition of the slave-trade, which, with respect to the coasts north of the line, was to be immediately enforced, and on those south of the line, the prohibition was to take place on the 30th of May 1820; and all who controverted this edict, were subjected to severe penalties.

The ministers of Ferdinand, however despotic and successful in repressing all attempts at insurrection, held no enviable situation. Many subjects of great difficulty called for their attention and exertions. The deficiency of the revenue to meet the current expenditure, the low state of industry and commerce, and the insurrections in the colonies, required a mind of no ordinary kind to remedy and control. These evils acted upon one another in such a way, as almost to preclude the possibility of relief. The state of the colonies produced a stagnation of commerce, by depriving it of that immense transit, upon which it had for many centuries almost entirely depended; this decay of trade produced a corresponding falling off in the ordinary revenue; and this again deprived government of the means of supporting the royal cause in South America. Under all these embarrassments, however, attempts were made to restore order and stability to the finances. A papal bull was obtained for the appropriation of a tenth part of the income of all ecclesiastics, which was to continue for six years; and for the present exigencies of the kingdom, proposals were issued for raising a loan of sixty millions of reals. But such was the low state of public credit, that although eight per cent. interest, and the guarantee of the war taxes for future payment were offered, few of the capitalists came forward, and the government was compelled to have recourse to a forced loan, to which foreign merchants residing in the sea-port towns were obliged to subscribe. This supply enabled ministers to proceed with activity in fitting out an expedition at Cadiz for America, which had been long in preparation, and which the merchants of that city had incessantly called for, as the only hope of restoring their ancient prosperity. But the troops collected for the purpose were very averse to such a service, and their repugnance to embark was well known. A plot was consequently formed by several of the officers of the expedition, supported by some of the most distinguished citizens of Cadiz, not merely to escape from a disagreeable service, but to overthrow the government, and to restore the constitution of the Cortes. The accomplishment of their object, however, was for a time defeated by the treachery of the Conde d'Abisbal, commander-in-chief of the expedition, who, being informed of the existence of a conspiracy, pretended to join heartily in the enterprise, and promised to promote it with all his influence. Having by these means become acquainted with the views of its promoters, he adopted the most decisive measures for its suppression. He assembled the garrison of Cadiz, amounting to about 6,000 men, marched to the camp at Santé Maria, where the plot had originated, and arrested above a hundred of the officers. He then dispersed several of the refractory regiments throughout the interior of Andalusia, and having appointed new officers to the remainder, embarked them for America. This act of dissimulation and treachery did not meet with the expected reward. Abisbal was superseded in the command of the expedition, which was given to the Conde de Calderon; and while his measures delayed the open expression of hostility, they aggravated the evil, by rendering the conspirators more cautious and determined. Aware of the prevailing discontent among the troops, the utmost exertions were made by government for the departure of the expedition; but when every preparation was completed, and the fleet in readiness, the conspiracy exploded, and gave a new aspect to the affairs of this unhappy kingdom.

Quiroga, a lieutenant-colonel, and one of the officers put under arrest by Abisbal, having concerted with Riego and other officers the plan of the insurrection, they fixed upon the first of January as the decisive day, when Riego burst into the town of Arcos, made prisoners of Calderon and all his staff, and proclaimed the constitution. On the same day Quiroga, having made his escape, joined his battalion at Alcala, and, surprising the garrison of San Fernando, incorporatd the troops with his own. He was then joined by Riego, and their united forces, amounting to more than 6,000 men, were immediately organized under the title of "the constitutional army." An address in the name of the army was then presented to the king, in which, after enumerating the evils which the brave defenders of their country had suffered from the measures of his government, they declared "that their sole object was to restore the constitution; and that to have it recognized that the nation, legitimately represented, has solely the right of giving herself laws, excited in them the purest ardour, and taught them to speak in accents of the warmest enthusiasm." At the same time Quiroga issued an address to the Spanish people, reminding them of the ancient glory and liberty of the nation, of its heroic resistance against the usurpation of Bonaparte, of the recompense which it had met with, and the miseries which had been the consequence: and calling upon them, therefore, "to co-operate in the glorious effort now made to restore to them the rights of which they had been deprived."

Shut up within the narrow boundaries of the Isla, and surrounded by 15,000 royalist troops under General Freyre, the patriots had no apparent means of extending their operations. Weeks elapsed in this stationary state, and their situation was becoming insensibly worse. The enthusiasm excited by their first success was gradually evaporating. Their resources and supplies were cut off, and little hope of deliverance remained, unless some effort could be made to rouse the country in their favour. In these circumstances, Riego, whose bold and adventurous spirit prompted him to undertake whatever was difficult and hazardous, suggested the romantic idea of marching at the head of a flying column to scatter the seeds of liberty in the provinces; while the rest of the army should maintain its position in the Isla. Having selected a band of 1500 men, he set forward on this daring enterprise. In many of the cities he was received with the warmest demonstrations of joy; but, seeing the patriotic cause supported by so small a force, none of the inhabitants were hardy enough to join its standard. His route was no sooner known than general O'Donnell was sent in pursuit with a considerable body of royalists. With this superior force Riego had constantly to contend, and, from the want of necessaries, always at a disadvantage. Pursued from post to post, and daily thinned by fatigue and repeated skirmishes, this little band presented in their progress a series of adventures and privations of which history offers few examples. Driven to seek for safety in the heights of the Sierra Morena, which could be reached only by the bridge of Cordova, Riego formed the daring resolution of marching the remnant of his column through that large city. As they passed through the streets barefooted, badly clothed, and chanting the patriotic hymn, the inhabitants, assembling in crowds, viewed them with wonder and admiration. They then hastened towards the mountains, but were overtaken by the royal army and suffered considerable loss. Reduced at last to 300 men, destitute of every thing, closely pressed, and hopeless of success, they were compelled to disperse, and each individual to seek safety for himself. "Such," says San Miguel, "was the fate of a column, worthy by its patriotism and valour of the most brilliant triumphs. Where so many concurrent circumstances combined against us, it was morally impossible for the result to be different. Fanaticism on the part of an enemy always more than triple our numbers; dismay and timidity in the well affected: pusillanimity and weakness in those who abandoned us in the hour of danger; the violation of promises by those who had engaged in the cause; unheard of labour and fatigue in such rapid torrents, and marches night and day through a mountainous country intersected by ravines,—all these circumstances combined must have disheartened the bravest troops. Wherever the column of patriot soldiers passed, the people applauded them, gave them provisions, effects and money; but no one joined them; at their departure they wished them success, and then proceeded to prepare lodgings for the troops that pursued them."

Quiroga still maintained a defensive attitude at San Fernando, and repulsed every attack of the enemy; but insulated from the rest of Spain, and enclosed on all sides by superior forces, the constitutional cause seemed to all appearance fast hastening to a close. The column of Riego, however, though annihilated, had accomplished its object. The flame of patriotism was excited in the places through which it had passed, and had extended to the remotest parts of the kingdom. The cry of "the constitution" was in a short time raised in Galicia, Navarre, and other provinces, with a demonstration of support which could not be resisted. The government made an imperfect attempt at reconciliation; but Madrid, which had been long secretly agitated, declared for the constitution. As a last resource, an extraordinary gazette was published on the 7th of March for convoking the Cortes; but this concession came too late. The whole population of Madrid tumultuously assembled, tore down the placards, and set up the constitutional stone, demanding, with loud cries, the constitution of 1812. The king was compelled to yield, and to submit to the degrading humiliation of restoring a constitution which it had been the first act of his reign to dissolve with every mark of reprobation, and to condemn to dungeons and to exile all who had been concerned in framing and upholding it. A decree was consequently issued by the king, in which he stated that, "as the general will of the people had been pronounced, he resolved to swear to the constitution promulgated by the general and extraordinary Cortes in the year 1812."

This revolution occasioned universal rejoicings among the friends of liberty. The dungeons gave up the tenants, who for so many years had been immured within their cells; the inquisition was suppressed by a royal decree; and the liberty of the press established on the same footing as by the former Cortes. The general harmony, however, was interrupted by an unfortunate collison between the military and the inhabitants of Cadiz, which produced very dismal consequences, General Freyre, who had steadily supported the royal cause, suddenly formed the resolution of proclaiming the constitution in Cadiz, and invited the chiefs of the national army to be present on the occasion. Quiroga, suspecting treachery, declined attending himself, but sent a deputation to represent the patriots in the approaching spectacle. After a night of joyful preparaton, Cadiz exhibited, on the morning of the 10th of March, a scene of indescribable animation. The deputies from the Isla were received with triumph; and the assembled multitude, arrayed in their festal dresses, waited only the arrival of General Freyre to begin the ceremony; when, on a sudden, the troops commenced firing on the populace, who, dispersing in all directions, were pursued and butchered wherever they were met. Even the houses afforded no protection to the wretched inhabitants; and Cadiz was for several hours like a city given up to pillage. In this inhuman massacre four hundred and sixty were killed and upwards of a thousand wounded; but its authors were never brought to punishment. Strong suspicions were excited against Valdes, the governor of the city, and Freyre was not without his share; but after a long investigation into this unhappy affair, its origin was never fully ascertained.

The elections for the approaching Cortes were completed without any disturbance, and were decidedly favourable to the liberal party. On the 6th of July, the king, attended by the queen, the royal family, and his ministers, opened the assembly, and, after renewing his oath of fidelity, strongly expressed his attachment to, and his determination to support the constitution. "At length," said he, "has come the day, the object of my ardent wishes, when I see myself surrounded by the representatives of the heroic and generous Spanish nation, and when a solemn oath identifies my interests and those of my family with the interests of my people. It is to the establishment and the entire and inviolable maintenance of the constitution, that I will consecrate the powers which this same constitution assigns to the royal authority; in it I will concentrate my power, my happiness, and my glory." After voting an address in reply to the king's speech, the Cortes received from the different ministers a view of the state of their respective departments. Of these the most important was that of finance, which detailed a deficiency of nearly two millions sterling, which it was proposed should be relieved by a loan of 200,000,000 reals. They then proceeded to the consideration of some permanent reforms in the political system; but here, throwing aside the lessons of experience which might have taught them that the constitution of 1812, without some considerable modifications, was adapted neither to the wants nor the wishes of the great majority of the people, they persisted in a series of measures calculated to excite the hostility of the nobles and clergy, and through them the great body of the peasantry. By abolishing the system of *maiorats* or entails, a severe blow was given to the family pride of the Spanish Grandees, which, added to their exclusion from the supreme legislature of their country, completely alienated them from the government; and by the suppression of the religious orders, and declaring their property national, thus reducing to a state of comparative beggary a numerous body who had always held a great sway over the public mind, and also throwing into a state of absolute destitution those swarms of mendicants who had been accustomed to receive supplies at the convent gates, they raised up a host of foes who could not but feel the bitterest enmity against the authors of their degradation and misery, and would be ever ready to join the ranks of the disaffected, and to disturb the tranquillity of the kingdom. If these proceedings, however wise in themselves, may be considered, in the present circumstances of the country, and from the time and manner of their execution, premature and precipitate, their regulations respecting trade were radically unwise and ruinous. Instead of those liberal views which were recommended in the writings of their most eminent economists, they adopted a system of commercial intercourse, the leading principle of which was, a complete exclusion of whatever Spain could produce within her own territory. This not only increased her financial embarrassments, but gave rise to an extensive contraband trade, which induced tumultuous and irregular habits among the people, and which had always been one of the greatest scourges of Spain. Their arrangements, however, for public instruction were of the most enlightened description, and evinced a laudable anxiety for the education of the people. Three gradations of schools were to be established throughout the kingdom, the first for elementary instruction, of which there was to be one for every five hundred families; the second for those destined for public employments; and the third for special and profound studies.

But while the Cortes were busily employed in these and other important discussions, and fixing the great outlines of the constitution, the nation in general was agitated by the most violent commotions. The king had given a reluctant sanction to the law for the suppression of the monastic orders; and the execution of it was in many places tumultuously opposed. The ejected monks every where called the peasantry to arms in defence of the throne and the altar, which they said were trampled under foot by the constitutional system. Assuming the form of guerillas, they were with difficulty reached by the regular troops, and when dispersed in one quarter immediately reappeared in another. On the other hand, the ultra-liberal clubs in the large cities, outraged and alarmed at these hostile movements, branded the government with want of energy, and even denounced the highest persons in the state as secretly encouraging them. Vinuesa, the king's chaplain, was openly accused of plotting the overthrow of the constitution; and when his majesty appeared in public, the crowd along with their acclamations of "Live the constitutional king," loudly demanded the death of Vinuesa, the disbanding of his guards, and the dismissal of such ministers as they considered not sufficiently devoted to the new system. These insults were so often reiterated, that some of the king's guards, determined to be no longer tame spectators of such treatment, charged the multitude sword in hand, by which several of the populace were wounded. This excited a dreadful ferment, and a general cry was raised for dissolving the regiment. The ministers so far yielded that the guards were superseded by another corps in attending upon the king's person.

Amidst these commotions, the Cortes was opened on the 1st of March by the king, who, in the conclusion of his speech, complained of the indignities which had been offered to his person, and broadly stated that "these insults would not have been repeated if the executive power had displayed all the energy which the constitution prescribes and the Cortes desires. The want of firmness, and the little activity of many of the authorities, have given room to the renewal of such excesses, and, should they continue, it will not be astonishing if the Spanish nation finds itself enveloped in numberless evils and misfortunes." The same evening that these complaints were uttered, all the ministers but one received their dismissal. This measure excited an extraordinary emotion among the liberal circles. It was considered a direct blow against the constitution: and so strong was the expression of public opinion, that the king did not venture to appoint their successors without requesting the advice of the Cortes. This assembly, however, declined interfering with the royal prerogative, but recommended that his majesty's confidence should be given only to those who had given decided proofs of their adherence to the constitutional system. A ministry was at length formed, which, in its composition, embraced both parties, and consequently gave satisfaction to neither. From this period the king showed evident symptoms of aversion to the ruling party in the Cortes, and they also had little confidence in his declarations of attachment to the constitution.

The attention of the Cortes was now strongly drawn to the internal security of the kingdom. The report of the committee on this subject stated the existence of a combination of plots for the overthrow of the constitution, all directed by a supreme junta. This was corroborated by the discovery of a document, in the hand-writing of Vinuesa, detailing a scheme for the re-establishment of the old government, which produced a strong sensation among the people. Vinuesa, whose trial for treason had been in progress, was soon after condemned to ten years close confinement in the galleys. A punishment so inadequate to the offence raised the indignation of the populace, who, rushing in a body towards the prison, and in spite of the guards, burst open the doors, and executed that terrible sentence which they judged due upon the unfortunate chaplain.

Strong guerilla parties headed by the monks, continued to disturb the provinces; and though repeatedly routed by Lopes Banos, an original and zealous champion of the revolution, they as often rallied, and were reinforced by the peasantry, who flocked in crowds to their standard. Severe decrees were passed for the suppression of these insurrections. All who were found engaged in them were to be tried by a council of war, and executed in forty-eight hours; and every Spaniard who propagated opinions tending to the overthrow of the constitution, was to be punished with fines and banishment.

The fermentation of parties was daily rising higher and higher. Petitions were poured in from all quarters for the dismissal of ministers; but they, determined to face the storm, endeavoured, by a course of vigorous measures, to overawe the hostile factions. They resolved that all the high commands should be filled only by persons devoted to their interest; and consequently they superseded the commandants of Cadiz and Seville. These cities, deeply embued with revolutionary principles, refused to receive the new governors, and addressed representations to the Cortes, justifying their rejection of chiefs sent by a ministry whom they had every reason to suspect. The command of the Cortes to submit was met by fresh representations, which called forth the just indignation of that body, who characterized such conduct as decidedly seditious and tending to rebellion. These cities, however, still continued refractory, and gave no signs of submission.

While these disputes were threatening the very existence of regular government, a contagious distemper of the most virulent nature broke out at Barcelona, and withdrew for a time the public attention from political dissensions. It continued to rage for upwards of two months, and is supposed to have carried off 20,000 of the inhabitants of Barcelona, and a proportional number in the neighbouring cities. It was under the pretext of guarding against the introduction of this pestilence, that the French government established an army on the frontiers, under the title of "the sanctary cordon," which afforded encouragement and even protection to the royalist guerillas, or, as they were now called, "the army of the faith." These insurgents were daily gaining strength, particularly in Navarre and the northern provinces. The great mass of the peasantry favoured their cause; and their bands were increased by many of the lower ranks from the cities, and by all who were connected with the Church. Ample funds were mysteriously supplied for their support. Pay, equipments, and even high bounties were given to all who joined their standard; and the soldiers of the faith were furnished with every necessary, when the regular troops drew neither pay nor subsistence except by forced contributions. They continued for a time to overrun the open country; but their force was at length broken by Lopes Banos, and was compelled to seek refuge in France, or to wander in detached bands amidst the most inaccessible mountains.

The king still retained his ministers, in spite of the representations of the Cortes; and the cities still resisted their authority. The dismissal of the one, however, was immediately followed by the submission of the other, who opened their gates to the governors, appointed by the king. A new ministry was formed under Martinez de la Rosa, who soon became equally unpopular with their predecessors. A proposition, introduced by them into the Cortes, for repressing the licentiousness of the press, and subjecting the patriotic clubs to a close surveillance, was passed by a great majority, in consequence of which the most violent of the clubs were shut up, and a strict police enforced in Madrid and the other great cities. But this seeming tranquillity was of short duration. Insurrectionary movements became general throughout Catalonia, Aragon, and Navarre. The armies of the faith under the Trappist and other leaders, were soon masters of the whole open country in these provinces. They had taken Cervera, surprised Mequinenza, and carried by a midnight assault the strong fortress of Seo d'Urgel, which, from its situation and inaccessible position in the mountains, afforded them a sure retreat in the greatest exigencies, and kept open their communication with France. They at one time had entered Tarragona, and, though driven out by general Haro, had gained the outworks of that important place, and kept it closely blockaded.

These events called for the most rigorous measures on the part of the Cortes. Servile principles were evidently spreading among the people; and, as the constitution could only be maintained by keeping on foot an overwhelming force, orders were issued for increasing the army to 63,000 men. The state of affairs, however, was rendered more critical by the well-grounded suspicion that the king himself encouraged the malcontents, and waited only a favourable opportunity openly to join them. This was confirmed by his conduct towards his favourite guards, whom he supported in their rebellion against the constituted authorities; and even declared that, after repeated insults towards his person, and the refusal of all means of protection, the constitutional compact was dissolved, and he was entitled to resume all his original rights. The rebellious guard, however, were at last reduced, and the king was under the necessity of allowing his unpopular advisers to retire. The formation of a new ministry was entrusted to Lopes Banos, which, of course, was strictly constitutional; and the most strenuous efforts were now made for suppressing the insurgents.

The royalists had, in the mean time, installed a regency at Urgel, consisting of the Marquis of Mata Florida, the Bishop of Tarragona, and the Baron d'Eroles, who issued a series of proclamations, declaring that the king was in a state of captivity, and that, till his deliverance, the only legitimate government of Spain resided in themselves. They called upon all true Spaniards to rise in the cause of the king and the church: and such was their influence that a levy en masse took place in the valley of Cerdagne, from which d'Eroles organized an army of 15,000 men, fully equipped and disciplined, leaving the remainder to act as guerillas. Against this formidable force, which held possession of all Catalonia, except the principal fortresses, which the national troops were with difficulty able to maintain, the whole power of the Spanish army was directed. The militia were entrusted with the garrison duty of the large towns, which rendered the regular troops disposable for active service; and all the regiments in the southern provinces were drawn towards Catalonia. The command in this arduous service was confided to the celebrated Mina, whose high reputation and particular experience in mountain warfare inspired the most sanguine hopes of a successful termination to the contest. Proceeding to Lerida, he detached a corps to observe Upper Aragon, and pushed forward towards Urgel, the focus of the insurrection. Cervera was evacuated at his approach, and Castelfolit yielded after a vigorous resistance. At Tora he encountered d'Eroles whose little army fought with the greatest fury, but were at last compelled to give way, and seek refuge among the mountains. D'Eroles, however, recovered and mustered a considerable force in front of Urgel. Here the decisive struggle was long and obstinately contested, but finally issued in the total rout and destruction of the army of the faith, whose scattered bands crowded towards the French frontier. The triumphant progress of Mina expelled the insurgents from Catalonia; but his career was marked with that ferocious rancour, which a civil war is so apt to engender, and which often confounds the innocent with the guilty. The "factions," as they were called, wherever met, were put to death without trial or any legal inquiry; and such villages as were known to have assisted the rebels, were sacked, demolished, or reduced to ashes. No quarter was given on either side, and all prisoners who fell into their hands were butchered in cold blood.

While Mina was employed in the mountains of Urgel, Bessieres and Ulman, two insurgent leaders, determined to make a dash at the capital, by which they expected to astound their enemies, and revive the courage of the royalists. Having collected a force of nearly 5000 men, they, by a rapid movement, reached Guadalaxara, before the authorities in Madrid were informed of their approach. The regular troops and militia in the neighbourhood were hastily assembled, and marched against the enemy, who, retiring, took up a position near Torvega. O'Daly, the constitutional general, commenced the attack, but his right wing, which was composed of raw militia, gave way, and he was obliged to retreat upon Guadalaxara, which he soon after abandoned to the enemy. In this crisis the Conde d'Abisbal was called to the command. Having obtained considerable reinforcements, he compelled the royalist army to fall back, which afterwards separated, Bessieres retiring upon the Ebro, and Ulman upon Valencia. The former was closely pursued and suffered considerable loss and dispersion; the latter, having been joined by numerous partizans in the neighbourhood of Segorbe, surprised the strong fortress of Murviedro, the ancient Saguntum, where he was enabled to maintain his ground, and to give a firm footing to the war in that province. In this critical state, Spain was now called to resist a more formidable enemy in defence of her national independence; but whose numbers and resources precluded all hope of a successful issue.

The affairs of Spain had formed a principal object of discussion at the congress of Verona; and the powers there assembled, with the exception of Great Britain, assumed the high authority of interfering with the internal arrangements of an independent kingdom, and of dictating terms humiliating and injurious to its present rulers. They demanded an immediate change in her institutions, and, in case of non-compliance, threatened her with all the horrors of war. Notes to this effect were delivered by their respective ambassadors at the court of Madrid, and were conceived in language calculated to excite the most hostile feelings, and a just indignation against their authors. They described the constitution of Spain as "an event the most deplorable,—the work of perjured soldiers—overturning the whole social system, and recalling times which made Europe tremble." The replies of ministers to these communications were by no means conciliating, but rather breathed too much a spirit of defiance and resentment. After representing, in answer to the French note, the constitution of 1812 as produced by the united will of Spain, and as recognised by all the powers now forming the congress at Verona, they add, "that the professions of France to contribute to the happiness of Spain cannot be held to be sincere until she dissolve her Pyrenean army, and repulse the factious enemies of Spain who take refuge in her territory." In a circular transmitted to the Spanish ambassadors resident at the other courts, and which was of a very concise nature, their notes are described as unworthy of an answer, and are characterized as a tissue of lies and calumnies; and they declare, in conclusion, that the Spanish nation will never admit the right of any power to interfere in her affairs. When these documents, with their answers, were laid before the Cortes, they excited a burst of noble and generous indignation: and the assembly, in their address to the throne, declare "their surprise and indignation at the strange calumnies, the manifest falsehoods, and the calumnious imputations contained in these documents, as vicious in their substance, as contrary in their form to the practices established among civilized nations, horribly injurious to the Spanish nation, to its most distinguished members, to its Cortes, to its government, to the throne even of your majesty, which, resting on the constitution, suffers not less from the attacks of which it is the object: lastly, to your sacred person, whose good faith and love for your subjects are attempted with an impious temerity, to be made the subject of doubt." The result of such language might easily have been anticipated. Louis XVIII. in his speech at the opening of the chambers, declared that the safety of France demanded the overthrow of the Spanish constitution. "Let Ferdinand VII. be free to give to his people *the institutions which they can hold only from him*, and which, in securing their repose, may dissipate the just inquietudes of France." That such iniquitous doctrine should emanate from the conclave of the Holy Alliance was not to be wondered at; but that it should be supported by any, except the most illiberal bigots of the most unmixed despotism, is humbling to human nature. These sentiments of the king were re-echoed by the representatives of the French nation. "To your majesty it belongs to deliberate; it is our part to concur with all our efforts in the generous enterprise of stifling anarchy to conquer only peace; of restoring liberty to a king of your blood; of securing the repose of Spain to confirm that of France; of delivering from the yoke of oppression a magnanimous people, who aided in breaking our chains, and which can *receive institutions conformable to its wishes and its manners only from its legitimate sovereign.*"

Six years of direful experience had taught Spain what she had to expect from the uncontrolled will of Ferdinand. He had subverted all her liberal institutions, and had consigned to dungeons and to exile some of the bravest and most enlightened of her sons. During that period she indeed enjoyed repose, but it was the repose of the grave, whose gloom no ray of light is permitted to penetrate,—a repose fatal to the industry, the intelligence, and the happiness of the people. Her only alternative therefore was war; and never was she in a worse condition to meet a foreign invader. Her finances in the most deplorable disorder—one half of her population in insurrection—her army weak and inefficient—her sovereign leagued with her enemies—and the invader powerful both in numbers and resources, and backed by all the kingdoms of continental Europe. The Spanish rulers were honest and earnest in the cause, but were miserably deficient in that wisdom and energy which such a crisis required. Their preparations were consequently far from being commensurate with the danger. Instead of putting under arms that portion of her people that were devoted to the constitutional cause, and which comprehended the inhabitants of all the great cities, the Cortes ordered the army to be raised merely to the war establishment of 120,000 men, and this order could only be imperfectly executed in consequence of the numerous districts in a state of insurrection, and the loose ties by which authority was held in the rest of the kingdom. But besides being greatly deficient in numbers, the Spanish army was greatly inferior in discipline and equipments to those veteran troops with which they were destined to contend. The Cortes, however, still held the language of confidence. "If the invading army invoke the God of St. Louis, we will invoke the God who protected the Spanish arms at Roncevaux and at St. Quentin; we will invoke the God of justice and of victory."

Great Britain, as the friend of both, endeavoured to avert the miseries of war, wisely forbearing, however, to commit herself in the cause; but her exertions were unavailing. The demands of France were unreasonable, and Spain refused all concession or approximation. Preparations for the campaign were carried on on both sides with the characteristic dispositions of the two nations: on the one side with energy and activity, on the other with sluggish apathy. While the Spanish ministers were slow but honest, the king was watching opportunities for paralyzing their exertions, and for subverting the constitution. Although he declared in his speech at the dissolution of the extraordinary Cortes, that "the law of national independence, and the necessity of preserving the constitution of 1812, were the replies which the nation would give to the antisocial principles contained in the speech of the King of France;" yet the same evening he dismissed his ministers, and obstinately opposed the removal of the seat of government from Madrid to a place of greater safety, and more remote from the frontier. This conduct, in the present circumstances of the nation, excited the popular indignation to such a height, that the palace was immediately surrounded by crowds of people, who loudly demanded the re-establishment of the dissolved ministry; and occasional cries were heard of "down with the tyrant—depose him—kill him." This intimidation had its effect. The ministers were restored, but their resignation was afterwards announced to the Cortes on the 2d of March, with this condition, however, that the new ministry should delay their operations till their predecessors had each read reports on the state of their respective departments. A warm debate ensued, in which it was openly stated, that a conspiracy was organized in the heart of the palace, and that the crisis required the Cortes to declare the physical incapacity of his majesty. The majority, however, agreed that in order to avert the evils which would follow an immediate dissolution of the ministry, they should delay hearing the reports till the removal of the seat of government had been effected: and thus, in virtue of the king's declaration, ministers would continue till that time in the exercise of their functions. The king, under various pretences, resisted his leaving Madrid, but it was at last pressed by the Cortes in such a way as left no room for choice, when he reluctantly yielded and set out for Seville on the 20th of March.

The entrance into the peninsula by the French army under the duke d'Angouleme was preceded by a proclamation, in which that prince professed himself to be the friend of Spain. "Born of the same blood with your kings, I can desire only your independence, your happiness, and your glory. The French are, and wish only to be your auxiliaries; your standards alone will float on your cities; the provinces traversed by our soldiers will be administered in the name of Ferdinand by Spanish authorities; the most severe discipline will be observed; all that shall be necessary for the service of the army will be paid with religious exactness." The defence of the peninsula was intrusted to the bravest and most experienced of its generals; with means indeed totally inadequate to the struggle, but what was worse, in some with hearts not earnest in the cause. Mina held the command in Catalonia; Ballasteros in Aragon, Valencia, and Murcia; Abisbal in the Castiles and all the centre of Spain; Morillo in the north; and Villacampa was employed in Andalusia to organize an army of reserve.

The French crossed the Bidassoa on the 7th of April, and reached Madrid on the 23d of May, without encountering any resistance, except at Logrono, where a sharp action was maintained with the vanguard. The troops and militia, stationed in the different towns, retired on the approach of the enemy. The strong fortresses of Pampluna and St. Sebastian answered the summons to surrender by a brisk sally; and as no immediate impression could be made upon them, they were subjected to a blockade; but Saragossa was evacuated by Ballasteros without striking a blow in its defence.

Everywhere upon the line of march the *serviles*, consisting chiefly of the priests and lowest classes, rose against their opponents, and maltreated and plundered all whom they suspected of liberal sentiments. Both factions bore a greater enmity to each other than to the foreign invaders; and the constitutionalists were often obliged to seek protection from the enemy against the infuriate excesses of their own countrymen. The arrival of the French was consequently hailed in many places as a deliverance from more serious evils. The duke, having installed a Spanish regency at Madrid for the general administration of the country, despatched two divisions under generals Bourmont and Bourdesoult to the south of Spain, with orders to advance upon Seville and Cadiz, the one by the way of Estremadura, and the other by that of La Mancha.

In the meantime the Cortes had commenced their sittings at Seville; but all their proceedings with respect to the defence of the country were carried on with their usual supineness and apathy. No symptom of national rising had yet appeared, and their only hope rested on the force actually under arms, which could not be depended upon for any protracted resistance. But the rapid advance of the French called upon them to consult for their own safety; and they determined to transfer the government to Cadiz. This was openly resisted by the king, who now expected that in a few days Seville would be in the hands of his friends, when he would be restored to absolute sovereignty. He was consequently declared to be in a state of moral incapacity for fulfilling his functions; and a provisional regency was appointed, who set out for Cadiz on the 12th of June, carrying with them the king, now openly and avowedly a prisoner. The constitutional cause, however, was rapidly declining; and its sunshine adherents were dropping fast into the ranks of the enemy. The Conde d'Abisbal had been driven from his command by his own army on account of his correspondence with the opposite party: the defection of Morillo hastened the subjugation of the northern provinces; and Ballasteros had concluded a convention, in which he agreed to acknowledge the regency appointed by the French. As a contrast, however, to these sad instances of weakness and treachery, the gallant Mina was maintaining a desultory and protracted war against a very superior force in the mountains of Catalonia; and the reduction of that province was as distant as at the commencement of the campaign.

The French armies reached Cadiz without any serious encounter, and during the whole of their advance, conducted themselves with great caution and moderation. Not so their faithful allies, who, urged by personal enmity and the hope of plunder, wished to commit every species of outrage against their political antagonists; and the attempts of the French officers to repress their hostility, occasioned such frequent disputes and dissensions as led at last to the decree of the duke at Andujar, which prohibited any arrest by Spanish authorities, without the consent of the French officer commanding in the district, and authorised this officer to set at liberty all those who had been arbitrarily arrested. The duke joined the army before Cadiz on the 16th of August, where was collected a force of 30,000 French troops, with a formidable train of artillery. An attempt at negotiation having failed, the French commenced their operations by storming the Trocadero, a small peninsula nearly opposite to Cadiz, and commanding the naval approaches to the city. The fall of this important post spread dismay and discouragement among the constitutionalists. The troops felt the impulse, and began to show symptoms of royalism; and the only body of men that could now be relied on was the militia, particularly that of Madrid. In these circumstances the Cortes would gladly have purchased peace, by consenting to modify the constitution; which, had it been done in time, might have saved Spain, but it was now too late. The duke d'Angouleme demanded the immediate liberation of Ferdinand, and declared that he could not consider him as free until he saw him in the midst of the French army. He at the same time expressed his confident expectation, that his majesty, on being restored to liberty, would grant a general amnesty, and convoke the ancient Cortes of the kingdom. The Spanish government, however, were not yet prepared for such unqualified submission; but they were also wanting in that heroic spirit of resistance which was requisite to throw a lustre around a sinking cause. The same weakness and infatuation which had been so conspicuous on the part of the constitutionalists in the progress of this most inglorious campaign, marked also its close; and it terminated by an unconditional surrender of their liberties and lives into the hands of an unfeeling and senseless despot.

Before his departure for the French camp, the oath-breaking Ferdinand promised a full and complete oblivion of all offences, and that, in the re-establishment of his government, some regard would be paid to the liberties of the nation; but, on the very day of his deliverance, he characterized the late revolution as "the most criminal treason, the most shameful baseness, and the most horrible wrong against his royal person." He soon after issued a succession of decrees, breathing the most unbounded fury against every one who was in any way connected with the constitutional system; and all who had been deputies to the Cortes, or had filled any office or function of government since March 1820, or who had even been in the ranks of the national militia, were prohibited from approaching within five leagues of his majesty on his way to Madrid, and during their whole lives, from coming within fifteen leagues of the capital.

The fall of Cadiz was soon after followed by the surrender of all the important fortresses in the kingdom. Mina, who held the command of the strong garrisons of Barcelona, Tarragona and Hostalrich, obtained an honourable capitulation; and the same terms were granted to Torrijos in Carthagena.

Ferdinand's arrival at Madrid was preceded by that of the Duke d'Angouleme, to whom the nation looked for some mitigation of his proscriptions; but whether that prince, who had repeatedly pledged himself that the restored government would act with lenity, and grant some form of a free constitution, found his advice neglected, or was unwilling to use his influence, no alleviating decree ever appeared. He spent only a few days with the king, and left him absolute master of Spain, with a French army ready to execute whatever purposes of vengeance his caprice or his tyranny might dictate.

Only one noble victim was in his power, who, it was resolved, should be immolated upon the altar of despotism; and this was the gallant and unfortunate Riego. Upon the first investment of Cadiz, he had been entrusted with the command at Malaga, and had been taken prisoner while again endeavouring, at the head of a flying column, to rouse the spirit of the provinces. After a mock trial he was condemned, and he died in a manner worthy of the glorious cause of which he was a martyr. The members of the Cortes, and of the former government, with the principal chiefs, lost no time in removing from their oppressed country; and Spain was daily thinned of the most intelligent and industrious of her population.

But while the presence of the French army prevented any effective reaction on the part of the constitutionalists, France made no secret of her disapprobation of the measures of Ferdinand, which were characterized by the most senseless severity; and when her remonstrances were disregarded, she threatened to withdraw her forces from Spain, and leave the absolute king to depend upon the loyalty and affection of his own people. This had the effect of producing some alleviating decrees; but they were so clogged with exceptions, that the exiles, deprived of all hope of mercy, were driven to despair. Several insurrections in different parts of Spain were the consequence, but they were all equally unsuccessful; and this fine kingdom, notwithstanding the superior intelligence of many of its inhabitants is fast sinking into a state of barbarism.

The finances of Spain are in the most deplorable condition. The great capitalists of Europe have refused every accommodation until the loans of the constitutional government be recognised; and the expenses of the army of occupation have fallen entirely upon France.

The sway of Ferdinand, however, has been considered even too mild by the servile and monkish faction; and a plot was formed for his dethronement, and the substitution of his brother Don Carlos. In this conspiracy many of the nobles and prelates were seriously implicated; and general Bessieres, its ostensible organ, who had raised the standard of revolt at Torrija, was taken and shot. Nearly at the same time two constitutionalists, Paul Iglesias, and the famous Empecinado, Don Juan Martin, were apprehended at Tariffa, and publicly executed. The serviles have now the complete ascendency in the councils of Spain; but its infatuated monarch is only preparing for himself and for his country new troubles and commotions. The bands of oppression are already stretched nearly to the utmost, and must sooner or later give way, when this unhappy kingdom may be again involved in all the miseries of revolutionary anarchy; and in the reaction of parties, the happiness and safety of its inhabitants may be sacrificed in the gratification of private ambition or revenge. See Laborde's *View of Spain;* Townshend's, Swinburne's, and Burgoing's *Travels in Spain;* Dobledo's *Letters from Spain; Ancient and Modern Universal History;* Gibbon's *Roman History;* Robertson's *History of Charles V.;* Coxe's *Memoirs of the Kings of Spain;* and *Edinburgh Annual Register*, vols. v—xviii.

PART II.—STATISTICS.

Chap. I.—*Boundaries and Extent—Progressive Geography—Modern Division—Mountains—Rivers—Canals—Climate—Natural History.*

Spain, a kingdom, famous both in ancient and modern history, forms, along with Portugal, an extensive peninsula in the south-western division of Europe; and is separated from the Continent by a chain of mountains, which furnish it either with an easy communication, or a formidable barrier. It lies between 43° 44′ and 35° 57′ north latitude; and 21° and 8° 20′ west longitude from Paris, making its greatest breadth from Cape Creus to Cape Finisterre, 219 leagues, and its greatest length from Cape Ortugal to Gibraltar, 195 leagues. It is bounded on the north and north-east by the Bay of Biscay and Pyrenees; on the south and south-east by the Mediterranean, the Straits of Gibraltar, and the Atlantic; and on the west by the Atlantic and Portugal.

This Peninsula was first divided by the Romans into *Hispania Citerior* and *Ulterior*, but was soon after known by the names of Lusitania, Boetica, and Tarraconensis. *Lusitania* formed the western part, and had its limits marked by the Douro on the north, and on the south by the Guadiana, including in its extent Portugal, Leon, and part of Estremadura. *Bœtica* was surrounded on three sides by the sea and the Guadiana, and had for its eastern boundary, a line drawn from Cazlona to Murgis on the Mediterranean. It extended from Badajos to Cape de Gatte, and contained modern Andalusia and part of Estremadura. All the other parts of Spain were comprehended under *Hispania Tarraconensis.* This division, however, underwent some alterations under the last Roman Emperors, and was totally changed after the invasion of the Visigoths. But it is from the conquest of this country by the Moors that we must date the modern division of Spain; and the origin of the different kingdoms and principalities, which were progressively formed from the middle of the 8th to the end of the 15th century.

The geographical division of Spain most commonly adopted in modern times, is limited to fourteen provinces, kingdoms, or lordships, all of which are governed by a captain-general, except Navarre, the governor of which has the title of viceroy. These are

Biscay,	Murcia,
Asturias,	Valencia,
Galicia,	Catalonia,
Leon,	Aragon,
Estremadura,	Navarre,
Andalusia,	Old Castile,
Granada,	New Castile.

As all these provinces, except Valencia, have been already particularly described in this work, we shall content ourselves merely with references to the above articles, and proceed to a general account of the kingdom.

"No country of Europe," says M. Humboldt "presents so singular a configuration as Spain. It is this extraordinary form which accounts for the aridity of the soil in the interior of the Castiles, the power of evaporation, the want of rivers, and that difference of temperature which is observable between Madrid and other towns situated in the same degree of latitude." The interior of the country is an elevated plain, gradually declining towards the south-west; and the table-land of the two Castiles exceed in height and extent any of the same kind of Europe, having its mean elevation 300 fathoms above the level of the ocean.

The Spanish mountains appear to be arranged in distinct chains; but they are, in fact, ramifications from one another, and though separated by considerable intervals, are all linked to the same stock. "The first chain that we perceive," says Laborde, "on leaving Cape Finisterre, stretches along the whole of the north of Spain, and joins the Pyrenees; in this are the sources of the Minho and Douro, which throw themselves into the Atlantic, and that of the Ebro, the course of which is towards the Mediterranean. These mountains, advancing towards the south-east, divide the streams which flow into the Ebro from those which augment the Douro. On one side, they form the outline of Aragon, and on the other, that of Old Castile. They advance thus as far as Cuença and Molina, the names of which they take; and soon after give rise to the Tagus on the right, and the Xucar and the Guadalaviar on the left. Here we find the nucleus, and, as we may say, the knot of the whole chain, Mount Cayo, which seems to be the reservoir of all the waters that rise in springs around this point, and take their course towards the two seas. This same chain, still advancing towards the south, forms a mass from whence the Guadiana flows, and further on the Guadalquivir; it then stretches on and terminates at Cape de Gatte. Let us now reflect, that the rivers which rise within this chain, in a manner divide it, into so many large valleys and intermediate plains, yet leaving, in the intervals, considerable ramifications, all of which are attached to the principal trunk. Just as they all flow in parallels towards the ocean, so do the mountains which overhang and swell them with their waters, run in parallel ridges from the mountains of the Asturias in the north to the Alpuxarras in the south. Thus, the mountains of St. Andero, which join the Pyrenees, run along between the Douro and the sea. The mountains of Guadarrama, which separate Old from New Castile, run between the Tagus and the Douro. Another chain which divides New Castile from the plains of La Mancha, rises from the north-east to the south-east, between the Tagus and the Guadiana; in this we find the Sierra de Guadaloup. On the other side of the Guadiana, is the famous Sierra Morena, from which we descend into the beautiful plains of Andalusia, which are watered by the Guadalquivir, and overlooked by the last chain of mountains in Spain, the Alpuxarras, which extends to the coast." The other remarkable mountains, besides those mentioned in the preceding extract, are, the Sierra Nivada, situated nearly in the centre of the kingdom of Granada, and which takes its name from the circumstance of its summits being constantly covered with snow. It is seen from an immense distance, and is well known to mariners, its highest peak, called Mulahacen, being 1824 fathoms above the level of the sea. The Sierra de Mondonedo covers the whole extremity of the north-east of Galicia, and extends to the north as far as Cape Ortugal, and to the Atlantic ocean on the west. The Sierra d'Occa, one of the principal ramifications of the Pyrenees, stretches across the southern parts of Spain, and the Sierra d'Orihuela, a lofty and extensive mountain, is situated on the boundaries of Murcia and Valencia.

Spain abounds with rivers and rivulets, many of which become impetuous torrents upon the melting of the snows, or after heavy falls of rain. They expand themselves over the country, and sufficiently serve for the purposes both of commerce and of agriculture. With the exception of the Ebro, all the principal rivers run into the Atlantic, and some of them are navigable to a considerable extent. The Ebro rises in the mountains of Asturias, near Reinosa, and after pursuing a south-eastern course of about 380 geographical miles, enters the Mediterranean below Tortosa. This river was once navigable as far as Logrono, about 60 leagues from its embouchure, but at present it is very difficult of access, being obstructed by shifting banks of sand, which increase and diminish in size, and which change their situation after storms and the swelling of the water. The Guadalquivir, the ancient *Boetis*, which gave its name to the district of *Boetica*, has its source in the Sierra Morena. It flows into the Gulf of Cadiz, a distance of 300 miles, and is navigable for large vessels as high as Seville. The Guadiana originates near Cuidad Real on the north side of the Sierra Morena. Where it springs from the ground, it forms several small lakes; and the apertures through which the water flows, are called the eyes of the Guadiana. It falls into the Gulf of Cadiz, and its circuit is nearly equal to that of the Ebro. The Minho rises in the Sierra Mondonedo and is said to derive its name from *minium*, or vermilion, which is found in abundance in its neighbourhood. It separates Galicia from Portugal, and falls into the Atlantic, after a course of 160 miles. The Douro springs near the ruins of the ancient Numantia, on the frontiers of Aragon and Navarre, and crossing Leon and Portugal, reaches the Atlantic below Oporto. Its course is 350 miles. The Tagus has its source near Albarrazin, in a spring called Abrega, and holding a course of 450 miles, embouches into an arm of the Atlantic in Portugal. The other rivers of less importance are the Guadalaviar, the Xucar, and the Sagura, which run into the Mediterranean, and the Ansa, which empties itself into the Bay of Biscay.

Many attempts have been made to improve the inland navigation of this country, but almost every project has had a similar result, and still remains unexecuted. The navigation of many of the rivers, which in the time of the Romans, were covered with barks and gallies, has been completely neglected, and has become impracticable. During the reign of Philip II. in 1580, the navigation of the Tagus was established from Lisbon to Alcantara. It was afterwards, according to a plan of Jean Baptiste Antonelli, carried as far as Toledo; and at the lower part of that city, the quay where the boats were loaded and discharged, still bears the name of *Plazuela de las Barcas.* This navigation, however, entirely ceased in the beginning of the 17th century, but the cause of its cessation is unknown. In the succeeding reigns, various plans were suggested for again opening the river, and also for cutting canals from Madrid to Aranjuez, and from Aranjuez to Alcala de Henarez, which, however, were never carried into effect. The establishment of canals between the inland and maritime provinces, have also been frequently attempted, but none of them have been fully executed. Of these, the most important is the canal of Aragon. It was begun in 1529, and after frequent and long interruptions, it is now brought nearly to a conclusion. But the success of this enterprise was greatly owing to the efforts and indefatigable zeal of a citizen of Saragossa; and to him Aragon is chiefly indebted for the revival of its industry and its commerce. This canal commences near Tudela, in the kingdom of Navarre, and from thence to where it discharges itself into the Ebro, its extent is about twenty-six leagues and a half. It has been proposed to carry forward this undertaking to the opposite coast, through Navarre and part of Biscay, which would thus form a communication between the Bay of Biscay and the Mediterranean. Several bridges are constructed upon it; and it has every where outlets to convey the water to the neighbouring lands, for the purposes of irrigation. This canal has cost upwards of £135,000 sterling. The canal of Campos, which was intended to open a communication between Old Castile and the Douro, passing by Valencia and Duenas, and extending to Segovia, is still in an unfinished state; and even the part of it which had been completed, has been so entirely neglected, that the excavations are insensibly filling up by the falling in of the earth. The canal of Manzanarez was undertaken for the purpose of supplying Madrid with provisions and other articles. It was to extend from the bridge of Toledo as far as the river Xarama, which was to be rendered navigable to form a communication with the sea. A part has been executed, and seven sluices constructed; but the scheme appears to be relinquished. Another canal was projected and determined upon some time ago, to open near the palace of the Escurial, extend to the Tagus, join the Guadiana, and abut on the Guadalquivir, below Anduxar. This canal would have passed through great part of Spain, and would have been attended with the most solid advantages; but the death of Le Maur, who furnished the plan, and was commissioned to see it constructed, suspended this important enterprize. Various similar undertakings have been in contemplation, both for the purposes of commercial communications, and the irrigation of the country, but they have been abandoned, or permitted to languish through the want of resources.

The climate of Spain is greatly influenced by local causes, such as elevation of site, proximity to the sea, or to a chain of mountains, &c., for while the mean temperature of the elevated plains is 59° of Farenheit, that of the coast from the 41° to the 36° of Lat. is between 63½° and 68 degrees. But, in general, it is very dry, and consequently exposed to severe droughts, which have frequently occasioned famines and epidemic diseases. Mariana mentions that, in 1210, "a great scarcity was felt in the kingdom of Toledo; there was not a drop of rain for nine successive months, insomuch that the husbandmen were forced to quit their lands and their dwellings, to seek an asylum in other provinces." It has, however, been deservedly praised as equal if not superior, to that of any country in Europe. According to Laborde, "the climate of New Castile is more mild than that of the old; in the former the winters are temperate, and the summers very hot: in the latter, the plains are very temperate, and the mountains as well as the parts bordering on them, very cold; there are even some parts of the low country where the cold is severely felt in winter. The skies of both are very fine, almost always clear, serene, and of a beautiful blue, but those of New Castile are the most constantly so; in some parts of the old, it is often cloudy.

The climate of Valencia is very temperate in winter, hot in summer, but refreshed by breezes from the sea; dry in the interior, somewhat moist in the plain of Valencia, generally inconstant, and subject to winds. The sky is usually clear and blue, except in the plain of Valencia, where the atmosphere is slightly thickened by the vapours rising from the great quantity of water collected there for the purpose of irrigation.

Catalonia, considered with regard to its numerous plains, is the most temperate province of Spain; the winters with some exceptions, are mild, and the heat of summer is not often extremely violent; but the hills and valleys bordering upon the Pyrenees are very hot in summer, and cold in winter, at which time the summits are covered with ice and snow. The higher parts are here less subject to variations of the atmosphere than the lower: these latter, especially on the side of Barcelona, experience continual changes: it varies rapidly, sometimes in the same day, from hot to cold, from dry to wet, from calm to stormy, and from a clear sky, to rain or cloud. The air is dry in the interior, and moist on the sea coast, especially in the basin in which Barcelona is situated. The east and south-east winds are those which blow with most frequency and violence in the parts near the sea. They bring with them a constant moisture and often rain.

Aragon is much drier and cooler than Catalonia; its temperature is even rather cold than hot: yet its plains and valleys are sometimes scorching, and a keen cold is felt upon its mountains. Winds are frequent and violent. The sky is clear, and more constantly so than in the maritime parts of Catalonia. The vicinity of the Pyrenees renders storms frequent in this province during the summer.

Navarre being situated among the Pyrenees, is a cold tract: its winters are usually very severe.

Biscay, comprehending the three districts of Biscay, Guipuzcoa, and Alava, is cold; the winters are sharp, and the summers temperate; it is dry in the interior, and moist on the coasts, where the cold is less felt. The sky is often cloudy and the air loaded with fogs.

The Asturias are mild near the sea, but cold farther up the country and upon the mountains: there are frequent and violent winds; the sky is seldom very clear, but rather cloudy; the air is moist and it rains frequently.

The climate of Galicia is very similar in all respects; its sky is the most cloudy of any in Spain, and more rain falls here than in any other part.

The climate of the kingdom of Leon varies in different tracts. In the eastern part it is very similar to that of Old Castile; in the north and west it resembles that of Galicia; and in the south it is similar to that of Estremadura.

Estremadura is a very hot and dry country, where the heats of summer are very violent, and the winters extremely mild. Its air is usually very dry, and its skies are perhaps the finest and brightest of Spain.

Andalusia is very hot on the coast, temperate in the interior, very cool at the foot of the mountains, and cold on their summits. It is a dry country, though watered by several rivers, and is exposed to several winds, especially near the sea. The east is the most prevalent near the Mediterranean; and a wind sometimes blows there from the south-south-east called the *Solano*, which has a very dangerous effect upon the human frame, and occasionally produces a state very similar to phrensy.

The climate of Murcia is cool upon the mountains, temperate towards the sea and at the foot of the mountains in the south, but very hot in the valley which is watered by the river Segura, and in which the city of Murcia stands, as well as in the Campo de Lorca, and burning in that of Carthagena. It is very dry, except in the valley of Segura, where it is almost always moist. The skies of this kingdom are most beautiful, almost always clear, bright, calm, and of a brilliant blue; on which account this country has been named the most *serene* kingdom of Murcia."

The natural history of Spain presents a vast field of inquiry, but it has hitherto been but little cultivated; so that our account of this department of science must be very general and imperfect. The highest ridge of mountains, between Daroca and Saragossa, are composed of argillaceous schistus and freestone, probably resting on granite. Those in the neighbourhood of Ansuela are limestone with shells, and sometimes contain beds of red gypsum with crystals of the same colour. The mountains north of Madrid, and also those surrounding Toledo are granite; and those to the north of Leon, which rise in bold and rugged rocks, are chiefly marble or limestone resting on a basis of argillaceous schistus. The higher regions of the Sierra Morena are granite; the lower, argillaceous schistus with gypsum and limestone; and the branches of the Sierra Nivada near Malaga present limestone and marble, surmounted by argillaceous schistus. On the south-east of the city of Granada are found rocks, which, on a basis of shingle, present sandstone with shells, surmounted with pudding stone; but in general the rocks are gypseous with strata of the same substance crystallized. The soil of La Mancha is sandy, and the rock gypsum; in fact gypsum appears to be as abundant in Spain as chalk is in England. The south-east part of the kingdom seems calcareous. The mountain of Montserrat in Catalonia is a compound of calcareous stone, sand, and pebbles, cemented together, and forming the kind of aggregation known by the name of pudding stone; and the cathedral of Murcia is built with a kind of limestone resembling the roe of a fish. The hills near Cape de Gatte are supposed to be volcanic.

The gold and silver mines of this country must in former times have been both numerous and productive, as the Carthaginians drew immense quantities of the precious metals from their colonies in Spain; and afterwards the Romans, when it became a province of the empire, explored its treasures with extraordinary success. Polybius informs us that the silver mines near Carthagena yielded 25,000 drachms daily. "Cato, after his proconsular government of this province, brought into the treasury of the republic no less than 25,000 lbs. of silver in bars, 12,000 lbs. of coined silver, and 400 lbs. of gold. Helvius from his province of Andalusia alone, brought into the treasury 37,000 lbs. of coined silver, and 4,000 lbs. of silver in bars. Minutius exhibited on his triumph 8,000 lbs. of silver in bars, and 300,000 lbs. of silver coin: and Flaccus returned from Spain with a treasure of 124 crowns of gold, 31 lbs. of gold in bars, and 70,000 lbs. of coined silver." Many vestiges of gold and silver mines are still in existence, but scarcely any of them are in operation; and what are so are very unproductive. Several, which were in a state of activity in the seventeenth and eighteenth centuries, are now abandoned, either in consequence of an influx of water, or for want of resources. Mines of lead and also of copper are very numerous and considerably abundant. The principal lead mine, which is wrought on the king's account, is near Linares, in Andalusia. The ore, which is galena, when analyzed, produces from 60 to 70 and 80 lbs. of lead per quintal, and three quarters of an ounce of silver. It is wrought at a small expense, and furnishes annually about 12,000 quintals of lead. Iron abounds in almost every province, but the most celebrated mine of this description is that of Samosostro in Biscay. The ore forms an irregular bed between three and ten feet in thickness, under a stratum of whitish calcareous rocks; and is of the species called by mineralogists *spathose iron*. It yields about 30 per cent., and the metal is soft and ductile, and perhaps the most malleable of any in Europe. A mine of antimony, belonging to the king, is wrought near Santa Cruz de Mudela, in La Mancha. The ore is very abundant and rich, the mineral being in almost a pure state; and sometimes lumps of metal will occur, weighing from two to three hundred pounds. A very abundant and productive mine of mercury and cinnabar united, also wrought for the king's benefit, is situated in La Mancha, near Almaden. The cinnabar is generally mixed with a large proportion of pyrites; but is often found in masses of great purity, one lb. of ore yielding ten ounces of mercury. Mines of rock-salt, and also salt springs and marshes, are found in many parts of Spain.

Three of the most productive of the former, with two of the latter, besides five salt pits in the environs of Cadiz, belong to the king. The two salt marshes furnish annually about 6000 tons, and the five pits about 1,600,000 quintals of salt. But the most remarkable mass of this mineral is the mountain of salt near Cardona in Catalonia. It is nearly three miles in circumference, and 500 feet high, without cleft or crevice. The salt of which it is composed is very white; and the river Cardonero, which washes its base, is so impregnated with salt that fish cannot exist in its waters within three leagues below the mountain. Some beautiful specimens of this substance, perfectly transparent, are manufactured at Cardona into various ornamental articles, such as crosses, figures of saints, chandeliers, &c. Amethysts, agate, chalcedony, and garnets are found near Vich, in Catalonia, and at Cape de Gatte, in Granada; and the marbles of Spain are abundant and valuable.

With respect to the botany of Spain, we refer the scientific reader to the Flora Hispanica of Joseph Quer, and the work of Cavenilles; and must confine ourselves to a few general notices on the subject. While the plains of this extensive country produce a great variety of curious and useful vegetables, the mountains are covered with rare and valuable plants well worthy the attention of the enterprising botanist, particularly Gaudaloupe, in Estremadura; Moncayo, in Aragon; Pineda, Guadarrama, and Cuença, in New Castile; Carascoy, in Murcia; Pena-Colosa, Mongi, Aytona, and Mariola, in Valencia; and the Pyrenees. The extensive and arid tracts of heath present a gayer and richer profusion of plants than those of any country in Europe. Among the thick woods of the yew-leaved fir, and stone pine, and the groves of cork trees, "the traveller is regaled with the fragrance of numberless aromatic plants, the mastick thyme, spike lavender, common and Spanish sage and rosemary. The golden blossoms of the gorse, a plant chiefly found in England and in Spain, and the crimson, flesh-coloured, and snowy flowers of the arborescent heaths mutually heighten each other; the elegant lithospermum fruticosum entangles itself among the thickets of dwarf myrtle, and every spot of sand or dry rock, forsaken by other vegetables, is adorned and perfumed by the cistus; of this plant there are no less than fourteen species natives of Spain, all of them eminently beautiful for their broad silken blossoms of pure white and yellow, with deep crimson eyes; the laurel-leaved cistus is most frequent in Old Castile, but the commonest of all is the gum cistus, a most elegant and fragrant shrub from six to seven feet high, which occupies whole miles of dry rock, and, on this account, forms a very peculiar feature in the scenery of Spain." The flat sandy tracts on the sea-shore are occupied by the sea daffodil, and some coarse kinds of grass; and in the neighbourhood of Alicant and Barcelona are extensive plantations of the *falsola fativa*, from which are manufactured annually some thousand tons of barilla, which is partly exported, and partly used for the preparation of fine Spanish soap. The calcareous rocks on the coast abound with samphire, tree violet, tragacanth vetch, caper bush, and esparto grass; this last, on account of its extraordinary toughness, is used for making ropes, mats, chair bottoms, and other similar purposes. In the woodlands the trees are neither so large, nor is the foliage so ample, as in England and Germany. There are several clumps of chestnut and box; but the great mass of the woods consists of the evergreen sweet oak, intermixed with the wild olive, the kermes oak, the walnut and carob tree. The almond, along with the sumach, fix themselves in the crevices of the rocks; and the laurel, the bay, the lauristinus and Portugal laurel attain to such a height as to afford a cool and shady summer retreat. In deep and rich soils a number of beautiful bulbous rooted plants appear in early autumn and spring, of which the most common in the Spanish landscape are, two species of asphodel, yellow amaryllis, jonquil, clustered hyacinth, dog's tooth violet, orange and martagon lily, and wild tulip. The banks of the rivers are adorned with the oleander, laburnum, tamarisk and myrtle; the fallows and dry thickets abound with the fan-palmetto, yellow lupin, Spanish and white broom; and in the hedges are found the laurel and common passion flower. The high mountains in the maritime districts are crowned with the finest timber; the oak, the lime, the birch, the mountain ash, the yew, the beech, the larch, the holly and the juniper, grow to a considerable size. In the interior provinces, however, trees are very rare; and whole districts are almost entirely destitute of wood.

Besides the domesticated animals, of which the most important in Spanish zoology are the horse, the mule, and the sheep, wolves are met with in all the higher and mountainous parts of the country; wild boars are found in some of the mountains of Valencia; lynxes and ibexes in the Sierra de Cuença, and in the valleys of Gistau and Aure; and roebucks in Navarre. Bears occur in several parts of the great Pyrenean chain, and especially on certain mountains in Aragon and Old Castile. In general, the birds, quadrupeds, reptiles, and insects of this country, are the same as those found in the southern provinces of France. The rivers abound with fish, of which those in highest estimation are from the river Tormes, some of them weighing above 20 lbs. The tench of some lakes in New Castile are remarkably fine and delicate, and are taken in great plenty during the months of May and June. The *Coccus ilicis*, or gall insect, familiarly known by the name of *Kermes*, which affords the fine crimson dye, so highly esteemed by the ancients, abounds in many parts of Spain. These insects feed upon the leaves of the *Quercus ilex*, or ever-green oak, and are collected in great quantities as an article of commerce, or of domestic manufacture.

Chap. II.—*Agriculture—Soil—Productions—Forests—Pastures—Domestic Animals.*

From the genial nature of the climate, and the general fertility of the soil, Spain, in the reign of Augustus, became the granary of the Roman Empire. It continued to be an exporting country until the expulsion of the Moors, when the Spaniards, deprived of the skill and industry of this people, and unaccustomed themselves to agricultural pursuits, allowed some of their most productive districts to lie waste; and, at present, this country is under the necessity of importing from foreign states a large supply of corn for the subsistence of its scanty population. Scarcely two-thirds of the land is now under cultivation. Commons are so frequent that, for six, eight, or ten leagues together, not the smallest trace of culture appears: and what land is under tillage, with the exception of a few districts, presents only a languid system of slovenly husbandry. Many attempts have been made at different times, and by various encouragements, to rouse the spirit and invigorate the system of agriculture; but a variety of obstacles are still in operation which tend to impede its advancement, and also the prosperity of the country. The principal of these obstacles are, 1. The deficiency of agrarian strength; and, 2. The *Mesta*, or the privileges granted to sheep proprietors in preference to agriculturists.

Spain does not nearly possess power adequate for the cultivation of her territory. Out of a population of above ten millions, scarcely two millions and a half are employed in husbandry; and this diminished number is owing to several causes:—1. The facility afforded in this country for persons to enter into the church, which induces many to become students who would otherwise be employed in agricultural pursuits. These receive their education at the monastic school, and often depend entirely upon public alms for their subsistence. 2. The crowd of mendicants and vagrants which infest every corner of this kingdom. 3. The great number of officers belonging to the different judicial courts and departments of government. 4. The swarms of domestics which are here retained as a principal object of luxury, and the greater part of whom are unprofitable, and even injurious to their master's service. And 5. The continual emigration from Galicia especially to Portugal, where from sixty to eighty thousand Spaniards are generally reckoned to reside. This want of agricultural strength is greatly aggravated by the loss of much time, arising from the multiplicity of feast days, the heat of the climate, and the indolence of the peasantry. The Spanish labourers consume a great part of the day in taking their *siesta*, and smoking their *cigarros;* and besides the usual feast days, which are now abridged to forty-one, and when they are obliged to attend mass, they seldom neglect to celebrate the different feast days of the titular saints of particular parishes, the patron saints of private families, and the guardian saints of individuals, which is just so much valuable labour lost to the community.*

The greatest obstacle to agricultural improvement, however, is the *Mesta*, which is a name given to an incorporated company of proprietors of migratory sheep, who are endowed with particular privileges highly prejudicial to the interests of agriculture. This association is formed chiefly of the nobles, persons in power, members of rich monasteries, and ecclesiastical chapters. Their flocks are united into one collective body, which does not strictly attach to any district, but travel backwards and forwards twice in the year, passing part of it in one place and part in another. The pastures upon which they feed are similar to the commons in England, and are denominated *waste lands*, which are prohibited by the legislature from ever being enclosed, or brought into a state of cultivation. These flocks they call *Merinos* or *transhumantes*, and consist usually of about 10,000 sheep in each. The number of the whole has varied at different periods, but at present they may be estimated at nearly 5,000,000. Each flock is conducted by an officer called a *mayoral*, who has under his authority fifty shepherds, with as many dogs. He has the sole management of the sheep, directing their route and choosing their pastures. They commence their migrations the latter end of April or beginning of May, and leaving the plans of Estremadura, Andalusia, Leon, and the two Castiles, where they winter, they repair to the mountains of the two latter provinces, and those of Biscay, Navarre, and Aragon. Toward the end of September, they descend from the mountains, and again repair to the warmer parts of the country, generally wintering on the same pastures, which they had grazed the preceding year, and where most of them had been yeaned. "The journey which the flocks make in their peregrinations is regulated by particular laws, and immemorial customs. The sheep pass unmolested over the pastures, belonging to the villages, and the commons which lie in their road, and have a right to feed upon them. They are not, however, allowed to pass over cultivated land, but the proprietors of such lands are obliged to leave for them a path ninety *varas*, or about eighty-four yards in breadth. The whole of their journey is usually an extent of one hundred and twenty, thirty or forty leagues, which they perform in thirty or thirty-five days." The Mesta has its peculiar laws, which are digested into a code entitled, *Leys y ordenanzas de la Mesta*, and there is also a particular tribunal consisting of four judges, under the title of *Honrada consejo de la Mesta*, whose jurisdiction extends to all matters that are in the slightest degree connected with the interests of the mesta, and who are particularly watchful against any infringement of its privileges. Of the numerous grievances to which this system has given rise, the following are stated by Laborde as the most vexatious, and the most opposed to agricultural improvement. 1. The number of persons it employs is very great, 40,000 or 50,000, which are so many subjects lost to the state, as to the purposes of agriculture and population, as they almost never marry. 2. An immense extent of highly valuable land is converted into pasturage, and produces comparatively nothing. 3. The cultivated lands which lie near the route of the flocks to and from the mountains, are subject to continual trespass, which is committed with impunity, for in vain do the owners appeal against such abuses, and solicit indemnity. The damages sustained on these occasions are so much greater, owing to the season of the year in which the journeyings of the flocks are made. The first is when the corn is generally far advanced in its growth, and the second when the vines are loaded with grapes. 4. The commonable pastures also, which are in the line of the route, are equally devastated, so that the flocks belonging to places in the vicinity can scarcely find a bare subsistence. 5. The flocks of the Mesta are unprofitable for agricultural purposes, for never being folded upon the arable land, they consequently contribute nothing towards their fertilization. The directors and shepherds are dreaded in every

* The Count de Capomanez calculates the sum lost every feast day by the suspension of labour, comprehending tradesmen, manufacturers, &c., as well as husbandmen, at sixteen millions of reals, equal to £166,666, 13s. 4d., and this for forty-one feast days amounts to £6,833,333, 6s. 8d. sterling.

place through which they pass, for they exercise a most insufferable despotism, the consequence of the improper privilege which they possess, of bringing whoever they may choose to insult before the tribunal of the Mesta, whose decisions are almost invariably in favour of its servants.

These grievances have frequently called forth the protestations of the public, and even the general states of the realm have repeatedly requested the suppression of the Mesta. But for a long series of years these calls were made in vain, till towards the middle of the 18th century, when the government found itself obliged to pay some attention to such powerful appeals. A committee of inquiry was then formed, and has continued for above half a century, but without proposing one remedy for any of its evils, so that the interest of a few powerful individuals still obtains the advantage over the public good. In a memoir, addressed to the Supreme Council of Castile, by the Patriotic Society of Madrid, on the advancement of agriculture, and drawn up by one of its ablest members, and a disinterested patriot, Don Gaspar Melchor de Jovellanos, we find the following observations on this subject: "The members of that body, (the Mesta,) have always aimed at soliciting peculiar privileges, and having been sufficiently powerful to obtain and extend them, have invariably given the most decided resistance to every system proposed for enclosure. Not pleased with possessing the privilege of keeping lands, once under pasturage, for ever in the same state; not content with preserving and extending the *canadas*, (roads for the sheep); not satisfied with the right of successively participating in all the public pastures, and obtaining an universal fictitious franchise, directly in opposition to the meaning and intent of the ancient laws; the Mesta wishes also to alienate individual property. Its laws perpetuate the prohibition of enclosures; its courts support this prohibition with increasing zeal; its oppressions eternize the laying open estates, and by its undue influence and authority the liberty of proprietors and their tenants is annihilated." "Even the very existence of such a pastoral assembly, on which such privileges have been conferred, is an outrage upon all law and reason, and the one by which it subsists the most prejudicial of all. Were it not for the existence of such a fraternity, which combines the opulence and power of the few against the imbecility and wretchedness of the many, and who form a body capable of resisting the representatives of the provinces, and even of the whole nation, who, for two centuries past, have found all their zeal vainly exerted in favour of agriculturists, and proprietors of stationary cattle; were it not for such a fraternity, how could privileges so unbounded and shameful be maintained." "Sufficient has been advanced, and the subject is so evident, that you should not refuse to pronounce a prompt sentence of dissolution upon this powerful association, annul its abused privileges, abrogate its unjust regulations, and suppress its oppressive tribunals. Then would disappear for ever that convention of nobles and monks, turned shepherds, who traffic under the revered sanction of political magistracy. This would eventually produce subsistence for stationary cattle, restore liberty to agriculture, to property its just rights, and allow reason and justice to exercise their proper offices."

There are various other impediments in this country to the progress of agriculture, of minor importance indeed when compared with the Mesta, but which all form additional discouragements to its improvement, namely, the difficulties attending the transporting of heavy articles, particularly in the central provinces, from the want of canals and good roads; the uncertainty of a market for farm produce, owing to the frequent changes in the laws respecting exportation; the high price of labour, and the various imposts, tolls, and taxes, which the local magistrates lay upon the productions of the soil, according to the price for which they are supposed to sell.

The soil of Spain is almost in every part excellent; and it requires only a little assistance to render it both valuable and productive. But the industry of the inhabitants is paralyzed by the oppressive restrictions and exactions of the government. Their implements of husbandry are in general rude and imperfect. The plough in many provinces is composed entirely of wood, and has neither coulter, fin, nor mould-board; but instead of these, some of them have two wooden pins placed near the tail of the share, and so disposed as to lay the furrow in high ridges; and others have only the tail of the share divided, so as to perform the same operation as the heel and ground wrist of our ploughs. Mr. Townsend has given a description and drawings of several of these ploughs. Those near Oviedo he represents as of the most clumsy construction. The coulter is fixed in a beam by itself, with two oxen and a man to work it; the plough then follows in the same tract, the point of the share only being shod with iron; and although the land is mostly strong and requires to be well ploughed, this instrument merely scratches the ground. There the harrows have no iron, and are used only for maize; the wheat and barley being always left unharrowed. In Catalonia they use a light plough drawn by two oxen, or one strong mule, and their harrows have iron furniture; but instead of a roller to break the clods they use a board, on which a boy stands, and drives the mule which draws it. In the rich vale of Huerta near Alicant, and also in the vale of Valencia, the earth is never allowed to rest. They use a one-horse plough, and never attempt any thing more than to pulverize the soil, which is easily done, as it is mowed eight or ten times a-year. "Wheat is put into the ground the beginning of November, and is reaped the middle of June, when they obtain from twenty to forty for one. Barley is sown in October, and in May they receive from eighteen to twenty-four for one. Oats are in the ground from the middle of October to the middle of June, and yield from twenty to thirty for one. Maize follows the barley as the second crop in the same year, and with a favourable season gives at the end of October a hundred for one. Rice, commonly sown about the first of April, is transplanted in June, and in October rewards the farmer forty fold. Beans may be put into the ground either early in the autumn, or in the beginning of the year. Hempseed is scattered on the land in April, and is cleared about the middle of July. The intermediate crops are vetches, cabbages, cauliflowers, carrots, turnips, cucumbers, melons, sandias, and a variety of other esculents. Thus with a warm sun, plenty of water, and a rich choice of crops, suited to every season of the year, the grateful earth repays the labours of the husbandman at least three times in the course of twelve or thirteen months." In some places particularly on the coast, they often sow barilla for a fallow crop, which is one of the most valuable productions of the country. After the land is well manured and ploughed they smooth its surface with boards instead of harrows, and sow the seed only in wet weather in January and February. When the plant is about the size of a shilling, they clear off all the weeds, and in September they collect the crops, which yield from ten to twelve quintals on a fanega of land, about an English acre. This crop, however, is liable to be instantaneously destroyed even at the moment of harvest, by a beetle, a species of *scarabeus*, depositing its larva in the roots of the plant. The foxes also are particularly fond of it, and will in one night lay waste an entire field.

A very particular mode of cultivation prevails in Biscay. The ground is dug up with an instrument called a *laya*, which resembles our dung grape with one of the outer prongs taken away, and the clods being broken with a mattock, are left to pulverize during winter by the action of the frost. In the spring the clods are again broken by means of harrows and wooden beetles, and afterwards levelled by a cylinder; deep holes about two feet apart, and in a straight line, are then made with hoes, in which are deposited seeds of Indian corn, French beans, peas, pompions, &c. and filled up with manure. When the plants appear above ground, the suckers both of blossoms and ears are cut away, and, when dried, constitute an excellent fodder for cattle. After the crop is cut, which happens about the end of September, the land is sown with corn without any farther preparation than covering the seed with the plough. In the course of the winter it is hoed to destroy the weeds, which operation is repeated in May and June; and the harvest commences about the end of August, when the stubbles are depastured. The light lands are allowed to rest for one year; but the stronger lands a few months after, undergo the process of the laya, and are again manured and cropped.

The manures generally employed are dung from the stables and sheepfolds, and the sweepings of houses and streets. In some districts of Guipuzcoa, the fields are covered with a marly earth which greatly fertilizes the land; and in Valencia the upper layer of the high roads, which is supposed to be impregnated with excrementitious particles, and the sand from the unpaved streets, which has been long subjected to the tread of animals, are carefully collected, and form an excellent manure for strong soils.

In a country like Spain, however, where the soil is generally dry, and the climate warm, nothing in the shape of manure is so beneficial to the land as regular irrigation. "In the northern provinces, situated at the foot of the Pyrenees, and the mountainous country branching from that Alpine chain which extends far into the interior of Spain, scarcely a district can be found where irrigation would not multiply threefold the produce of the soil; and there are large tracts of land which can yield nothing, or at best a scanty pasturage, unless assisted by the benefits of irrigation." This fertilizing system, however, is either neglected or not properly understood throughout the greater part of the kingdom. The lands which lie contiguous to rivers or streams are made to profit a little by their situation; but the art of conveying water above the level of the land by means of canals, and distributing it properly over the surface according to the quality of the soil, is very seldom practised. In Asturias, owing to the mountainous nature of the country, it would be difficult and expensive to profit in this way by its numerous streams; but the rivers of Leon, which supply a vast body of water, are suffered to run unheaded through extensive plains, without the inhabitants deriving the least advantage from them for agricultural purposes. The practice of irrigation is equally limited in Old and New Castile, though these provinces are watered by a multiplicity of rivers. It is almost entirely neglected in Aragon, and it scarcely deserves to be mentioned in Estremadura and La Mancha. But Catalonia, Valencia, Murcia, and some parts of Andalusia, form an exception to this general indifference to the means of agricultural improvement. In these provinces the system of irrigation is extensively and successfully prosecuted; and in Granada the skill and industry of the Moors are perpetuated by the numerous reservoirs and canals still in existence, which they formed for the purposes of watering and fertilizing their land.

Spain produces a great quantity of wheat, which is of a most excellent quality, plump, well grown, and well flavoured. It yields a very white flour, and a small quantity of bran, and the pellicle or skin is so thin, that, in the process of grinding and dressing, it does not lose more than a fifteenth, while the corn of the north of Europe loses a fifth. The difference which exists in the quality and quantity of bread produced from a given measure of each is also very considerable; and it is on this account that the wheat grown in Andalusia sells at Seville for nearly double the price of that imported from the north of Europe. The principal wheat districts are Andalusia, Old Castile, Aragon, and Murcia, which, besides supplying their own population, grow a sufficient surplus to satisfy the demands of the neighbouring provinces; while few of the other provinces produce what is necessary for the consumption of their inhabitants. Barley and maize are cultivated to a considerable extent throughout the kingdom; very few oats are grown; and rice is confined chiefly to Catalonia and Valencia. The crops in this country, however, are often exposed to severe droughts; and a hot and blasting wind occasionally prevails which instantaneously blights and scorches the tender blade. Severe scarcity is sometimes the consequence; but the disastrous effects of famine are in a great measure prevented by the judicious measures of the government, who many years ago formed an establishment, by which subsistence is provided for the inhabitants, in case of ungenial seasons or bad harvests. "Magazines or store-houses, denominated *positos*, are erected in various parts of the kingdom to the number of more than five thousand. When it is requisite to establish any of these granaries, every occupier of land is obliged to bring and deposit a certain quantity of corn proportionate to the extent of his farm. The following year he takes back the corn he had thus deposited and replenishes the empty garners with a larger quantity, and thus he continues annually to increase the stock, by these increments called *creses*, till a certain measure of grain is deposited; then every one receives back again the whole corn which he has furnished, and replaces it by an equal quantity of new corn. Whenever a scarcity happens, these repositories are opened and the corn dealt out to the people at a moderate price. In some places seed corn is also distributed to necessitous husbandmen, who are bound to restore as much in lieu of it the ensuing harvest."

Though flax is produced of an excellent quality, particularly in the central provinces, yet its cultivation is much neglected. More attention seems to be paid to the raising of hemp, which is successfully and profitably cultivated in Biscay and Galicia. A considerable quantity, about 168,000 quintals, is grown in Catalonia, Valencia, and Aragon; and it also forms a part of the produce in some parts of Andalusia and Old Castile. The hemp and flax raised in the interior districts of Spain are of a shorter and finer fibre than those of the northern provinces, and are consequently better adapted for general use, and capable of being better and more expeditiously bleached.

The sugar-cane at one time was extensively cultivated in Spain, but owing to the introduction of West India sugar, this species of produce is now almost entirely neglected, except in Granada, where a sufficient quantity is still raised to supply a considerable manufacture of sugar, and the canes produced in this country are usually disposed of to Provençal merchants, who buy them for the purposes of fermentation. Madder is grown in several of the provinces, but particularly in Old Castile and Andalusia, where are reckoned above two hundred mills for grinding the root, and which produce annually 7500 quintals of fine madder. The plants from which soda is made are almost all indigenous in this country. Some of them are cultivated with great care, especially *barilla*, (the *Salsola soda* of Linneus,) and *agua-azul*; but others grow wild in great abundance. The largest plantations of the former are found in Murcia and Valencia, which alone furnish 300,000 quintals of soda. The cultivation of saffron has long been on the decline, and is now confined chiefly to Murcia, which supplies annually about 150 quintals. Honey is produced in every district, but that which is most esteemed for the delicacy of its flavour is collected on the mountains to the north of Alicant in Valencia. The mountains of Cuença afford about 1000 quintals of honey, and forty-one and a half quintals of wax.

Though the soil of Spain is in general favourable to the growth of fruit trees, yet their cultivation in the interior and western provinces is entirely neglected; but in the other districts of the kingdom almost every species of fruit is produced. "Catalonia produces a considerable quantity; several districts in Aragon have scarcely any but fruit bearing trees; Biscay and Guipuzcoa abound with varieties; the four kingdoms of Andalusia are still more abundant; and the whole of the kingdom of Valencia is covered; the latter, in conjunction with Aragon, supplies Madrid and the greater part of New Castile. The fruit of Biscay, Guipuzcoa, and Catalonia is good; of Aragon and Andalusia, excellent; and that of the kingdom of Valencia the most beautiful, but less succulent and less delicate in the flavour."

Olive trees abound in almost every part of the country, but there is a considerable difference in the flavour and size of the fruit. The olives of Aragon are sweeter than those of Catalonia, and both are surpassed by those of New Castile. The olives of Valencia, and also those which grow in the vicinity of Seville are very large and beautiful: and as they contain a small quantity of oil, are more agreeable to the palate, and are generally preferred for eating. The olives of Seville were in high estimation among the Romans, and still retain their celebrity: but the best and most adapted for pickling are those grown in the districts of Alcala and Guadayra. The oil, however, of Spain is by no means equal to the fruit, and this arises from the way in which it is extracted. Oil of the finest quality might be obtained were only the necessary precautions taken in its manufacture. But the fruit is often over ripe, black and shrivelled, before it is gathered; the putrid and sound are indiscriminately mixed together, and it is allowed to remain for some time collected in heaps before the oil is expressed, all which tends to produce that sharp and often rancid flavour which is so observable in Spanish oils. In some districts, however, more attention is paid to the manufacture of this article; and when proper precautions are used, olive oil is produced not inferior in quality to the best oil of Provence. The principal oil districts are Granada, Seville, New Castile, Aragon, Catalonia, Murcia, and particularly Valencia. The annual produce of the three last provinces is about 266,600 quintals; and the district of Malaga contains 500 oil presses constantly at work during the season.

Almonds are very abundant in Catalonia, and in the environs of Malaga; but the most delicious are those which are grown at Ibi in Valencia. There they have a particular method of cultivating almond trees. They engraft them on the wild almond, which is supposed to bring them sooner to perfection. The fruit produced in this way is superior to any in Spain. The husk is smooth, and they keep fresh for several years, while the others often spoil in a short time. Fig trees are very numerous in Biscay, Aragon, and Catalonia; but the greatest quantities grow in Valencia and some districts of Andalusia. Those in the neighbourhood of Jaen and Ronda are most esteemed. Quantities of this fruit are dried both for exportation and home consumption: and Andalusia exports annually, by the port of Malaga alone, nearly 100,000 quintals. Nut trees are very general throughout Spain, but they are most successfully planted in Biscay and Catalonia; the latter province producing annually 105,000 bushels, of which 78,000 are exported.

This country abounds in vines, especially its eastern and southern provinces, but they are most numerous in Andalusia; and the kingdoms of Seville and Granada are usually denominated the *wine-vaults* of Spain. In many districts, however, very little attention is paid to the kind of soil on which the vines are cultivated; and, in general more regard is had to the quantity than to the quality of the fruit; for though this plant thrives best upon a gravelly slope, and produces grapes of a very superior flavour to those grown on a rich level soil, which is more congenial to the production of corn: yet vineyards are indiscriminately planted upon either, as if both situations were equally well adapted to its culture. The general method of planting is by cuttings, which are not permitted to grow very high, and consequently form very stout stocks; but upon sandy soils the stocks are sometimes set in small round hillocks about two feet and a half in height, and separated about three feet distant from each other. Poles for supporting the vines are not used in Spain: but espaliers are numerous in Andalusia and Valencia, on which are produced grapes of an extraordinary size, the branches frequently weighing twelve and fourteen pounds. In the districts around Malaga they gather the grapes at three different periods of their ripening. In the month of June those called *early* are gathered, which yield a wine of the consistence of honey; but the greater part of these are dried for raisins. The second crop is collected in September, which furnishes a clearer and stronger wine; but the real Malaga wine is formed from the last crop, called *tardies*, which is gathered about three weeks later. Besides the Malaga grapes, which are excellent, those of Aragon, Valencia, and Granada, are next in estimation. There is a small white grape, peculiar to Biscay, which has a very thin skin and is of an acido-saccharine flavour. The muscadine grapes of this province are also good and very similar to those of Frontignac.

The principal wine districts are Malaga, producing annually 700,000 quintals; Aragon 537,840 quintals; Catalonia 180,000 quintals; Valencia 955,000 quintals; and Murcia 320,000 quintals. The best red wines are those of Aragon, which possess a good body, and are very rich; those of La Mancha are pleasant, but thin and weak; those of New Castile are generally harsh and poor; those of old Castile are very light; those of Murcia are luscious and heavy; those on the plains of Valencia are below mediocrity, but those on the hills with a southern aspect are of a very superior quality; those of Granada have an agreeable scent and pleasant flavour; and those of Biscay are destitute of body, rough and sour. Many districts of Spain produce excellent sweet wines. The wine of Alicant in Valencia, and that of Carthagena in Murcia, are both good and very similar in their quality. Some muscadel wine is made in Aragon, and also in New Castile at Faencaral in the vicinity of Madrid. Navarre produces the wine of Tudela and of Peralta; the former much like Burgundy, though not so delicious, and the other a sweet wine not unlike the wine of St. Lawrence, but stronger and more grateful. But Andalusia is particularly famous for sweet wines. The wine of Montillo is very excellent, and those of Xeres, or *Sherry*, and Rota are well known. The most esteemed, however, is Malaga, of which there are two different sorts principally distinguished by connoisseurs, *Lagrima* and *Guindas*. The former is the unpressed wine from the grapes of the best districts; and the other is the common Malaga, in which are infused the soft buds of a cherry tree, the fruit of which, called in Spanish *guindas*, gives its name to this wine. Distilleries for making brandy are confined chiefly to Aragon, Valencia, and Catalonia; and this last province produces annually about 50,000 pipes.

Dried grapes or raisins are prepared in considerable quantities in Valencia, and in the environs of Malaga; and constitute an important branch of commerce. The latter district furnishes annually 300,000 quintals, of which 250,000 are exported: and the former 40,000 quintals, of which 33,000 are exported. The Malaga raisins are of a very superior quality, and obtain the highest price in the market, being both larger and of a more delicate flavour than those produced in other places. They are simply dried in the sun without any other preparation, and consequently retain all their juice: while those of Valencia are steeped in boiling water sharpened with a lye made of vine stems, and then exposed to the sun and air till they are sufficiently dry; by which process much of their substance is lost by escaping through the skin: part of it indeed crystallizes on the outside of the fruit, and forms a saccharine crust, which hardens in the colder countries to which they are exported.

Forests are numerous and extensive in the maritime provinces of Spain; but the interior is almost entirely destitute of wood. This scarcity of timber arises principally from the many absurd restrictive statutes existing in this kingdom respecting woods and forests; and from the prohibiting of enclosures throughout a great portion of the country. It cannot be expected that proprietors of land will incur the trouble and risk the expense of forming plantations, or pay any attention to their management and preservation, while they are prevented from raising enclosures to defend them from the depredations of the idle, and the encroachments of cattle; and the timber of which they cannot dispose of but at the will of the government. What inducement can proprietors have to cover their land with wood who must "submit to have their trees marked with a stamp of slavery, which places their disposal in the hands of another; to solicit as a favour, and pay for the permission of cutting a single tree for private use; to shroud and lop in a prescribed time, and subjected to certain regulations, and to sell the wood, whether agreeable to themselves or not, at a stated price; to allow the inquisitorial visits of official surveyors; and to make returns of the state and number of trees in their respective plantations?" Were these restrictions abolished, and timber become exclusively private property, the country would soon be rich in beautiful and extensive forests. The mountains of Catalonia are covered with beech, pines, evergreen oaks, and cork trees; and elms and willows fringe the margins of the rivers. In the plains, olives, almonds, walnuts, oranges, lemons, figs, plums, pears, apples, cherries, apricots, and peaches are everywhere abundant and flourish to an astonishing extent. Valencia abounds with trees of almost every description, but Carob trees, palm trees, olives, and mulberries are particularly prevalent; and not only are the mountains and hills, but the valleys and plains are clothed with forests. Some parts of Murcia, as the Huerta, produce an immense number of different kinds of trees, especially the mulberry; in other parts scarcely a tree appears for leagues together. Andalusia is equally defective. Fruit-bearing trees are exceedingly numerous in the plain of Granada, where are also woods of ash, elm, and white poplars more than four miles long: but the plain which leads from Cantillana to Seville, an extent of nearly thirteen miles, presents nothing except here and there a sprinkling of miserable olives. Many of the mountains, however, are well clothed with lentisks, cistuses, and evergreen oaks; and others with firs, yews, and cork trees. Estremadura, Leon, and the two Castiles, are but scantily adorned with sylvan scenery. Some of their mountains are covered with pines and oaks of different species; and in the plains of New Castile are some large forests of olives. Fruit trees abound in the Asturias, especially apples, which afford a considerable quantity of cider. Aragon and Navarre have a few oaks and pines, with some cork, ash, and cedars. Biscay, however, exhibits more extensive forests than any province of the kingdom. The mountainous part of Guipuzcoa is beautifully clothed with wood, and the hills are covered with evergreen oaks, hard oaks, chestnuts, and various kinds of fruit trees, particularly apples, and a great variety of shrubs. Orchards are abundant in the cultivated parts, where are immense quantities of figs, cherries, walnuts, peaches, and a variety of delicious pears. In some parts of Spain, more particularly in the two Castiles, Estremadura, and Andalusia, the acorns of the evergreen oak, which in other parts of the country serve only for food to the vilest animals, are eaten by the inhabitants and considered a delicacy. The ladies are particularly fond of this fruit, which they call *bellotas*, and which they use either raw, or roasted upon the coals like chestnuts. The taste is said to be very similar to that of walnuts, and when roasted more delicate.

Spain abounds with excellent pastures. The Spanish Pyrenees, and the collateral range of mountains, which ramify and extend into the provinces of Catalonia, Aragon and Navarre, are covered with them. The mountains of Asturias, Galicia and Andalusia, together with the plains of Estremadura, almost wholly consist of pasture land. New Castile abounds in grass, and the territory of Vellon for several leagues from Madrid is covered with beautiful and rich meadows, finely interspersed with a diversity of trees. The best grasses are found in Old Castile; and the mountains of Burgos are clothed with the richest herbage. Notwithstanding this abundance of pasture land, few horned cattle are reared in this country, except in the Asturias and some parts of Castile, and these are by no means adequate to the average consumption of the inhabitants. This deficiency is supplied by importation from other countries, especially from France. In the neighbourhood of Burgos, however, this branch of rural economy is very successfully cultivated. Cows constitute the principal wealth of the inhabitants; and their milk is manufactured into excellent cheese and butter. A sufficient quantity of the latter article might be made in this district to supply the demands of the whole kingdom; but the people are deficient in industry, and are unacquainted with the proper method of curing by salting and preserving it in casks. Mules form an important class of Spanish animals. They are employed as beasts of burden, and for agricultural purposes; and are generally preferred to horses and oxen for domestic use. The greatest attention is consequently paid to the breeding and rearing, and also to the proper breaking and training of these animals to fit them for the respective services in which they may be subsequently employed. The most esteemed are to be found in La Mancha, and also in Andalusia and Leon; but the numbers reared are not sufficient for the service of the country, and a large importation is annually made from France. The Spanish horse owes his high reputation to the care of the Moors; and the breed which this people introduced still exist in the province of Andalusia. The strongest horses are bred in Asturias; but the most beautiful in Andalusia; and this animal, though of a low stature, possesses almost perfect symmetry of form, carries his head remarkably well, and shows a bold fore-head; but is unable to sustain much fatigue. Those in highest estimation are reared in various parts of the kingdom of Cordova; and the royal stud at Cordova contains six hundred animals of all ages, among which are twenty stallions. There is another stud established at Aranjuez, where are reckoned twenty stallions, and four hundred mares. Great attention is paid to the preservation and increase of the native breed; and every precaution is used to prevent any admixture of a foreign race. The importation of foreign horses is absolutely prohibited; and there are also severe enactments against the exportation of Spanish horses. It was in contemplation, however, to try the experiment of crossing the breed, and for this purpose a hundred beautiful mares were brought into the royal studs from Normandy. This may be the means of introducing more bone and hardihood into the Spanish horse, and render him in every respect more adapted for military purposes. But notwithstanding the greatest care the breed has much degenerated; and the number of good horses is daily decreasing. The food of horses and mules in this country is generally straw, which in some provinces is chopped, and in others given whole. Hay is very rare; and oats are seldom given as provender, barley being substituted in their stead. Carob beans, mixed with bran, are very generally used both in Valencia and Catalonia.

Spain appears to have always abounded with flocks; and its breed of sheep has been long celebrated as perhaps superior to any in the world for the delicacy of the mutton, and the beauty of the fleece. The wools of Betica and Cantabria were in high esteem at Rome for their fineness, colour, and length of fibre. The excellence of the wool of this country is said to be owing to the crossing of the Spanish breed by the introduction of English sheep, which took place "in the year 1394. When the hereditary prince of Castile, son of king Henry the Third, married Catherine, the daughter of the duke of Lancaster, that princess brought with her from England a numerous flock of peculiarly fine sheep. Those animals so throve in the climate of Castile that they speedily formed one of the most considerable branches of commerce: the manufacture of cloth flourished in proportion, and so rapidly, that in the year 1419, the deputation of the kingdom requested the prohibition of the sale of foreign cloth, lest it might injure the use of the national fabrics." The sheep of this country are distinguished into two kinds—the *migratory* sheep, and *stationary* sheep. The former receive the appellation of Merinos, and have been already mentioned when treating of the Mesta; the latter always abide in the fields, and by night are penned in the sheep folds; and amount to nearly eight millions. The greatest number of them pasture in the provinces of Andalusia, Catalonia, and Valencia; and while the owners of the migratory flocks derive little more benefit from them than the profit of the wool; the lands where the others are fed are strengthened and enriched, and rendered capable of producing vigorous and flourishing crops of grain. In September the sheep are ochred, their backs and loins being rubbed with red ochre or ruddle dissolved in water; and this practice is supposed not only to defend the animal from the inclemency of the approaching winter, but also to improve the quality of the fleece. Sheep-shearing commences in May. It is introduced by a pompous preparation, and is considered a time of feasting and recreation. "One hundred and twenty-five men are usually employed for shearing a thousand ewes, and two hundred for a thousand wethers. Each sheep affords four kinds of wool, more or less fine, according to the parts of the animal whence it is taken. The ewes produce the finest fleeces, and the wethers the heaviest: three wether fleeces ordinarily weigh, on the average, twenty-five pounds; but it will take five ewe fleeces to amount to the same weight." The Spanish wools are, in general, excellent, being long and fine in the staple, and soft and silky to the touch. The annual produce is about 500,000 quintals, one half coarse, and the other fine wool. The Merino sheep afford the most valuable fleeces; and this superiority has been attributed to their being exposed to a more equal temperature, ranging upon the northern mountains during summer, and pasturing in winter on the plains and valleys of the south. In some districts, however, the stationary flocks bear an equally fine fleece, especially in the environs of Segovia, and in some parts of Estremadura and Aragon; but considerable differences exist between districts of the same province. In general, the finest wools are those of Segovia, Avila, Leon, and Aragon. Mr. Townsend states, that the wool of the Merino sheep is worth about twelve pence a pound, while that of the stationary flocks sells only for sixpence; and that every sheep is reckoned to yield a clear profit of tenpence to the proprietor, after all expenses are discharged.

Chap. III.—*Manufactures.*

In remote periods Spain was equally celebrated for the industry of its inhabitants as for the fertility of its soil, and the variety of its productions; and many of the useful arts had arrived at considerable perfection in the time of the Romans. Linen stuffs were first manufactured in the city of Zoela, in the district of Tarragona. and the cloths of San Fellippe, the ancient Sætabis, were famous throughout Italy and Greece. The manufacture of fine woollen cloths was also in a very flourishing state. The Spaniards had derived from the Phœnicians the art of dyeing these of a beautiful purple colour; and of this article great quantities were annually exported to Italy. They were equally celebrated for their mode of tempering steel; and the military arms of the Celtiberians were early adopted by their conquerors. The manufactures of Spain fell with the Roman power; and were almost annihilated while under the dominion of the Goths. But they were again revived by the genius and industry of the Moors, who formed several independent kingdoms in the centre of the country. The Spaniards, driven to the mountains, and having acquired a spirit of energy which they had not for a long time experienced, had the wisdom to profit by the example of the Arabs. Possessing the mines of Biscay, and the flocks of Leon, they retained the fabrication of woollen cloths and of arms; and allowed the manufacture of leather, linen, silk, &c. to remain almost entirely in the hands of the Moors. During the period between the middle of the 15th and the end of the 16th century, Spain is represented by her own writers as perfectly independent of foreign nations; manufacturing the greater part of its silk and wool; supplying the wants of its inhabitants from within itself; and exporting more manufactured than raw articles. This, however, is a very exaggerated picture, and is not supported by cotemporary historians, who make no mention of her manufactures, while they give an account of the quantity of wool and other raw materials exported from her shores. We know, however, that after the death of Philip II. a sudden and rapid change took place; and manufactures experienced an almost instantaneous decline, which nearly amounted to an absolute annihilation of trade. This revolution was produced by the combination of various causes; the expulsion of the Moors in 1614; a general taste for foreign stuffs in preference to those fabricated in the country; and the impolicy of the government in not only permitting the importation of foreign manufactures, but in laying a stamp duty, called *bolla*, upon articles manufactured in Catalonia, and a heavy tax upon silks. The effect of these measures was such, that the national manufactures were generally neglected, and in a short time almost absolutely abandoned. The manufactures of cotton, linen, gloves and swords, entirely vanished, and by the close of the 17th century, scarcely a vestige of its former prosperity remained. Such was the state of destitution in which Philip V. found the trade of Spain, when he ascended the throne in 1700. The intestine wars which accompany a disputed succession; and the low state of the national finances prevented for a time any attention being paid to the subject of manufactures. But Philip, having restored tranquillity to his dominions, and established the public revenue, induced his subjects to wear the national fabrics; and thus laid a foundation for the revival of trade, which was ably and cordially supported by his successor Ferdinand VI. This prince not only encouraged the formation of manufactories by peculiar privileges, and pecuniary assistance, but also established several at his own expense; and by giving employment to foreign artisans, induced many of them to settle in the kingdom. Charles III. followed his example, and greatly increased and multiplied the means of encouragement. A spirit of competition introduced life and vigour into trade; and though this regeneration was not equally prompt in all parts of the monarchy, yet gradually new branches of manufacture started up; and the different ramifications are now sufficiently numerous.

The woollen stuffs fabricated in Spain are, in general, of a very inferior quality, and cannot stand a competition with the woollen goods of foreign countries. This is owing, in a great measure, to their imperfect knowledge in the arts of fulling and dyeing, the latter being so badly executed that the colours are never permanent. From this general reflection, however, we may except the superfine cloths manufactured at Terrassa in Catalonia, and at Brihuega, Segovia, and Guadalaxara in New Castile. These are intrinsically of the most excellent quality, and not inferior to the best French cloths, though they do not possess their lustre. In Guadalaxara is an extensive manufactory of Vigogna cloths, which are so much esteemed and so difficult to procure. This establishment is maintained at the expense of the king, and is consequently making but little progress. Those employed in its management feel no interest in its success. Profusion, waste, and idleness, prevail in every department: and this undertaking, which would have prospered under private owners, is, under its present directors, scarcely able to support itself. Manufactories of coarse cloths, baize, flannels, swandowns, druggets, and other common woollen stuffs are scattered over the kingdom; but none of any extent, except at Puebla de Valencia, in Leon, which manufactures annually 5,000 pieces of flannel, estimated at L.18,840 Sterling. Woollen stockings are made at Burgos in Old Castile, and at Aulot, and Vich in Catalonia. Aulot supports 400 looms; the number woven at Burgos is considerable; and Vich produces annually 24,000 pairs. Numerous looms for blankets are established at Barcelona, but they are not collected in factories. Burgos has twelve factories for this purpose; but the finest blankets are made at Valencia, which furnishes annually about 63,000. This town also manufactures tammies to the amount of L.10,500 Sterling. Woollen carpets are woven at Cuença in New Castile; and fifty looms are employed at Aulot in making bands for woollen caps. An elegant manufacture of tapestry is carried on at Madrid, which was established by Philip V. in 1720. Its productions are carpets and tapestry, the subjects of which are often drawn from fable or history; and it affords daily employment to 80 persons, including dyers, drawers, designers, and all its various branches.

The silks of this country are in general stout and excellent; but destitute of the brilliancy observable in French silks. The damasks of Valencia are extremely beautiful; and that city produces mohair stuffs which appear superior to those of France and England. The manufacture of silk handkerchiefs and bands, employs 500 looms at Reus, 600 at Manresa, where are annually made 60,000 dozen of handkerchiefs. Barcelona produces a much larger quantity. This city possesses also an extensive silk-stocking manufactory, besides a considerable manufacture of ribands, and of gauzes. The stockings are of a loose texture, badly dressed and glossed: and very inferior to the French stockings. Few of them are worn in the country, being exported chiefly to America. The ribands are also thin and flimsy, possessing neither permanency nor brilliancy of colour. Silk taffeties, serges, common and figured satins, damasks, plain and flowered velvets, are made in various parts of Spain; but it is only at Toledo and Talavera de la Reyna that the looms for these purposes are collected in factories. The making of blond lace is confined chiefly to Catalonia, and is fabricated in the villages upon the sea-coast by poor women and children. The principal manufactory for this article is at Almagro in La Mancha, which gives employment to about twelve or thirteen hundred persons.

The manufacture of linen cloth is still in a very imperfect state in Spain: and there are only two considerable manufactories for this article in the kingdom. The rest is made in the towns and villages by what are called *custom* weavers, who work for private families. The greatest quantity, and the best, is made in Galicia. This province produces annually above 5,000,000 yards, of which nearly 790,000 are exported to America; 1,740,000 are sent to the two Castiles; and the remainder consumed at home. Excellent table linen is made at Barcelona, which also furnishes a considerable quantity of thread stockings. These, however, are of an inferior quality. In the district of Bayonne are manufactured annually about 100,000 pairs. Cordage, cables, and sailcloth, are prepared principally in the three marine departments, Cadiz, Carthagena, and Ferrol. Various other articles composed of linen thread, as nets for the hair, laces and tapes, are fabricated in different places; and at Barcelona this manufacture employs 12,000 persons.

The cotton manufacture has of late years greatly increased in Spain; but it prevails chiefly in Catalonia; and the principal factory for cotton cloths of different qualities is established at Barcelona. This city produces annually about 4,090,000 yards, valued at £369,000 Sterling. At Aulot 600 looms are employed in the manufacture of cotton stockings and caps; and Tarragona produces annually 9,000 pieces of cotton riband. Cotton spinning was first introduced at Barcelona in 1790; and there are now not less than 100 spinning factories, some of which are very considerable. Aulot has 200 spinning machines, and Reus 250. There are also two factories of this description at San Lucar de Barrameda.

Manufactories for preparing hides, skins and all kinds of leather are very general throughout the kingdom. The greatest quantity of sole leather is manufactured in the provinces of Aragon and Catalonia. At Aragon are tanned annually 800 quintals and 750 at Brea. A much greater quantity, however, and also of superior quality is prepared in Catalonia, which after the supply of its own consumption, furnishes annually 700,000 pair of soles; and further, exports leather to the amount of £41,660 sterling. Shoemaking is prosecuted to a great extent at Barcelona, which, besides supplying the demand of the contiguous provinces, exports large quantities to America.

The paper manufactured in this country is far from excellent, being deficient both in whiteness and texture. The number of paper-mills, which are confined chiefly to the kingdom of Aragon, amounted in 1776 to eighty-six, which were augmented in 1785 to one hundred and five; and are now above two hundred, fabricating annually 444,000 reams of paper.

The best delf-ware is made at Alcora and Manisez in Valencia; and the finest china at Madrid. At Valencia is a manufacture of delf paving tiles, which are finely varnished and beautifully painted, and with which they pave their apartments, and encrust the walls of their houses. These tiles are of different dimensions; and it takes a certain number to form a picture. The price varies according to the size of the tile, the beauty of the varnish, and the variety of the drawings, from fifteen shillings to £15, 12s. 6d. a thousand. There is a considerable demand for them, and they are said to be superior, both in beauty and strength to those used in Holland.

The principal iron forges are in Catalonia, Aragon, Asturias, and Biscay. Those in Biscay proper, and in the district of St. Andero, produce annually 124,000 quintals. In Asturias are forty-eight iron mills, of which nine are appropriated for bar-iron, thirty-seven for the nail trade, and two for copper. The cutlery of this country is in little estimation, being badly finished, worse polished, and destitute both of taste and elegance. The best is made at Solsona in Catalonia; but the greatest quantity at Albacete in Murcia. A manufactory of steel and brass needles and brass nails has recently been introduced into Valencia, and also into Catalonia; and the two most considerable pin manufactories are established at Corunna in Galicia. Polished arms, such as swords, hangers, bayonets, &c. of superior temper, are made at Toledo and Barcelona; and the best fire-arms are manufactured at Ripoli. Brass cannon are cast at Barcelona and Seville; and iron ordnance at Lierganez and Cavada.

The glass of Spain is in general of a very inferior quality; being both dark and destitute of lustre. The most beautiful and transparent is made at Pajarejo and Recuenco in Castile; and at St. Ildefonso, bottles are wrought of a superior quality, and white glasses, which are carved with great ingenuity. In this town also is established a manufactory for mirrors, which produces the largest that have yet been fabricated. They are sometimes from 100, 130, to 150 inches in height, and 50, 60, or 65 inches in breadth. The process of polishing is performed by a machine; and they are then transported to Madrid for the purpose of being metallized.

The only manufactory for tobacco is established at Seville; and is conducted on the government account. The snuff prepared here is made from the tobacco grown in the Brazils, the island of Cuba, and some other Spanish colonies. The leaves when dried are reduced into an impalpable powder; and then mixed with a very fine unctuous reddish earth found in the environs of Almazarron, a village in Murcia. The earth fixes the volatile particles of the tobacco, gives it various shades of red colour, and communicates to it an unctuosity and delicacy of scent. This preparation is called by the Spaniards *polvillo*, but by other nations *Spanish snuff*. Rolled and cut tobacco are also manufactured in this establishment; and it likewise monopolizes the sale of another kind of tobacco, used for smoking, and called *cigarros*. These are not prepared at Seville, but are imported from the American colonies; and the most esteemed are brought from the Havanna. There is a prodigious consumption of this article in Spain; and vast quantities are annually exported to foreign countries. This manufactory comprises 202 mills, which employ 1404 persons; and the annual proceeds of net profit, which accrues to the king, is estimated at about £833,333 sterling.

Saltpetre and gunpowder are made almost every where on the king's account; and the most considerable manufactory for the latter article is established at Villafeliche, which keeps seventy mills in constant employment.

The other manufactures of Spain are very unimportant, and we shall therefore content ourselves with merely enumerating the most considerable. Soap is made in a variety of places; and also hats; but the best are made at Badajos. Aquafortis and salt of lead are manufactured at Manreza in Catalonia; pewter buttons at Gihon in the Asturias; playing cards at Macharaviaya in Granada; white wax at Puerto de Santa Maria; potash at Valencia; veneered articles at Madrid; and gold and silver laced and brocaded stuffs at Talavera de la Reyna, which city consumes annually in this manufacture 4000 marks of silver and 70 of gold.

The manufactures of this kingdom in general, possess none of those qualities which give such a pre-eminence to similar articles at present manufactured in England and France; and the quantity produced, so far from allowing any exportation to other countries, is not adequate to supply her own wants and those of her colonies. Spain is therefore obliged to import large quantities of manufactured goods from Holland, England, France, and Germany; and the Count de Campomanez, in the year 1775, observed that eight millions of people belonging to the Spanish monarchy were clothed with foreign manufactures.

Chap. IV.—*Commerce.*

The commerce of Spain had the same periods of rise, decline, and revival, as its manufactures; and the same causes operated almost equally upon both. In the fifteenth and sixteenth centuries, the trade of this country extended to all parts of Europe. The cities of Almeria, Valencia, and Barcelona, pushed their commercial concerns into Syria, Egypt, Barbary, and the Archipelago; and Barcelona, under the kings of Aragon, had established factories in the extreme parts of Europe and Asia, as far as the Tanais, and was enabled to equip and maintain armed ships for the defence of her trade. At that period Spain had a large navy, and possessed a thousand merchant vessels, all constructed in her own ports. Few of these, however, belonged to native Spaniards; for while the principal manufactures were engrossed by the Moors, the Jews constituted their most intelligent and active merchants. The expulsion of this people in 1492, consequently gave a severe blow to the commerce of the country, from which it with difficulty recovered, during the following century, by the activity and wealth of the Moors. But when they in their turn were driven from the kingdom, its destruction became complete; and commerce and manufactures equally disappeared. By these impolitic measures, Spain was deprived of a great proportion of her wealth and population. Her shipping interest was annihilated; and what few ships she possessed were purchased from foreign yards. The monarchy in a short time became so enfeebled as to be totally unable to defend the small remains of her trade, and to repress the piracies of the Corsairs of Barbary, who not only seized all her vessels in the Mediterranean, but made incursions upon her coast, and carried off many of her subjects as captives. Many fruitless attempts were made at different times to revive the commerce of the kingdom; but these feeble and insufficient efforts served only to show the imbecility of the government; and it was not until the accession of the House of Bourbon to the throne, that a revival of trade could be said to be in operation. Philip V. was no sooner in quiet possession of the sceptre, than he devoted his attention to this subject; he encouraged manufactures, bestowed honorary rewards on trade, granted premiums to merchants, and instituted commercial boards. His subjects seconded his endeavours, and suddenly "displayed a spirit and activity of which they seemed incapable; the ports were filled, and the sea was covered with shipping; they ceased to purchase foreign built ships, but constructed them at home; their dockyards for shipbuilding quickly increased; and at present there are yards for building armed vessels at Ferrol, Cadiz, and Carthagena; and for merchant vessels at Bilboa, Corunna, Cadiz, and along the whole coasts of the kingdoms of Valencia and Catalonia. Notwithstanding, nearly the whole coasting trade of Spain is yet carried on by the French, the English, and the Dutch. The Catalonian, Valencian, and Biscayan vessels are the only national vessels which participate in this trade. The merchant vessels belonging to Spain are destined for the American rather than the coasting trade."

The internal and home trade of Spain is very inconsiderable for want of sufficient means of communication; and chiefly consists in the exchange of national produce and manufactures between one province and another. But this subject has been already sufficiently treated in our description of the different provinces. To these we must refer our readers, and also for an account of the various branches of foreign trade which are respectively peculiar to each. We shall merely give a short general statement of the principal commercial transactions which this country prosecutes with the other states of Europe, and with its American colonies.

The European commerce of this country is confined chiefly to England, France, Holland, Italy, and the Baltic, and may be considered as entirely passive. For though it exports immense quantities of its agricultural productions, it sends abroad none of its manufactured articles, except a few fancy goods from Valencia; but on the contrary imports them from all countries.

The wine trade suffered considerably from an impolitic regulation of Philip V. who during the war of the succession, prohibited the exportation of Spanish produce into those countries which were inimical to his interests. The English were of course driven to Portugal for a supply, and have ever since given a preference to the red wines of that country. The wine of Xeres or Sherry, however, and some sweet wines, are still received by England in considerable quantities. Catalonia exports to Italy 4000 charges;* and Valencia sends to England, America, and France 1,200,000 cantaras. The quantity of Xeres wine exported to different places amounts to 80,000 quintals; that of Malaga to 400,000 quintals; and that of Alicant is estimated at 800,000 reals.

The brandy trade is confined principally to the ports of Catalonia and Valencia. From the former are exported 20,000 pipes to Holland, Russia, Sweden, and Denmark, 10,000 to England, and 4000 to Guernsey and Jersey; and from Valencia, France and England receive annually 500,000 cantaras.

Spanish oil constitutes a principal article of exportation. That produced in the kingdom of Aragon is sent to France and England; that of Catalonia, to the amount of 8000 charges, goes partly to Holland and partly to France; and the quantity sent from Andalusia, by the port of Malaga, to England, Holland, and the north of Europe, is estimated at 20,000,000 reals.

Soda, barilla, salicor, and agua-azul, are exported in considerable quantities, by the ports of Alicant and Carthagena. The province of Valencia furnishes upon an annual average 100,000 quintals of barilla, 25,000 quintals of soda, and 4000 quintals of agua-azul; and Murcia exports 150,000 quintals, four-fifths of which go to France, and the remainder to England.

The exportation of fine wools is greatly encouraged by the Spanish government, on account of the very considerable duties which they bring to the revenue. The quantity annually exported amounted to about 125,000 quintals of washed wool, and 105,000 of wool in the grease, both of which are sent to Holland, France, and England. The same wools are returned in a manufactured state, in the shape of cloths, serges, swandowns, flannels, &c. and the remunerating price demanded by the foreign manufacturer absorbs nearly the whole of the money previously received for the raw material. Spain thus loses all the advantage arising from the employment of her own population; for were these wools kept in the kingdom they might serve both to extend the manufactures of the country and contribute to national wealth. Burgos is the staple for all the wools shipped in the ports of the Bay of Biscay; the remainder is exported by Barcelona, Grao, Cullera, Alicant, Carthagena, and Malaga, in the Mediterranean; a portion also passes by way of Seville and Cadiz.

The corn trade forms a considerable branch of Spanish commerce, but the least advantageous to the country. Though this kingdom be naturally fertile it frequently experiences a scarcity of grain, and is under the necessity of importing this indispensable commodity from France, Italy, Africa, Greece, and sometimes from the north of Europe.

The trade of tobacco is wholly in the hands of the government, and affords a very ample profit. Besides these principal branches of commerce, Spain exports a variety of other articles, viz. salt, fruits of various kind, sumac, anchovies, rice, palmes, kermes, nuts, cork both in boards and manufactured, madder, bar-iron, and anchors, lead, silk, and fancy articles called *azulejos*. The exportation of piastres, though prohibited by the government, forms a great object of speculation, and they are smuggled into France from the frontier provinces to a considerable amount.

The following table contains a general statement of the principal articles exported from Spain into the other countries of Europe.

* For the weights and measures of Spain, and their comparative value with those of England, see the conclusion of this article

Articles.	Quantities.	Value. Reals de Vellon.	Value. Sterling Money. £ s. d.
Wine from Catalonia	4,000 charges	256,000	2,666 15 0
Do. from Valencia -	1,200,000 cantaras	912,000	95,000 0 0
Do. from Alicant -		800,000	8,333 6 8
Do. from Xeres - -	50,000 quintals	12,000,000	125,000 0 0
Do. from Malaga - -	400,000 ditto	36,000,000	375,000 0 0
Brandy from Valencia	500,000 cantaras	12,000,000	125,000 0 0
Do. from Catalonia -	35,000 pipes	25,200,000	262,500 0 0
Dried Raisins from Malaga - - - - -	252,000 quintals	10,000,000	104,166 13 4
Do. from Valencia -	38,000 ditto	1,140,000	11,875 0 0
Dried Figs from Malaga	100,000 ditto	3,300,000	34,375 0 0
Do. from Valencia -	16,000 ditto	512,000	5,333 6 8
Walnuts from Catalonia	26,000 sacks	2,496,000	26,000 0 0
Chestnuts from Biscay		320,800	3,333 6 8
Nuts from the Asturias		800,000	8,333 6 8
Dates from Valencia -		400,000	4,160 13 4
Almonds from ditto -	3,000 quintals	630,000	6,562 10 0
Oil from Malaga - -		20,000,000	208,333 6 8
Do. from Catalonia -	8,000 charges	2,560,000	26,666 16 4
Barilla, Soda, Agua-azul } from Valencia	129,000 quintals	6,096,000	63,500 0 0
Barilla, Soda, Agua-azul } from Murcia	200,000 ditto	10,000,000	104,166 13 4
Kermes from Valencia	140 ditto	700,000	7,295 13 4
Cork from Catalonia -	30,000 ditto	21,600,000	225,000 0 0
Corks from ditto - -	1,200 ditto	862,996	8,989 10 10
Madder from Old Castile	4,000 ditto	6,400,000	66,666 13 4
Brooms from Barcelona		660,000	6,875 0 0
Wool washed - - -	125,000 ditto	64,000,000	666,666 13 4
Wool in the grease -	105,000 ditto	20,700,000	215,625 0 0
Salt from Valencia -	6,000 tons	888,000	9,250 0 0
Do. from Puerto Real		80,000,000	833,333 6 8
Total		341,233,796	3,640,018 12 2

The imports of this country are very considerable; but we have no means of ascertaining their amount. Spain receives

From Holland, linen drapery, common lace, tapes, cutlery goods, paper, and spices.

From Silesia, linen drapery.

From Germany, by Hamburgh, quantities of haberdashery.

From England, calicoes, iron and steel goods, fine cloth, quantities of cod fish and ling, whale oil and butter.

From France, calicoes, linen drapery, silk stockings, silks, camlets and other kinds of worsted stuffs, fine cloths, gilded articles, jewellery, iron and steel goods, haberdashery, perfumery, and spices.

The principal trade of Spain is with her American colonies. Previous to 1720, this trade, for two centuries, had been confined to the city of Seville by an absurd regulation of Charles I. in 1529, who, though he permitted merchants to freight vessels from Carthagena, Malaga, and the chief ports of Galicia, Asturias, and Biscay, bound them, under the penalty of death and confiscation of their cargoes, to return to Seville. In consequence of this exclusive system, and the heavy duties imposed upon all goods exported to, or imported from America, little business was done to advantage; and the contraband trade became very lucrative and extensive in its operations. About the middle of the 17th century, when the trade between Seville and the colonies was at its height, it never employed more than 27,500 tons of shipping. In 1720 the emporium was changed to Cadiz; and the whole American trade was carried on by twenty-seven galleons and twenty-three flotas, the smaller vessels being about 550, and the others between 800 and 1000 tons. The galleons sailed annually to Porto-Bello, for the commerce of Peru, and the flotas once in three years to Vera Cruz, for that of Mexico. During the annual fair at Porto-Bello, which lasted forty days, the merchants brought their gold and silver, with bezoar stones, Peruvian bark, and Vicuna wool; and received in exchange provisions and European goods. On the return of the fleets the market was glutted with colonial produce; and, as no single ships were permitted to sail in the interval, the occasional demand was left to be supplied by the contraband trade; so that the trade to Peru, when confined to the galleons, gradually decreased, insomuch that instead of employing 15,000 tons, it was reduced in 1748 to 2000. It began to revive, however, upon the introduction of *register ships*, which, upon paying a douceur to government, were allowed to make voyages between the sailing of the periodical fleets; and when Charles III. extended the privilege of a general trade between Vent, Buba, Hispaniola, Porto-Rico, Marguerita, Trinidad, Louisiana, Yucatan and Campechy; and the ports of Seville, Carthagena, Alicant, Barcelona, Corunna, St. Andero, and Gijon; this trade, "which," says Mr. Townsend, "had been like the summer's brook, soon resembled a great river, and enriched all the countries through which it flowed." This freedom of trade was no sooner established than the mercantile spirit availed itself of so favourable an opportunity; and in the same year 162 vessels sailed for America from the different ports of Spain.

But notwithstanding this permission to particular ports, the Spanish government has granted from time to time, exclusive privileges to chartered companies, which have in general greatly tended both to the injury of the mother country, and also to the oppression of those transatlantic provinces which have been subjected to the monopoly. The first of these was the Caraccas company of Guipuscoa, established in 1728. This company possessed the exclusive trade of Caraccas, with the privilege of reshipping by smaller vessels all its surplus commodities for Cumana and Guayana, with Trinidad and Marguarita, two islands at the mouth of the Oronoco, that they might exchange European goods for gold, silver, hides, tobacco, cocoa, sugar, and such other fruits as these countries produced. This trade was carried on by the ports of Cadiz and St. Sebastian, and employed twelve carrying vessels, with as many more for the suppression of smuggling, and 2,500 seamen. Cocoa became at last their staple commodity, and under their management its importation increased so considerably that the price of chocolate in the Spanish market fell one half. From the year 1770 to 1774, they imported 179,156 panejas of cocoa, 75,496 hides, 9052 quintals of tobacco, and 221,432 pezos in specie, arising from the sale of cocoa which had been sent to Mexico. This company, however, sustained many severe losses at the commencement of the American war, among which was the capture of a rich convoy by Lord Rodney, valued at more than £200,000 Sterling; and a few years afterwards it was completely dissolved, and its capital absorbed in a new establishment called the Company of the Philippines.

This new company commenced its operations in 1785, with a capital of 115,200,000 reals, and with valuable privileges granted to it for a term of twenty-five years. Previous to this establishment the trade of the Philippine islands was carried on by means of two large galleons which sailed annually; the one, from Acapulco, crossing the Pacific ocean, carried the treasures of America to the Philippines; the other returning by the same course, a distance of nearly 8400 miles, came to Acapulco laden with china ware, spices, tea, perfumes, silks, calicoes, muslins and printed linen, the produce of the East, which were bartered with the merchants from Lima for cocoa, quicksilver, and hard dollars. The direction of this traffic was immediately changed. The precious metals of Mexico and Peru were sent directly westward to the place of their final destination; and the productions of the East, to the same amount in value, was brought round by the Cape of Good Hope to Spain, where they were admitted under easy duties, with a drawback of one-third on their exportation. The prospects of this company were at first very flattering, but soon after it met with many unfavourable circumstances, and sustained very heavy losses; yet at the close of the year 1796 it had derived a profit of 22,000,000 reals. This traffic, however, had a tendency to injure the national manufactures, by the quantity of foreign articles, such as silks and muslins, which were imported; and as they had extended their speculations to Vera Cruz, Buenos Ayres, and to most sea-ports of South America, where no limited capital could stand in competition with their operations, had they met with the support they had reason to expect, they must soon have swallowed up the whole trade of Spain, and, in the issue, have been the ruin of that country.

"The chief trade between Spain and America consists in exporting a considerable quantity of Spanish manufactures, and importing a large quantity of gold and silver, the produce of the colonies. Spain sends to America a vast quantity of the fancy articles called *azulejos*, and coarse woollen, for clothing the troops, from Valencia; numerous iron utensils, quantities of marbled paper, dyed and printed cottons, and calicoes, from Catalonia; cotton stockings, 600,000 pieces of cotton ribands, and 80,000 dozens of silk handkerchiefs from the same province; from Galicia 50,000 pairs of knit thread stockings, 850,000 varas of linen drapery, table linen, tapes, hides, skins, and various kinds of dressed leather; numbers of silk stockings are sent from Talavera de la Reyna and Barcelona; quantities of silks and silk stuffs mixed with gold and silver, from Talavera de la Reyna, Toledo, Requena, Valencia and Barcelona; large quantities of writing paper from the kingdom of Valencia; about 200,000 reams of the same kind of paper from Catalonia, from whence are also sent 200,000 pairs of shoes; playing cards from Granada; and house brooms and brushes from Barcelona.

In return the colonies supply Spain with coffee, sugar, some cotton, tobacco, cocoa, leather, and particularly gold and silver, both in ingots and coined into money. Part of the precious metals belong to the king, and the remainder is imported on account of the merchants, being sent as the balance for articles obtained from Spain. Upon a moderate calculation the annual value of gold and silver imported amounts from five to six millions Sterling. In the year 1791 there arrived in the port of Cadiz alone, gold and silver, in money, bars, or ingots, to the value of 25,788,175 piastres, (£5,370,619.) This only includes the quantity known to be imported, from its having paid the duty; it is supposed what is clandestinely imported amounts to nearly an equal sum."

The following tables will give a brief view of the extent and value of the American trade. In 1778, when the American trade was first thrown open, the exports from Spain were,

	Reals de Vellon.	Sterling Money.		
In national merchandise	28,636,619	£298,298	2	3¼
Foreign merchandise	48,378,342	503,941	1	3
Total	77,014,961	802,239	3	6¼

Within ten years, in 1788 the exports were nearly quadrupled, as appears from the next table.

In national merchandise	158,223,239	£1,648,158	14	9¼
Foreign merchandise	142,494,290	1,484,315	10	5
	300,717,529	3,132,474	5	2¼
Imports from America in 1788	804,693,733	8,382,226	7	8
Excess of imports	503,976,204	5,249,752	2	5¼

This commerce is still chiefly carried on by the port of Cadiz, from which were exported in 1792 merchandise to the amount of 270,000,000 reals, and its imports amounted to 700,000,000 reals. From that period the Spanish trade with America has continued to increase; and America has equally profited by the freedom of traffic. The trade with Vera Cruz in the year 1802, amounted in imports to 21,998,588 piastres; and in exports to 38,447,367 piastres, of which sum three millions and a half were paid for cochineal, three millions for indigo, and one million and a half for sugar.

The information contained in the following tables, which we have selected from M. Cæsar Moreau's excellent Commercial Tables, will give the reader some idea of the trade between Spain and Great Britain.

Table of the value of British goods Imported into Spain.

	1824.		Annual average of ten years.
Woollen goods	£82,709	-	£119,473
Cotton manufacture	86,259	-	97,049
——— yarn	65	-	927
Linen manufactures	103,438	-	95,442
Silk do.	49,485	-	55,842
Hardware and cutlery	40,293	-	34,759
Iron and steel	20,095	-	22,223
Glass and earthen ware	9,293	-	13,896
Brass and copper	12,104	-	9,657
Haberdashery and millinery	6,534	-	9,565
Other articles	60,029	-	9,873
Total imports from Britain to Spain	470,304	-	468,706

The following table shows the amount of the trade of Great Britain with Spain, including Majorca, Minorca, Ivica, and the Canaries; W. signifying war, and P. peace.

		Imports into Britain.		Exports to Spain.
W. 1697	-	£360,893	-	£183,985
P. 1700	-	631,718	-	616,169
W. 1710	-	298,668	-	237,423
W. 1720	-	291,627	-	519,169
P. 1730	-	541,711	-	811,514
W. 1740	-	231,699	-	101,636
P. 1750	-	386,836	-	1,813,222
W. 1760	-	466,098	-	1,117,107
P. 1770	-	523,018	-	941,169
W. 1780	-	86,868		
P. 1790	-	738,485	-	667,222
W. 1800	-	717 690	-	15,381
W. 1810	-	1,473,830	-	1,392,677
P. 1820	-	926,698	-	666,912
P. 1821	-	861,406	-	421,277
P. 1822	-	827,561	-	514,653
P. 1823	-	808,748	-	452,882
P. 1824	-	845,339	-	684,806
P. 1825	-	1,372,957	-	469,687

Table of British and Foreign vessels that have entered inwards and cleared outwards to and from Great Britain for Spain, Majorca, Ivica, and the Canaries, P. denoting years of Peace, and W. those of War.

		Ships.		Tons.
P. 1787	-	652	-	65,422
P. 1790	-	567	-	66,676
P. 1792	-	725	-	84,994
W. 1794	-	542	-	67,077
W. 1796	-	373	-	50,176
W. 1798	-	159	-	25,767
W. 1800	-	240	-	61,317
P. 1802	-	638	-	90,976
W. 1804	-	532	-	81,382
W. 1806	-	349	-	59,187
P. W. 1814	-	963	-	117,579
P. 1816	-	588	-	71,676
P. 1818	-	741	-	92,573
P. 1820	-	570	-	68,735
P. 1822	-	599	-	69,387
P. 1823	-	648	-	74,897
P. 1824	-	...	-	78,614
P. 1825	-	...	-	100,831

At one period few national ships were employed in the trade of Spain. The number, however, has considerably increased. Catalonia alone possesses above a thousand vessels; and in the city of Cadiz are more than a hundred shipowners.

The following account of Spanish probity, in commercial transactions, is given by Laborde:—"Good faith and punctuality are generally prevalent among merchants, the instances of deception, negligence, fraudulent dealing, and non-fulfilment of engagements, so general in the trading world, being unknown, or not practised among them. Their integrity has been manifested on many important occasions: a few examples will be sufficient to justify this assertion. The fleets that sail from Spain to Porto-Bello, on their arrival attract a concourse of merchants, who give the silver coinage of America in exchange for the commodities of the European continent; and not a case of the former, nor a bale of the latter is opened, but all is received with a noble and mutual confidence upon the simple verbal assurances of the parties respecting the contents; and only one single instance of deception was ever known, for the space of two centuries, to have been practised. All the coined silver sent home in the year 1654 was found debased by the admixture of a fifth part of baser metal; but no sooner had the fraud been discovered, than the Spanish merchants appeared eager to support the whole loss themselves, and to indemnify all foreigners, with whom they had transacted business on that occasion. The treasurer of finance, *Du Perron*, was convicted as the author of the debasement, and for the crime was publicly burnt alive. The contraband trade of America furnishes daily new proofs of the probity which is evinced by the Spanish merchants; the French, English, and Dutch bear testimony to this high character, who lend their names, and in other ways assist the merchants of Spain; and scarcely an instance has occurred where these have not proved faithful to their engagements. Neither apprehension of danger, nor the attraction of gain can ever induce them to betray or deceive those who honour them with their confidence."

Chap. V.—*Population—National Character—Usages and Customs—Religious Festivals.*

When we consider that this country is one of the richest in the world, and possesses resources equal to any nation in Europe, we cannot but wonder at the deficiency of its population; for while England yields 169 inhabitants, France 174, and Naples 201 to the square mile, Spain has only 74. It is however agreed on all hands that, in more distant periods, this country was much better peopled than at present. Abundant vestiges indeed still exist of its former populousness. "The heights," says Laborde, "are covered with the ruins of Gothic castles, mansions, &c. and through the whole country appear dilapidated chapels, and other religious edifices in solitary places, situated in the midst of fields or uncultivated lands. The number of these in Catalonia, of which nothing remains but the names, is equal to a fourth part of those which at present exist. In Aragon are reckoned 149; in Catalonia 304; twelve in the kingdom of Jaen; 70 in the jurisdiction of Leon and Toro; 87 in Valencia; 11 in La Mancha; 194 in New Castile; and in Old Castile 308; constituting a sum total of 1141. Under the caliphs, kings of Cordova, 1200 villages enlivened the banks of the Guadalquivir, of which 200 scarcely are at present left. In the district of Malaga, to the west of that city, were 50 villages; and 16 only remain. A part of the diocese of Salamanca, in Leon, comprised 748 villages; which number is now reduced to 333. On the confines of the same bishopric 127 villages existed in the space of five leagues, and only 13 remain. Many of the villages and hamlets still subsisting present little more than ruins, and are in most instances reduced to a few houses, and a small number of inhabitants; 385 of this description may be enumerated in Aragon alone." Some idea may be formed of the loss in inhabitants which Spain has sustained, from the difference of population in some of its cities in ancient and modern times, as contained in the following table:

Cities.	Date.	Ancient population.	Modern population.
Tarragona	Under the Romans	2,500,000	10,000
Merida	Had a Roman garrison of	90,000	5,000
Truxillo	17th century	12,000	4,000
Montijo	Ditto	10,000	3,600
Seville	13th century	300,000	96,000
Cordova	Under the Caliphs	1,000,000	35,000
Medina del Campo.	16th century	60,000	6,000
Salamanca	Ditto	50,000	13,000
Burgos	Ditto	40,000	8,000
Valladolid	Ditto	60,000	20,000
Segovia	Ditto	38,000	12,000
Toledo	14th century	200,000	25,000
Cividad real	Ditto	25,000	9,000
Granada	15th century	250,000	50,000

Many causes for this depopulation have been assigned by different writers, of which we may enumerate the following as the most considerable. 1st, The plague, which spread over Europe in the years 1341 and 1348, made a most rapid and destructive progress in Spain, continued its ravages for three years, and carried off nearly two-thirds of the inhabitants. The same scourge renewed its desolations in the succeeding centuries, in 1483 and 1488, 1501 and 1506, and particularly in 1649, when, in the southern provinces, it swept away a population of more than 200,000; Cadiz and Seville alone lost 100,000 of their inhabitants. 2d, The expulsion of the Jews and Moors deprived this country of the most industrious and intelligent portion of her population. The former in 1492, to the number of 800,000, left the kingdom, and carried with them all the wealth and property which they had acquired by industry and trade: and in 1614, 2,000,000 of Moors were driven from their homes, and their towns and villages left desolate. 3d, The almost incessant and sanguinary conflicts between the Spaniards and Moors, which continued with little interruption for nearly seven centuries, and which terminated only with the taking of Granada in 1492 by Ferdinand, carried off many millions of Spaniards; and the civil wars, which have so frequently divided this kingdom, have probably been equally destructive of its population. 4th, The *Mesta*, by which immense tracts of land are converted into a state of pasturage, affords few means for the lower classes to obtain a subsistence by being employed in the labours of agriculture; and the 50,000 persons, who are engaged in taking care of the flocks, lead a wandering life, and seldom or never marry. Besides these, we may mention the constant emigration to America; the great number of unmarried monks and clergy; and the unremitted operation of a bad government. It would appear that the population of this kingdom had gradually decreased from the time of the Romans to the beginning of the 18th century; since which period, however, its increase has been uniform and rapid. Under the Romans, Spain is supposed to have contained at least twenty millions of inhabitants; in 1715 this number was reduced to six millions; but in 1799 it had increased to twelve millions.

The following table exhibits a state of the comparative population of Spain in 1788, divided into classes, when the population amounted only to 10,043,975.

Provinces.	Parishes.	Villages.	Secular clergy.	Convents.	Monks.	Nuns and friars.	Nobles.	Servants.	Individuals.
Andalusia	1,001	767	5,600	745	12,111	4,737	9,914	31,629	1,837,024
Murcia	101	108	1,077	91	2,000	646	4,704	6,408	337,686
Valencia	562	550	3,221	225	5,311	1,688	1,076	18,963	783,084
Catalonia	2,738	2,103	6,614	284	4,544	1,257	1,266	20,963	814,412
Aragon	1,396	1,625	4,843	228	3,864	1,551	9,144	22,009	623,308
Navarre	753	830	1,827	70	1,121	510	13,054	9,910	227,382
Biscay	720	632	2,511	111	902	1,141	116,913	8,713	308,157
Asturias	688	670	2,268	23	393	205	114,274	6,141	347,776
Leon	2,460	2,695	5,598	196	2,064	1,570	31,540	25,218	665,432
Galicia	3,683	3,658	9,382	98	2,394	604	13,781	18,960	1,345,803
Estremadura	415	360	2,782	172	2,060	1,748	3,724	11,036	416,922
La Mancha	111	167	749	78	729	610	603	8,410	206,160
New Castile	1,190	1,140	4,676	375	5,949	2,845	12,698	50,528	930,601
Old Castile	4,555	3,909	9,014	394	5,564	3,210	146,036	36,683	1,190,180
Royal demesnes	5	5	78	4	264	12	9	520	10,048
Total	20,378	19,219	60,240	3,094	49,270	22,337	478,736	276,091	10,043,975

Respecting the proportion between the extent of territory and the number of inhabitants, no very accurate estimate has ever been made in Spain. It is, however, stated in Hassel's "Satistique Europeenne," which is sufficiently correct for general purposes, that the whole of Spain contains 9053 German square miles, and 10,730,000 inhabitants, which will allow 1185 inhabitants for every German square mile, or 74 for every geographical square mile.

The people who now inhabit Spain have derived their origin from a variety of stocks, its soil having been occupied in succession by the Carthaginians, Romans, Goths, Arabs, and French. The original natives were in course of time confounded with their conquerors; and, as all of these nations introduced, in some degree, their own laws, manners, and customs, hence has resulted that diversity of appearance and character which is so observable among its present inhabitants. As the physical constitution of a people is almost uniformly influenced by the nature of the climate under which they live, and as every province of Spain differs materially in this respect, this circumstance may likewise in a great measure account for this variety. "The Castilians," says Laborde, "appear delicate, but they are strong. The Galicians are large, nervous, robust, and able to endure fatigue. The inhabitants of Estremadura are strong, stout, and well made, but more swarthy than any other Spaniards. The Andalusians are light, slender, and perfectly well proportioned. The Murcians are gloomy, indolent and heavy; their complexion is pale, and almost lead-coloured. The Valencians are delicate, slight, and effeminate, but intelligent and active in labour. The Catalans are nervous, strong, active, intelligent, indefatigable, and above the middling stature. The Aragonese are tall and well made, as robust as, but less active than the Catalans. The Biscayans are strong, vigorous, agile, and gay; their complexion is fine, their expression quick, animated, cheerful, and open." In general terms, the Spaniards may be described as rather below than above the middle stature, well proportioned, and of a swarthy complexion, with an intelligent countenance, regular features, and eyes quick and animated. The females are naturally beautiful, and the greater part are brunettes, of a slender and delicate shape, with a fine oval face, and black or rich brown hair. "They have large and open eyes, usually black or dark hazel, delicate and regular features, a peculiar suppleness, and a charming natural grace in their motions, with a pleasing and expressive gesture. Their countenances are open, and full of truth and intelligence; their look is gentle, animated, expressive; their smile agreeable; they are naturally pale, but this paleness seems to vanish under the brilliancy and expressive lustre of their eyes. They are full of graces, which appear in their discourse, in their looks, their gestures, and all their motions, and every thing that they do."

The dispositions and character of this people are perhaps even more diversified than their outward appearance; and there are not two provinces in which they are exactly alike. "The Old Castilians," says the author already quoted, "are silent, gloomy, and indolent; they are the most severely grave of all the Spaniards, but they possess a steady prudence, an admirable constancy under adversity, an elevation of soul, and an unalterable probity and uprightness; they are faithful, friendly, confiding, unaffectedly kind: in short, completely worthy people. Some districts have peculiar shades of character. The *Pariegos* are active and clever in trade, and are the pedlars of a great part of Spain. The inhabitants of the valley of Mena are robust, courageous, and employed in agriculture, they believe themselves descended from the ancient Cantabri. The *Maragatos* are lean, dry, frank, but the most taciturn of the Old Castilians; there are some among them who were never seen to laugh; they particularly addict themselves to the business of carriers.

The character of the natives of New Castile is nearly the same, but more open and less grave and taciturn; it is also somewhat modified in the districts bordering on other provinces. The qualities usually acquired by residing in or near a capital may be observed in them. The inhabitants of Alcarria ought to be distinguished from the rest, as simple, amiable, and industrious.

The inhabitants of La Mancha greatly resemble those of New Castile, but are more serious, more gloomy, and more laborious; they are a good kind of people.

Indocility and conceit make part of the character of the people of Navarre: they are distinguished by lightness and adroitness.

The Biscayans are proud, conceited, impetuous, and irritable, they have something abrupt in discourse and in action, and an air of haughtiness and independence: they are less sober than most other Spaniards; but are industrious, diligent, faithful, hospitable, and sociable. They have an open countenance, and a quick, animated, and laughing expression. The women are equally haughty and courageous. They labour in fields and at other works, where strength is required, like the men. The idea of something noble attached to being a native of Biscay, influences the character of the inhabitants of this province in a singular manner; it keeps up among them a feeling of dignity which gives a haughtiness to their carriage, and an elevation to their sentiments, even in the lowest stations of life.

The Galicians are gloomy, and live very little in society; but they are bold, laborious, very sober, and distinguished for their fidelity.

The Asturians participate in the character both of the Galicians and Biscayans, but they are less industrious than the former, less civilized, less sociable, less amiable, and more haughty than the latter. Their haughtiness, derived from the same source, an opinion of innate nobility, is also more marked, more repulsive, and less softened by their temper and manners.

The people of Estremadura are proud, haughty, vain, serious, indolent, and still more sober than the Galicians. They seldom go out of their own province, are afraid of strangers, and shun their company; but they are true, honourable and courageous.

The Murcians are lazy, listless, plotting and suspicious; they scarcely ever go out of their own country, and neither addict themselves to science, to the arts, to commerce, navigation, nor a military life; they only cultivate their land from necessity, and make but little advantage of a rich and fertile soil, a facility of irrigation, and a most happy climate. The common people are sometimes dangerous; they too frequently make use of the knife and the dagger; people of a superior condition lead a melancholy and monotonous life.

The Valencians are light, inconstant, and without decision of character; gay, fond of pleasure, little attached to one another, and still less so to strangers; but they are affable, gentle, and agreeable in the intercourses of society, and able, by their diligence, to ally the love of pleasure with industrious occupation. They are accused of being vindictive, and hiding under a calm and mild exterior their wishes and schemes of vengeance, till an opportunity offers of executing them in a safe and secret manner; but the hired assassins, formerly common in Valencia, have disappeared, and the people are daily becoming more civilized by the operation of wealth and prosperity.

The Catalans are proud, haughty, violent in their passions; rude in discourse and in action, turbulent, untractable, and passionately fond of independence; they are not particularly liberal, but active, industrious and indefatigable: they are sailors, husbandmen, and builders, and run to all corners of the world to seek their fortunes. They are brave, intrepid, sometimes rash, obstinate in adhering to their schemes, and often successful in vanquishing, by their steady perseverance, obstacles which would appear insurmountable to others.

The Aragonese are haughty, intrepid, ambitious, tenacious of their opinions, and completely prejudiced in favour of their country, their customs, and themselves; but prudent, judicious, able to appreciate foreign merit, good politicians, good soldiers, and zealous for their laws and privileges.

The Andalusians are boastful and arrogant; their discourse is always full of hyperbole; their expressions, their gestures, their manners, their tone of voice, their carriage, all bear the stamp of this prevailing disposition; in short, they are the Gascons of Spain. Of this country are the Majos, or bullying coxcombs, whose favourite weapon is the dagger, and they handle it with skill. Andalusia is a dangerous country in summer when the *solano* blows; a south south-west wind which blows from Africa, and the effects of which much resemble those of the *sirocco* in Italy, but are more obvious and violent. It inflames the blood, causes vertigo, and produces excesses of every kind."

There are, however, some traits of character which may be called national, and which are almost universal. Almost all Spaniards possess a natural dignity of sentiment, and have the highest opinion of their nation and themselves, which they energetically express by their gestures, words, and actions. They are very reserved, especially to strangers. Their address is serious, cold, and sometimes even repulsive; but under this apparent gravity they possess an inward gaiety, which sometimes bursts out, and, though usually noisy, is genuine, frank, and natural. The sum of their virtues is thus summed up: "They are sober, discreet, adroit, frank, patient in adversity, slow in decision, but wise in deliberation, ardent in enterprise, and constant in pursuit. They are attached to their religion; faithful to their king; hospitable, charitable; noble in their dealings; generous, liberal, magnificent; good friends, and full of honour. They are grave in carriage, serious in discourse, but gentle and agreeable in conversation, and enemies to falsehood and evil speaking. They are of quick and lively parts; intelligent, ingenious, fit for the sciences, literature and the arts." The Spaniards, indeed, possess many of these virtues in an eminent degree; but the defects of their character are equally conspicuous; and superstition and a bad government have degraded them far below the average of the other nations of Europe. One of the most prevailing defects in this people is their invincible indolence, and hatred of labour, which has, at all times, paralysed the government of their best princes, and impeded the success of their most brilliant enterprises. In every undertaking, even the most trifling, the Spaniard deliberates when he ought to act, and seems to be continually influenced by the spirit of one of the common proverbs of his country, "That one should never do to day what may be put off till to-morrow." The happiest eras of this nation have not been exempted from this fatal apathy, which has almost always kept them dependent on the industry of their neighbours, or at least far behind them in improvement; and the effects of which have been deplored by all their historians. "Sloth and idleness," said Sancho de Moncada in 1619, "are the prevailing vices of the Spaniards, and foreigners are so well aware of it, that they come running from all sides to bring us the products of their industry; they have reduced this poor kingdom of Spain to the condition in which the children of Israel were, when they were obliged to go and seek even the smallest instruments of labour among the Philistines." "In this country alone," says another Spanish writer, "are the mechanic arts held in dishonour; whence that multitude of idle people, and women of bad fame, and all the vices which accompany the want of employment. The result is, that our lands lie fallow, and that our country is a slave to the industry of strangers." This listlessness of disposition, however, is not so general but that there are some exceptions; and the inhabitants of some of the districts on the sea coast are conspicuous for their activity and industry. But this defect of the Spanish character is a virtue when compared with that depravity of morals which pervades every class of society in this country. The high and chivalrous spirit of a former age, when love, honour, and religion, maintained a generous rivalry, and gave birth to many splendid achievements, has been succeeded by a love of low intrigue and stratagems. The example of a dissolute court has given prevalence to practices which were before restrained, and has made that honourable which formerly had been attended with disgrace. Spanish jealousy, which was once proverbial, has given place to the most culpable indifference: and the most degrading connections have assumed among this people an authentic and respected character. The marriage ceremony is the prelude to the most ruinous gallantry. While it would be considered indecorous in an unmarried female to be seen alone out of doors, or sitting *tete-a-tete* with a gentleman, the married lady goes where she pleases, receives what company she likes; and even when indisposed in bed, she does not scruple to see every one of her male visiters. Many gentlemen are introduced to ladies of the first fashion, and visit them on the most familiar footing, without the least acquaintance, or even personal knowledge of their husbands. Immediately after marriage the lady must have, a matter of course, a *cortejo* or lover, who has in general a very strong hold upon her affections, and compared with whom the husband is a person of very secondary consideration. He attends her upon all occasions, in private and in public, in health and in sickness. When she sits at home, he is at her side;

when she walks out, his arm supports her; and when she joins in the dance, he must be her partner. This connection, however, is invariably attended with jealousy and suspicion. Both are conscious that there is no other band between them but the precarious tie of mutual affection; and each, therefore, must tremble at the approach of any one who might interrupt their union. Hence they are constantly engaged in watching each other's looks; and for want of confidence, renounce, in a great measure, the charms of social intercourse. "It sometimes happens," says Mr. Townsend, "that a lady becomes weary of her first choice, her fancy has fixed upon some new object, and she wishes to change; but the former, whose vanity is flattered by the connection, is not willing to dissolve it. In lower life, this moment gives occasion to many of those assassinations which abound in Spain; but in the higher classes, among whom the dagger is proscribed, the first possessor, if a man of spirit, maintains possession, and the lady dares not discard him, lest an equal combat should prove fatal to the man of her affections. In this contest the husband is out of sight, and tells for nothing." "It is reckoned disgraceful to be fickle; yet innumerable instances are seen of ladies who often change their lovers. In this there is a natural progress; for it cannot be imagined, that women of superior understandings, early in life distinguished for delicacy of sentiment, for prudence, and for the elevation of their minds, should hastily arrive at the extreme, where passion triumphs, and where all regard to decency is lost; as for others they soon finish the career. It is however humiliating to see some who appear to have been designed by nature to command the reverence of mankind, at last degraded, and sunk so low in the opinion of the world, as to be never mentioned but with contempt. These have changed so often, and have been so unfaithful to every engagement, that, universally despised, they end with having no cortejo. So general is this system, that there is scarcely a lady of respectability who has not her cortejo. The author already quoted mentions the circumstance of a gentleman in Carthagena saying one morning to a friend, 'Before I go to rest this night, the whole city will be thrown into confusion.' This he himself occasioned by going home an hour before his usual time, to the no small vexation of his wife and of her cortejo, whose precipitate retreat, and unexpected arrival in his own house, occasioned the like confusion there; and thus by successive and similar operations, was literally fulfilled the prediction of the morning." Though it would appear from this extract that married men do not hesitate to hold the situation of a cortejo, yet in this disgraceful connection the clergy in general hold the principal places; in the great cities the canons of the cathedrals, and in country villages the monks. The corruption of morals in general may be traced to the celibacy of the clergy; but the almost universal infidelity to the marriage vows in this country originated in the introduction of Italian manners on the arrival of Charles III. from Naples, connected with the previous want of reasonable freedom in the commerce of the sexes.

The Spaniards may in general be divided into two classes, nobles or Hidalgos, and plebeians. The former includes all those whose families, either by immemorial prescription, or by the king's patent, are entitled to particular privileges. This honour branches out through every male whose father enjoys that privilege, and thus Spain is overrun with *gentry*, many of whom earn their living in the meanest employments. The grandees hold the first rank, and are divided into three classes, which, however, differ from each other only in the form of the ceremonial to be observed by them when introduced at court. A grandee of the highest rank, when presented to the king, covers himself before he replies to the salutation of his majesty; one of the second remains uncovered till he has paid his compliments, but one of the third rank is not allowed to cover himself till he has paid his compliments, made his bow, and mingled with the crowd of courtiers. The character of these grandees is thus drawn by an admirable painter of Spanish manners; "surrounded by their own dependants, and avoided by the gentry, who are seldom disposed for an intercourse in which a sense of inferiority prevails, few of the grandees are exempt from the natural consequences of such a life; gross ignorance, intolerable conceit, and sometimes, though seldom, a strong dose of vulgarity. I would, however, be just, and by no means tax individuals with every vice of the class. But I believe I speak the prevalent sense of the country upon this point. The grandees have degraded themselves by their slavish behaviour at court, and incurred great odium by their intolerable airs abroad. They have ruined their estates by mismanagement and extravagance, and impoverished the country by the neglect of their immense possessions. Should there be a revolution in Spain, wounded pride and party spirit would deny them the proper share of power in the constitution to which their land, their ancient rights, and their remaining influence entitle them. Thus excluded from their chief and peculiar duty of keeping the balance of power between the throne and the people, the Spanish grandees will remain a heavy burthen on the nation, while, either fearing for their overgrown privileges, or impatient under reforms which must fall chiefly on them and the clergy, they will always be inclined to join the crown in restoring the abuses of arbitrary government." The privileges of this body are very important. They are alone admissible into the four military orders; they are exempt from certain imposts, from service in the militia, and from the billeting of troops. They are not liable to imprisonment for debt, except for arrears of taxes payable to the king; they cannot be confined in the common prisons, nor can their house, their horse, their mule, or their arms, be taken in execution. The nobility of Spain in 1788 amounted to 478,736, above $\frac{1}{12}$ of the whole population; of these 129 were grandees, and 535 marquisses, counts, and viscounts; but nearly one half of this privileged order belongs to the provinces of Asturias and Biscay.

The Spanish dress is now very much altered from what it was a century ago; and French fashions are daily gaining ground, especially among the higher ranks, and destroying entirely the national costume. During the seventeenth century, it consisted of light breeches, bound with garters, and fastened up with points: a short doublet, with large flaps, and hanging sleeves, covered with a frieze cloak, all of black; a round hat, usually turned up in front, and often adorned with a plume of feathers; a *golilla*, or white ruff, worn round the neck; a dagger at the girdle, and a very long sword. The accession of Philip V. however, introduced a total change; and the costume of France soon prevailed over that of Spain. Black was exchanged for the most varied and conspicuous colours; the old swords disappeared; and bags and queues came in place of the simple crop. The cloak and slouched hat are still much in use, except in the large cities, where they are seldom worn except in winter as a protection from the cold. Uniforms are very common, and a well-bred Spaniard would be ashamed to show himself without one. They are not confined to the military, but are worn by all the officers employed in the king's household, or attached to the treasury, post-office, &c. Judges, magistrates, and professors of the universities, are also distinguished by peculiar dresses. The nobility have an uniform for the holy week, which they wear at court and in town. The coat is of black velvet lined with crimson satin, with gold, or gold embroidered buttons, and facings of gold brocade on a crimson ground, or of satin of the same colour embroidered with gold. The waistcoat is the same as the facings, and the breeches are black. This dress is worn by the king and the royal family.

Women of rank in Spain have all adopted the French dress, which they wear at home, in their carriages, at visits and public spectacles; and assume the Spanish habit only when they walk out, or go to church. This at present consists of the *basquina*, or black petticoat, which is sometimes ornamented with gold embroidery, and trimmed with coloured ribands; the *mantela*, a broad black veil hanging from the head over the shoulders, and crossed on the breast like a shawl; and a showy fan, which is indispensable in all seasons, both in and out of doors. This instrument is of singular utility to the ladies; and "an Andalusian woman," says the author of Dobledo's Letters, "might as well want her tongue as her fan. The fan, besides, has this advantage over the natural organ of speech, that it conveys thought to a greater distance. A gentle tap commands the attention of the careless, a waving motion calls the distant. A certain twirl between the fingers betrays doubt or anxiety, a quick closing and displaying the folds indicates eagerness or joy. In perfect combination with the expressive features of my countrywomen, the fan is a magic wand, whose power is more easily felt than described."

The peasantry still preserve a diversity of dress in different provinces, but the common dress among them is a dark-coloured frock strapped round the waist, short breeches, with neither buttons nor gaiters, and a large round hat, or a *montera*, which is a cap of woollen or leather, sometimes round, and sometimes pointed at the top.

The usages and customs of this people have a reference in general to the national religion, and almost all their actions are blended with some superstitious observance. Every one has his patron saint to whom he applies on any emergency. The bed of an invalid is covered over with relics, amulets, and pictures; and a lady near her confinement is often wrapt in the episcopal robes of some saint, which are supposed to act most effectually when in contact with the body of the distressed petitioner. Their very names are derived from the same source; and it is a general notion among them, which is encouraged by the priests, that as many saints as have their names given to a child at baptism, are in some degree engaged to take it under their protection. Few have less than half-a-dozen names entered in the parish register, and many of them double that number. Their devotion to the Virgin Mary, who has innumerable images and titles in this country, furnishes them with a considerable variety. Almost every other Spaniard has Maria for a second name; and the most common names among the females are Encarnacion, Concepcion, Natividad, Esperanza, &c.

It used to be a common practice among the Spaniards to make pilgrimages to the shrines of their most celebrated saints, as St. James of Compostella in Galicia, our Lady of Guadeloupe in Estremadura, our Lady of Montserrat in Catalonia, and our Lady of the Pillar in Aragon. This custom, however, has fallen much into disuse, as also that of making short journeys to celebrated chapels and hermitages on the eve of the festival of the patron saint. The promiscuous crowd, assembled on these occasions, often spent the night in the most irreverent and dissolute revelries; and it was on account of the impieties which were there committed that the practice has been almost generally abolished. A few pilgrims still remain, but they are mostly strangers; and when persons of rank and opulence make a vow to beg alms, "they travel," says Laborde, "with every convenience, dismount from their carriage at the entrance of every town and village, beg through the streets, give away all that they receive to the poor, and then get into their carriage again and continue ther pilgrimage."

Religion with this people is rather a business than a feeling, and their devotion consists merely in external ceremonies, to which they are so habituated as to perform them almost instinctively, and the neglect of which would expose them to the horrors of the inquisition. In populous towns the inhabitants are frequently thrown into devotional attitudes by the sound of the little bell which precedes the priest who is carrying the consecrated wafer to a dying person. Its sound operates upon a Spaniard like magic. In whatever company or situation, in the street or in the house, he throws himself upon his knees, and in this posture he remains until the tinkling dies away in the distance. In the midst of a gay and noisy party, this sound brings every one to his devotions; if at dinner, he must leave the table, and if in bed he must at least sit up. Even in the public theatres, as soon as the bell is heard, "Dios, Dios," resounds from all parts of the house, and every one falls that moment upon his knees. The actor's ranting, or the rattling of the castanets in the *fandango*, is hushed for a few minutes, till the sound of the bell growing fainter and fainter, the amusement is resumed, and the devout performers are once more upon their legs, anxious to make amends for the interruption."

The Spaniards are very fond of public walks, and almost every town has its *alameda* or promenade, where the better classes assemble in the afternoon. Their chief amusement here, however, is not to walk, but to sit upon the stone benches, and take a view of the surrounding objects, or to carry on a whispering conversation with the next lady, which is termed in the idiom of the country *pelar la Pava*, "to pluck the hen turkey." Dinner parties are extremely rare, and only when an extraordinary occurrence happens in the family, as that of a young man performing his first mass, or a daughter taking the veil. On these occasions the dinner is always brought ready dressed from the coffee-house; and even then they never sit at table after the desert, but every one goes home or retires to his chamber to take his *siesta*. Evening parties for cards and conversation, which they call *Tertulia*, are very common, and often numerously attended, and which generally conclude with a light supper. There is little ceremony in these parties, every one entering and retiring as it suits his convenience or his humour. Smoking has become very prevalent among all classes, even the ladies freely partake of it; and a Spaniard is seldom seen without his cigar—in the streets or public walks, in coffee-houses, at cards, or even at a ball. As these cigars are very expensive, the poor inhabitants make imitations of them by rolling up bruised tobacco in paper cylinders. Their ideas on this subject are not the most delicate; for sometimes a smoker presents his cigar to his neighbour, who passes it on to the rest, and thus all use it in turn. Mr. Townsend mentions the circumstance of a tradesman of Luanjo having lighted his cigar, began to smoke, and finding it work well, presented it to the Countess of Penalba. She bowed and took it, smoked it half out, and restored it to him again; but as the Asturians consider smoking to be of no use unless the smoke passes through the lungs, a few minutes after she had joined the conversation, she opened her mouth and sent out a cloud of smoke.

The Spaniards are greatly attached to their national spectacles and public festivals. These festivals, however, are differently celebrated in different parts of the country. They are brilliant and magnificent in the provinces of Aragon, Valencia, and Catalonia; but simple and unostentatious in the other provinces. In the latter processions are very rare, but in the former they are very frequent, and performed with great pomp and preparation. The principal of these festivals are, the Carnival, Holy Thursday, Good Friday, Corpus Christi, St. John's Eve, &c. It would be tedious and difficult to describe all that passes at these festivals. The streets and squares are crowded from sun-rise to midnight. Business is completely neglected; and the spirit of devotion, which prevails in the morning, is converted by the shades of night into that of intrigue and licentiousness. There is on such occasions little fear of their evil practices being discovered. They are surrounded by multitudes who have the same intentions, and therefore indulgence is reciprocal. But the great national spectacle of Spain is the *bull fight*. This amusement was at one time suppressed by order of the government; and the prohibition continued for several years. This favourite spectacle, however, was again granted to the wishes of the people in 1799: and "the news of the most decisive victory," says Dobledo, "could not have more elated the spirits of the Andalusians, or roused them into greater activity." But for a description of this spectacle, we must refer our readers to the article Bull-fights in this work.

The shadow of ancient chivalry still exists, in some part of Spain, in those festivals called *parijas*, which are given by the *maestranzas* of Valencia, Granada, Seville, &c. The maestranza is a body of nobility, commanded by a lieutenant, who is usually a prince of the blood, and is elected every year; and is divided into four companies, each under the command of a knight. Every member, before admission into this corps, must prove a descent of four degrees. Three feasts are given every year on the birth days of the king, queen, and the prince who is at the head of the particular maestranza; and the whole expense is defrayed by the lieutenant. On these occasions they perform a variety of military evolutions, which are executed with great exactness. They also run at the ring, engage in sham-fights, dart their lances, and throw balls made of spongy earth. These imperfect representations of the ancient tournaments often terminate the amusements of the court before leaving Aranjuez. Mr. Townsend saw one of these parijas at Aranjuez in 1786, in which "the prince of Asturias, with his two brothers, the infants Don Gabriel and Don Antonio, attended by five and forty of the first nobility, all in the ancient Spanish dress, and mounted on high-bred Andalusian horses, performed a variety of evolutions to the sound of trumpets and French horns; forming four squadrons, distinguished from each other by the colour of their dresses, which were red, blue, yellow, and green; they executed this figured dance with great exactness, and made an elegant appearance."

Chap. VI.—*Government—Laws—Administration of Justice—Finances—Army—Navy—Military Orders.*

Before the union of the crowns of Castile and Aragon, each of these kingdoms possessed constitutions extremely favourable to liberty. Their assembly of the states or Cortes, which were composed of the clergy, the grandees, the nobles, and the commons, or representatives of cities and towns, enjoyed many privileges well calculated to restrain the authority of the sovereign. In Castile the four different orders met and deliberated as one collective body, and their decisions were regulated by the sentiments of the majority. In them alone resided the right of imposing taxes, of acknowledging the heirs of the crown, of enacting laws, and of redressing grievances; and in order to secure the assent of the king to such statutes and regulations as related to the public welfare, it was usual to grant no supplies till such business was concluded. "There was not any body of nobility in Europe," says Dr. Robertson, "more distinguished for independence of spirit, haughtiness of deportment, and bold pretensions, than that of Castile. The history of that monarchy affords the most striking examples of the vigilance with which they observed, and of the vigour with which they opposed, every measure of their kings that tended to encroach on their jurisdiction, to diminish their dignity, or to abridge their power. Even in their ordinary intercourse with their monarchs, they preserved such a consciousness of their rank, that the nobles of the first order claimed it as a privilege to be covered in the royal presence, and approaching their sovereigns rather as equals than as subjects."

The constitution of Aragon, however, had some peculiarities, which distinguished it from that of Castile. Though the form of its government was monarchical, its genius and maxims were purely republican; and its laws had a reference to the monarch as well as to the lowest subject, the infraction of which might cost him his crown. The following compact, entered into between the states and the king on his accession to the throne, shows what were their ideas of the submission of subjects, and in which an opening was evidently left for rebellion: "We who are equal to you, and who have more power than you, make you our king, upon condition that you do not infringe our privileges; if not, NOT." The cortes of Aragon was composed of the same number of orders, and endowed with similar privileges as that of Castile; but no law could pass without the assent of every single member who had a right to vote. This court was assembled on four different occasions: 1st, On the accession of the king to the throne, to do homage to him, and to administer the oath: 2dly, To deliberate upon the supplies and services which they ought to afford him when they were necessary; 3dly, To agree to the establishment, alteration, or suppression of laws; and, 4thly, to debate upon the taxes, tributes, and duties that they should allow the prince. After the cortes was called together, the king had no right to prorogue or dissolve it without its own consent, and the session continued forty days. This body exercised powers, unknown in any other kingly government. They claimed the privilege of nominating the members of the king's council, and the officers of his household; and of appointing officers to command the troops raised by their authority. Their exertions, however, were not confined merely to the upholding of their own privileges, and maintaining the freedom of the constitution, but they were equally solicitous in securing the personal rights of individuals; and in 1335 they abolished the practice of torture, which was then permitted by the laws of every other nation in Europe. The same spirit prevailed among the people in 1485, when an attempt was made by Ferdinand and Isabella to introduce the inquisition into Aragon, they took up arms, put to death the chief inquisitor, and long opposed the establishment of that horrid tribunal. So jealous were the Aragonese of their freedom, that, not willing to commit the sole guardianship of their liberties to the vigilance and power of the Cortes, they had recourse to an institution peculiar to themselves. They elected a *Justicia-mayor*, or supreme judge, whose office bore some resemblance to that of the Ephori in ancient Sparta; and who acted as a judge between the king and the nation—moderating the authority of the monarch, and defending the rights of the people. The person of this magistrate was sacred, his power and jurisdiction almost unbounded, and he was responsible to the Cortes only for the manner in which he discharged the duties of his high office. "The attachment of the Aragonese to this singular constitution of government was extreme, and their respect for it approached to superstitious veneration. In the preamble to one of their laws, they declare that such was the barrenness of their country, and the poverty of its inhabitants, that if it were not on account of the liberties by which they were distinguished from other nations, the people would abandon it, and go in quest of a settlement to some more fruitful region."

The peculiar privileges of the two kingdoms of Castile and Aragon continued to exist long after their reunion; but, in the beginning of the 16th century, the princes of the house of Austria began to take umbrage at their exercise; and, while they dared not openly attack them, they had recourse to the more effectual method of secretly undermining them; and thus were so far diminished, that, at the conclusion of the 17th century, they were little more than mere forms. In Castile the nobles had been formally excluded from the legislative assembly in 1538, by which step the privileges of the commons were virtually abolished; and though the states-general in this kingdom continued to form a part of the constitution, their convocation was reduced to a vain ceremony; and before the invasion of Spain by Bonaparte, they had not been assembled for more than a century. Philip V. suppressed the states-general of Aragon in 1720.

At present the government of Spain is an absolute monarchy, the whole authority centering in the king and his ministers. These ministers, and also the members of the different councils which conduct the national affairs, are appointed by the crown, and are removable at pleasure. There are five ministers of state, viz. the minister for foreign affairs; the minister for administering justice, and dispensing favours; the minister of war; the minister for conducting the business of the navy; and the minister of finance. Connected with these are five councils: *The council of Castile*, which possesses both legislative and executive powers, and exercises the double function of advising the king, and administering justice. Its decrees are decisive in the courts, but its judgments are under the control of the king: *The Royal and supreme council of the Indies*, which is invested with the same powers, and exercises similar functions for the colonies, as the former does for the continent of Spain: *The supreme council of war*, which conducts every thing relating to military concerns: *The royal council of finance;* and *the royal council of orders*. The council of state, or privy council, which, at its institution, consisted of the king's confidential advisers, has for a century past, been merely an honorary association, and serves at present only to recompense such persons as the king wishes to distinguish by conferring on them the high honours and appointments attached to the title of a counsellor of state. All the most important offices are filled by men taken from the lower ranks of society. The grandees, satisfied with hereditary wealth and honours, have no objection to partake of the splendours of the throne, or to bask in the sunshine of royal favour; but shrink from the drudgery and responsibility of official situations; and such is the general neglect of education in this country, that the ministers find it difficult to obtain proper persons to fill the common offices.

The common law of Spain has undergone various modifications. The code established by the Romans was abrogated by the Goths; and theirs in their turn was abolished by the Saracens. During the re-conquest of Spain by the Christian princes, many different systems sprung up in the various small kingdoms into which the country was divided; and upon its final recovery to Christendom, each of these was governed by its own peculiar laws, which were, in general, a mixture of Roman and Gothic law, with some particular usages and local statutes. Upon the union of the different independent states under Ferdinand and Isabella, these sovereigns established some new laws under the title of *Ordenamiento real:* and in 1505 the states of Castile published a new code, which became the established code of that kingdom, and afterwards of all Spain, except Navarre and Biscay, which still retain their ancient laws and constitution. The laws, by which justice is at present administered in Spain, are contained in the codes known by the following titles: *Fuero juzgo*; *Ley de las siete partidas*; *Ordenamiento real*; *Fuero real*; and *Recopilacion*, which last is a collection of occasional edicts of the kings of Spain, and enjoys very high authority.

The tribunals of justice are sufficiently numerous. Every city, town, or village has its corregidor or alcalde, who exercise their jurisdiction within a certain extent of district. They have also the superintendence of the police in the places where they reside, and are the official presidents of the municipal body. These magistrates are nominated by the king, and take cognizance of all causes whatever that occur within their particular districts, except such as belong to the *Tribunals of Exception*, which will be afterwards noticed. In the principal cities, which are at once the centre of a corregidorate, and the residence of a military governor, the two offices are united, and the administration of justice is committed to the superior alcalde; the former being entrusted with the command of the military force, the immediate execution of the orders of the court, the regulation of the markets, the price of commodities, and with all that relates to the billeting and expediting the march of troops; and to the latter, it belongs to determine in all suits of law, whether civil or criminal. From the decision of the inferior courts, appeals are carried to the *Royal Audiences*, of which there are seven, namely, that of Galicia at Corunna, that of Seville, that of Asturias at Oviedo, that of Aragon at Saragossa, that of Valencia, that of Catalonia at Barcelona, and that of Estremadura at Cacerez. These tribunals take cognizance of all matters of police, and of appeals from the sentences or judgments of the lower courts. In criminal cases their sentence is final; but in civil suits their decision is absolute only when the object of litigation does not exceed 10,000 maravedis, about three pounds sterling, when an appeal lies to one of the *Chanceries*, or to the Council of Castile. There are only two Chanceries, one at Valladolid, which comprehends within its jurisdiction all the territory of Spain lying beyond the right bank of the Tagus; and the other at Granada, which includes the country beyond the left bank of the same river, except the kingdom of Navarre, which having retained a considerable portion of its ancient privileges, possesses a royal council at Pampeluna, which judges definitively without allowing farther appeal to any of the audiences or chanceries. The chanceries, besides receiving appeals from decisions made by the courts of audience, take cognizance of all civil and criminal causes that occur within five leagues of the cities wherein they are established; also of all causes in which the royal household is concerned, or in which the corregidors, alcaldes, and other officers of justice, are personally interested as plaintiffs or defendants; also of all questions relative to the privileges of the nobles, and the recognition and maintenance of nobility." From their sentence there is no appeal, unless it be in a civil suit involving property to the amount of 5000 gold doubloons (£10,000) and upwards, when a petition is presented within twenty days to the king, who refers the final decision of the cause to the Council of Castile. This council, as it regards its judicial capacity, is the supreme tribunal of the state, and before it all sentences pronounced by the superior courts may be brought for revision. For the better despatch of business, it is divided into five chambers or committees; two chambers of government, the chamber of fifteen hundred, the chamber of justice, and the chamber of the provinces. Each of these has its own department of business, taking cognizance only of causes of a particular description.

Besides these various courts of judicature, there are others of a very peculiar nature, generally called *Tribunals of Exception*, and which are so very numerous that at least half the business of the kingdom is withdrawn from the ordinary tribunals. The principal of these, besides the military courts, the ecclesiastical courts, and the fifteen courts of the inquisition, are, the *Court of general superintendence of rural affairs, and of successions in cases of intestacy*; the *Court of Prato Medica*, which takes cognizance of affairs relative to medical, surgical, and pharmaceutical police; the *Court of the Mesta*, which has been already alluded to; the *Court of general direction and superintendence of couriers, posts, inns, roads, and canals*; the *Real Junta de Obras y bosques*, which has the superintendence of the forests, fisheries, chases, parks, and palaces of the king: the *Court of Alcaldes de Corte*, or of the royal household, which is intrusted with the police of the capital, and whose jurisdiction also extends to every place where the king and his household actually reside. There are also four courts of exception relative to particular branches of the royal revenue; and *Consulates* in the principal commercial towns,, which take cognizance of disputes between the buyer and seller of mercantile produce.

Notwithstanding, however, this multiplicity of tribunals, justice is very badly administered in this kingdom. The facility of appeal from one court to another renders law-suits both tedious and expensive; and the circumstance, that the losing party, however unjust his claim, or however weak his defence, is scarcely ever obliged to pay his adversary's costs, puts it in the power of the rich to oppress and ruin those who are unable to support the expenses of a law-suit, which in Spain are enormous. But the greatest evil of all arises from the oppression and misconduct of the provincial judges, who are frequently influenced in their decisions by mercenary views. Their venality is so notorious, and their power so great, that to complain would be dangerous, and therefore every citizen is anxious to secure the favour and protection of a corregidor or alcalde as the only means of safety for his person and his property. Mr. Townsend mentions several instances of the rapacity of these magistrates. A military governor, who was much favoured by the king, when new in office, refused taking bribes, and ruled his rapacious officers with a rod of iron, but soon became infected with the love of money, and received it upon the most infamous occasions without a blush. Under his protection merchants defrauded the revenue, and bankrupts found shelter from their creditors. Another magistrate, having promised, for a bribe of one hundred dollars, not to grant an attachment to a person, who had pretensions to some property, yet granted it, and being reproached for his conduct, he replied with coldness, "How could I avoid it, when he gave me forty dollars; but be not uneasy, for to-morrow I will take off the attachment."

When such abuses prevail we may be certain that the government is vicious, that the laws are weak, and that violence has usurped the throne of equity.

The revenues of the kingdom of Old Spain are derived from various sources, and are classed under the following heads.—1*st*, *Personal Revenues of the Sovereign*, which comprise the produce of certain crown lands; the grand masterships of the four military orders, which were annexed to the crown by Ferdinand V.; the pasturage of the Serena, in Estremadura; the national or royal lottery; the produce of the mines, which are wrought on the king's account; the effects of clergymen dying intestate, and some other rights of minor consideration.—2*d*, *Rights of Chancery*, which include the droits arising from letters of naturalization, and dispensations respecting age, impediments, and illegitimacy; letters patent for erecting or restoring the rank of peerage, which, in the former case, costs forty thousand reals, and in the latter varies from twenty to forty thousand; fines levied upon all who succeed to rank or title; the annual fines called *lanzas*, paid in lieu of military service, and levied upon all who bear the title of duke, marquis, earl, or viscount, except some few who have obtained special dispensations; fines upon all employments and situations filled by royal nomination, and upon the admission of physicians, counsellors, &c. 3*d*, *General Rents*, which comprehend the revenue of the post office; duties upon imports and exports; premiums paid for licenses to ships trading to America; and taxes on tobacco, salt, lead, playing cards, quicksilver, stamped paper, sealing wax, gunpowder, and sulphur. 4*th*, *Provincial Rents*, which include the *Alcavalas*, which is a tax upon every article sold or bartered, whether belonging to agriculture, trade, or manufactures, and is paid every time the property is transferred, at the rate of two per cent. *ad valorem*, for home produce, and articles manufactured in Spain, and fifteen per cent. for those brought from foreign countries; the *alcavala y cientos*, which is similar to the last, and is a duty upon moveables and immoveables, every time they are exchanged or sold; it varies in different provinces and cities according to their respective privileges, but the average is from six to seven per cent. *ad valorem*. These are the most grinding of any description of taxes, and fall heavier upon the lower orders, who, from their scanty means of subsistence, are obliged to purchase from a fourth or fifth hand, and who consequently must pay this duty an equal number of times over; while the rich, who can buy by wholesale, and of the first supplies of the market, pay it only once. Their collection also gives rise to many vexatious proceedings on the part of the subordinate officers of excise, whose dishonesty and covetousness are well known, and whose exactions it is difficult to satisfy. Owing to the inconvenience attending this branch of the revenue, Ferdinand VI. established a commission in 1749, which was empowered to consolidate all imposts of this description into one general tax; but this object still remains to be accomplished. 5*th*, *Local Taxes*, which embrace the duties upon a great variety of articles, as gold and silver coin, brandy, beer, wool, a per centage upon leases of land, &c. 6*th*, *Taxes peculiar to certain provinces*.—Biscay is subject to none of the preceding imposts, but pays its portion of taxation under the name of a benevolence, which is assessed upon the inhabitants without the interference of the officers of the crown; and the impost trade of Navarre pays no duty unless the articles are sent out of the province. None of the provincial rents extend to Catalonia, that province being subject to taxes peculiar to itself, namely, the tenth of the rent of houses, lands, tithes and mills; a similar tax upon the supposed gains of merchants and mechanics; a duty of eight and a-half per cent. upon labour, whether of artists, manufacturers, or day labourers; a poll-tax upon animals according to their size; a duty upon the sale of glass; and a tax in lieu of furnishing lodgings and provisions for the army. The provinces of Aragon and Valencia are freed from the duty of Alcavala, upon payment of a single contribution as an equivalent. This is assessed equally upon all kinds of property, and is very moderate. 7*th*, *Taxes upon the Clergy*, which consist of various imposts levied upon all ecclesiastical offices, and the revenues arising from vacant benefices, suppressed religious orders, &c. The amount of these different taxes for 1778 was as follows:

	Reals de Vellon.	*Mara.*
Class First	1[illegible],[illegible]22,9[illegible]9	16
Second	7,0[illegible],[illegible]96	25
Third	3[illegible]1,[illegible]25,[illegible]3	27
Fourth	122,857,13[illegible]	
Fifth	22[illegible],[illegible]36,461	12
Sixth	[illegible]1,1[illegible],[illegible]9	
Seventh	42,347,392	
Total	777,111,881	13

Before the South American states had raised the standard of independence, the king of Spain derived a considerable revenue from the two Indies. The produce of the mines with the alcavala, customs and duties upon various articles, yielded annually a gross revenue of 405,000,000 reals; but the expense of collection, and of the colonial government, absorbed nearly two-thirds of the whole amount, so that scarcely more than 140,000,000 reals arrived at the royal treasury.

Total Revenues of the Kingdom.

Revenues of the continent of Spain	777,111,831	13
Nett revenues of the colonies	140,000,000	0
	917,111,[illegible]1	13 reals,

which is equal to £9,553,218, 15s. 5¾d. Sterling.

We give the subjoined account from Laborde, as affording every necessary information respecting the receipts and disbursements of the government. It contains a statement of the sums lodged in the royal treasury, and payments made out of the same in 1791.

Receipts.	*Reals de Vellon.*	*Mara.*
Receipts on tobacco	55,041,433	23
Provincial receipts	65,4[illegible]5,872	14
Salt pits	16,56[illegible],559	16
General receipts	133,396,782	33
Brandies	71,2[illegible]5	0
Wools	1[illegible],093,518	33
Extraordinary or casual effects	8,9[illegible]0,358	19
Produce on lead, and playing cards	655,9[illegible]5	7
La casa de aposento	891,353	33
Proprios y arbitrios	486,932	4
Tax upon beer	11,007	3

	Reals de Vellon.	Mara.
Stamped paper	4,424,820	31
Duty on inns	213,038	4
Farmed duties	8,305,956	4
Cloth manufactory	6,177,775	20
Balance in the treasury at the end of 1791	99,836,037	0
Receipts and revenues in the Indies	142,456,768	32
Demi-annates	793,265	3
Lanzas	535,972	22
Fines granted by the tribunals	223,859	29
Privileges granted by the chamber of Castile	521,642	15
Produce of the pasturage in the Serena	310,236	0
Rent of masters	1,205,307	16
Bail of notary-publics	485,288	8
Tax du subsidio de l'escusado, and ecclesiastical pensions	4,337,741	30
Bulls for the crusade	20,441,279	0
Permanent tax de la casa excusada	9,130,522	32
The lottery	5,115,333	0
All sums received by the treasurer up to the time his function ends	133,609,754	8
Deficient remittances, for which goods have been distrained	4,567,579	20
Sums paid and remitted to the treasurer	5,489,499	20
For the consentimientos, according to the receipts given by the treasurer of the army	57,959,572	11
Total,	800,488,687	17

Disbursements.	Reals de Vellon.	Mara.
Expenses of the royal household	47,740,929	6
The offices of foreign affairs and the exchequer	8,977,395	2
The officers and courts of justice	19,759,879	13
State pensions	3,336,098	14
Sums paid for ecclesiastical pensions to vicars	9,201	0
To ambassadors and envoys in foreign courts	9,316,729	0
The 3 per cent. and premiums	4,854,598	0
Extraordinary expenses of government	82,551,362	0
Treasurers and paymasters	34,768,930	4
The 4 per cent. royal debentures	17,373,498	17
Discharged receipts, audited and approved	146,829,025	5
Testamentary tents	5,321,050	3
Grants, bills, and debts before liquidated by the treasury	11,930,597	4
The equipment and clothing of the army	8,960,820	4
Victualling the army	25,744,297	8
Life guards and halberdiers	4,748,678	9
Spanish and Walloon guards	12,521,918	24
Infantry, invalids and militia	58,797,784	11
Artillery and staff	7,213,314	24
Cavalry and dragoons	22,799,643	27
Staffs of different places	7,401,014	20
General officers	5,935,261	11
To ministers of war and state	4,566,449	2
Supernumeraries	5,396,030	11
Engineers	1,616,334	14
Widows for remittance in arrears of six doubloons	22,675	22
War pensions	2,035,172	0
Patriotic fund for granting pensions in time of war	652,211	6
The descendants of Oran, and the peaceable Moors	60,461	33
Pay of the army and navy	34,710,646	33
Pay of soldiers and expense of hospitals	9,536,783	27
Fortification and artillery expenses	26,319,222	18
Extraordinary war expenses	31,876,133	10
Expenses allowed to treasurers	132,079,686	8
Bank of piety for the military and its administration	4,723,654	2
Total,	800,488,687	17

Previous to the year 1747, the taxes were leased out or farmed, and consequently the abuses committed in the collection were numerous and grievous. The poor peasants were robbed and plundered with impunity, not merely by the farmers general, and those who rented under them, but by the judges, who, being bribed by the farmers, justified their oppression. The people reiterated their complaints from year to year; but the evil was never wholly removed until the Marquis de la Ensenada, the minister of Ferdinand VI. abolished the farms, and placed the collection of the taxes in the hands of administration. This plan, however, is very expensive, owing to the great number of tax-gatherers, which, besides the numerous guards, which are requisite to enforce payment, and to prevent smuggling, amount to nearly 28,000. The state of Spanish finances is so very complicated, that their collection is still every where attended with many harassing circumstances, and perplexing difficulties; and though numerous tribunals are attached to the different branches of revenue for the hearing of complaints, and the settlement of disputes, yet the people still suffer from the impositions and extortions of the collectors.

The national debt of Spain has been contracted at different periods. According to the Abbé Raynal, Charles V. alone, for the support of the rash and ruinous wars in which he was engaged, borrowed to the amount of 4,000,000,000 of reals, equal to £41,666,666, 13s. 4d. sterling. As the interest of this sum exceeded the whole revenue of the state, the government became bankrupt. Upon the accession of the Bourbon dynasty, public credit was again restored, and Philip V. taking advantage of this reviving confidence, contracted fresh engagements to the amount of nearly 700,000,000 reals. Ferdinand refused to discharge any debts contracted by his predecessors, and left his coffers replenished with 640,000,000 reals. Charles III. expended the half of this sum in the redemption of the debt, and the remainder in fruitless wars. Since that period additions have been made to it at different times, and also small portions of it redeemed; but in the beginning of the present century, it amounted to the very moderate sum of 1,800,000,000 reals, or £18,500,000 sterling. This debt consists of bills issued by government, which bear interest at 4 per cent. and are divided into *vales reales*, which are not in circulation, neither taken in payment of taxes, and *vales dinero*, which are payable at sight by the *casa de consolidacion*, or redemption board. Large portions of the debt have been redeemed by this board; but since the commencement of the peninsular war the redemption of the *vales* has entirely ceased: and when we consider the low state of credit at present in that unhappy country, it is not likely that it will soon be renewed.

The following table shows the amount of money raised in England for Spain from 1820 to 1823.

Year.	Amount of Capitals created.	Rate per cent. By contract.	Rate per cent. Per An.	Extreme Rates. Max	Extreme Rates. Min.	Amount of money raised by England.	Annual obligation.
1820	£3,000,000	47	5	10	74	3,820,000	700,000
1821	3,000,000			8½	73½		
1822	3,000,000	54		7	71	3,210,000	
1822	4,000,000			7	70¾		
1823	1,000,000	26		4	33	260,000	

When Philip V. ascended the throne of Spain, he had not a single ship fit for sea; and there were scarcely 15,000 troops in the whole kingdom. But no sooner was this monarch in quiet possession of the crown, than he directed his principal attention to the increasing of his army, and the establishment of military discipline. When Mr. Townsend visited Spain in 1787, the military establishments of every description were upon a very respectable footing. Since that time the army has been considerably augmented; and in 1798, the whole forces of the kingdom, including militia and invalids, amounted to 163,992 men, which consisted of the following description of troops:

	Officers.	Men.	Total.
1. *Army Staff.*			
General officers - -	560		
Inspectors, intendants, commissaries, &c. - - -	140		
	700		700
2. *King's Household Troops.*			
Life guards, 4 companies -	87	880	
Flying artillery, 1 ditto -	7	61	
Halberdiers, 1 ditto - - -	3	100	
Spanish guards, 6 battalions	171	4200	
Walloon guards, 6 ditto - -	171	4200	
Carabiniers, 4 squadrons -	51	600	
	490	10,041	10,531
3. *Horse Regiments.*			
Cavalry, 13 regiments of three squadrons each - - - -	364	5382	
———, 2 ditto, of 4 ditto -	74	1104	
Dragoons, 8 ditto of 5 ditto -	240	4416	
Chasseurs, 2 ditto of 5 ditto -	60	1104	
Hussars, 2 ditto of 5 ditto -	60	1104	
	798	13,110	13,908
4. *Infantry.*			
Spanish, 38 regiments of 3 battalions each - - - - -	2210	59538	
———, 10 ditto of 1 ditto -	280	6930	
Italian, 1 ditto - - -	58	1536	
Swiss, 6 ditto - - -	330	7658	
Artillery - - - - -	404	4400	
Engineers, with sappers and miners	150	1400	
Invalids, effective, 45 companies	137	3510	
———, ineffective, 26 ditto -	82	1820	
Militia, provincial, 42 battalions	1470	34340	
———, civic, 120 companies -	363	9317	
Provincial grenadiers, 4 regiments	120	2800	
	5604	133,249	138,853
Total - - - -			163,992

The Spanish troops are all distinguished by a red cockade, except the Walloon and Swiss guards; that of the former being red and black, and that of the latter red and yellow.

The pay of the infantry is fixed at the following sums per month, the *reals* being equal to 2½d. sterling.

		Foreign Infantry.
Commandant - -	1000	
Captain of grenadiers	800	- 600
Captain General - -	700	- 500
Lieutenant of Grenadiers	480	- 421
First Lieutenant - -	400	- 321
Second Lieutenant - -	320	- 301
Sub-Lieutenant - -	250	- 261
Private per day - -	1½	- 1½

The militia are raised only in the provinces belonging to the crown of Castile, the others being exempted from these levies. The provincial militia in times of peace are embodied one month in the year in the principal city of the department to which they belong, and receive the same pay as the infantry of the line. They are liable at an hour's notice to be called out upon actual service, and have frequently been most advantageously employed in defending the frontier, and in maintaining internal tranquillity. The civic militia neither receive pay, nor are liable to be called away from the particular stations to which they belong. They choose their own officers, and most of them have peculiar commandants.

Spain is divided into eleven grand military departments, viz. Old Castile; Aragon; Catalonia; Valencia, and Murcia; Navarre; Guipuscoa; Andalusia; the coast of Granada; Galicia; Estremadura; and Madrid. Each of these comprises several smaller divisions, which have an appointment of a larger or smaller staff. The chief command resides in the governor, who assumes the title of captain-general, to which the governor of Navarre adds that of viceroy. In general, these governors possess both civil and military powers, preside in the supreme courts, and have the sole management of the police.

The military character of the Spaniards, which shone so conspicuous in the 15th and 16th centuries, has now so completely degenerated that the government have great difficulty in raising the regular quota of troops, and none of the national regiments have their full complement of men. All classes have a natural repugnance to a military life. The lower ranks are in general grave and sober, attached to home, and have no relish for moving about from place to place. They, however, make excellent soldiers; and are seldom wanting in valour. The nobles have even a greater reluctance to the service; which, however, arises from a different cause. No person can arrive at the rank of an officer, without having previously served as a cadet in the same regiment; and, as the number of cadets in the cavalry and infantry are indefinite, their promotion is consequently so very slow, that they sometimes remain five or six years without rank. Serjeants are also promised promotion among all the different forces, except the artillery and the Spanish and Walloon guards, these regiments requiring every candidate for rank to exhibit some proofs of his alliance with nobility. These regulations, while they produce emulation among the privates to become serjeants, and among the serjeants to be promoted as officers, disgust the nobles, whose Spanish pride cannot endure to see officers of mean birth become their equals, and sometimes their superiors. The consequence of this is, that a great many officers, who have been elected from cadets, after a short time quit the service, while those raised from serjeants never retire: so that the regular army is commanded by officers principally, who have arrived at that rank from serjeants. In some instances the number amounts to a half, and in others to a third. At one period there were not four noblemen in all the troops of the Spanish monarchy.

The Spanish navy, in 1776, was so low, that it contained only 57 ships of 30 guns and upwards, besides small craft. In a few years, however, it advanced so rapidly, that in 1793 it was more than doubled, as appears in the subjoined statement.

70 Ships of the line, carrying from	112 to 54 guns.
46 Frigates	42 to 18
3 Corvettes . . .	20 to 18
16 Xebecs	36 to 14
13 Bylanders . . .	20 to 10
28 Brigantines	24 to 10

12 Ourques	40 to 20
4 Gallies	3
4 Galliots	3
3 Bomb-vessels	10
8 Packet-boats	
7 Goelettes	
2 Fireships	
216 Vessels in all.	

The marine department comprises the naval forces, the sea and port service, the arsenal service, the naval administration, hospitals, &c.

The naval forces consist of a marine staff, officers, cadet guards, engineers, artillery, and infantry, or marines, appropriated entirely to the service of the navy.

The sea and port service comprehends all persons employed about the shipping, both those who are actually employed, and those who are kept in reserve, but ready to act when their services may be required. The former includes the port captains and different orders of pilots, with a considerable number of seamen and boys. The latter consists of the registered seamen, amounting to above 60,000, who, during peace remain at their homes, but are subject to be summoned and employed at a moment's warning: the war commissaries, recorders, sub-delegates, &c. who are stationed at the different depots, and constitute courts for taking cognizance of all affairs relative to the registered seamen.

The arsenal service is carried on chiefly at Cadiz, Ferrol, and Carthagena, which are the three grand naval depots, at which a great number of persons are constantly employed, under the orders of an inspector-general of marine, and a general of engineers.

The naval administration is composed of the commissioners, superintendents, comptrollers, clerks, &c. belonging to the various marine departments.

The following is a general statement of the Spanish marine:

Naval forces in 1798	16,552
Sea and port service in 1792	64,363
Arsenal service	20,257
Naval administration	470
Hospitals	227
Total	101,869

The Spanish navy, however, was crippled in the last war with England: and the ships of the line will now scarcely exceed 50.

Spain has numerous establishments for the education of the youth intended for the army and navy. The principal military schools are at Cadiz, Barcelona, Zamora, and Segovia. The three first are chiefly designed for the instruction of such young men as are intended for the engineering department, though young officers of every description are admitted, and where are taught drawing, mathematics, engineering, and fortification. That of Segovia is confined entirely to the artillery. In 1796 a school was founded at Madrid for the benefit of the younger officers belonging to the corps of cosmographical engineers, and who are instructed in geometry, mathematics, geography, meteorology, and astronomy. Marine schools of different descriptions are established at the three naval stations, Cadiz, Ferrol, and Carthagena. Those appointed for the marine guards, into which only sons of gentlemen are admitted, have masters of mathematics, physics, gunnery, and manœuvre; and in those established for the naval artillery are taught those parts of mathematics which are essential to the artillery and pyrotechnic service, drawing, fortification, statics, hydraulics, hydrostatics, and aerometry. Nautical seminaries and schools of pilotage are distributed in various places along the coast.

The widows of all officers of the army above the rank of lieutenant are entitled to an annual pension; but the husband must have obtained the rank of captain previous to marriage. The fund, from which these pensions are paid, is not supplied by the state, but is derived from different sources: 1st, A sum of 6,000 doubloons, appropriated to the establishment: 2d, Twenty per cent. granted by the king from the revenues of vacant bishoprics: 3d, Half a month's pay from all officers upon promotion: 4th, Two per cent. upon all military appointments: and 5th, The effects of officers who die intestate and without natural heirs. The administration of these funds is conducted by an establishment at Madrid, called "The Mount of Piety."

The principal military orders of Spain are those of Calatrava, San Jago, Alcantara, and Montesa, which, at their original foundation, were intended for active service against the enemies of the faith, particularly the Moors, who then possessed a considerable portion of the Spanish territory: but, since the annexation of the grand masterships of these orders to the crown by Ferdinand V., they no longer constitute a peculiar description of the public force. To these orders are attached several valuable commanderies, amounting in all to 19,656,000 reals. Of these the lowest is 1260 reals and the highest 840,000. Besides knights, each order has also so many monks and nuns annexed to it, who are bound by particular vows. There are in all 10 houses containing 169 monks, and 11 convents with 136 nuns. The qualifications for admission into these military orders at present are, eight years of active service in the Spanish army, and proofs of nobility of four degrees on the side of both father and mother; but no knight can be appointed to a commandery unless he has taken the vow of combating the infidels, of fidelity towards the sovereign, and of conjugal chastity.

The other orders are those of the *Golden Fleece* and of *Charles III.* The first was founded by Philip the Good, Duke of Burgundy, and passed by succession to the Spanish crown upon the accession of the Austrian family. It is confined to fifty members, of whom the king is the sovereign chief; and has alone the disposal of the collars. About a third of these are at present in the possession of foreigners. The order of Charles III. was founded in 1771 by the king of that name, and is composed of sixty grand crosses, two hundred pensioned knights, and an indefinite number of others. The pensions of the knights, which are fixed at 4000 reals, are given to military men, to men of letters, to lawyers, to gentlemen, and to those employed in the ministerial departments. Besides these, we may mention the order of *Maria Louisa*, which was established in 1792 by Charles IV. in honour of his queen, in whom the grand mastership was vested. Ladies only are admitted, and the number is confined to thirty.

Chap. VII. *Religion—Ecclesiastical Division—Clergy—Literature—Language—Weights—Measures—and Monies.*

Strabo informs us that the ancient inhabitants of Spain adored a nameless God, of whom they formed no visible representation, and to whom they erected no temples, performing their simple rites in the open air, on the first night of every full moon. This simple worship, however, by the conquests of the Carthaginians and Romans, was exchanged for the superstitions and fables of Paganism; but these in their turn soon yielded to Christianity, which met with an early and welcome reception in this country; and from the first ages of the church, Spain furnished many martyrs to the faith. The introduction of Arianism by the Goths and Suevi occasioned many dissensions. While the natives adhered to the Roman Catholic creed, their conquerors were devoted to the heresy of Arius, and each party had their separate churches, bishops, and priests. An attempt was made in 579 to establish uniformity of religious faith and worship. But this was resisted by the Catholics, and was followed by a civil war with all its numberless evils. About ten years after, however, Ricaredo, king of the Goths, abjured the doctrines of Arius in a national assembly held at Toledo, when the whole of Spain was reunited to the Catholic church. From this period to the invasion of the Moors, the Spanish church was remarkable for the purity of its doctrine, and the efficacy of its discipline; and even under that people the Spaniards continued for a time to retain their religious establishments, and held several ecclesiastical councils. But they began insensibly to adopt the manners and customs of their conquerors, and their faith became at last a monstrous mixture of Islamism and Christianity, in which the leading tenets of each were undistinguishably confounded; and so completely was the Christian religion corrupted, and almost eradicated from these parts of Spain under the dominion of the Arabs, that on the reconquest of Seville in 1248 by Ferdinand III., and of Granada in 1492 by Ferdinand V., the slaves were the only Christians that could be found.

At present, the religion of Spain is strictly Roman Catholic; and, until the middle of the last century, the pope nominated to all benefices and dignities under ecclesiastical patronage if they became vacant in the months of January, February, April, May, July, August, October, and November; and at all times if the incumbent happened to die at Rome. He also levied a considerable revenue from benefices, universities, colleges, &c. All these privileges, however, were unwillingly ceded by Benedict VI. to Ferdinand VI. and his successors in 1753. But in this forced renunciation of his rights the pope retained two very important privileges, viz. the supreme administration of the *contentious jurisdiction* over all cases that are brought before the ecclesiastical tribunals, which is exercised by his nuncio, and the *court of nunciature* at Madrid; and the nomination, at all times of the year, to fifty-two of the best benefices, independent of the royal authority. The king, besides nominating to all benefices under the immediate patronage of the crown, now appoints also to those under ecclesiastical patronage, which fall vacant in any of the eight months above mentioned; and ecclesiastical patrons have the right of nomination only when the vacancy happens in any of the other four months. Lay patrons fill up vacancies under their nomination at whatever time of the year they happen; for neither the king nor the pope have ever been able successfully to infringe on their privileges. The influence of the papal court is consequently greatly reduced, having now no authority or jurisdiction in the temporal concerns of ecclesiastical benefices; and while very high respect is paid to the sovereign pontiff, his power is circumscribed within narrow limits.

Spain is divided into eight ecclesiastical provinces, over each of which presides an archbishop, with the rank of metropolitan; and these again are subdivided into forty-four dioceses, governed by bishops. The archbishoprics, with their revenues and suffragans, are stated in the following table.

Archbishoprics.	Revenues Sterling Money.	Suffragans.
Toledo	£125,000	Cuenga, Siguenza, Segovia, Osma, Valladolid, Cordova, Jaen, and Murcia, with two assistant bishops *in partibus infidelium*, the one residing at Toledo, and the other at Madrid.
Seville	34,375	Malaga, Cadiz, Ceuta, and the Canary isles.
Santiago	28,621	Avila, Salamanca, Astorga, Zamora, Ciudad Rodrigo, Tuy, Orense, Mondonedo, Lugo, Coria, Placencia, and Badajos.
Granada		Guadix and Almeria.
Burgos		Pampeluna, Tudela, Calahorra, Valencia, and Santander.
Tarragona	18,333	Barcelona, Gerona, Lerida, Vicq, Tortosa, Urgel, Solsona, and Iviza, in the Mediterranean.
Saragossa	25,208	Huesca, Balbastro, Jaca, Taracona, Albarrazin, and Teruel.
Valencia	32,083	Segorbia, Orihuela, and Majorca and Minorca.

The cities of Oviedo and Leon have likewise each an episcopal seat, independent of any metropolitan authority, being under the immediate jurisdiction of the pope.

There are in Spain fifty-eight cathedral chapters, and eighty-two collegiate chapters, and abbeys of different orders; and almost every religious order is to be found in this country The most numerous are the Franciscans, who have 610 convents and 19144 monks. The Spanish church, as may be seen from the princely revenues of the archbishops, is very richly endowed. Some of the bishops, and other dignitaries, have also very considerable incomes. The bishop of Murcia receives annually about L.20,833 sterling, and the bishop of Lerida L.10,000. The canonries are not less opulent in proportion, averaging between 100,000 and 40,000 reals; and the dignitaries of the chapters are still more richly beneficed. Some of the monastic orders also possess immense wealth; the Carthusians and Hieronymites in particular are proprietors of the greatest part of the districts that they inhabit, and the latter have a monastery at the Escurial, the revenue of which amounts to L.29,166 sterling. The following statement is drawn up from the enumeration of the Spanish clergy in 1768 and 1788, by which it appears that the number of the clergy had been very considerably diminished within the space of twenty years.

	In 1768.	In 1788.	Diminution.
Secular clergy - - -	66687	60240	6447
Subaltern ministers of the church	25248	15875	9373
Monks of 1925 convents -	56457	49270	7187
Nuns of 1081 convents - -	27665	22337	5328
Total - - -	176,057	147,722	28,335

Since 1788 the diminution of the clergy of Spain has been comparatively much greater. In many convents the religious of both sexes have been reunited, and many have become extinct by having been prohibited from receiving novices.

All the clergy of this country, both secular and regular, are amenable to no secular tribunal, either in civil or criminal cases. The church has tribunals of its own, whose jurisdiction is sufficiently ample, extending in certain circumstances even over the laity. The police of each diocese is entrusted entirely to the bishop, who generally has a prison within the boundaries of his own palace. From the diocesan courts an appeal lies to the metropolitan tribunal, and from thence to the court of nunciature at Madrid. The most dreaded tribunal, however, is the inquisition, which cannot be named by protestants but with horror and detestation. It was first established in this country by Ferdinand and Isabella in 1480; and there are now fifteen tribunals of this description in the different cities of Spain. Each of these has a department or district, within which alone it is allowed to exercise its functions; but the principal tribunal, and that on which all the others depend, is established at Madrid. The inquisition, however, which, at its first establishment, was intended for the special purpose of watching over the purity of the Christian faith, is now rather an engine of state-policy; and the objects of its notice are political principles, rather than religious opinions. We are told that it is no longer what it formerly was, that its sentences are now dictated by sentiments of mildness and peace; and that its prisoners, while in custody, are treated not merely with humanity, but enjoy every possible indulgence. But no change has taken place in the form and manner of its proceedings, which are always covered by impenetrable secrecy; and, though the light of knowledge and civilization, which has been diffused over Europe, may have taught even inquisitors humanity; yet, wherever inquisitorial power exists, it must be liable to abuse, and clemency must be merely accidental. Its name will always continue to be odious, however its influence may be diminished, or its constitution modified; and it is an engine of tyranny to which no free people will submit, and which every wise government will be anxious to abolish. See our article INQUISITION.

The Spanish clergy, either with respect to intellectual endowments or moral character, when compared with those of most nations of Europe, are far below mediocrity. Many of their dignitaries, however, are bright examples of charity, purity, and piety; and it is stated by Laborde that "whatever may be the rank of an ecclesiastic in the sacerdotal hierarchy, he never habitually absents himself from his proper place of residence, where he expends the revenue of his benefice in alms or public works." This author records several instances of the public spirit and beneficence of those venerable men. "The most beautiful aqueducts, fountains, and public walks in the cities, have been constructed at the expense of their bishops; from them also the poor have received the most effectual relief in times of scarcity, epidemic disease, and war. The bishop of Orense converted his episcopal palace into an alms-house, where were lodged and supported three hundred French ecclesiastics condemned to transportation during the furies of the revolution: the prelate himself took his place at their table, and refused to partake of any indulgence that he could not also procure for his guests; and the bishop of Cordova, during the scarcity of 1804, and for a long time afterwards, made a daily distribution of twelve hundred rations of bread to the poor inhabitants of his diocese." But our commendation must stop here, for few of the clergy, either secular or regular, think it necessary to imitate the virtues of their superiors.

The religious orders, in particular, are the most degraded and depraved. They may all be comprehended under two classes,—monks and friars,—of whom the author of Dobledo's Letters has given the following accurate and spirited description: "The distinguishing characters of the monks are wealth, ease, and indulgence; those of the friars, vulgarity, filth, and vice. Among the monks the Benedictines are at the top of the scale for learning and decency of manners, while the Hieronymites deservedly occupy the bottom. To the friars I am forced to apply the Spanish proverb, 'There is little to choose in a mangy flock.' The Franciscans, however, both from their multitude and their low habits of mendicity, may be held as the proper representatives of all that is most objectionable in the religious orders. The inveterate superstition which still supports these institutions among us, has lost, of late, its power to draw recruits to the cloister from the middle and higher classes. Few monks, and scarcely a friar can be found, who, by taking the cowl, has not escaped a life of menial toil. Boys of this rank of life are received as novices at the age of fourteen, and admitted after a year's probation, to the perpetual vows of obedience, poverty, and celibacy. Engagements so discordant with the first laws of human nature could hardly stand the test of time, even if they arose from the deepest feeling of enthusiasm. But this affection of the mind is seldom found in our convents. The year of noviciate is spent in learning the cant and gestures of the vilest hypocrisy, as well as in strengthening, by the example of the professed young friars, the original gross manners and vicious habits of the probationers. The result of such a system is but too visible. It is a common jest among the friars themselves, that in the act of taking the vows, when the superior of the convent draws the cowl over the head of the probationer, he uses the words *Tolle verecundiam*, 'Put off shame.' And indeed were the friars half so true to their profession as they are to this supposed injunction, the church of Rome would really teem with saints. Shameless in begging, they share the scanty meal of the labourer, and extort a portion of every product of the earth from the farmer. Shameless in conduct, they spread vice and demoralization among the lower classes, secure in the respect which is felt for their profession, that they may engage in a course of profligacy without any risk of exposure. When an instance of gross misconduct obtrudes itself upon the eyes of the public, every pious person thinks it his duty to hush up the report, and cast a veil on the transaction. Even the sword of justice is glanced aside from those consecrated criminals; and crimes of the blackest description were left unpunished during the reign of Charles III. from a fixed and avowed determination of that monarch not to inflict the punishment of death upon a priest."

The state of science and literature in Spain has been marked by different eras; but perhaps at no period has it been so fettered and degraded by the deadening influence of absolute despotism as at the commencement of the present century. This country, when subject to the Roman power, could boast of names still held sacred in the annals of knowledge. Seneca, the Philosopher, Pomponius Mela, Quinctilian, Lucan, Martial, Cornelius Balbus, &c. were natives of Spain, and even under the barbarous Visigoths a few were distinguished for their genius and their virtues. Upon the invasion of the Moors, however, when driven to the mountains of Asturias and Galicia, they for a time sunk into a state of powerless apathy. The very name of science was forgotten, and their priests could hardly read the services of the temple. But these invaders introduced a high degree of civilization, and united with the most romantic bravery a passionate love of science and the arts. As the basis of national happiness and improvement, public schools were established in almost every town, and colleges, with well selected libraries, were splendidly endowed in all the principal cities under their dominion. In these the sciences of geography, experimental philosophy, optics, botany, natural history, and geometry, were cultivated with great success. The Moors were the first great improvers of chemistry; they excelled in astronomy; they enriched the medical art which they had acquired from the writings of the Greeks, with many important discoveries; and to them we owe both the science of arithmetic, and the invention of those numerical characters, which have been adopted by all European nations. Their most renowned universities were those of Seville, Cordova, and Granada; and such was the reputation which they had acquired, that crowds of learned men from various countries resorted to Spain to study those sciences which were no where else taught so successfully. Among those distinguished foreigners were the famous Gerbert, afterwards Pope Sylvester II., Daniel Morley, Campano de Novare, and Gerard de Carmana. To this people also we are chiefly indebted for the treasures of Greek and Roman learning, which they collected and translated, and thus preserved this sacred deposit when it was lost to the rest of Europe. The works of many distinguished Arabian authors who flourished at this period, have been handed down to our times; and the illustrious names of Averroes and Avicenna will ever occupy a high rank in the annals of philosophy and medicine. The Spanish Arabs were, in short the bravest and most enlightened people of their age. Their learning, their industry, their generosity, were the admiration of all Europe; and such also was the noble confidence which they inspired, that many of the Christian princes in Spain sent their sons to be instructed in their schools, and called in their physicians in dangerous cases.

When the native Spaniards were restored to the quiet possession of their country, by the final expulsion of the Arab armies from the peninsula, they were fortunate in having a monarch who knew the value of learning, and who was anxious for its revival among his subjects. Many of them had studied under their Moorish conquerors; and by the munificent patronage of Ferdinand and Isabella they were the means of disseminating a taste for science and literature among their countrymen, who had long sacrificed every other kind of knowledge to that of the art of war. A spirit was thus excited, which being fostered and encouraged by succeeding princes, raised Spain, in the reign of Philip II. to a high rank among the civilized nations of Europe; and the period between the end of the fifteenth and the beginning of the seventeenth centuries, may well be considered as the golden age of Spanish learning. During this era flourished many eminent philosophers, historians and poets, whose fame added lustre to the age in which they lived, and whose names still continue to embellish the annals of their country. But the successors of Philip inherited neither his talents nor his love of learned men; and, though the impulse which the sciences had received from his protection and bounty continued to manifest its energy for several years, yet, when withdrawn from under the shade of royal favour, their progress became impeded, and their professors suspended their labours. Public disasters, arising from tedious and unsuccessful wars, also contributed to hasten their decay, and to direct the attention of the nation to other matters. From that time science and literature have been allowed to languish, neglected alike by the throne and the people; and though a few eminent and favoured geniuses have arisen during this inauspicious period as meteors in the midst of darkness, yet Spain has never been able to recover her celebrity as a learned nation, though the names of Lopez de Vega, Cervantes, Francisco Cernandes, Ulloa, Quevedo, Saavedra, Benedict Feyjoo, Anthony Augustine, Archbishop of Tarragona, called by *de Thou* "the lamp of Spain," Christopher Acuna, and Calderon, may well preserve her fame.

There were formerly twenty-four universities in Spain, but they are at present reduced to seventeen, and of these six only deserve the name:—Salamanca, Toledo, Saragossa, Valencia, Alcala, and Cervera. That of Salamanca is the most ancient, and was at one time the most celebrated in Europe. It was founded by Alphonso IX. about the beginning of the thirteenth century, and considerably enlarged by his grandson Ferdinand III. It consisted of twenty-five colleges, a library, and an hospital, called *del Estudio*, intended for the amelioration of poor scholars; and such was the high reputation which it enjoyed, that students flocked to it from all parts of Spain, and from foreign countries. Its celebrity continued for nearly three centuries, but as rival institutions sprung up it began to decline, and the number of its students, at the conclusion of the sixteenth century, had decreased from 15,000 to 7000. At present though the establishment is still unimpaired, and consists of sixty-one professors, yet its schools are almost deserted, there being seldom more than 1000 scholars. The university of Toledo has twenty-four professors, and 3000 students; that of Saragossa twenty-two professors, and 900 students; and that of Cervera forty-three professors and 900 students. None of these establishments are of any great repute; and the last is scarcely known beyond the boundaries of Catalonia. The university of Alcala, founded by Cardinal Ximenes, was once a splendid institution. It consists of thirty-one general professors, and thirteen colleges, each of which has its particular establishment of masters, and the students receive gratuitous support and instruction. Scarcely a vestige, however, of its ancient splendour remains, and the whole number of its scholars does not exceed 500. But the most popular university in Spain is that of Valencia. It has fifty-eight professors; two for latin grammer, one for poetry and oratory, two for Greek, one for Hebrew, six for philosophy, two for mathematics, one for mechanics and natural philosophy, one for astronomy, eleven for medicine, seven for civil law, five for the canon law, one for ecclesiastical discipline, and eighteen for theology. Yet even here the system of instruction is very imperfect and faulty. They have not yet escaped entirely from the philosophy of Aristotle, and the theology of Thomas Aquinas: and as late as 1793 there was neither a laboratory nor apparatus for exhibiting a single experiment in chemistry and natural philosophy.

Besides the universities, and the military and naval schools, which have been already mentioned, there are numerous other establishments for the education of youth. Every monastery almost has a school for theology and philosophy, which is open to the public. There are also many colleges independent of the universities: and several seminaries attached to episcopal sees, and under the direction of the bishops. But in all the system is radically defective. In what relates to scientific discoveries they are half a century behind: and they devote too much of their attention to subjects which have long since been abandoned by the rest of Europe. "Their schools of astronomy," says Laborde, "are destitute of instruments and observatories: their courses of natural philosophy are without experiments: their teachers of natural history are unfurnished with cabinets: their professors of anatomy give no demonstrations: their schools of chemistry are without laboratories and apparatus: and their libraries are destitute of modern books."

With regard to what is called *polite literature*, they have made greater advances: but the numerous restrictions laid upon the publication of national works, and upon the introduction of foreign books, cramp the energies of genius, and must retard in every state the progress of liberal ideas. Among the modern authors whose writings have done honour to Spain, and who, in spite of numerous obstacles arising from the oppressive measures of a corrupt court, and a bigoted priesthood, have endeavoured to uphold her falling fame, the names of Father Isla, Bayer, Campomanes, Larugo, and Jovillanos, will ever rank among those of the benefactors of their country.

The poetry of Spain is perhaps the department of literature which has gained least by modern improvements; for since the introduction of the Italian measures by Bascano and Garcilaso in the 16th century, her best poets have been merely servile imitators of Petrarch. The prolix and pompous style of the writers of that school, though sometimes exhibiting an ingenious and happy invention, with occasional flights of sublimity, bear evident marks of a confusion of ideas; and Don Ignatius de Luzano, who published an Art of Poetry in 1737, attributes the scarcity of good writers to "a certain haughtiness, which accounts it a degradation to submit to prescribed rules, and which mistakes for enthusiasm and inspiration, what is only the fruit of a bewildered imagination." Some poets, however, have arisen in the present day, who have endeavoured to emancipate themselves from the prevailing errors, and to correct the national taste. In this number may be ranked Yriarte, Melendez, Moratin, Quintana and Ariaza. Yet such is the almost complete destruction of the love of literature in this country, that their works are read and appreciated but by a few. The great bulk of the nation manifest no relish or desire for mental improvement. Books are little read: and all, who are not engaged in business, are occupied in their attendance upon the ladies, with whom nothing of this kind is heard of. "Years pass away," says the author of Dobledo's Letters, "without the publication of any original work. A compilation, entitled El Viagero Universal, and the translation of Guthrie's Grammar of Geography, are looked upon as efforts both of literary industry, and commercial enterprise. There exist two royal academies, one for the improvement of the Spanish language, the other for the advancement of national history. We owe to the former an ill-digested dictionary, with a very bad grammar; and to the latter some valuable discourses, and an incomplete geographical and historical dictionary. The Spanish academy has published a volume of prize essays and poems, the fruits of a very feeble competition, in which the poetry partakes largely of the servility of imitation, and the prose is generally stiff and affected. Our style, in fact, is at present quite unsettled, fluctuating between the wordy pomposity of our old writers, without their ease, and the epigrammatic conciseness of second-rate French writers, stripped of their sprightliness and graces. As long, however, as we are condemned to the dead silence in which the nation has been kept for centuries, there is little chance of fixing any standard of taste for Spanish eloquence."

The Spanish language is a compound of the Latin and Teutonic, with a small admixture of Arabic. When the country was divided into a variety of independent sovereignties, each kingdom had a dialect of its own. But since the union of the crowns, the dialect of Castile has become the general language of the whole monarchy, and is still called the Castilian language. It is spoken in its purest state in New Castile, especially in the ancient kingdom of Toledo, and is one of the finest of the European languages. "It is dignified, harmonious, energetic and expressive; and abounds in grand and sonorous expressions, which unite into measured periods, whose cadence is very agreeable to the ear. It is a language well adapted to poetry, but it also inclines to exaggeration: and its vehemence easily degenerates into bombast. Though naturally grave it easily admits of pleasantry. In the mouth of well educated men it is noble and expressive; lively and pointed in that of the common people; sweet, seductive, and persuasive when uttered by a female. Amongst the orators it is touching and imposing, though rather diffuse; at the bar and in the schools it is barbarous; and is spoken by those about the court in a concise and agreeable manner." In the other provinces its purity has suffered considerably from the introduction of foreign words and idioms. It is mixed with French in Navarre, Catalonia and Valencia; with Portuguese in Galicia; and with Arabic in Murcia and Andalusia. The Basque, which is still spoken in Biscay, is supposed to be the ancient language of that country, before the invasion of the Romans, and is mentioned by Strabo and Seneca. It has no analogy with any known tongue; and is preserved without alteration or corruption in the mountainous parts of Biscay. Though it appears harsh and coarse to those who do not understand it, yet it is said to be destitute neither of elegance nor expression.

The liberal arts in Spain have had the same periods of splendour and decline, as science and literature. The architecture of the 16th century is worthy of being compared with that of the Romans: and the bridges of Badajos and Toledo, with some of the public buildings of the latter city and Madrid, deserve the careful attention of the skilful observer. The famous Escurial, of which a description has been given in this work, belongs to the same age, and is called by the Spaniards, the eighth wonder of the world. This building astonishes by its great extent, and the magnificence of its execution, as much as by the repulsive appearance of its site and neighbourhood. Spain can also boast of some distinguished sculptors; but "of all the liberal arts," says Laborde, "painting is that which has been most cultivated in Spain, and in which its natives have best succeeded. The Spanish school is little known, and deserves to be more so; it holds a middle place between the Italian and Flemish scools: it is more natural than the first, more noble than the second, and participates in the beauties of both." In this department Spagnolet, whose name was Joseph de Ribera, and Bartholomew Murillo, are well known; and in more modern times, Antonio Raphael Mengs supported the credit of the Spanish school. But here also the efforts of genius have sunk under the black and noisome influence of Spanish bigotry and despotism; and while the present government, both civil and religious, of this country continues, Spain must remain the most wretched and degraded of European nations.

We shall conclude the statistics of this country in the words of Mr. Townsend, who was well acquainted with the national character, institutions, and resources of this people, and whose faithful and lively descriptions have been universally appreciated. "Should this people banish the inquisitors, and assert their freedom; should they, happy in possessing one of the richest countries upon earth, contract the bounds of their unwieldy empire; should they confine their views within the limits of their own peninsula, and cultivate the arts of peace; should they, to cherish industry, abolish the monastic orders, lessen the number of their festivals, establish an agrarian law, and strike off the fetters by which their commerce has been bound, considering the soil, the climate, the abundance of water, the natural productions, the rivers, the harbours, and the local situation, we may venture to affirm, that no country of the same extent would be more populous, more wealthy, or more powerful than Spain."

The weights and measures of Spain vary in almost every province, and occasion much trouble and perplexity in every kind of commercial relation. The standard measure of length is the royal foot, which is divided into 12 inches, and each of these into 12 lines, and is to the English foot as 153.41 to 144. The royal foot, however, is very little used, many provinces having their own peculiar foot. The foot of Catalonia measures 11 inches and $\frac{3}{4}$ths of a line of the royal foot, that of Valencia 11 inches, and $2\frac{1}{4}$ lines, and that of Castile 10 inches, and 4 lines.

Cloths and stuffs are measured in Catalonia by *canas*, and by *varas*, in other parts of the kingdom; the *cana* is divided into eight *pams*, and the *vara* into four; but the *pam* varies in different places.

The *pam* of Catalonia	= 7 in.	4 lines of the royal foot.	
Aragon	= 6	$7\frac{2}{3}$	
Valencia	= 8	4	
Castile	= 7	8	

In the provinces belonging to the crown of Castile, land is measured according to the following table:

2 varas	= 1 brass =	5 feet	1 in.	4 lines.
2 brasses	= 1 estadel =	10	2	8
400 estadales	= 1 fanega =	4.088	10	8
50 fanegas	= 1 ungada =	204.444	5	4
The fanega of Seville and Toledo is	=	5.111	1	4
Valencia only		1.250	0	0

In itinerary measure, the common league of Spain is equal to

	13.619 feet	7 in.	6 2-3 lines.
Ancient legal league	17 037	7	4
Present legal league	10.222	2	8
New league fixed in 1760	16.555	6	8

The measures of capacity, both dry and liquid, are also very various, differing very considerably both in size and denomination; but we have room only for the principal ones. Their relative value is shown by comparing them with the pound of 16 ounces.

In the kingdom of Castile corn is measured as follows:—

4 quartillos = 1 celemine	=	10 lbs.	$5\frac{1}{3}$ oz.
12 celemines = 1 fanega	=	124	0
12 fanegas = 1 cahiz	=	1528	0
The fanega of Asturias is	=	161	$5\frac{1}{3}$
of Granada	=	136	$5\frac{1}{2}$
of Biscay	=	131	$5\frac{3}{4}$
The cahiz of Valencia is	=	463	1
of Aragon	=	262	0

In oil measure the *aroba* of New Castile			
and Seville is	=	25	0
of Madrid	=	24	8
of Valencia	=	31	8
of Aragon	=	27	0
of Catalonia	=	22	12

In wine the cantara of New Castile			
and Seville is	=	34	2
of Madrid	=	48	0
of Asturias	=	39	3 3-5
of Valencia	=	26	4
The *olla* of Galicia	=	340	0
The *tormeaux* of Cadiz	=	1020	0
The charge of Aragon	=	420	0
of Catalonia	=	273	12

Every province has its own particular weights, but in the kingdom of Castile the pound generally consists of 16 ounces, and of 12 in the kingdom of Aragon.

The quintal of Castile is	=	100 lbs.	0 oz.
of Galicia	=	125	0
of Biscay	=	154	13
of Guipuscoa	=	105	$15\frac{7}{8}$
of Aragon	=	111	1 2-6
of Valencia	=	126	0
of Catalonia	=	91	0

The weights for gold and silver are the same almost throughout the whole of Spain, and are as follows:—

12 grains	=	1 tomina
6 tominas	=	1 ochava
8 ochavas	=	1 ounce
8 ounces	=	1 marc.

Owing, however, to the grains of Catalonia and Valencia being heavier than the grain of Castile, 100 marcs of Catalonia are equal to 116 marcs $5\frac{1}{3}$ oz. of Castile, and 100 marcs of Valencia are equal to $103\frac{1}{2}$ marcs of Castile.

The monies of Spain, like most countries are real and imaginary; the former used for the purpose of exchange, and the latter serving only for keeping accounts and striking bargains. The real monies, both gold and silver, at present in circulation, have been coined at three different periods. Those coined previous to 1772 consist of different sized pieces of metal, unequally cut, whose currency is only by weight. Those of more modern coinage bear the head of the king on one side, and on the other the arms of Spain; and are current throughout the whole kingdom. Several of the provinces, however, have both real and imaginary money peculiar to each. The denomination and value of the latest coinage is as follows:

			Sterling Money.		
Silver Money.		*Reals.*	*L.*	*s.*	*d.*
Real, real de vellon, or realito - - -	=	1	0	0	$2\frac{1}{2}$
Real de Plata - - - - - - -	=	2	0	0	5
Peceta, or real de a dos - - - -	=	4	0	0	10
Escudo - - - - - - - -	=	10	0	2	1
Duro, pezoduro, or real de a ocho -	=	20	0	4	2
Gold Money.					
Durito, escudo chico de oro, or veinteno de oro - - - - - - -	=	20	0	4	2
Escudo de oro, or doblon senzillo -	=	40	0	8	4
Doblon de oro - - - - - - -	=	80	0	16	8
Doblon de a quatre - - - - -	=	160	1	13	4
Doblon de a ocho, or onza de oro - -	=	320	3	6	8

Imaginary Money.		*Reals*	*Mara.*		*Sterling*	*Money.*	
Ducado de vellon - - - -	=	11	1	nearly	0	2	$3\frac{1}{2}$
Ducado de Plata nueva - -	=	16	17		0	3	$5\frac{1}{4}$
Ducado de Plata doble, or ducado de Plata de Antigua - -	=	20	25	nearly	0	4	$3\frac{3}{4}$
Pezo, pezo senzillo, or piastra	=	15	0		0	3	$1\frac{1}{2}$
Doblon - - - - - -	=	60	0		0	12	6

The smaller denominations of money are,

2 maravedis - - -	=	1 ochavo
2 ochavos - - - -	=	1 quarto
$8\frac{1}{2}$ quartos or 34 maravedis	=	1 real.

The monies peculiar to the provinces are chiefly fictitious: those that are not, are of small value. The *denier* of Valencia is equal to one *maravedi;* and the *denier* of Catalonia is equal to $1\frac{1}{2}$ *maravedi.*

There are three mints in the continent of Spain, at Madrid, Seville, and Segovia. At the latter place, however, only copper pieces are coined. The greatest part of the silver *duros* are imported from Mexico. All the business relative to the coinage is under the superintendence of a supreme court established at Madrid under the title of *Real junta de comercio, meneda, minas, &c.*

SPAN.* See BRIDGES in our supplementary volume.

SPARTA. See LACEDÆMON.

SPAWN of Salmon. See FISHERIES, and Dr. Brewster's *Journal of Science*, Oct. 1826. No. x. p. 238.

SPECIFIC HEAT. See CHEMISTRY.

SPECIFIC GRAVITY. See CHEMISTRY, and HYDRODYNAMICS.

SPECTACLES. See OPTICS.

SPECTRUM. See OPTICS.

SPECULUM. See OPTICS.

SPENSER, EDMUND, a celebrated English poet, was born in London in 1553. In 1569 he was a sizer in Pembroke College, Oxford. A love adventure with a lady, whom he has immortalised under the name of Rosalinda, is supposed to have been the origin of his "Shepherd's Complaint," which appeared in 1577. In 1580, he was secretary to Lord Grey of Wilton, Lord-deputy of Ireland; and in that capacity he exhibited great capacity for business. Having received from the crown a grant of 3000 acres out of the Desmond estates, he went to Ireland in 1587, and resided in Kilcolman Castle, where he was visited in 1589 by Sir Walter Raleigh. At this time he had written three books of the Fairy Queen, and accompanying Sir Walter to England, he published it in 1590, and dedicated it to Queen Elizabeth, who rewarded him with a pension of £50 per annum. In 1591, he returned to Ireland, where he married a young woman of humble degree. In 1596, he published a new edition of his Fairy Queen, with additional books.

In consequence of the rebellion which broke out in Ireland in 1598, he was compelled to take refuge with his wife in England. His house was burnt, and an infant is said to have perished in the flames. Thus reduced to indigence, he sunk under his misfortunes, and died in 1599 or 1600, and was buried at the expense of the Earl of Essex. Anne, Countess of Dorset, afterwards erected a monument to his memory.

The Fairy Queen, though obscure in its allegories, has always been considered as one of the finest poetical compositions in our language.

SPERMACETI. See CHEMISTRY.

SPHERE. See GEOGRAPHY.

SPIDER. See ENTOMOLOGY *Index*, under *Aranea;* and Dr. Brewster's *Journal of Science*, No. xv. p. 153.

SPINNING. See COTTON SPINNING.

SPINOZISM, is the name given to the metaphysical doctrines of a celebrated Dutch Jew, who was born at Amsterdam in 1632, and who died in 1667. See METAPHYSICS.

* In the article BRIDGES, vol IV. p. 532, reference is made to this article for an account of the timber and chain bridges in America; it is, however, deemed more consistent with the plan of this work that it should appear under its proper head as above referred to.

SPIRITS OF WINE. See CHEMISTRY.

SPIRITS. See DISTILLATION.

SPOTTING. See BROCADE.

SPRINGS. See PHYSICAL GEOGRAPHY.

STADE, a town of Hanover, situated on the Schwinge, a tributary to the Elbe. Its chief public buildings are a town-hall, merchants' hall, gymnasium, two churches, containing handsome monuments, and an orphans' hospital. It has manufactures of hats, flannel, lace, and stockings. The different public offices for the provinces of Bremen and Verden are situated here. A packet sails daily for Hamburgh. Population 4800.

STADIUM, a measure of length in use among the ancient Greeks. M. le Chevalier Lapie considers that he has demonstrated that the length of a stadium is the 700th part of a degree; a result which was rejected by D'Anville, but adopted by M. Gosselin. M. Jomard has recently found that the length of the ancient cubit is between 523 and 524 millimetres. See Dr. Brewster's *Journal of Science*, No. xii. p. 372.

STAFFA, a small island in the Hebrides, on the west coast of Scotland, celebrated for its grand caverns and basaltic columns. It is situated in the parish of Kilninian and county of Argyle, about five leagues to the west of Mull, and three leagues from Icolmkill. It is of an irregular oval form, consisting of an elevated table land, terminating on all sides in precipices of various altitudes. It is about one mile long and half a mile broad. The loftiest cliffs, which are on the south-west of the island, are 144 feet high; and on the north it declines to a flat rocky shore, only a few feet raised above the sea, and where the landing place is situated.

The objects of interest in this island are *Fingal's* cave, *Mackinnon's* cave, and the *Boot* cave.

The cave of Fingal, which looks to the south-west, was first pointed out as an object of interest by Mr. Leach, an Irish gentleman, who visited the island in 1772. It was afterwards visited by Sir Joseph Banks, Dr. Von Troil, bishop of Linkoping, and M. St. Fond; and it is now frequented by crowds of visiters, who are carried thither by steam boats, which leave Glasgow in the summer season once every fortnight for the express purpose.

The opening of the cave into which the sea flows is perpendicular at the sides, and terminates above in something like a Gothic arch. The following are its dimensions, given chiefly by Sir Joseph Banks:

	Feet.	Inches.
Length of the cave from the rock without	237	6
According to others - - -	227	0
Do from the pitch of the arch - -	256	0
Breadth of the cave at the mouth* -	53	7
——— farther end -	20	0
Height of the arch at mouth - -	117	6
——— at the end - -	70	0
Depth of water at the mouth - -	18	0
——— end - - -	9	0
Height of the tallest columns on the right side of the entrance - - -	45	0
Other measures make their height only -	36	0
Height of pillars at the eastern side -	18	0
Height of the cave varies from - -	50	44

The sides of the cave consist, like the mouth of it, of basaltic columns, similar to those which we have already described in our articles GIANT'S CAUSEWAY, and FAIRHEAD. They are, generally speaking, perpendicular; but they have not that regularity which is given to them in the ordinary engravings of the cave. The roof of the cave varies in different places. A deep channel forms the ridge of the roof. On each side of this fissure towards the mouth of the cave, the roof is formed of minutely fractured rock, similar to the stratum incumbent on the columns; about the middle of the cave the roof is composed of the broken ends of columns, and at the inner end of the cave, a portion of each kind of rock enters into the formation of the roof. Calcareous spar formed by incrustation between the ends of the columns in the roof, render them more distinctly visible.

The cave is never entirely free of the sea; but the broken range of columns, which forms the extensive causeway, is continued on each side within it. This causeway is most perfect on the eastern side, and allows the visiter to pass over it to the farthest extremity, provided the state of the tide permits it; but on the western side, the columns terminate at a considerable distance from the end of the cave. "When we behold," says Dr. Von Troil, "the Cave of Fingal, we are forced to acknowledge that this piece of architecture, formed by nature, far surpasses that of the Louvre, that of St. Peter at Rome, all that remains of Palmyra and Pœstum, and all that the genius, the taste, and the luxury of the Greeks were capable of inventing."

Mackinnon's Cave, also called the Cormorant's Cave, is situated on the north side of the island, in the midst of a magnificent colonnade. When the sea is a quarter ebb, the height of the cave is 50 feet, and its breadth 48. Its length is 224 feet, and it has nearly the same height and breadth throughout, excepting at the end where the roof and walls approximate, and a pebbly beach is formed. The general effect of the cave is very fine, though, in point of symmetry and elegance, it is inferior to the Cave of Fingal.

The Boot Cave is situated farther to the east, and from its mouth being beset with rocks, it can only be entered in calm weather, and at high water. It is from 14 to 16 feet high above high water. Its breadth is 12 feet, and its length 150. The roof and sides are smooth, and resemble the gallery of a mine. But though small in size, its effect is very picturesque, from the great symmetry of the columnar range in that part of the face, beneath which it is situated.

A family used to reside on the island both summer and winter, but we believe they now quit it at the end of summer. For farther information respecting this island, see Pennant's *Tour in Scotland* 1790, containing Sir Joseph Banks' description of Staffa, which has been lately reprinted in Thomson's *Pleasure Tours in Scotland*, Dr. Von Troil's *Letters on Iceland*, St. Fond's *Tour in Scotland*, and Macculloch's *Description of the Western Islands*.

STAFFORD, a borough and market-town of England, and capital of the county of the same name. It is built on the north bank of the river Sow, about three miles from where it joins the Trent. Its form is that of an irregular ellipsis, the greatest breadth of which is from south-east to north-west. Formerly

* Other measurements make this breadth only 42 feet.

it was surrounded by a wall, and defended by a castle, some remains of which still exist: it had also four gates. It is a very ancient borough, having been incorporated by King John in the seventh year of his reign. Stafford is very pleasantly situated; the streets are in general well paved, and most of the houses are neatly and regularly built of stone, and roofed with slates. The principal streets are built in the form of a cross, and the two largest ones occupy the sides of the road from Newcastle-under-Line to Wolverhampton. It is 135 miles north-west from London, and 16 from Litchfield, in the same direction.

The public buildings are numerous. There are two churches, St. Mary's and St. Chad's. The former is a spacious building, in the form of a cross, and consists of a nave, two side aisles, a transept, and a chancel of three aisles, in the middle of which is a large octagonal tower, with eight bells and chimes. The church also possesses a good organ, and a very ancient font. There are several fine monuments, both ancient and modern, in this church, the most remarkable of which are, an altar tomb in honour of Lord Edward Aston of Tixal, and the Lady Ann, his wife; a monument to the memory of Sir Edward and Lady Aston, and one to Lady Barbara Crompton, wife to Sir Thomas Crompton, judge of the High Court of Admiralty in the reign of Queen Elizabeth. The other church, viz. that of St. Chad's, is a very ancient structure, with a fine tower, but not containing any thing worthy of particular notice. The other public buildings are, the County Hall, an extensive modern structure, 100 feet long in front, in which the assizes and quarter-sessions are held. The county infirmary is a plain and substantial edifice, built about the year 1772. The county gaol, which is opposite the infirmary, is a large and convenient modern building, with accommodation for 150 prisoners. The free school is an ancient edifice, founded by Edward the Sixth in 1550. Stafford contains a number of alms-houses, built for the accommodation of the indigent inhabitants of the town, each of which has a garden adjoining to it. Stafford is governed by a mayor, recorder, twelve aldermen, twenty common council men, a town clerk, two serjeants at mace, and other inferior officers. The principal manufactures are those of cloth, cutlery, shoes, and beer. The town enjoys a considerable trade with the neighbouring counties by means of its canal. Stafford returns two representatives to parliament. The right of election is vested in the mayor, aldermen, and burgesses, there being about 400 voters in all. In 1821, the population was 5736 of both sexes: the number of houses was 991; the number of families 1090; and the number of families employed in trade 712. See the *Beauties of England and Wales*, vol. xiii. p. 881.

STAFFORDSHIRE, an inland and central county of England. It is bounded on the north by Cheshire and Derbyshire, on the east by Leicestershire, on the west by Shropshire, and on the south by Warwickshire and Worcestershire. Its figure is that of an oblong, extending from north to south. Its utmost length from north-east to south-west is 60 miles, and its greatest breadth from east to west is 38 miles. It contains 1148 statute miles, or 734,720 acres, the greater part of which is arable. The civil divisions are five hundreds, one city, (Litchfield) three boroughs, and twenty-four market towns. Staffordshire is in the province of Canterbury, and, with the exception of a small portion in the diocese of Litchfield and Coventry, it contains 180 parishes, and is included in the archdeaconry of Stafford. The general appearance of the county varies extremely in the different districts: thus, the middle and southern parts, which consist of one level plain, only interrupted by a few inconsiderable elevations, present a remarkable contrast to the northern district, which is distinguished by desolate and unproductive hills, and by the general air of bleakness that pervades its scenery. In this district, which is called the moorlands, there are several hills of considerable height, of which Bunster and the Weever Hills are the highest; the latter are 1154 feet above the level of the sea. The general elevation of the moorlands above the southern districts, is between 100 and 200 yards. Although the appearance of the uplands is so desolate, yet there are some districts in the southern part of the county, on the banks of the rivers, which may vie with any other part of England in beauty of scenery, and luxuriance of vegetation, the most celebrated of which are the banks of the Dove, especially at Ilam, and the country between Litchfield and Stone.

Staffordshire contains almost every variety of soil, but the most prevalent are the strong clays, and the gravelly and sandy soils. There is very little calcareous soil, and no chalk. In the waste lands, there is abundance of peat, which, however, when drained is highly capable of improvement. The meadows, particularly those on the banks of the Trent, are rich and fertile. The climate of Staffordshire is decidedly wet and moist. The annual fall of rain is about 36 inches. In winter, a considerable quantity of snow falls on the moorlands, which may account for the coldness of that district.

The rivers of Staffordshire, most of which have their origin in the moorlands, are not of any great size, and none of them are navigable. Yet they are of inestimable value to the county, as they supply with water the numerous canals that intersect it. The principal rivers are the Trent, which is the third river in England, the Dove, the Stour, the Blythe, the Tame, and the Penk, which last are all tributaries of the Trent. The Trent has its source at Newpool, near Biddulph, on the borders of Cheshire; it enters Derbyshire at Burton, where it receives the Dove. While it flows through Staffordshire it is a bold and rapid stream, bearing some resemblance to the Thames. After flowing through Nottinghamshire and Lincolnshire, it empties itself into the Humber, about forty miles below Gainsborough, to which place it is navigable for vessels of considerable burthen. The Dove, which is the river in Staffordshire next in importance to the Trent, rises in the moorlands, and after running through the beautifully picturesque country called Dovedale, and receiving the Manifold and Hamps, it joins the Trent at Burton in Derbyshire. Staffordshire is better supplied with navigable canals than any other county of England, which amply compensate for the want of navigable rivers, which otherwise would be a serious loss to the commercial interest of the county. The Grand Trunk Canal, which was planned and carried through by the late celebrated engineer Mr. Brindley, unites the three ports of Liverpool, Bristol, and Hull. Its total length is about ninety-one miles; the fall of water on the northern side is about 326 feet, and on the southern side 316. In the former there are thirty-five locks, and in the latter forty; the usual breadth at the top is twenty-nine feet, and it is four and a half feet deep. The numerous branches of this canal serve to establish a regular communication between the principal sea-ports and the central districts, and also a ready mode of conveyance for those goods, the value of which, owing to their weight and bulk, would be more than counterbalanced by the expense attending the carriage by land. There are few lakes of any size in this county, but the largest is that of Aquelate, which is 1848 yards long, and 672 broad.

Staffordshire is remarkable both for the variety and the abundance of its mineral products. Coal exists in such abundance that more than 50,000 acres have been found to contain almost inexhaustible strata of coal, which vary in thickness from twenty-four to thirty-six feet. Iron ore is raised in considerable quantities in the coal mines; the strata of iron usually occurring under a stratum of coal. A remarkable species of coal called the peacock coal, owing to the circumstance of its exhibiting prismatic colours, is raised at Handly Green. Copper and lead also exist, although by no means in such abundance as the iron. The other products are ochre, freestone, limestone, gypsum, alabaster, marbles of different colours. A great variety of clays are dug up, which are of the greatest service, as they supply the potteries, which are the chief support of the county.

The manufactures of Staffordshire are as extensive as they are various. The working of metals is carried on to a great extent in the southern part of the county. At Wolverhampton a great quantity of the heavier sort of iron goods,besides locks, hinges, keys, steel chains, &c. Wednesbury furnishes guns, saws, hammers, edge tools, and almost every description of cast iron articles. Stafford produces a number of articles in the leather and cutlery trade. Walsal supplies bits, spurs, buckles, stirrups, and all the iron work required by saddlers. The potteries, which are carried on in the northern part of the county, have been long celebrated for the superior excellence of the earthenware they produce, which is exported to almost every part of Europe. They occupy an extent of ten square miles, in which there are several considerable towns. This district, which goes by the general name of the Potteries, although the most barren, is now the most populous and wealthy part of the county. These potteries owe all their celebrity to the skill and perseverance of the late famous Mr. Wedgewood, who by his judicious admixture of the various descriptions of clay with which the county abounds, brought the earthenware to its present state of perfection. At Stourbridge there are extensive manufactories of glass. A quantity of salt is obtained at Shirley Wick, and at Ingestrie, by boiling brine from natural springs. Burton has long been celebrated for its ale, and possesses manufactories for hats and cotton goods. At Tamworth there is a large establishment for printing calico. There are brass and copper works at Cheadle. At Leck a considerable quantity of silk goods of various descriptions are made.

The agricultural products of Staffordshire are chiefly wheat, barley, rye, oats, potatoes, and turnips; crops of flax, hemp, pease, beans and vetches are also raised. The grasses most in use are clover and trefoil, and several artificial grasses have been introduced of late.

The cattle of Staffordsire, which are of the long-horned breed, are reared in such numbers as to supply the whole county, and still to leave a considerable surplus for other markets. The sheep are of different breeds; but the new Leicesters are the most common. The black-faced sheep with horns are reared on the commons in the west of the county. At Cannock and Sutton Colfield there is a variety, bearing a strong resemblance to the South Down.

The breed in the eastern part of the moorlands are white-faced without horns, and having long combing wool.

The only Roman antiquities in Staffordshire are the Watling Street, and Ichnield military roads which pass through the county. There are also a few ancient encampments. There are few remains of the Saxons worthy of notice.

The parliamentary representatives are ten, two for the county, and two for each of the undermentioned towns, viz Litchfield, Stafford, Newcastle, and Tamworth.

The population, by the returns under the census of 1821, was 341,040: of whom the males were 177,668, and the females 169,372. The number of inhabited houses was 63,319, and of families, 68,780; out of these families, 18,285 were employed in agriculture, 42,435 in trade and manufactures, and 8060 in neither of these departments.

STAHL Ernest. See Chemistry.

STAMFORD or Stanford, a town of England in the county of Lincoln, is situated on the slope of a hill on the banks of the river Welland, which is crossed by a narrow and ancient stone bridge. The town is built in the form of a cross, its principal streets coinciding with the great north road and that which goes from Uppingham to Market Deeping. The houses are generally well built with stone and covered with slate. Stamford contains six parish churches, St. Michael's, St. Mary's, St. George's, All Saints, St. John the Baptist's, and St. Martin's. St. Michael's consists of a nave and choir with north and south aisles, and chancels, extending beyond the nave. In St. Mary's church there is a monument to Sir David Phillips, who distinguished himself in the battle of Bosworthfield. St. George's church is a large plain building with chancel, nave, north and south aisles, and a square embattled tower. All Saints is large and symmetrical, having a lofty and handsome embattled spire at the west end of the north aisle. The founder of it, Mr. John Brown, is interred in the north aisle. The church of St. John the Baptist contains some excellent specimens of stained glass. St. Martin's church is a large and handsome edifice, with a square pinnacled tower, and containing, among other monuments, one of Lord Burleigh. The other public buildings are the town hall, built in 1776, and having two handsome fronts, an elegant theatre recently erected, and a good assembly room. New shambles have been lately built. The schools in Stamford are Radcliffe's free school, Wells' school, the Blue Coat school, and a girls' school on Dr. Bell's plan. The charitable establishments in the town are numerous. The most opulent of them is that founded in the reign of Richard III. by William Brown, of whom there is an effigy in All Saints church. By the river Welland the neighbourhood is supplied with articles of foreign and coasting trade, and the inhabitants export malt and freestone. The town is governed by a mayor, a recorder, town clerk, 12 aldermen, and 24 capital burgesses. It returns two members to parliament, and the right of election is vested in about 500 voters. The practice of bull baiting is said to be still repeated here on the 13th of November. In 1821 the population was as follows:

Inhabited houses	892
Number of families	1038
Families in trade	663
Total population	5050

About a mile to the south-east of Stamford is Burleigh house, the seat of the Marquis of Exeter. See the *Beauties of England* vol. ix. p. 793, and Blore's *Account of the Public Schools and Hospitals, &c. in Stamford*, 1813.

STARCH. See Chemistry.

STARS. See Astronomy, Index, and Parallax.

STANNANE. See Chemistry.

STATIUS Surculus Papinius was born at Naples about A. D. 61, and died about A. D. 96. His works, which are extant, are his Sylvæ, a miscellaneous piece in five books, his Thebaid, an Epic Poem, on which his fame rests, and two books of an unfinished poem entitled Achilles. The best editions of the Thebaid are those of Caspar Barthius, 4to. 1664, and of Veenhuysen, Ludg. Bat. 8vo. 1671.

STAUROLITE. See Mineralogy, Index.

STEAM.

Steam is the name generally given to the visible vapour which is driven off from fluids or moist bodies by heat. It is most frequently applied, however, to denote *aqueous vapour*, or the vapour raised from water by ebullition.

When water, exposed to the pressure of the atmosphere, is heated to the temperature of 212°, globules of steam, composed of heat and water in a state of combination, are formed at the bottom of the vessel, and rising through the fluid, may be collected at its surface. In its perfect state it is transparent, and consequently invisible, but when it has been deprived of a part of its heat by coming in contact with cold air, it becomes vesicular and of a cloudy appearance, as when it issues from a tea-kettle.

By increasing the heat, the temperature of the water never rises above 212°, nor that of the steam which is generated; the only effect being a more copious production of vapour. But if the water is confined in a strong copper vessel, both it and the steam which is produced may be brought to any temperature.

Like all gaseous fluids, steam is highly elastic; but if it is separated from the fluid from which it is generated, it does not possess a greater elastic force than the same quantity of air. If, for instance, a copper vessel is filled with steam only, at 212°, it may be brought even to the temperature of red heat, without any danger of bursting; but if water is also in the vessel, each additional quantity of caloric causes a fresh quantity of steam to rise, which adds its elastic force to that of the steam already generated till the constantly accumulating force bursts the vessel in pieces.

The latent heat of steam,* according to the experiments of different philosophers, is given in the following table:

Rumford	1021°	Watt	950° or 960°
Thomson	1016	Southern	945
Lavoisier	1000	Black	800
Clement	990		

The mean of these results is 950° agreeing with the measure obtained by Mr. Watt.

Since steam therefore of the temperature of 212° contains 900° of heat, which is not detected by the thermometer, while it retains the gaseous state, its real quantity of heat will be $950°+212°=1162°$; consequently, if we mix a quantity of steam with $5\frac{1}{2}$ times its weight of water, at 32°, the temperature of the water will rise nearly to the temperature of ebullition, because $5\frac{1}{2}\times 32°+32°=208°$. Hence the great utility of steam not only in manufactures where great quantities of hot water are required, but also for heating large buildings, and for drying whatever is liable to combustion.

The elasticity of steam, arising, no doubt, from the great quantity of heat which it contains, is very great, and from its extensive application as an impelling power, it has been investigated with considerable attention.

Mr. Watt was the first philosopher who made any accurate experiments on the elasticity of steam. The following account of them which Mr. Watt drew up at the request of the editor of this work, for his edition of Dr. Robison's System of Mechanical Philosophy, is as follows:—

"In the winter 1764-5, I made experiments at Glasgow on the subject, in the course of my endeavours to improve the steam-engine, and as I did not then think of any *simple* method of trying the elasticities of steam at temperatures less than that of boiling water, and had at hand a digester by which the elasticities at greater heats could be tried, I considered that, by establishing the ratios in which they proceeded, the elasticities at lower heats might be found nearly enough for my purpose. I therefore fitted a thermometer to the digester with its bulb in the inside, placed a small cistern with mercury also within the digester, fixed a small barometer tube with its end in the mercury, and left the upper end open. I then made the digester boil for some time, the steam issuing at the safety-valve, until the air contained in the digester was supposed to be expelled. The safety-valve being shut, the steam acted upon the surface of the mercury in the cistern, and made it rise in the tube. When it reached to 15 inches above the surface of the mercury in the cistern, the heat was 236°; and at 30 inches above that surface, the heat was 252°. Here I was obliged to stop, as I had no tube longer than 34 inches, and there was no white glass made nearer than Newcastle-upon-Tyne. I therefore seal-

* See Chemistry.

ed the upper end of the tube hermetically whilst it was empty, and when it was cool immersed the lower end in the mercury, which now could only rise in the tube by compressing the air it contained. The tube was somewhat conical; but by ascertaining how much it was so, and making allowances accordingly, the following points were found, which, though not exact, were tolerably near for an apperçu. At 29½ inches (with the sealed tube) the heat was 252°, at 75½ inches the heat was 264°, and at 110½ inches 292°. (That is, after making allowances for the pillar of mercury supported, and the pillar which would be necessary to compress the air into the space which it occupied, these were the results.) From these elements I laid down a curve, in which the abscissæ represented the temperatures, and the ordinates the pressures, and thereby found the law by which they were governed sufficiently near for my then purpose. It was not till the years 1773-4, that I found leisure to make further experiments on this subject, of which, though I do not consider the results as accurate, I shall give an account here, as they were in point of date prior to any other that I was then acquainted with.

A tin pan of about five inches in diameter, and four inches deep, had a hole made in its bottom near one side, and in this hole was soldered a socket somewhat conical, which nearly fitted a barometer tube with which the experiments were to be made. This tube was about 36 inches long, and had a ball at one end about 1½ inches diameter, the contents of which were nearly equal to those of the stem of the tube; some paper was lapped round the tube near the ball, and it was forced tight into the conical socket of the pan, so that the ball was within the latter, at such a height that it might be immersed in water. The tube and pan were then inverted, and the ball was filled with clean mercury, and the stem with distilled water fresh boiled. The tube was re-inverted, so that the ball and pan were uppermost; the lower end of the tube being shut by the finger, the water ascended into the ball, and the mercury occupied the tube. The lower end of the latter being then placed in a cistern of mercury, and released from the finger, the mercury and water descended, and the ball was left partly empty: being agitated in this position, and let stand some time, much air was extricated from the water; the tube was inclined as much as it could be, and again inverted, the air let out, and its place supplied with boiling water. It was again placed with the ball uppermost, the end of the tube stopt, the pan filled with hot water which was made to boil by means of a lamp, the lower end of the tube being placed in the cistern, and released from the finger, the mercury descended into the cistern, but, upon the water in the pan being suffered to cool, partly rose again into the tube. Much air was thus liberated, and more was got rid of by agitation, in the manner of the water-hammer, and by leaving it standing for some time erect, until at last I got it so free from air, that when I raised it upright, it supported a column of mercury 34 inches high; and no vacuum was formed until it was violently shaken, when it fell down suddenly and settled at 28.75 inches, but upon being inclined, a speck of air always remained, though, when it was expanded by a pillar of mercury 27 inches high, this speck was not larger than a pin's head.

In this state, when the tube was perpendicular, I found the mercury to stand at 28.75 inches, the column of water above it was about 6½ inches, half an inch of mercury. The whole then being 29.25 inches when the stationary barometer stood at 29.4, the difference, or pillar supported by the elasticity of the steam = 0.15 inch. The water in the pan was then heated exceeding slowly by a lamp, and stirred continually by a feather, to make the heat as equal as possible. The results are shown in the following table.

To determine the heats at which water boils when pressed by columns of mercury above 30 inches, a tube of 55 inches long was employed; one end was put through a hole in the cover of a digester, and made tight by being lapped round with paper, and within the digester the end of the tube was immersed in a cistern of mercury. A thermometer was fixed in another opening, so that the bulb was in the inside of the digester, and the stem and scale without: and the bulb was kept half an inch from the cover of the digester by a wooden collar. The cover being fixed on tight, and the digester half filled with water, it was heated by means of a large lamp.

The air in the upper part of the digester expanding by heat, the column of mercury in the tube was considerably raised by that expansion before the water boiled. The air was let out, and the water heated to boiling; still, however, some air remained, for the mercury stood at 213½°. That deduction being made, the following table shows the heats and corresponding elasticities.

In making these experiments, the digester was heated very slowly, and the heat was kept stationary as much as was possible at each observation, so that the whole series occupied some hours. The degrees of elasticity were observed by my friend Dr. Irvine, whilst I observed those of the thermometer in all these experiments.

With the whole of the observations, I was, after all, by no means satisfied, as I perceived there were irregularities in the results which my more urgent avocations did not permit me to explore the cause of, and to correct.

Table of the Elasticities of Steam for Heats below and above the Boiling Point, according to Mr. Watt.

Heats.	Elasticities	Heats.	Elasticities	Heats	Elasticities	Heats	Elasticities
Deg.	Inches.	Deg.	Inches	Deg.	Inches	Deg.	Inches
55	0.15	175	12.83	223.5	36	248.5	56
74	0.65	177.5	13.81	225	37	250.5	58
81	0.80	180	14.73	226.5	38	252.5	60
95	1.30	182.5	15.66	228	39	255	62
104	1.75	185	16.58	229.5	40	257	64
118	2.68	187	17.51	231	41	259	66
128	3.60	189	18.45	232.5	42	261	68
135	4.53	191	19.38	234	43	262.5	70
142	5.46	193.5	20.34	235	44	264.5	72
148	6.40	196.5	21.26	236.5	45	265.5	74
153	7.325	213	30	237.5	46	268	76
157	8.25	215	31	238.5	47	269.5	78
161	9.18	217	32	240	49	271	80
164	10.10	219	33	242.5	50	272.5	82
167	11.07	220.5	34	244.5	52		
172	11.95	222	35	247	54		

[illegible] lished, in the Memoirs for [illegible] ments on the elasticity of steam, from the tempera-ture of 32° to that of 212°. The following are a few of the results, which are here compared with those of Mr. Watt and Mr. Robison:

Temperature.	Achard. Elasticities. Inches.	Watt. Elasticities. Inches	Robison. Elasticities. Inches.
168°	11.05	11.24	10.50
189	18.5	18.45	17.47
209	28.1	27.88	26.05

The following results were obtained by Dr. Robison by the different operations which he has described in the article Steam in his works.

Temperatures.	Elasticities.	Temperatures	Elasticities.
32°	0.0	160	8.65
40	0.1	170	11·05
50	0.2	180	14.05
60	0·35	190	17.85
70	0.55	200	22.62
80	0.82	210	28.65
90	1.18	220	35.8
100	1.6	230	41.5
110	2.25	240	54.9
120	3·0	250	66.8
130	3.95	260	80.3
140	5.15	270	94.1
150	6.72	280	105.9*

The next experiments on the elasticity of steam were made by Mr. Bettancourt, an ingenious Spaniard, who communicated them in 1790 to the Academy of Sciences, who published them in the *Memoires des Sçavans Etrangeres.*

The following are some of the results reduced to English inches, and to Fahrenheit's thermometer:

Temp. Fahr.	Elasticities. Inches.	Temp. Fahr.	Elasticities. Inches.	Temp. Fahr.	Elasticities. Inches.	Temp. Fahr.	Elasticities. Inches.
0		104	1.86	167	10.[illegible]7	230	41.38
41	0.0795	113	2.43	176	12.8[illegible]	239	53.77
50	0.1855	122	3.17	185	15.88	248	61.45
59	0.3133	131	4.05	194	19.66	257	76.32
68	0.509	140	5.16	203	24.[illegible]6	266	88.81
77	0.7366	14[illegible]	6.52	212	29.87	275	100.07
86	1.02	158	8.21	221	36.55	[illegible]	104.91
95	1.30						

Mr. Bettancourt made similar experiments on the elasticity of the vapour of spirit of wine, and he found it at all temperatures equal to $2\frac{1}{4}$ times that of steam.

The next set of experiments on steam were made by Mr. Dalton about 1800, with a degree of accuracy and care, which gives them a high value. The results from 32° to 212° were obtained by direct experiment, but those from 212° to 325° were obtained by calculation.

The following is his own account of the method by they were made:—

I take a barometer tube perfectly dry, and fill it with mercury just boiled, marking the place where it is stationary; then having graduated the tube into inches and tenths by means of a file, I pour a little water, (or any other liquid the subject of experiment) into it, so as to moisten the whole inside; after this, I again pour in mercury, and carefully inverting the tube, exclude all air. The barometer, by standing some time, exhibits a portion of water, &c. of one-eighth or one-tenth of an inch upon the top of the mercurial column, because, being higher, it ascends by the side of the tube, which may now be inclined, and the mercury will rise to the top, manifesting a perfect vacuum from air. I next take a cylindrical glass tube, open at both ends, of two inches diameter, and fourteen inches in length, to each end of which a cork is adapted, perforated in the middle, so as to admit the barometer tube to be pushed through, and to be held fast by them; the upper cork is fixed two or three inches below the top of the tube, and is half cut away, so as to admit water, and to pass by, its service being merely to keep the tube steady. Things being thus circumstanced, water of any temperature may be poured into the wide tube, and thus made to surround the upper part, or vacuum, of the barometer; and the effect of temperature in the production of vapour within, can be observed from the depression of the mercurial columns. In this way, I have had water as high as 155° surrounding the vacuum; but as the highest temperatures might endanger the glass apparatus, instead of it I used the following:—

Having procured a tin tube, of four inches in diameter, and ten feet long, with a circular plate of the same, soldered to one end, having a round tube in the centre, like the tube of a reflecting telescope, I got another smaller tube of the same length soldered into the larger, so as to be in the axis or centre of it; the small tube was open at both ends, and on this construction, water could be poured into the large vessel to fill it, whilst the central tube was exposed to its temperature. Into this central tube, I could insert the upper half of a syphon barometer, and fix it by a cork, the top of the narrow tube also being corked; thus, the effect of any temperature under 212° could be ascertained, the depression of the mercurial columns being known by the ascent in the exterior leg of the syphon.

The force of vapour from water between 80° and 212°, may also be determined by means of an air-pump; and results exactly agree with those determined above. Take a florence flask, half filled with hot water, into which insert the bulb of a thermometer, then cover the whole with a receiver on one of the pump-plates, and place a barometer gage on the other; the air being slowly exhausted, mark both the thermometer and barometer at the moment ebullition commences, and the height of the barometer gage will denote the force of vapour from water of the observed temperature. This method may also be used for other liquids. It may be proper to observe, the various thermometers used in these experiments were duly adjusted to a good standard one.

* "Experiments on this subject have been published by M. De Bettancourt, (See Prony Arch. Hydraulique) by Mr. Schmidt, and by Mr. Dalton, (see Manchester Memoirs)

After repeated experiments by all these methods, and a careful comparison of the results, I was enabled to digest the following table of the force of steam from water, in all the temperatures from 32° to 212°.

Mr. Dalton's Table of the force of Vapour from Water at every Temperature, from that of the congelation of Mercury, or 40 degrees below Zero, or 325 degrees.

Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.
40	0.013	55	0.443	114	2.84	173	13.02
30	0.020	56	0.458	115	2 92	174	13.32
20	0.030	57	0.474	116	3.00	175	13.62
10	0.043	58	0.490	117	3.08	176	13.92
0	0.064	59	0.507	118	3.16	177	14.22
1	0.066	60	0.524	119	3.25	178	14.52
2	0.068	61	0.542	120	3.33	179	14.00
3	0.071	62	0.560	121	3.42	180	15.15
4	0.074	63	0.578	122	3.50	181	15.50
5	0.076	64	0.597	123	3.59	182	15.86
6	0.079	65	0.616	124	3.69	183	16.23
7	0.082	66	0.635	125	3.79	184	16.61
8	0.085	67	0.655	126	3.89	185	17.00
9	0.087	68	0.676	127	4.00	186	17.40
10	0·090	69	0.698	128	4.11	187	17.80
11	0.093	70	0.721	129	4.22	188	18.20
12	0.096	71	0.745	130	4.34	189	18.60
13	0.100	72	0.770	131	4.57	190	19.00
14	0.104	73	0.796	132	4.60	191	19.42
15	0.108	74	0.823	133	4.73	192	19.86
16	0.112	75	0.851	134	4.86	193	20.32
17	0.116	76	0.880	135	5.00	194	20.77
18	0.120	77	0.910	136	5.14	195	21.22
19	0.124	78	0 940	137	5.29	196	21.68
20	0.129	79	0.971	138	5.44	197	22.13
21	0.134	80	1.00	139	5.59	198	22.69
22	0.139	81	1.04	140	5.74	199	23.16
23	0.144	82	1.07	141	5·90	200	23.64
24	0.150	83	1.10	142	6.05	201	24.12
25	0.156	84	1.14	143	6.21	202	24.61
26	0.162	85	1.17	144	6.37	203	25.10
27	0.168	86	1.21	145	6.53	204	25 61
28	0.174	87	1.24	146	6.70	205	26.13
29	0.180	88	1.28	147	6.87	206	26.66
30	0.186	89	1.32	148	7.05	207	27 20
31	0.193	90	1.36	149	7.23	208	27.74
32	0.200	91	1.40	150	7.42	209	28.29
33	0.207	92	1.44	151	7.61	210	28.84
34	0.214	93	1.48	152	7.81	211	29 41
35	0.221	94	1.53	153	8.01	212	30.00
36	0.229	95	1.58	154	8.20	213	30.60
37	0.237	96	1.63	155	8.40	214	31.21
38	0.247	97	1.68	156	8.60	215	31.83
39	0.254	98	1.74	157	8.81	216	32 46
40	0.263	99	1.80	158	9.02	217	33.09
41	0.273	100	1.86	159	9.24	218	33.72
42	0.283	101	1.92	160	9.4	219	34.35
43	0.294	102	1.98	161	9.68	220	34.99
44	0.305	103	2.04	162	9.91	221	35.63
45	0.316	104	2.11	163	10.15	222	36.25
46	0.328	105	2.18	164	10.41	223	36.88
47	0.339	106	2.25	165	10.68	224	37.53
48	0.351	107	2.32	166	10.96	225	38.20
49	0.363	108	2.39	167	11.25	226	38 89
50	0.375	109	2.46	168	11.54	227	39.59
51	0.388	110	2.53	169	11.83	228	40.30
52	0.401	111	2.60	170	12.13	229	41.02
53	0.415	112	2 63	171	12.43	230	41.75
54	0.429	113	2.76	172	12.73	231	42.49

Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.
232	43.24	256	63.76	280	88.75	303	115.[illegible]
233	44.00	257	64.82	281	89.89	304	116.50
234	44.78	258	65 78	282	90.99	305	117.6[illegible]
235	45.58	259	66.75	283	92.11	306	118.8[illegible]
236	46.39	260	67.73	284	93.2[illegible]	307	120.0
237	47.20	261	68.72	285	94.35	308	121 2[illegible]
238	48.02	262	69.72	286	95.48	309	122.[illegible]
239	48.84	263	70.73	287	96.64	310	123.5[illegible]
240	49.67	264	71.74	288	97.80	311	124.6[illegible]
241	50.50	265	72.76	289	98.96	312	125.8[illegible]
242	51.34	266	73.77	290	100.1[illegible]	313	127.00
243	52.18	267	74.79	291	101.28	314	128.15
244	53.03	268	75.80	292	102.45	315	129.2[illegible]
245	53.88	269	76.82	293	103.63	316	130.2[illegible]
246	54.68	270	77.85	294	104.80	317	131.4
247	55.54	271	78.89	295	105·97	318	132.87
248	56.42	272	79 94	296	107.14	319	133.7[illegible]
249	57.31	273	80 98	297	108.31	320	135.00
250	58.28	274	82·01	298	109.48	321	136.14
251	59.12	275	83.13	299	110.64	322	137.28
252	60.05	276	84.35	300	111.81	323	138.4[illegible]
253	61.00	277	85.47	301	112.9[illegible]	324	139.5[illegible]
254	61.92	278	86.50	302	114.15	325	140.7[illegible]
255	62.85	279	87.63				

Dissatisfied with his own experiments, in the results of which he observed irregularities which he could not explain, Mr. Watt, in the year 1796, requested Mr. Southern to try them over again, and, in fulfilling his request, he was assisted by Mr. William Creighton. The results of these experiments, which were first published in Dr. Brewster's edition of Professor Robison's works, vol. ii. p. 16. are as follows:—

Mr. Southern's Experiments on the Elasticity of Steam.

Temperature. Fahr.	Elastic Force in Inches of Mercury.	Temperature. Fahr.	Elastic Force in Inches of Mercury.
32	0 180	132	4.71
42	0.230	142	6.10
52	0.350	152	7.90
62	0.520	162	10.05
72	0 730	172	12.72
82	1.02	182	16.01
92	1.42	212	30.00
102	1.96	250	60.00
112	2 66	293	120.00
122	3.58	343.6	240.00

The next experiments on the elasticity of steam were those of Dr. Ure, which were made at temperatures from 24° to 312°. They are as follows:—

Table of Dr. Ure's Experiments on the Elastic force of Steam from 24° to 312°.

Temp.	Elastic force.	Temp.	Elastic force	Temp.	Elastic force.	Temp.	Elastic force.
24°	0.170	155°	8.500	242°	53.600	281.8°	104.400
32	0.200	160	9.600	245	56.340	283.8	107.700
40	0.250	165	10.800	245.8	57.100	285.2	112.200
50	0.360	170	12.050	248.5	60.400	287.2	114.800
55	0.416	175	13.550	250	61.900	289	118.200
60	0.516	180	15.160	251.6	63.500	290	120.150
65	0.63	185	16.900	254.5	66.700	292.3	123.100
70	0.726	190	19.000	255	67.250	294	126.700
75	0.860	195	21.100	257.5	69.800	295.6	130.400
80	1.010	200	23.600	260	72.300	295	129.000
85	1.170	205	25.900	260.4	72.800	297.1	133.900
90	1.36	210	28.880	262.8	75.900	298.8	137.400
95	1.640	212	30.000	264.9	77.900	300	139.700
100	1.86	216.6	33.400	265	78.040	300.6	140.900
105	2.100	220	35.540	267	81.900	302	144.300
110	2.456	221.6	36.700	269	84.900	303.8	147.700
115	2.820	225	39.110	270	86.300	305	150.560
120	3.300	226.3	40.100	271.2	88.000	306.8	154.400
125	3.830	230	43.100	273.7	91.200	308	157.700
130	4.366	230.5	43.500	275	93.480	310	161.300
135	5.070	234.5	46.800	275.7	94.600	311.4	164.800
140	5.770	235	47.220	277.9	97.800	312	167.000
145	6.600	238.5	50.300	279.5	101.600	312	165.5
150	7.530	240	51.700	280	101.900		

As Dr. Ure's experiments have been regarded as furnishing us with the most accurate and uniform series of results, we shall lay before our readers an account of the apparatus and methods by which they were made.

Fig. 1. Plate DIV. "represents the apparatus used for temperatures below and a little above the boiling point, and Fig. 2. and 3. for higher temperatures, Fig. 3. being the most convenient. "One simple principle," says Dr. Ure, "pervades the whole train of experiments, which is, that the progressive increase of elastic force developed by heat from the liquid incumbent on the mercury at *l l′ l″* (Fig. 1, 2, 3.) is measured by the length of columns which must be *added* over L, the primitive level below, in order to restore the quicksilver to its primitive level above at *l*. These two stations or points of departure are nicely defined by a ring of platina wire twisted firmly round the tube.

At the commencement of the experiment after the liquid now freed from the air has been let up, the quicksilver is made a tangent to the edge of the upper ring, by cautiously pouring mercury in a slender stream into the open leg of the syphon D. The level ring below is then carefully adjusted.

From the mode of conducting these experiments, there remained always a quantity of liquid in contact with the vapour, a circumstance essential to accuracy in this research.

Suppose the temperature of the water or the oil in A to be 32°, F. as denoted by a delicate thermometer, or by the liquefaction of ice, communicate heat to the cylinder A by means of two argand flames playing gently on its shoulder at each side. When the thermometer indicates 42°, modify the flames, or remove them, so as to maintain an uniform temperature for a few minutes. A film, or line of light, will now be perceived between the mercury and the ring at *l*, as is seen under the vernier of a mountain barometer, when it is raised a few feet off the ground. Were the tube at *l* and L, of equal area, or were the relations of the areas experimentally determined, then the rise of the quicksilver above L would be one half, or a known submultiple of the total depression, equivalent to the additional elasticity of the vapour at 42°, above that at 32°. Since the depressions, however, for 30 or 40 degrees in this part of the scale are exceedingly small, one half of the quantity can scarcely be ascertained with suitable precision, even after taking the above precautions; and besides, the other sources of error, or, at least, embarrassment, from the inequalities of the tube, and from the lengthening space occupied by the vapour as the temperature ascends, renders this method of reduction very ineligible."

By the other plan, we avoid all these evils. For whatever additional elasticity we communicate to the vapour above *l*, it will be faithfully represented and measured by the mercurial column, which we must add over L, in order to overcome it, and restore the quicksilver under *l* to its zero, or initial level, when the platina ring becomes once more a tangent to the mercury.

At E, a piece of cork is fixed between the parallel legs of the syphon to sustain it, and to serve as a point, by which the whole is steadily suspended.

For temperatures above the boiling point, the part of the syphon under E is evidently superfluous, merely containing in its two legs a useless weight of equipoise mercury. Accordingly, for high heats, the apparatus, Figs. 2 or 3 is employed, and the same method of procedure is adopted. The apertures at O, Fig. 3, admits the ball of the thermometer, which rests as usual on *l*." The recurved part of the tube is filled with mercury, and then a little liquid is passed through it to the sealed end. Heat is now applied by an argand flame to the bottom of C, which is filled with oil or water, and the temperature is kept steadily at 212° for some minutes. Then a few drops of quicksilver may require to be added to D″ till L″ and *l″* be in the same horizontal plane. The further conduct of the experiment differs in no respect from what has been already described. The liquid at C is progressively added over L″ to restore the initial level or volume at *l″*, by equipoising the progressive elasticity. The column above L″ being measured, represents the succession of elastic forces. When this column is wished to extend very high, the vertical tube requires to be placed for support in the groove of a long wooden prism.

The height of the column in some of the experiments being scarcely twelve feet, it became necessary to employ a ladder to reach its top. It was found to be convenient in this case, after observing that the column of vapour had attained its primitive magnitude, to note down the temperature with the altitude of the column, then immediately to pour in a measured quantity of mercury, nearly equal to three vertical inches, and to wait till the slow progress of the heating again brought the vapour in equilibrio with this new pressure, which at first had pushed the mercury within the platina ring at *l″*. When the lower surface of the mercury was again a tangent to this ring, the temperature and altitude were both instantly observed. This mode of conducting the process will account for the experimental temperature being very often odd and fractional numbers. They are, therefore, presented to the public as they were recorded on the instant.

The thermometers were constructed by Creighton with his well known nicety; and the divisions were read off with a lens, so that one-sixteenth of a degree could be distinguished. After bestowing the utmost pains in repeating the experiments during a period of nearly two months, it was found that the only way of removing the little discrepancies which crept in between contiguous measures, was to adopt the astronomical plan of multiplying observations, and deducing truth from the mean. It is essential to heat with extreme slowness and circumspection the vessels A, B, C. One repetition of the experiment occupies, on an average, seven hours."

The next experiments on the elasticity of steam, were those of Mr. Philip Taylor, at temperatures from 212° to 320°. The results which he obtained, are given in the following table.

Mr. Philip Taylor's Experiments on the Elasticity of Steam, from 212°—320° Fahrenheit.

Temp.	Elasticity in inches.	Temp.	Elasticity in inches.	Temp.	Elasticity in inches.	Temp.	Elasticity in inches.
214°	31.00	242°	51.75	269°	81.14	295°	124.15
216	32.30	243	52.6	270	82.50	296	126.05
217	33.00	244	53.5	271	83.9	297	128.06
218	33.70	245	54.4	272	85.45	298	129.8
219	34.2	246	55.3	273	86.95	299	131.62
220	35	247	56.25	274	88.50	300	133.75
221	35.5	248	57.2	275	90.00	301	135.60
222	36.2	249	58.2	276	91.55	302	137.55
223	37.00	250	59.12	277	93.15	303	139.75
224	37.5	251	60.1	278	94.70	304	141.90
225	38	252	61.1	279	96.26	305	144.05
226	38.8	253	62.15	280	97.75	306	146.15
227	39.5	254	63.2	281	99.25	307	148.30
228	40.2	255	64.[illegible]	282	100.70	308	150.65
229	40.85	256	65.5	283	102.20	309	153.70
230	41.5	257	66.6	284	103.8	310	155.00
231	42.25	258	67.75	285	105.6	311	157.20
232	43	259	69.0	286	107.3	312	159.45
233	43.75	260	70.1	287	109.0	313	161.75
234	44.6	261	71.25	288	110.8	314	164.20
235	45.5	262	72.45	289	112.65	315	166.70
236	46.4	263	73.5	290	114.50	316	169.15
237	47.3	264	74.8	291	116.40	317	171.70
238	48.2	265	76.00	292	118.30	318	174.30
239	49.1	266	77.2	293	120.25	319	176.80
240	50.0	267	78.5	294	122.20	320	179.40
241	50.9	268	79.8				

Most of the philosophers who have investigated the elastic force of steam, have endeavoured to construct empirical formulæ, for representing the relation between the temperatures and the elastic forces. It would be a waste of time to reprint and to explain these formulæ, as they are of little service when we possess the experimental results.

Our distinguished countryman, however, Mr. Ivory, has recently investigated a numerical formula, with the view of finding some property or law which may give us some general information respecting the elasticities beyond the range of our experiments. For this purpose he makes Dr. Ure's experiments the ground work of the following table:—

Mr. Ivory's Comparative Table of Dr. Ure's Experiments on Steam.

Indices x.	Temperatures τ	Elastic forces in inches of mercury e.	Log. of elasticities in parts of an atmosphere of 30 in. Log. $\frac{e}{30}$	Temperature below and above boiling point t.	Log. $\frac{e}{30}$ / t	Diff.	Computed quantities. Log. $\frac{e}{30}$ / t	Elastic forces in inches.
0	50°	0.360	—1.29082	—162	.011857		.011857	0.360
1	70	0.726	—1.61618	—142	.011381	476	.01110[illegible]	0.721
2	90	1.360	—1.34359	—122	.011013	368	.010968	1.378
3	110	2.456	—1.08689	—102	.010656	357	.0105[illegible]	2.634
4	130	4.366	—0.83704	— 82	.010208	448	.010158	4.468
5	150	7.53	—0.60032	— 62	.009682	526	.00978[illegible]	7.424
6	170	12.05	—0.39613	— 42	.009432	250	.00942[illegible]	12.05
7	190	19.00	—0.19837	— 22	.009017	425	.009092	18.93
8	210	28.88	—0.01652	— 2	.008260		.008777	28.81
9	230	43.10	+0.15736	+ 18	.00874		.008482	42.63
10	250	61.90	+0.31457	+ 38	.008278	461	.008206	61.50
11	270	86.30	+0.45889	+ 58	.007912	366	.007949	86.70
12	290	120.15	+0.60260	+ 78	.007726	186	.007714	119.9
13	310	161.30	+0.73051	+ 98	.007454	272	.007497	162.8
1	2	3	4	5	6	7		9

In the above table, col. 2, marked τ denotes the temperatures beginning at 50°, and increasing by 20° as far as Dr. Ure's table carries us. In col. 1. are the indices x, or the number of intervals of 20°. Hence we have for any temperature the corresponding index.

$$x = \frac{\tau - 50}{20}$$

The third column contains the elasticities e as found by Dr. Ure, and then follow in column fourth, the logarithms of the same elasticities estimated in parts of an atmosphere of 30 inches. Column fifth contains the temperatures, reckoned from the boiling point, those below it being negative, and those above it positive. Column sixth is the quotient of column fourth divided by column fifth. These quotients are irregular, near 212°, because as $\frac{e}{30}$ approaches to unity, its log. varying rapidly with any variation of e, the errors of observation have a great influence in this part of the table. It is remarkable that the numbers in this column continually decrease, and it would be interesting to determine if they would decrease to a fixed limit, or if they would decrease to a minimum and then increase again. Column seventh contains the differences in these quotients which are extremely irregular, and which, taken directly, seem to furnish no clue to guide us in our present research. But as they decrease slowly, we may infer that the quotients may be expressed with tolerable accuracy by means of the first and second orders of differences. If we represent the first and second differences by Δ and Δ^2, we have the following general expression of the quotient corresponding to the index x.

$$\frac{\text{Log. } \frac{e}{30}}{t} = .011857 - x \cdot \Delta + \frac{x^2 - x}{2} \Delta^2 \quad \text{(A)}$$

Two values in the table answering to given indices, are sufficient for finding Δ and Δ^2; but on account of the irregularities of observation, it will be better to proceed as follows: Form the expressions of the seven quotients in the table corresponding to the indices 1, 2, 3—7, and take a mean of the whole; thus

$$.010198 = .011857 - 4\,\Delta + 8\,\Delta^2.$$

In like manner, form the expressions of the four last quotients, and take a mean; thus,

$$.007842 = .011857 - \frac{23}{2}\,\Delta + 61\,\Delta^2.$$

By means of these two equations we get $\Delta = .0004545$ and $\Delta^2 = 00001986$, and by these values of Δ and Δ^2 the values of $\frac{\text{Log.}\ \frac{e}{30}}{t}$ and of e are computed by the formula A, and inserted in columns 8 and 9. Thus to find e for temperature 130° and index 4 we have $t = -82°$ and $\frac{\text{Log.}\ \frac{e}{30}}{-82°} = .010158$ whence

$$\text{Log.}\ \frac{e}{30} = -0.8329 = -1 + .1671, \text{ then}$$

$$\begin{array}{lr} & -1.1671 \\ \text{Log. } 30 & 1.4771 \\ \hline \text{Log. } e & 0.6442, \end{array}$$

$e = 4.408$. In this way all the elasticities in col. 9. have been calculated, and their agreement with the experimental quantities is very striking, so that the formula A may be considered as representing the elasticities as exactly as could be wished.

In reducing the formula to a proper form for use, Mr. Ivory proceeds thus, substituting the values of Δ and Δ^2, and arranging the terms according to the powers of x. Thus

$$\frac{\text{Log.}\ \frac{e}{30}}{t} = .011857 - .00046143\,.\,x + .00000993\,.\,x^2$$

$$\text{But } x = \frac{\tau - 50}{20} = \frac{162 + t}{20}$$

wherefore by substituting,

Logarithms of co-efficients.

$$\begin{array}{lll} \text{Log.}\ \frac{e}{30} = .0087466\,t & - & 3.9418393 \\ \quad - .000015178\,t^2 & - & 5.1812202\ (B) \\ \quad + .000000024825\,t^3 & - & 8.3871228. \end{array}$$

At 32°, $t = -180°$ and e, comes out 0.185, very near 0.2, Dr. Ure's result. Hence the formula (B) is nearly exact for the range of Dr. Ure's experiments.

Mr. Ivory then proceeds to apply this formula to two experiments, at temperatures of 343° and 419°, made by Mr. Southern and Mr. Clement. He finds that at 343°, it gives the elasticity 261 inches, which is 24 inches above Mr. Southern's result: but at 419° the formula gives only 23.8 atmospheres in place of 35 atmospheres, as determined by Mr. Clement. "The formula therefore," says Mr. Ivory, "although it is very accurate for a long range of temperatures, finally digresses altogether from the truth." Mr. Ivory is led to the important result that the quotient $\frac{\text{Log.}\ \frac{e}{30}}{t}$ decreases to a minimum, and then increases again, not only in the formula, but in nature. For example, in Clement's experiment, where $t = 207$, we have $\frac{\text{Log.}\ 35}{207} = .007454$, but in the table we find .007454 in the column of quotients opposite 310°; consequently, while the temperature increases from 310° to 419°, the quotient must have decreased to a minimum, and then increased again to its first magnitude. Hence Mr. Ivory concludes that the minimum takes place at 364½°, or about 152° or 153° beyond the boiling point.

Mr. Ivory concludes by stating, that the quotient is represented by the square of the ordinate to the conjugate axis of a hyperbola, the square of the semi-transverse axis being the minimum, for the expression B becomes $\frac{\text{Log.}\ \frac{e}{30}}{t} = A + B\,(n - t)^2$ A and B being known numbers, and n the distance of the minimum from the boiling point.

The expansive power of steam had been hitherto examined and used only at moderate temperatures, till Mr. Oliver Evans of Philadelphia, and Mr. Jacob Perkins, conceived the idea that great advantage would be gained by using steam of a high expansive force. "When I reflected," says Mr. Perkins, "on the almost infinite power that is sometimes displayed in the eruptions of Mount Vesuvius, throwing up incalculable masses of matter into the very clouds, I was induced to consider how this immense power could be generated. How is it that this power is so wonderfully great? Is it not high elastic steam? The thought struck me that it must be owing to the water being confined by pressure, until it got sufficiently charged with heat to enable it to rend asunder whatever confined it, thereby driving every thing before it. If one wanted farther proof of the tremendous power of steam, we have only to inquire of many practical iron founders what it is which has sometimes caused the liquid iron to leave its mould, and pass off through the roof of the foundry, in a metallic shower. The answer would be, that a small quantity of water had accidentally found its way into the bottom of the mould; and it might also be added, that a thousand times that quantity thrown on its heated surface would be perfectly harmless."

These considerations led Mr. Perkins to make a number of experiments on the elastic force of steam generated at very high temperatures, with the view of improving the high pressure engine. He has applied degrees of temperature so great, that the water in the boiler or gasometer was brought to a red heat. He has not, we believe, completed any regular series of experiments on the elastic force of steam generated with such enormous heat; but he considers the observations which he has made as leading to the following result:—*That while the temperature rises in an arithmetical ratio, the expansive force will be that of an increasing ratio, and the increments of fuel will be a decreasing ratio.*

During these experiments, Mr. Perkins had occasion to observe the very curious phenomenon that steam generated at such high temperatures produced no scalding effect. "I have frequently observed," says he, "that when the stop-cock of a high pressure boiler was opened, whether at the water or steam cocks, the temperature was lowered in proportion to the height of the steam. In a recent experiment on high steam it occurred to me that the great force and rapidity of motion of the steam caused the atmospheric air to be driven before it, evidently tending to produce a partial vacuum, to which the surrounding atmosphere would rush in and diminish its temperature. To test this theory, the following contrivance was resorted to: I took a vessel containing heated water of a temperature of 420 degrees of Fahrenheit; a tube eight inches in diameter. and four feet in length, and open at both ends, was suspended immediately over the stop-cocks, and in such a manner as to be raised or lowered at pleasure. This tube was raised eight inches above the stop-cock; the stop-cock, the area of which was one-fourth of an inch, was then opened, and the steam rushed out with great velocity into and through the tube. It was observed, that the steam condensed rapidly on the inside as well as the outside of it. The tube was lowered directly over the stop-cock, and when it came in contact with the vessel, it allowed very little air to find its way between it and the tube. The condensed steam in the tube immediately evaporated, and the tube soon became too hot for the touch of the hand; and when the thermometer was inserted eight or ten inches into the upper end of the tube, it indicated 230 degrees of temperature. The tube was again raised to about the same height, and immediately the condensation commenced as before.

A lighted lamp was now introduced, and when it was within 24 inches of the tube, the flame of it visibly inclined to where the steam entered the tube. The lamp was then moved gradually towards the lower end of the tube, and at six inches from it the flame disappeared, being carried away by the strong current of the air: The tube was now wholly removed, and it was evident from the inclination of the flame of the lamp, as it was moved eight or ten inches from the volume of the steam, that a strong atmospheric air was continually passing into and going off with it.

The thermometer, when placed twelve inches from the stop-cock, and in the centre of the volume, showed the temperature to be 120 degrees; but when at four or five inches from the centre, although within the circumference of the volume, it was down to eighty degrees, showing, as might have been expected, that where the air first joined the volume, it was less heated. Twenty-four inches above the cock the thermometer was at ninety degrees at the centre: thirty-six inches from it, it was at eighty degrees at the centre.

May we not conclude from this experiment that the cooling down of the steam is occasioned by the great quantity of air which is combined with it; aided in a slight degree by the expansion which takes place immediately after leaving the stop-cock.

I have frequently, since the experiment was made, washed my hands in the water, which, when in the generator, was at 500° of heat, and which was rushing from the stop-cock with very little expansion, but with great velocity, showing clearly, that it is the rapid rush through the atmosphere, and not the expansion only, which cools it down."

STEAM ENGINE.

Steam Engine is the name given to a machine in which the moving power is obtained from the elastic force of steam, and from its capability of being condensed into water, and thus creating a vacuum in the space which it occupied.

Like every other invention which has become important to society, the steam engine has been ascribed to a variety of authors, and he who enjoys the undoubted title to that distinguished honour, has been robbed of his just rights by the obtrusive claims of a number of contrivances, as devoid of genius as they are destitute of utility.

The power of national prejudice has been singularly exhibited, and the spirit of scientific criticism as singularly degraded, when the invention of the steam engine has been ascribed to Hero and Branca, who whirled round a wheel by the steam of a kettle, or to Solomon de Caus, who squirted water out of a vessel by the steam which it generated. Upon such principles, we may refer the invention of the telescope to him who first looked through a glass ball filled with water, and the discovery of the air balloon to the little urchin who first committed his soap bubble to the atmosphere.

That the Marquis of Worcester was the inventor of the steam engine, or of a machine in which the elastic force of steam was proposed as the first mover in raising water, is a fact beyond dispute. In his *Century of Inventions*, a work published in 1663, he has described this engine in No. 68, and he has again referred to it in Nos. 98, 99, and 100. He has also left behind him what he calls a definition of his engine, the only copy of which is preserved in the British Museum. These different articles we shall now lay before our readers.

"No. 68. An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *infra sphaeram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessel be strong enough; for, I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end, as also the touch hole: and making a constant fire under it, within twenty-four hours it burst, and made a great crack: so that having found a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, have seen the water run like a constant fountain's stream, forty feet high; one vessel of water rarefied by fire, drinketh up forty of cold water: and a man that tends the work is but to turn two cocks that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self same person may likewise abundantly perform in the interim between the necessity of turning the said cocks.

No. 98. An engine so contrived that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, straight upright or downright, yet the pretended operation continueth and advanceth; none of the motions above mentioned, hindering, much less stopping the other; but unanimously, and with harmony agreeing, they all augment and contribute strength unto the intended work and operation; and therefore I call this a *semi-omnipotent engine*, and do intend that a model thereof be buried with me.

No. 99. How to make one pound weight to raise an hundred as high as one pound falleth, and yet the hundred pounds descending doth what nothing less than one hundred pounds can effect.

No. 100. Upon so potent a help as these two last mentioned inventions, a water work is by many years experience and labour, so advantageously by me contrived, that a child's force bringeth up one hundred feet high an incredible quantity of water even two feet diameter; and I may boldly call it *the most stupendous work in the whole world.*

Not only with little charge to drain all sorts of mines, and furnish cities with water though never so high seated, as well to keep them sweet running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions, but likewise supplying the rivers with sufficient to maintain and make navigable from town to town, and for the bettering of lands all the way it runs, with many more advantageous, and yet greater effects of profit, admiration, and consequence; so that deservedly I deem this invention to crown my labours, to reward my expenses, and make my thoughts acquiesce in way of farther inventions. This making up the whole century, and preventing any farther trouble to the reader for the present, meaning to leave to posterity a book, wherein under each of these heads the means to put in execution and visible trial all and every of these inventions with the shape and form of all things belonging to them, shall be printed by brass plates. Besides many omitted, and some of three sorts willingly not set down as not fit to be divulged, lest ill use may be made thereof, but to show that such things are also within my knowledge, I will here in myne owne cypher sett doun one of each, not to be concealed when duty and affection obligeth me."

The following is the Marquis's definition, which is printed on a single sheet without date, and which Mr. Partington, supposes, had been written to procure subscriptions in aid of a water company then about to be established.

"A stupendous, or a water commanding engine, boundless for height or quantity, requiring no external, not even additional help or force to be set or continued in motion but what intrinsically is afforded from its own operation, nor yet the twentieth part thereof. And the engine consisteth of the following particulars:

A perfect counterpoise for what quantity soever of water.

A perfect countervail for what height soever it is to be brought unto.

A *primum mobile*, commanding both height and quantity, regulator-wise.

A vicegerent or countervail, supplying the place and performing the full force of man, wind, beast, or mill.

A helm or stern, with bit and reins, wherewith any child may guide, order, and control the whole operation.

A particular magazine for water, according to the intended quantity or height of water.

An aqueduct capable of any intended quantity or height of water.

A place for the original fountain or river to run into, and naturally of its own accord incorporate itself with the rising water, and at the very bottom of the aqueduct, though never so big and high.

By divine providence and heavenly inspiration, this is my stupendous water commanding engine, boundless for height and quantity.

Whosoever is master of height is master of force; whosoever is master of water is master of both; and consequently to him all forcible actions and atchievements are easie."

That the engine thus described was actually constructed and put to the test of experiment in some form or other however rude, we think cannot well be doubted. There is nothing in the character of the noble Marquis to justify the supposition that he could deliberately record a falsehood; and still less that he could leave behind him the prayer which he offered up to heaven on the completion of his experiment. This curious document is entitled, "*The Lord Marquesse of Worcester's ejaculatory and extemporary thanksgiving prayer, when first with his corporal eyes he did see finished a perfect trial of his water commanding engine, delightful and useful to whomsoever hath in recommendation either knowledge, profit, or pleasure.*" In this prayer he thanks God, next to his creation and redemption, for "vouchsafing him an insight in soe great a secret of nature beneficial to all mankind as this my water commanding engine."

Those who have opposed the claims of the Marquis of Worcester, have alleged that it is impossible to construct a steam-engine on the principles which he has laid down; but this is not entirely true, and we have great pleasure in giving the following sketch of what was probably the first steam-engine, communicated to us by our able and ingenious correspondent, Mr. Scott of Ormiston.

In Plate DIV. Fig. 4. A represents a boiler placed in a common air furnace: *a b c d*, and *e f g h*, two water vessels; *i k l*, the steam pipes, and *k* the steam cock; *x x x x* the force pipe; RS a cistern, which may be supposed to be placed at the height of forty feet above the engine, to receive the water from the force pipe; and *v v* valves placed within the force pipe to prevent the return of the water; *m n o* the cold water pipes, and *n* the cold water cock; the dotted lines *b z e* represent the cold water fountain, which is here supposed to be immediately behind the engine, and the water in it standing nearly upon a level with the stop of the cold water vessels. Fig. A is a ground plan of the fountain, where *m n o* represent the cold water pipes, *n* the water cock, and F the reservoir. Fig. 6. represents a section of the two cocks, which are in every respect similar; the black circle *a b e* represents the key of the cock, and the black shaded part the passage through the key; the dotted circle *r s t u* the shell or body of the cock, the two dotted lines *t z* the pipe that leads from the boiler, the two dotted lines *s z* the pipe that leads to the right hand water vessel, the two dotted lines *z u* the pipe that leads to the left hand water vessel, and the curved dotted line *x z y* the top of the boiler.

From an inspection of Fig. B, it will appear that by a quarter turn of the key of the cock *k*, (Fig. 4.) the steam may either be directed into the right or left hand water vessel, and in like manner, by a quarter turn of the key of the cock *n*, cold water may be permitted to pass into either of the vessels.

Suppose the fire burning, and the boiler sending forth steam, and the key of cock *k* turned so as to permit the steam to enter into the vessel *a b c d*, then will the steam drive out all the air of that vessel up the force pipe *x x x x*, and occupy its place; steam will then be seen to issue from the nosle *w* of the force pipe. When this is observed, the key of the steam cock *k* must be turned, to permit the steam to pass into the vessel *e f g h*, and at the same time the key of the cold water cock *n* must also be turned, to permit the water from the fountain to be forced into the vessel *a b c d*, (by the pressure of the atmosphere) as the steam therein condenses with the cold water; and when the vessel *a b c d* is filled with water, and the vessel *e f g h* with steam, the key of the steam cock *k* is to be turned back into its first position, which will again permit the steam to pass into the vessel *a b c d*, to act upon the surface of the water in that vessel, so as to drive it up the force pipe *x x x*, and, at the same time, the key of the cold water cock *n* must also be turned, to permit the cold water to condense the steam and fill the vessel *e f g h*, and which will also be forced into this vessel (by the pressure of the atmosphere) to occupy the vacuum effected by the condensed steam. The cock *n* is next to be turned so as to permit the vessel *a b c d* "to force and refill with cold water," and, at the same time, the steam cock *k* is to be turned, so as to permit the steam to act upon the surface of the water in the vessel *e f g h*, and so on alternately, producing a constant stream from the top of the force pipe. The boiler may be supplied with water from the cistern RS, by means of a small pipe and stop-cock.

To produce "a constant stream forty feet high, one vessel of water rarefied by fire, driveth up forty of cold water, (or in other words, forty times the quantity in the boiler.) A man that tends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, (by the pressure of the atmosphere) and so successively, the fire being tended and kept constant, which the self same person may likewise abundantly perform in the interim between the necessity of turning the said cocks."

Although the Marquis of Worcester has only proposed to force water by his engine to a great height, yet it appears that he knew that water could have been brought up from a limited depth by suction, (by the pressure of the atmosphere into a vacuum;) for the 68th article commences with these words: "An admirable and most forcible way to drive up water by fire, not by drawing nor sucking it upwards, for that must be, as the philosopher calleth it, *intra sphæram activitatis*, (within its sphere of activity) which is but at such a distance."

It is therefore very obvious, that the Marquis had a knowledge to what height water could have been raised from the effects of a vacuum, and which he had put a small value upon in comparison of what he had in view; for he adds, "but this way hath no bounder if the vessels be strong enough." The Marquis a little further on says, "so that having a way to make my vessels, so that they are strengthened by the force within them."

This can only apply to strengthening his boiler and vessels by rivetting radiating arms inside of them, and making them in other respects strong.

Sir Samuel Morland, celebrated as the inventor of the speaking trumpet, appears to have directed his attention, in 1682, to the force of steam as a means of raising water. In 1681, he was sent by Charles II. to Louis XIV., to direct the execution of water works in France, and while he was in that country in 1683, he wrote a small treatise in French, entitled *Elevation des Eaux par toutes sortes des Machines reduite a la Mesure au Poids, et a la Balance.* This work was presented to the French king, and is preserved in the Harleian collection at the British Museum. The chapter on Steam Engines, which occupies only the last four pages, is as follows: "The *Principles of the New Force of Fire invented by the Chevalier Morland in the year* 1682, *and presented to his Christian Majesty* 1683. Water being evaporated by the force of fire, these vapours immediately occupy a much greater space (about 2000 times) than the water occupied before, and its power is so great that if closely imprisoned it will burst a piece of cannon. But being governed according to the rules of statics, and reduced by science to measure, weight, and balance, it then bears itself quietly under the harness (like good horses) and becomes of great use to mankind, particularly to raise water according to the following table, which shows the number of pounds which can be raised 1800 times per hour to the height of six inches, in cylinders about half filled with water, as well as the different diameters and depths of the cylinders.

Cylinders.

Diameter in feet.	Depth in feet.	Pounds weight to be raised
1	2	15
2	4	120
3	6	405
4	8	960
5	10	1875
6	12	3240

Number of cylinders, having a diameter of six feet, and a length of twelve feet.	Required to raise the following weight of water.
1 - - -	3,240 pounds
2 - - -	6,480
3 - - -	9,720
4 - - -	12,960
5 - - -	16,200
6 - - -	19,410
7 - - -	22,680
8 - - -	25,920
9 - - -	29,160
10 - - -	32,400
20 . - -	64,800

Among the eminent men who speculated respecting the use of steam as a moving power, Dr. Denys Papin deserves an honourable place. Driven from his own country by the revocation of the edict of Nantes, he resided in London from 1680 to 1687. He seems to have invented his digester in 1680, and during the experiments which he made with it, he was necessarily led to observe the expansive force of steam, and to ascertain its great power from the strength which his digesters required, and the means which were necessary to keep down their covers. In the *Acta Eruditorum* of Leipsic, for 1690, he has described the following engine, which cannot fail to be considered by every candid inquirer as a real step to the invention of the steam engine. A cylinder AA, Plate DIV. Fig. 7. made of thin metal, is fitted with a piston B, which can slide freely up and down in the cylinder. A small quantity of water being put into the bottom of the cylinder, and the piston B depressed so as to touch the water, the air being driven out through a hole in the piston, which is afterwards closed by a plug M. The water being made to boil by a fire beneath the cylinder, it is changed into vapour, which exerts so strong a pressure against the piston that it surmounts the pressure of the atmosphere, and pushes the piston upwards to the top of the cylinder. The piston is prevented from descending by a latch E falling into a notch in the stem H of the piston. The fire must now be removed from beneath the cylinder, and the vapours in this cylinder soon recondense themselves into water by cold, and leave the cylinder entirely free of air. In this state the machine is ready to exert its force, for, by loosening the latch E, the piston will be pressed down into the cylinder by the weight of the atmosphere which presses upon its upper surface while there is no air beneath to resist its descent, and a rope fastened to the stem of the piston H may be taken over pulleys TT, and applied to raise weights. Papin actually tried this experiment with a cylinder 2½ inches in diameter, by which he raised 60 lbs., and he made it repeat its action once in a minute. Hence he computed that a cylinder about two feet in diameter and four feet high would raise 8000 lbs. every minute four feet high, which is nearly a horse power.

Papin states that this invention is suited to draw water from mines, to throw bombs, and to row vessels against wind and tide. For this last purpose, he proposed to fix on the sides of the vessels revolving rowers or paddle wheels, and by means of three or four of his new invented cylinders, to give a combined motion to the axis on which the paddle wheels are fixed. In order to give this motion to the wheels, the piston rods were to be toothed so as to drive small toothed wheels fitted on the axis of the paddle wheels, whenever the pressure of the atmosphere caused the pistons to descend into their respective cylinders. In order to make the motion of the paddle wheels uninterrupted, several cylinders were to work in succession one acting while the rest were heating. The toothed wheels on the axis of the paddles were to have ratchets and clicks that they might revolve freely in an opposite direction to the axis when the pistons were rising in their cylinders, but when the pistons were pressed down into the cylinders, the clicks would catch in the teeth of their ratchets, and carry the axis round with the toothed wheels.

This scheme was reprinted in 1695 in the *Recueil de diverses pieces touchant quelques nouvelles Machines par D. Papin, Cassel* 1695, in which he describes a new invented furnace and revolving bellows, which he had contrived to boil water by an internal fire-place, surrounded on all sides by the water; and he endeavours to show how it could be applied to heat the cylinders of his proposed engine with such increased rapidity as to perform four strokes in a minute. Papin made one of these machines in 1698, but before he had put it to the test of experiment it was destroyed by an accident.

It is impossible to peruse these details without being convinced that this ingenious author had advanced a considerable way in the construction of the steam engine, and had almost invented some of its most useful applications. We feel much satisfaction in having an opportunity of acknowledging the merits of this ingenious foreigner, as we had been induced, on the authority of Dr. Robison, and by an imperfect examination of the subject, to do injustice to the genius of this able author, when we had occasion to discuss the subject in another work.*

Notwithstanding all these attempts to construct a steam engine, no machine of this kind had yet been executed and applied to actual use. The honour of this great step was reserved for Captain† Thomas Savery, treasurer to the commissioners of sick and wounded. In a pamphlet entitled the Miner's Friend, published in 1696, he described a steam engine in which water is raised not only by the expansive force of steam, but also by its condensation, the water being raised by the pressure of the atmosphere into receivers, from which it is forced to a greater height by the elastic force of the steam. After having erected several of these engines, Savery took out a patent, in 1698, for a new invention "for raising water and occasioning motion to all sorts of mill work." In June 1699, he exhibited a working model to the Royal Society, who printed in their transactions for that year a drawing and description of it; but the most complete account of it appeared in a small pamphlet of eighty-four pages 12mo. which Mr. Savery published in 1707, under the title of "The Miner's Friend, or an Engine to raise Water by Fire described; and the manner of fixing it in Mines, with an account of the several uses it is applicable unto, and an answer to the objections made against it." This book was separately addressed to King William III. to whom the engine had been shown at Hampton Court.

This engine, which is perfect so far as it goes, displays much ingenuity. The following is Savery's own description of it, with some additions as given in Harris's *Lexicon Technicum*, vol. i. Art. Engine.

A A The furnaces which contain the boilers.

B1, B2. The two fire places.

C The funnel or chimney which is common to both furnaces. In these two furnaces are placed two vessels of copper, which I call boilers, the one large as L, the other small as D.

D The small boiler contained in the furnace, which is heated by the fire at B 2.

* In the short notice of the history of the steam engine, given by the Abbé Bossut in his *Hydrodynamique*, he has placed the invention of Savery after a contrivance of M. Dalesme in 1705, whereas, as will be presently seen, the date of Savery's patent is 1698. In consequence of this mistake, the invention of Dr. Papin, published in 1709, obtains the precedency of Captain Savery's engine. See Bossut's *Traité D'Hydrodynamique*, tom. II. p. 476. Paris, 1796.

† Mr. Farey informs us that the Cornish miners give the title of Captain to engineers, and that Savery hence derived it.

E The pipe and cock to admit cold water into the small boiler to fill it.

F The screw that covers and confines the cock E to the top of the small boiler.

G A small guage cock at the top of a pipe going within eight inches of the bottom of the small boiler.

H H A larger pipe which goes the same depth into the small boiler.

I A clack or valve at the top of the pipe H, (opening upwards.)

K K A pipe going from the box above the said clack or valve, into the great boiler and passing about an inch into it.

L L The great boiler contained in the other furnace, which is heated by the fire at B 1.

M, Fig. 9. The screw with the regulator which is moved by the handle Z, and opens or shuts the apertures at which the steam passes out of the great boiler into the steam pipes O, O.

N *n* Two small guage pipes which go down into the great boiler, one of which N has its lower end a little above the proper depth of water, and the other *n* a little below it, so that when N gives steam upon turning the cock, and *n* water, the water is at its proper height.

O1, O2. Steam pipes, one end of each is screwed to the regulator, (See Fig. 9.) and the other ends to the receivers PP, to convey the steam from the great boiler into those receivers.

P1, P2. Copper vessels called receivers, which are to receive the water which is to be raised.

Q Screw joints, by which the branches of the water pipes are connected with the lower parts of the receivers.

R1, 2, 3, and 4, valves or clacks of brass in the water pipes, two above the branches Q, and two below them; they allow the water to pass upwards through the pipes, but prevent its descent; there are screw plugs to take out on occasion, to get at the valves R.

S The forcing pipe which conveys the water upwards to its place of delivery, when it is forced out from the receivers by the impellent steam.

T The sucking pipe which conveys the water up from the bottom of the pit to fill the receivers by suction.

V A square frame of wood or a box with holes round its bottom in the water, to inclose the lower end of the sucking pipe to keep away dirt and obstructions.

X A cistern with a buoy cock coming from the force pipe, so as it shall always be kept filled with cold water.

YY A cock and pipe coming from the bottom of the said cistern, with a spout to let the cold water run down on the outside of either of the receivers P, P.

Z The handle of the regulator to move it by either open or shut, so as to let the steam out of the great boiler into either of the receivers.

The mechanism of the regulator and the guages will be better understood from the section of the boiler shown in Fig. 10. R being the regulator moved by the handle Z in Fig. 8, 9, which can thus be brought to slide alternately over the mouths of either of the pipes O 1, O 2.

The two boilers D, L are fixed in a good double furnace, so constructed that the flame of the fire may circulate round them. Before the fire is lighted, unscrew the guage pipes and cocks G and N, and at the holes fill the great boiler L two-thirds full of water and the small boiler D quite full. When these pipes are again screwed as tight as possible and the water brought to boil by the fire under the large boiler B 1, steam will be raised, and will endeavour by its elastic force to make its escape. This is effected by pushing from you the handle Z of the regulator (R Fig. 10.) as far as it will go, when the steam will rush with great force through the steam pipe O 1 into the receiver P 1, driving out all the air before it, and forcing it up through the clack R1 into the force pipe. When the receiver P 1 is thus thoroughly emptied and has become very hot, pull towards you the handle Z of the regulator, which will remove the slide R, Fig. 10. from the mouth of the pipe O 2, and place it on the mouth of the pipe O 1, so that no more steam can come into the receiver P 1, when it passes freely through the other steam pipe O 2, and fills the other receiver P 2, heating it and discharging its air through the clack R 2 up the force pipe.

Having condensed the steam in the receiver PY by cold water, from the spout Y, a vacuum will be created in it, and as there is nothing at the bottom of the receiver P 1 to counterbalance the pressure of the atmosphere on the surface of the water at the lower spout V of the sucking pipe T, the water will be pressed np and will fill the receiver P 1 by suction, the water lifting up the clack valve R 3, which afterwards falling down prevents the water from returning that way.

The receiver P 2 being emptied of its air, admits the steam again through O 1, and by its elastic force, which exceeds the weight of the column of water in the receiver and pipe S, it will press on the surface of the water and drive it up through the passage R 1 into the force pipe S, discharging it at the top as shown in the figure. In the same manner the receiver P 2 is alternately filled with water by suction, and then emptied by the elastic force of the steam, so as to keep up a constant stream at the top of the force pipe S. When the water has half filled the force pipe S, it also fills the little cistern X, by which the condensing pipe YY is supplied. This pipe can be turned sideways by its handle *n*, so as to throw cold water on the outside of either of the receivers.

The labour of turning the regulator Z, and the handle *h* of the condensing watercock, may be easily performed by a boy, though Mr. Savery recommends the employment of an intelligent workman. The use of the small boiler D is to replenish the large one L with water, which sinks in it about one foot in one and a half or two hours. For this purpose, the small boiler D is supplied with water from the force pipe by a small pipe and cock E, Figs. 8 and 10, which is closed when the boiler D is nearly full. A fire is then lighted in the furnace B *r*, and in consequence of the elasticity of the steam which it produces being stronger than that in the boiler L, it presses upon the water in

D, Fig. 10, forces it up the pipe HH, and through the cock I (which is for this purpose open) into the boiler L, into which it will flow till the surface of the water in D has descended to the lower end of the pipe H, which is within eight inches of the bottom. The size of the boiler D is such, that it supplies L with exactly one foot of water. In order to ascertain when the boiler L requires more water, we have only to turn the guage cocks N, *n*. If steam arises from N and water from *n*, as will happen in the state shown in Fig. 10, then no water is required, but if steam issues from *n* there is then a want of water, and if water should issue from N there is more than is necessary.

After giving the description of his engine, Mr. Savery enumerates the following purposes to which it may be applied, viz: 1. Raising water for turning all sorts of mills. 2. Supplying palaces, noblemen's and gentlemen's houses with water, and affording the means of extinguishing fires therein by the water thus raised. 3. Supplying cities and towns with water. 4. Draining fens and marshes. 5. For ships.* 6. Draining mines with water, and preventing damps in these mines.

The safety valve, which was invented by Papin in 1681, does not seem to have been used by Mr. Savery in any of his engines; and it is also evident from the preceding description of his engine, that he was not the inventor of the injecting pipe, or of the principle of condensing by injection, an honour which Mr. Watt has, by mistake, ascribed to him.†

In examining with some care the various accounts which have been given of Mr. Savery's labours, and the details of his engine, we are strongly disposed to believe, with Mr. Farey, that the whole of it was his own invention, and that he was even unacquainted with the previous contrivance of the Marquis of Worcester. The story told by Dr. Desaguliers, that Savery borrowed his invention from the Marquis of Worcester; and that, in order to conceal the matter, he bought up all the Marquis's books that he could purchase in Paternoster Row, and burned them in the presence of a gentleman who mentioned the thing to Dr. Desaguliers, is so improbable that we cannot give it credit; and even if we did, it could not affect the ingenuity and originality of Savery's engine. Whatever merit we may attach to the contrivance of the Marquis of Worcester, and in whatever manner we may apportion a certain share of merit to the different candidates to whom national partiality may have adjudged the invention of the steam engine, there cannot, we think, be any doubt that Mr Savery stands at the head of the list, and is more entitled to have his name associated with the invention, the construction, and the introduction of the steam engine into actual use, than any other individual that has yet been named.

Dr. Papin, who had still continued to direct his attention to the subject of the steam engine, published in 1707 a small tract, entitled *Nouvelle maniere pour lever l'eau par la force du feu, mis en lumiere*, Cassel. Papin admits in this work that he had seen the engraving of Savery's engine, which M. Leibnitz had sent to him from London; and, therefore, he does not bring forward his engine as having the precedence of Savery's, but merely as a construction which possesses superior advantages. He proposed to the Royal Society, of which he was a member, to bear the expense of constructing an engine upon his plan; but this learned body, who had a communication with Mr. Savery on the subject, do not seem to have attached any value to the contrivance of Papin, which we have represented in Fig. 11.

A copper boiler A communicates by means of a pipe Z with the cylinder I, which is connected by a curve pipe X to an upright OQ, which rises nearly to the top of the cylinder RR. This cylinder, which is air tight, is furnished with a pipe W and stop-cock P, Plate DIV, Fig. 11. Another pipe terminating in a funnel K with a stop-cock at M branches off from the bent pipe X. The pipe Z has a stop-cock at C, and another small pipe at E also furnished with a stop-cock. A *safety valve* F, of which Papin is the undoubted inventor, is placed above the boiler A. In the cylinder I is a piston or float N made of thin plates of metal, forming a hollow cylinder which floats on the surface of the water. A pipe and stop-cock D is inserted in the cylinder I. When steam is generated by lighting a fire beneath the boiler A, the cock C is opened to allow it to rush into the pump cylinder I, which is nearly filled with water. The elastic force of the steam depresses the float *n n*, and thus forces the water beneath it through the valve O, and up the pipe OQ into the receiver RR, the air in which it of course condenses. The stop-cock *p* is then opened, and the water pressed out by the elasticity of the condensed air in the receiver rushes out through the cock P, and strikes the float-boards U, S, X, of a wheel which gives motion to any other machinery. When the float *n n* has descended to N, the farther admission of steam into I is prevented by turning the cock C, and the steam above the float is allowed to escape into the air by the cock D. At the same time the stop-cock M is opened to allow the water in the funnel K to descend and raise the float *n n* to its first position as in the figure. The cocks D and M are now shut, and C is opened to re-admit the steam from the boiler, and impel more water against the wheel, which will thus be kept in constant motion. A pipe and cock is placed at E to allow the air in the boiler to escape when it is first filling with steam. A similar pipe empties the pipe X of water.

In order to increase the force of the steam, Papin proposed to introduce a red hot heater, H through G, but this was a clumsy contrivance, of no value; and indeed the whole machine, though ingenious, could not be put in comparison with the previous invention of Savery.

Dr. Gravesende, having come to England as secretary to the Dutch embassy in 1716, went through a course of experimental philosophy with Dr. Desaguliers. When they were considering Savery's steam engine, it appeared to them that there was a great waste of steam by its continually acting upon the receiver without intermission, since it became useless till it had heated the surface of the water in the re-

* This does not mean impelling ships, but emptying them of water.

† "It does not appear," says Mr. Watt, "that the Marquis of Worcester knew any thing of the use of an injection, as the machine described by him operated only by the expansive force of steam, whereas the injection was used in Savery's engine from the beginning, and is in all probability his invention."—Robison's *Works*, vol. ii. p. 50, note.

ceivers. They therefore made a model which could work either with one or two receivers, and they soon found by it that, "one receiver could be emptied three times, while two succeeding ones could be emptied only once a piece." Hence they concluded, that such an engine would save a third more water, and be erected at only half the expense.

This ingenious contrivance is shown in plate DV, Fig. 1, where A is the receiver of copper communicating at bottom with the making and forcing pipes between E and G, and at top with the steam pipe at D, and the rejecting pipe at I. The boiler B, which is also of copper, contains at least five times more than the receiver, round which the fire and flame are conducted at T, T, T. It has a copper cover screwed, in which contains the steam pipe CD communicating from the boiler to the receiver, and guage pipes N *n*, O *o*, with a valve at P, kept down by the steelyard PQ and weight Q. The surface SS of the water in the boiler must be lower than the bottom of the short guage pipe at *o*, and higher than the bottom of the long one at *n*. The steam cock DI has its key K kept down by the screw L held by the arm DL, while the handle K is either turned to *k* to receive the steam issuing from the boiler, or to K to shut off the steam and admit a jet of cold water coming from the ascending pipe EE2 through the cock M, the mechanism of which is shown in detail in Fig. 2, where 1 is the screw which, passing through the stirrup 2, presses on the piece of cast iron 3, made tight to the brim under it by double canvas, while the returns of the stirrup draw up the ring 4 under the brim to support it; 5, 6, 7, shows the key of the stop cock with a hole on the side at 6, which passes down through the bottom of the key to throw down alternately into the receiver the steam and the jet or injection. There is a notch in the key at 7 to receive the water from the force pipe, and carry it to the boiler, when it receives a fresh supply of water. The annexed section of the steam cock and key will make its construction perfectly intelligible.

The horse or pipe EEGZ, with several elbows, is soldered at E to the forcing pipe EE2. The sucking pipe ZH is soldered to it at Z, and the receiver at F. This horse contains the sucking valve at G, and the forcing valve at F, which are easily got at by unscrewing 1 to loosen the strap 2, and let down the flanch 3, as shown in Fig. 2. The cistern R communicates with the forcing pipe by a cock and small branch Y to fill the forcing pipe when required. A spreading plate I is used to make the steam and the water be alternately divided into little jets, and *b c* represents the surface of the steam pushing down the water in order to drive it up again into the force pipe EE through the valve E. The door of the fire place is shown at V, and the ash hole at W.

This engine operates as follows. Take off the steelyard PQ, and open the cock O of the short guage pipe O *o*, then holding up the valve by a long nail, pour in water at the valve, which will blow out the air at O till the surface of the water rises above the bottom *o* of the guage pipe, when the boiler will be sufficiently filled. Having then stopped the communication between the steam cock DI and the boiler, and shut the two guage cocks at N and O, replace the steelyard on the valve with its weight O near P, and light the fire at T. As the fire is increased remove the weight Q, notch by notch, till it comes to the last notch at Q, and see that no additional weight is put to it.

When the steam begins to lift the safety valve P, and when the receiver A has been filled with water, which is done by taking out the key of the cock under the screw L, and opening the cocks Y and M, turn the handle of the steam-cock on the receiver from K to *k* to admit the steam from the boiler along CD, first opening it partially, and then fully. The steam will now spread through the small holes of the plate at I, and pressing on the surface of the water at *b c*, will force it through the valve F, and up the pipe EE. This pipe being now full, and the cock M open, turn back the handle from *k* to K, and a jet of cold water will spout through the spreading plate I among the steam, which it will immediately condense, and the air pressing on the water in the well at H will push it up into the receiver A, and will force it up I. The handle being turned to *k* as formerly, the steam will be again admitted, and will again draw the water up the pipe EE into the cistern R.

The engine will thus continue to raise water four or five hours, till both the guage pipes N and O give steam, which shows that the boiler requires a supply of water.

In order to replenish the boiler, turn from you the handle K behind L, which will bring the notch 7 of the key in Fig. 2, to the situation in the right hand section in Fig. 2, and then the cocks M and Y being still open, the water will flow from the cistern through the forcing pipe and steam pipe into the boiler without going into the receiver, the steelyard being off the valve, and the cock O open to let out the air as the water enters. Whenever the cock O ceases to blow, and the valve descends, turn back the handle to K, and shut the cock Y.

Some of Dr. Desaguliers' engines were erected after 1717–1718, and one of them was for the Czar, Peter I. for his garden at St. Petersburg. The water was drawn up by suction 29 feet high, and then forced up 11 feet higher. In another the water was drawn up 29 feet, and forced up 24 feet higher.

Various engines on the principle of Mr. Savery's have been erected since his time, and various improvements have been made on the original construction; and as there are many circumstances under which they may still be advantageously employed, we shall describe one which was erected by Mr. P. Keir at St. Pancras, and which was employed for many years to turn lathes, &c. The following description of it is given by Mr. Keir himself in Nicholson's *Philosophical Journal*.

The figure, Plate DV, Fig. 3, is a section of the engine, taken through the centre. B represents a boiler, shaped like a wagon, seven feet long, five feet wide, and five deep: it was considered as being of dimensions sufficient to work a larger engine; a circumstance which must, in a certain degree, diminish the effects of the present one. The boiler feeds itself with water from an elevated cistern, by a pipe which descends into the boiler, and has a valve in it, at the upper end, which shuts downwards, and is connected by a wire with a float on the surface of the water within the boiler, so as to open the valve whenever the water subsides below the intended level; for the float which swims on the water then sinks, and by its weight draws the valve up, to allow the water from the cistern to run down the pipe and supply the deficiency: but as the water in the boiler rises the float closes the valve. The boiler therefore remains constantly or nearly at the same degree of fulness.

The steam is conveyed by a pipe C to a box D through which, by the opening and shutting of a valve it can be admitted to the cylindrical receiver A. The axis K serves as a key to open and shut the valve, which is a circular plate, formed conical on the edge, and fits in a corresponding aperture in the bottom of the box D. H is a cistern from which the engine draws its water through a vertical suction pipe, in which a valve, G, is placed to prevent the return of the water. R is another cistern into which the water is delivered from the receiver A, through the spout F, which is provided with a valve opening outwards. WW represents an overshot water wheel eighteen feet in diameter, of which the axis S communicates motion to the latches and other machines used in the manufactory.

The engine raises the water from the lower cistern H, by suction, into the receiver A, from which it runs into the upper cistern R, and thence flows through a sluice into the buckets of the water-wheel W to give it motion. The water, as it is discharged from the buckets of the wheel, falls again into the lower cistern H. As the same water circulates continually in both the cisterns, it becomes warmer than the hand after working a short time; for which reason the injection water is forced up by a small forcing pump from a well. This injection pump is worked by the water wheel, by means of a loaded lever, or pump handle, which is raised up by the motion of the wheel, and then left to descend suddenly by its weight, and force up the water into the receiver. A leaden pipe passes from this forcing pump to the upper or conical part of the receiver A, for the purpose of injecting cold water at the proper time. Neither of these could be represented with convenience in the present section.

The manner in which the steam and cold water are alternately admitted into the receiver A, remains to be explained. Upon the extremity of the axis S of the water wheel, a solid wooden wheel T is fixed; it is about four feet in diameter, and turns round with the water wheel. It is represented separately, as seen in the front; *a*, *b*, *c*, *d*, are four cleats, all or any number of which may be fixed on the wheel at a time. Each cleat has its corresponding blocks *e*, *f*, *g*, *h*, on the opposite surface of the wheel. The use of these is to work the engine. Thus, suppose the water wheel, and this wheel T, with all the revolving apparatus, is turning round, one of the cleats *a* meets in its rotation with a lever, which it lifts up, and this opens the steam valve D by a rod of communication reaching to the handle of the axis K. The steam consequently passes into the receiver A, and the steam valve shuts again, as soon as the cleat *a* of the wheel T has passed away from the lever by the motion of the wheel. All this time the corresponding block *e* on the other side of the wheel T had been operating to raise up the loaded lever which forms the handle of the forcing pump: and at the same instant that the steam valve D is shut, as above mentioned, the block *e* quits the loaded lever, after having raised it up, and leaves it to descend suddenly by its own weight. This depresses the forcer of the pump and thereby throws a jet of cold water up into the receiver A, and it falls in a shower of drops through the steam which fills the receiver, so as to cool and condense the steam and make a vacuum.

The pressure of the atmosphere upon the surface of the water in the cistern K then causes the water to mount up the perpendicular suction-pipe, through the valve G, towards the exhausted receiver.

When the engine is first set to work, the water-wheel being motionless, the steam valve and injection pump are moved by hand, and if the engine has been long out of work, two or three strokes may be necessary to raise the water to the top of the receiver A, so as to fill it full of water. As soon as this is the case, and the steam valve is opened to admit steam into the receiver, the whole contents of water, above the spout and valve F, then flows out of the receiver A, by its own gravity, into the upper cistern R.

The water which is thus raised, is suffered to flow from the cistern upon the overshot water wheel W through a sluice; and by that means keeps the wheel in motion, and replenishes the lower cistern. There is no reservoir for the injection water; but the requisite quantity is driven up at each stroke; and as this is done by the sudden descent of the loaded lever of the pump, the water is injected very suddenly into the receiver."

Before the improvements upon Savery's engine were proposed by Desaguliers, a very important invention had been made by Mr. Thomas Newcomen, an ironmonger in Dartmouth. There is reason to believe that this ingenious workman was occupied in the improvement of the steam engine as early as Mr. Savery. Switzer, indeed, who was a friend of Savery's, and therefore not likely to make any statement injurious to his reputation, distinctly informs us that he had good authority for stating that Newcomen was as early in his invention as Savery; but that the latter being nearer the Court, obtained his patent before the other knew of it, on which account Newcomen was glad to come in as a partner in the patent which was granted to them in 1705.

Dr. Desaguliers, however, has given a different account of the matter, and as the passage contains some interesting details, we shall give it in his own words. " Thomas Newcomen, ironmonger, and John Calley, glazier of Dartmouth (Anabaptists) made the several experiments in private, and having brought the engine to work with a piston, &c. they, in the latter end of the year 1711, made proposals to draw the water at Griff in Warwickshire; but their invention meeting not with reception, in March following, through the acquaintance of Mr. Potter of Bromsgrove in Worcestershire, they bargained to draw water for Mr. Bach of Wolverhampton, where, after a great many laborious attempts, they did make the engine work; but not being either philosophers to understand the reasons, or mathematicians enough to calculate the powers, and to proportion the parts, very luckily by accident found what they sought for. They were at a loss about the pumps, but being so near Birmingham, and having the assistance of so many admirable and ingenious workmen, they so soon came to the method of making the pump valves, clacks, and buckets, whereas they had but an imperfect notion of them before."

The engine thus constructed has received the name of the atmospheric engine, in consequence of the power which is employed, being only the weight of the atmosphere, the steam exerting no force whatever either upon the surface of the water, or upon the piston, and having no other functions to perform but that of forming a vacuum. Newcomen's engine, in its original state, is shown in Plate DV; Fig. 4. The steam generated in the boiler B, passes through the cock D into the steam cylinder A, beneath a piston S, which is attached by means of the piston rod *r*, to the great beam I, I. This beam or lever has at its extremities arch heads, upon which the chain R laps and unlaps itself during the motion of the beam round the fulcrum C, the chain being fixed at the upper end of the arched head. The cylinder A is surrounded with another cylinder ZZ, concentric with it, and communicating by a pipe F, with a reservoir G of cold water, while its lower end communicates with the well O, by another pipe EE.

The piston being at the top of the cylinder, as shown in the Figure, let steam be admitted into the cylinder till it is full. When this is done, turn the cock D to prevent the entrance of any more, and open the cock F, to allow cold water from G to flow into the outer cylinder ZZ. By cooling the steam cylinder A, this will condense the steam within it, which will form a vacuum under the piston S. The whole weight of the atmosphere, which now presses on the upper side of the piston, having no force on the other side to counterbalance, it will force the piston S down to the bottom of the cylinder. By this means, the end I of the great beam is depressed, and the opposite end I′ raised, so as to work the pump L, and raise the water which it contains. When the piston has reached the bottom of the cylinder, the cock F is shut, and the cock E opened, and the water in the outer cylinder ZZ, descends into the well O, while the small quantity formed by the condensation of the steam in A, descends also into O through the pipe P. By means of a counter-weight M, placed on the rod K, the piston S is brought up to the top of the cylinder, and steam being again admitted, and again condensed as already described, the piston is again forced down, and a fresh draught of water brought from the well L. The fire beneath the boiler is shown at N, the ash-pit at W, the flues at XX, and the pipe which supplies the reservoir G at TT. The mouth of the well or mine to be drained, is shown at L, and H is a pipe for admitting water above the piston, to keep it water-tight.

Such was the state of the atmospheric engine before March 1712, when the patentees, as above stated, obtained such important aid from the Birmingham artists. But an accident now occurred which turned out of great importance. Having observed the engine perform several strokes in very quick succession, they found, upon a strict examination, that there was a hole in the piston, which let the cold water in to condense the steam in the inside of the cylinder, whereas this had always been done on the outside. Hence arose the use of the injection pipe, which was afterwards made to squirt a jet of water upwards from the bottom of the cylinder into the steam which it contained. The outer cylinder ZZ, was therefore no longer necessary, and the pipe *f* entered the bottom of the cylinder, as shown in Fig. 5.

Dr. Desaguliers remarks, "that they used to work with a buoy in the cylinder, enclosed in a pipe, which buoy rose when the steam was strong, and opened the injection, and made a stroke, thereby they were capable of only giving six, eight, or ten strokes in a minute, till a boy, Humphry Potter, who attended the engine, added (what he called *scoggan*,) a catch, that the beam Q always opened, and then it would go fifteen or sixteen strokes in a minute. About this time (in 1713) the leathering of the piston was found out by accident. "Having then screwed a large broad piece of leather to the piston, which turned up the sides of the cylinder two or three inches; in working it wore through, and cut that piece from the other, which falling flat on the piston, wrought with its edge to the cylinder, and having been in a long time, was worn very narrow; which being taken out, they had the happy discovery, whereby they found that a bridle rein, or even a soft thick piece of rope or match going round, would make the piston air and water-tight." A few years afterwards, in 1717, Dr. Desaguliers communicated to Mr. Beighton the use of the steelyard safety valve.

Notwithstanding these great improvements, the mechanism of the steam engine was still very imperfect. The necessity of cock buoys to open and shut the cocks, and the number of catches and strings employed gave a character of complexity to its parts, which rendered them liable to derangement from the slightest irregularity. All this apparatus, however, was superseded in 1818, by the invention of what is called hand-gear, which Mr. Henry Beighton, an able engineer, first applied to an engine which he erected at Newcastle-upon-Tyne. In this engine, the cocks were all opened, and that by the hand-gear, which was put in motion by a rod suspended from the main beam. Mr. Beighton made also several other changes upon the engine, which improved the form and arrangement of its parts, and he introduced a neatness and accuracy of workmanship unknown to his predecessors.

The steam engine as constructed by Mr. Beighton, is shown in Plate DV. Fig. 6, where *h h* is the great beam, C the cylinder, A the fire, and B the boiler, all of which act in the manner already described. The part which we intend principally to describe, is the working perpendicular beam QQ, with all its machinery for opening and shutting the regulator and injection cock. This machinery is contained within the compass of the letters D *d* C 6 P 5 4 1 Q N F E, but its parts are here on such a small scale, that we have given them separately in Fig. 7. Between two perpendicular pieces of wood on each side of P, Fig. 6, and marked AB in Fig. 7, there is a square iron axis AB, which carries four iron pieces necessary for turning the regulator, by pushing forward and drawing back the fork fastened to the handle of the regulator Fig. 6, and marked QOEL, Fig. 7. In the beam QQ, there is a slit so contrived that its pins work on the fore part, middle, and back part, to raise and depress the levers 5, 4, that move the axle AB, as far about its centre as is necessary. A piece CED called the Y moves round AB on an axis, and carries a weight F, which by means of a key and wedge can be slipped along the arm C. By means of a hooked stirrup GLE, the axle AB is joined to the horizontal fork ON. A spanner or handle G 4 is driven on upon the axle AB; and another shorter spanner H 5, at half right angles to this, is forced on to where it is made fast. When the working beam QQ rises, the pulley *p* will lift up the spanner H 5, which turns the axle AB so far round as to throw the Y, CED with its weight F from C to 6, in which direction, after passing the perpendicular, it would continue to move towards O, if it were not stopped by a strap of leather fixed to its top at Œ, and made fast at the points *m*, *n*, in such a manner as to allow the Y to vibrate about a quarter of a circle in falling forwards and backwards after it has passed the perpendicular. The horizontal fork ON is joined at its end O to the spanner or handle of the regulator P 9 Q 10, there being several holes in these pieces, that any part of the end O may be kept in any part of the slit in the spanner, as may be necessary for the better motion of the two pieces. The other end N of the fork is fastened to the bottom EKNL of the stirrup by the long horizontal pin L, so that the fork may continue horizontal as it is pushed forward and drawn back by the spanner P 10, to shut and open the regulator in the manner to be afterwards described. There is a horizontal piece *u l* so placed that the end 10 of the spanner may bear upon it, and be supported as it slides backwards and forwards.

The situation of the machine as represented in Fig. 7, is as follows. The regulator is open, as appears by its plate TY, being removed from under the communication or throat pipe SS that goes into the cylinder. The piston is now at the place CW, Fig. 6, at the top of the cylinder, and consequently the great beam *h h* and the working perpendicular beam QQ are now almost at their utmost height: And the pulley P in the slit of the working beam has so far raised the spanner *h* 5 that the weight F is brought so much from beneath N as to be past the perpendicular over the axle AB; and being ready to fall over towards N, it will with a smart blow of its shank E strike the pin L, and drawing the fork OL horizontally towards the working beam, will draw the end 10 of the handle of the regulator towards *l*, and then shut it by slipping the plate Y under the pipe SS. In Fig. 6, the blow is already struck, as may be seen by observing that the weight at the head of the Y has got to 6, as far as the strap P 6 (or *n* 6 in Fig. 7.) will let it go.

When the regulator is shut, the next thing is to open the injection cock to produce the vacuum, and immediately to shut it when the piston begins to come down. The part of the pipe coming from the injecting cistern is shown at *o*, Fig. 7, and *c* is the part that leads to the cylinder, *e* is the key of the cock which has a narrow long upright hole, instead of a round one, that it may be the sooner opened. On the top of this key there is fastened a quarter of a toothed wheel *l*, turned by another quarter of a toothed wheel *i* hanging down from the axis *h g*, which is moved by the lever *h k*, commonly called the F.

As soon as the regulator is shut by the ascent of the pulley *p*, the beam QQ not immediately losing its motion upwards, the pin *s* on its outside lifts up the extremity 1 of the F, 1 *k h*, and opens the injection cock; and the jet immediately making a vacuum, the beam begins to descend, and the pin *r* which can be put higher or lower, depressing the F shuts the injection cock; while the beam QQ continuing to descend, the pulley *p* pressing on the handle C 4, throws back the Y, whose shank D throws forward the fork and opens the regulator to admit fresh steam in the way formerly described, which steam is shut off by shutting the regulator till the injecting cock is again opened.

In the engine represented in Fig. 6. there is a strong frame F 1 F 2, upon which fill two strong wooden springs S 1 S 2, that if the arch of the great beam *h h* should come down too low, no mischief may be done to the piston, and the whole stroke may be made upon S 1 S 2 by the strong iron pins P 1 P 2, which will there be stopped. The pump which the engine is to work, is shown at *p*, the pump rod at *i*, and *k* is the rod of another pump which raises some of the water at *p*, by the injection reservior *g*, through a pipe which passes by *o*, and behind the attendant *c*.

Hitherto the steam employed as a mechanical power had been reconverted into water by condensation; but about the year 1720, Leupold, the author of the *Theatrum Machinarum*, suggested the plan of blowing it out into the atmosphere, and may therefore be considered as the inventor of the high pressure engine. This engine is shown in Fig. 1 of Plate DVI, where A is the boiler communicating by the *four* way cock X with the lower ends of two cylinders R,S, in which two pistons C,D move up and down, and put in motion two levers G,H by the intervention of the piston rods, E,F. Pump rods K,L, fixed to the other ends of these levers, work the pumps O and P, and raise the water up the main pipe Q. The fire-place is shown at Z, and the ash-pit at Y. The levers G,H move upon pivots I,I, and the four way cock X is so constructed as to shut off the communication between the boiler A and either of the cylinders R,S, while it opens a communication with the external air. The operation of the engine is as follows.

The steam from the boiler A being admitted through the passage 3 into the cylinder R, forces the piston C up to the top, and thus depresses the pump rod K, which forces the water up Q. When C is at the top, the cock X is turned, and the passage B between the boiler and the cylinder closed, while a communication is opened from the inside of the cylinder into the atmosphere. The weight of the piston and piston rod FG, being made greater than that of K and O, the piston C will fall to the bottom of the cylinder, driving out the steam that had remained in it From the construction of the cock X a passage is opened between the boiler A and the other cylinder S, when the passage into R was closed. Hence the piston D is forced upwards, and the pump rod of the pump P descends and forces water up Q. The cock X being again turned, the steam is shut off from S, and a passage open into the external air, so that the weight of ED being greater than that of LP, the piston D will descend and press out the steam into the atmophere.

No attempt had yet been made to convert the reciprocating motion of the piston into a continuous rotatory motion: but Mr. Jonathan Hulls, who in 1736 proposed to apply the steam engine to tow vessels or ships into and out of harbour, described a contrivance by which the rise and fall of the piston should give a continued rotatory motion to the paddle wheels, but the proposal excited no notice; and his steam boat as well as his rotatory mechanism,* were left as a legacy to his successor. See our article Steam Boat.

* Mr. Robert Stuart, in his excellent *Descriptive History of the Steam Engine*, p. 83. Lond. 1824, seems to us to have committed a serious mistake in ascribing the invention of the *crank* to J. Hulls, and thus depriving Mr. Watt of the honour of an invention which he had considered so completely his own as to secure it by a patent. "*In this scheme*," (meaning

In the year 1756 a patent was taken out by Mr. Blakey, for a contrivance which prevented the steam from coming in contact with the water, as in Savery's engine. One of his contrivances consisted in interposing a quantity of oil between the steam and the water. He employed also two receivers or cylinders, the one placed above the other, so that the water beneath the oil might not be changed at each injection. Another contrivance was to interpose air in place of oil; but none of these were found to answer in practice, and Blakey's engine never attained any celebrity. In principle, indeed, it was the same as Savery's. At a much later period, viz. in 1775, Mr. Blakey made an important improvement in the boiler, whereby much fuel is saved. Three cylindrical vessels were placed, the one above the other, as shown in Fig. 2. Plate DVI, and connected so as to constitute a boiler. It is then surrounded with the fire, and the steam let off by the cocks shown in the figure.

In the year 1757 Mr. Keane Fitzgerald communicated to the Royal Society of London, a paper entitled *An attempt to improve the manner of working the ventilator by the help of the Fire Engine.** "As the lever of the fire engine works up and down alternately, and performs at a common medium about a dozen strokes in a minute, it was necessary to contrive some way to make the beam, though moving alternately, to turn a wheel constantly round one way, and also to increase the number of strokes to 50 or 60 in a minute. The model of a machine for this purpose, is composed of four wheels of different sizes, two clicks, three pinions and a fly, which is put into motion by the part of a wheel fixed to the arch of a lever of the fire engine. The wheel which is turned by the lever, or rather moved up and down by it, is loose on its arbor, and likewise one of the ratchets, and the wheel next to it. The outside ratchets and outside wheel are fixed on the arbor. There are two pinion wheels fixed on the arbor, one on each side near the edge of the wheel moved by the lever which turns them. There are also two clicks, one fixed to the great wheel, the other to the frame. These are exclusive of the wheel that moves the fly.

The effect is, when the lever moves the wheel downwards, its click forces the ratchet fixed on the arbor to move along with it, and the other wheels the same way. When it moves upwards, the click fixed on the frame stops the larger ratchet, and the wheel next to it, which are pinned together. This wheel being stopped, and the great wheel carried upwards by the lever, the pinion towards the edge of the great wheel is forced round it, and moves the pinion on the other side of the great wheel, which pinion moves the wheel fixed on the arbor the contrary way to the great wheel, which is carried upwards by the lever. By which means the arbor is constantly turned the same way, when the lever of the fire engine is moved either upwards or downwards.

Upon the arbor, there is also another great wheel fixed, which turns a pinion, on the arbor of which pinion is a crank to move the ventilator, and also a fly fixed to the end, to help the motion of the crank, which, in the model, is turned three times for each stroke of the lever, and may be increased or diminished according to the number of teeth in the pinion. The number of teeth in the great wheel moved by the lever is 66, but need not have teeth above half way round. The wheel fixed to the ratchet has 33 teeth, and its pinion 11. The wheel fixed on the arbor on the outside has 24 teeth, and its pinion 16. The wheel which turns the fly has 90 teeth, and the pinion turned by this wheel 10. The greater the number of teeth in the ratchets the better. This machine may also be applied to other useful purposes at mines, and may easily be made to turn a mill, to grind corn, or to turn a wheel to raise coals, or whatever else is wanted to be raised from the mines."

Dr. Robison had, without due consideration, regarded this contrivance of Mr. Fitzgerald as involving the invention of the crank, with which Mr. Watt had afterwards converted the vertical motion of the piston into a rotatory motion, and had therefore deprived Mr. Watt of that honour. Mr. Watt, who, as it will afterwards be seen, had been particularly harassed regarding the subject of the crank, corrected to a certain degree this error in his annotations on Dr. Robison's paper; but in a letter which he wrote to Dr. Brewster, dated February 23, 1814, he speaks still more decidedly: "Dr. Robison," says he, "mentions, that Mr. Keane Fitzgerald published in the Transactions, 'a method of converting the reciprocating motion of the steam engine into a continued rotatory motion, by means of a crank, or a train of wheel work,' and adds, in sec. 52, 'by this contrivance he hoped to render it of most extensive use, and that he, and others associated with him, obtained a patent for it. They also published proposals for erecting mills of all kinds driven by steam engines, and stated fairly their powers and their advantages.'

"Now, I find, (continues Mr. Watt,) in the *Philosophical Transactions*, vol. 50, part ii, an invention by Mr. Fitzgerald for working ventilators by means of a steam engine, in which the rotative motion is produced by a train of wheelwork, which *ultimately turns a crank*, which works the ventilators, *a very different thing from a rotatory motion produced by the inter-*

Hull's,) says Mr. Stuart, "*it was necessary to convert the alternate rectilineal motion of a piston rod into a continuous rotatory one*, and which he ingeniously suggested might be accomplished by means of a *crank*. This is now with justice considered that invention which introduced the steam engine as a first mover of *every variety of machinery*. Hulls was unable to interest the public in his project; and his mode of applying the crank was so completely forgotten, that at its revival about forty years after this period, a patent was obtained for the invention, and the merit of the application was also claimed by the celebrated Mr. Watt, evidently without any knowledge of Hull's suggestion." In Hulls' method the rotatory motion is effected by ropes and wheels, as will be seen in the drawing which will be given under our article STEAM BOAT, and no crank is ever mentioned. It is true that Hulls afterwards says, "up inland rivers, where the bottom can possibly be reached, the fans may be taken out, and *cranks placed at the hindmost axis to strike a shaft to the bottom of the river, which will drive the vessel forward with the greater force.*" But this cannot by any stretch of criticism be considered as the conversion of a reciprocating into a rotatory motion by means of a crank. Had Hulls once got hold of the idea of applying the crank in this way, he would never have adopted the other contrivance, the exposure of which to injury by the sea, he obviously considers as an objection. Mr. Watt must therefore be allowed the great merit of the application of the crank to convert the vertical motion of the piston rod into a continued rotatory motion.

* *Phil. Trans.* 1758, p. 727.

vention of a crank! As to the mill scheme, we can find no trace of it, nor of the patent; and being a matter of some consequence to clear up, I have written to some friends in London about it, but have yet received no answer. I shall thank you, if you cannot otherwise find out the matter of fact, to get a search made among Dr. Robison's memoranda, to learn upon what authority he made the assertion. If nothing more is learned about it, I must conclude the note to be a mistake, and comment upon it accordingly." No record of a patent was found at the public offices, and Mr. Watt accordingly made those alterations, &c. on Dr. Robison's paper, which are already before the public."

It is impossible to pass over this statement respecting the crank, without calling the attention of the reader to the annoyances to which an inventor is exposed by the rash decisions and criticisms of his friends. If Dr. Robison and Mr. Stuart, men of talents and character, and great admirers of Mr. Watt, have, under a sense of justice, attributed one of his finest inventions, the one to Mr. Fitzgerald, and the other to Jonathan Hulls, without any other foundation than the recommendation of a crank, as part of the machinery, it is not to be wondered at that writers of inferior judgment and integrity should so often commit the same mistake. To this species of persecution, Mr. Watt has been particularly exposed, and yet the whole history of science does not present to us an individual whose inventions were more original, and to which less approach had been made by the ingenuity of his predecessors.

When Mr. Watt's attention was turned to the subject of steam in 1759, it was then an effective and useful machine, and was used to a considerable extent in the mines and manufactories of the kingdom; but though it was then an effective machine, it was a very imperfect one, and required for its improvement all the energies of a mind deeply imbued with mechanical and chemical knowledge. In the year 1761 or 1762, Mr. Watt had constructed a model, with which he showed the practicability of what is now called the high pressure engine; but it was not till 1763, when he was repairing a model of Newcomen's engine, belonging to the college of Glasgow, that his mind was usefully directed to the subject. Having repaired it merely as a mechanician, he found, upon setting it to work, that its boiler, though apparently quite large enough,* could not supply it with steam. This he found to be caused by the small cylinder exposing a greater surface to condense the steam, than the cylinders of larger engines did in proportion to their respective contents. The cylinder of the model also, which was of brass, conducted heat better than the cast iron cylinders of larger engines, (generally covered on the inside with a stony crust) and hence Mr. Watt conceived the idea of making this cylinder of wood baked to dryness, and soaked in linseed oil. He soon found, however, that the steam which was condensed in filling it exceeded the proportion of that required for large engines, according to Desaguliers. This effect Mr. Watt ascribed to the fact (newly discovered by Dr. Cullen and some other philosophers) that water boiled in vacuo at heats below 100°, because at greater heats the water in the cylinder would generate steam, which would contribute to resist the pressure of the atmosphere.

In the progress of his experiments, Mr. Watt ascertained that *one* cubic inch of water formed about a cubic foot, or 1728 cubic inches of ordinary steam, and that the condensation of that quantity of steam would raise *six* cubic inches of water from the temperature of the atmosphere to the boiling point. Hence he concluded that six times this rise of temperature, or about 800° of heat, had been actually employed in the conversion of the water into steam, and all of which must be withdrawn before a perfect vacuum could be formed under the piston. Struck with this remarkable fact, and not understanding the reason of it, he mentioned it to his friend Dr. Black, who then explained to him his doctrine of latent heat, which he had for some time before this (summer of 1764) taught in the university.

Mr. Watt now perceived that, in order to make the best use of steam, two things were necessary. First, to maintain the cylinder as hot as the steam which entered it; and secondly, to cool down to 100°, and lower, if possible, the water produced from the condensation of the steam, and the injection water itself. The means of accomplishing these two leading objects did not immediately present themselves, but early in 1765 it occurred to him that if *a communication were opened between a cylinder containing steam, and another vessel exhausted of air and other fluids, the steam would immediately rush into the empty vessel, and continue to do so till it had established an equilibrium, and if that vessel were kept very cool by an injection or otherwise, more steam would continue to enter until the whole was condensed.* Thus did Mr. Watt discover the great principle of *condensation in a separate vessel;*† but in its application he had to contend with difficulties which required new resources. As both the vessels were exhausted, or nearly so, how was the injection water, the air which would enter it, and the condensed steam, to be got out. This he proposed to effect in two ways: one of these ways was to adapt to the second vessel a pipe reaching downwards more than 34 feet, by which the water would descend, (a column of that length overbalancing the atmosphere) and by extracting the air with a pump. The second way was to employ one or more pumps to extract both the air and the water, which would be applica-

* The boiler was *nine* inches in diameter, and the cylinder *two* inches in diameter, with a stroke of six inches.

† The invention of a separate condenser has been strangely though indirectly ascribed by Mr. Hornblower to the Rev. Mr. Gainsborough, and this is said to have taken place *about the time that Mr. Watt was engaged in bringing forward the improvement of the engine.* This is in reality an acknowledgment of Mr. Watt's priority, for Mr. Watt did not bring forward this great improvement till long after it was made. In the Review (*Edinburgh Review*, 1809, *p.* 328,) of Dr. Gregory's Mechanics, (vol. ii. p. 362,) where Mr. Hornblower's History of the Steam Engine appeared, (an article which Mr. R. Stuart has erroneously ascribed to Dr. Brewster) it is stated, and we believe with perfect correctness, that Mr. Gainsborough's idea was *twenty years posterior to Mr. Watt's.* This claim, in behalf of Mr. Gainsborough, urged neither by himelf nor by any of his friends, but by one of Mr. Watt's avowed enemies, must be considered as establishing Mr. Watt's original and undivided claim upon an impregnable basis

ble in all places, and essential in those cases where there was no well or pit. Mr. Watt preferred and invariably used the latter method.

In order to lubricate and keep the piston steam tight, Mr. Watt employed wax tallow or any other grease. This was effected by Newcomen, by having water above the piston; but when any of it entered the partially exhausted and hot cylinder it boiled, and prevented the production of a vacuum, besides cooling the cylinder by its evaporation during the descent of the piston. As the mouth of the cylinder was open, Mr. Watt found that the air which entered to act on the piston cooled the cylinder, and condensed some steam in again filling it. He, therefore, proposed to put an air-tight cover on the cylinder, through which cover there was a hole with a stuffing box for the piston rod to slide through; and when this suggested itself, it immediately occurred to him *to admit the steam above the piston*, to act upon it instead of the atmosphere. Another source of the loss of steam still remained, namely, the cooling of the cylinder by the external air, which would occasion at every stroke an internal condensation whenever the steam entered it. Mr. Watt proposed to provide against this, by placing the working cylinder within another cylinder containing steam, and to surround this by another of wood or of some bad conductor of heat. "When once," says Mr. Watt, "the idea of the separate condensation was started, all these improvements followed as corollaries in quick succession, so that in the course of one or two days the invention was thus far complete in my mind; and I immediately set about an experiment to verify it practically.

This experiment succeeded perfectly, and confirmed Mr. Watt's highest expectations. He therefore applied in 1768 for letters patent for "*methods of lessening the consumption of steam, and consequently of fuel in steam engines*, which passed the seals in January 1769. The specification recited *seven* different principles, viz.

1. To keep the steam cylinder as hot as the steam which enters it.

2. To condense the steam in separate vessels, to be kept as cold as the adjacent air by water or cold bodies.

3. To draw the air or vapour out of the cylinder, and condense by pumps wrought by the engine.

4. To employ the expansive force of steam to press upon the piston; and in cases where cold water is not plentiful, to work the engines by this force of steam only by discharging the steam into the open air after it has done its office.

5. Where rotatory motions are required, to make the steam vessels in the form of hollow rings, with inlets and outlets for the steam, mounted on horizontal axles.

6. To apply a degree of cold to contract the steam, so that the engine may be wrought by the alternate contractions and expansion of the steam.

7. To render the parts of the engine, air, and steam tight, by using oils, wax, resinous bodies, fat of animals, quicksilver, and other metals in a fluid state.

While this patent was passing through its different stages, Mr. Watt was engaged in experiments with an engine which, with the assistance of Dr. Roebuck, who had purchased part of his patent right, he had erected at a coal mine near Borrowstounness. It had a cylinder 18 inches in diameter, and was successively altered and improved so as to embody several of the principles above mentioned. When these experiments were finished, Mr. Watt and Dr. Roebuck began their arrangements for manufacturing the engines on a great scale, but pecuniary difficulties prevented Dr. Roebuck from giving the most necessary aid, and he accordingly, in 1773, with Mr. Watt's consent, resigned his share in the patent to Mr. Matthew Bolton, a man of generosity, enterprise, and talent, and every way fitted for bringing into action the talents and inventions of Mr. Watt.

The extent of the arrangements, and the length of time necessary to bring the improved steam engine before the public, were soon discovered by experience, and Mr. Watt saw that it was impossible to reimburse himself for the great outlay which these arrangements rendered necessary during the few years of his patent which had yet to run.

He therefore applied to parliament in 1774 for an extension of the term of his patent; and with the zealous aid of Mr. Bolton, Dr. Roebuck, and Dr. Robison, he obtained in 1778 the exclusive privilege of manufacturing his improved engine for the space of twenty-five years.

About that time Mr. Watt and Mr. Bolton commenced a partnership for the manufacture of the improved engine, which continued till the expiry of the exclusive privilege in 1800. At their establishment at Soho near Birmingham, many admirable engines were soon made; and erected in Staffordshire, Shropshire, Warwickshire, &c. and Messrs. Watt and Bolton granted licences to use their engines, on the condition of securing *a third part of the saving of coal*, compared with an atmospheric engine performing the same work with coals equal in quantity. The amount of this saving was determined by ascertaining experimentally the coals consumed during any number of strokes made by the common and the improved engine. The number of strokes made in any given interval was ascertained by a piece of machinery called the *counter*, which was struck at every ascent of the working beam. Two keys of this machine were kept, one by the patentees, and the other by the proprietors; and a traveller who examined it at stated times, calculated the saving of coal from the number of strokes.*

These different inventions of Mr. Watt we shall now proceed to describe in their order.

Description of Mr. Watt's Single Reciprocating Engine, as constructed in 1788.

This engine is represented in Plate DVII. Fig. 1. The cylinder is shown at A surrounded with its steam case E. The cylinder, which is truly bored, is closed at its top by a cover, in the centre of which is the stuffing box D, through which the piston rod C moves. This stuffing box is constantly supplied with melted tallow, and the piston rod being turned to a true cylinder, no steam can escape. The piston B is also

* For three large engines erected at Chacewater mine in Cornwall, the proprietors paid £800 annually instead of the third of the saving of coal. Hence the saving of coal in using the three engines must have been $3 \times 3 \times 800 = £7200$ annually.

made steam-tight, and for this purpose it is supplied with melted tallow, through a funnel in the top of the cylinder. The boiler for generating the steam is shown at the left hand side of the engine, where *n* is the boiler, *p* the grate, and *o o* the flues on the side of it, *r* the damper, *s* the chimney, *t* the feed-pipe by which the boiler is supplied with water, and 1, 2, the guage-cocks. The steam pipe F proceeding from the boiler, and passing through the well, conveys the steam to the upper steam nozzle or valve G, through which it enters by the horizontal passage above the piston, and presses it, by its elastic force, down to the bottom of the cylinder. The perpendicular steam pipe which conveys the steam from the top of the cylinder into the bottom of it is shown at I. K is the equilibrium valve or nozzle, or the lower steam valve, which admits the steam below the piston, through the curved horizontal passage, to the left of L. When the valve is open there is an *equilibrium* between the steam entering both above and below the piston, from which circumstance it derives its name. J is the eduction pipe by which the steam is conveyed from the cylinder to the condenser M, which is a cylindrical vessel surrounded by cold water. N is the injection cock, which admits a jet of cold water from the cistern to condense the steam in N. At O is seen the termination of a copper pipe, called the *Snift* or *Blow-valve pipe*. It reaches to the outside of the cistern, and has its orifice closed with a little valve opening outwards and immersed in a small vessel of water. The object of it is to discharge the air from the vessels when the engine is first set a going.

P is the air pump, communicating with the lower end of the condenser by means of the valve R, which by the action of the air pump opens to allow the water and air to escape from the condenser, but closes in order to prevent either of them from returning.

m is the upper valve or discharging spout, opening outwards, which conveys the air and hot water into the hot well, from which the boiler is supplied with water by the means of the hot water pump U U, and pipe *u*, the continuation of which to the boiler is not shown.

V is the injection or cold water pump, which, rising from a tank without the engine-house, supplies water for cooling the condenser, and supplying the injection.

Z is the plug-tree or beam which drives the working gear Y of the nozzle and regulator valves.

a is the main lever or working beam, made of oak, and moveable upon its gudgeon or centre of motion *b*, which is fixed to the upper side of the beam by iron straps.

d is a king-post, from the top of which iron straps *c c* extend diagonally to each end of the beam, so as to form a truss.

Two iron catch pins, not seen in the figure, are fixed on the arched heads *e*, *f*, to strike upon the springs *β*, *β*, in order to limit the downward excursions of the pistons.

g, *f*, and *e*, are three arch heads fixed to the main beam. The arched head *g* is double, the one on the other side, not being seen in the figure. The one is to receive two chains, by which the plug tree Z is suspended, the rods from the two chains being joined and connected with the upper extremity of the plug trees, while the piston rod S of the air pump P is fixed to its lower extremity. The plug tree is kept steady by a horizontal bar fixed across it at its lower end, the two extremities of which slide in the vertical grooves of two upright posts. Three projecting pieces of wood, two of which are shown at *π π*, are fixed to the plug tree to give motion to the intermediate handles of the working gear.

e is the arched head for receiving the chain *f*, which carries the piston rod *h*, and piston *i* of the pump *j* having a clack valve at *p*.

Operation of Mr. Watt's Single Reciproeating Engine.

The engine is supposed to be at rest, and its valves shut, and all the parts brought into the position shown in the figure, which is effected by the preponderance of the pump rod *h*.

When the steam is generated in the boiler *n*, the three valves, G, K, and L, are opened by relieving the handles from their catches and the steam rushes through them above and below the piston, and into the condenser. The cold metal at first condenses it, but as the different parts become hot, all the above cavities are occupied with elastic steam, which displaces the air, and drives it all out at the blow valve O, an operation called *blowing* through, the completion of which is indicated by a smart crackling noise at the blow valve O, arising from the condensation of the steam by the cold water, when the air is all discharged. When this has been repeated two or three times, the valves G, K, L, are shut, and the farther admission of steam prevented. The steam remaining in the condenser will be speedily condensed, especially when a jet from the injection pipe has been thrown into it; but the cylinder both above and below the piston J will be occupied with steam.

If we now open the valves G, L, and N, Plate DVII, Fig. 1, by allowing the two handles at Y to rise, the steam will pass through G to the top of the piston, and, at the same time, the steam below the piston will escape through L into the condenser, while a jet of water from N will condense the steam, and producing a vacuum beneath the piston B, will allow the elastic force of the steam above it to press it to the bottom of the cylinder. The pump bucket *i* will be drawn up, and a column of water raised in its barrel *j*. When the piston B has descended half way down the cylinder, the upper piece of wood *π* strikes the *expansion handle* Z, and forcing it down, shuts the valve G, and excludes the steam, so that the piston performs the other half of its descent by the expansion of the steam already admitted above it. When the piston is at the bottom of the cylinder, another piece of wood on the opposite side of the plug tree presses down the middle handle above Y, which closes the *exhausting* valve L, and also the injecting valve, by means of a strap and rod connected with it. At the same time, the equilibrium valve K is opened by the working gear, so as to occasion an equilibrium in the state of the steam above and below the piston.

In this state of things the counter weight of the great piston rod will, by its preponderance, descend in its barrel, and cause the piston B to rise in the cylinder. When the piston B has risen half way up, the equilibrium valve K closes; and when the piston is quite at the top, the exhaustion valve L, the injection valve N, and the expansion valve G, are all opened by the action of the catches upon the handles of the working gear.

The steam consequently again rushes through G to the top of the piston, while the steam beneath it escapes into the condenser, where it receives the jet of the injection, and is converted into water, again creating a vacuum beneath the piston B, and in the condenser. The piston B consequently again descends, and the engine continues to act in the same manner, and thus to work the pump *h j*.

The air pump P does not begin its operation till the water of condensation and the injection water have accumulated. When this is the case, this water, flowing through R, rises above the piston Q through its valve; whenever it is at the bottom of the cylinder P, and the valve closed upon it, and preventing its descent, it is raised and discharged through the valve S into the hot well. In like manner, if there is any air or vapour in the condenser, it will help to press the water through R, and will itself escape through the valve in the box Q, when all the water has been discharged at S.

The *hot-water pump* UU, which enters the hot well, forces the water from it along the tube *u* and feeding pipe *t*, to supply the boiler *n*, so that there must be a saving of fuel by using this hot water in place of cold water.

Although we have mentioned generally the construction of the plug tree, and the way in which it opens and shuts the valves, yet as this is an essential part of the engine, we shall give a separate drawing of the mechanism which opens and shuts the nozzle valves and regulator, along with Mr. Watt's own description of it. "The piston approaching the top of the cylinder, the slider *a* fastened upon the plug tree *z*, raises up the handle *b*, which is fixed upon the lower Y shaft or axis *c*, as is the detent *d*, and the latter takes hold of the double ended catch *e*; but, in doing this, the upper end of the catch allows the detent *f* to escape, and a weight hung to the rod *g* turns the axis *h*. The arm *i* and rod *j* are moved out of the straight line at *l*, and by a lever *k* turn the spindle *m* in the upper nozzle, which, by means of a toothed sector *n*, and rack *o*, raises the valve *p*, and admits steam into the cylinder *above* the piston through the horizontal pipe A. At the same time, another arm *u*, fixed upon the same shaft, by means of the rod *w*, acts upon a spindle, &c. in the lower nozzle, and opens the exhaustion valve L (Plate DVII. Fig. 1.), and thereby forms a communication between the cylinder *below* the piston and the condenser. The piston now descending, another slider *q* moves the handle *r* into the position *s*; this raises the weight *g*, while *i* and *k* are brought back to the position *l*, and the valves *p* and L are shut. The detent *f*, in acting upon the catch *e*, disengages *d*; the lower Y shaft turns upon its axis, and two arms attached to it (similar to those upon the upper Y shaft, which are omitted to avoid confusion) by means of the rod *x* and *y*, open the lower steam valve K (Plate DVII. Fig. I.) and the upper exhaustion valve *t*. The cylinder above the piston becomes exhausted, and the steam, entering below it, causes the piston to re-ascend."

The steam engine of the form, which we have now described, continued long in use for draining mines. Between 1778 and 1790, great numbers of them were erected by Messrs. Bolton and Watt, in different parts of England, but chiefly in Cornwall. Their cylinders were generally from forty-eight to sixty-six inches in diameter, and according to Mr. Watt, they were found to raise from twenty-four to thirty-two millions of pounds of water one foot high by means of *one* bushel of good Newcastle or Swansea coals, when working more or less expansively.

As the action of these engines is suspended during the ascent of the piston, they were particularly suited for pumping up water, since during the intermission the piston of the pump descended to make a new stroke. But when a continued power was required for the purpose of driving machinery in which there was no intermission of action, this form of the steam-engine was by no means applicable.

Mr. Watt proposed to remedy this defect by placing a cylinder under each end of the great beam, in order that one of the pistons should be rising while the other was falling; and as both the cylinders were to be supplied from the same boiler, and the steam condensed in the same condenser, it was probable that these two actions on the beam would be regular and uniform.

This plan, however, was we believe never carried into effect, and Mr. Watt resolved upon using only one cylinder, and upon giving the engine a double action by introducing steam both above and below the piston, and thus forcing the piston both *upwards* and *downwards*. For this double engine he took out a patent in 1782, but as it was afterwards greatly improved, we shall describe one of those which existed at a later date for the Albion Mills. In his specification of 1782, the piston rod gave motion to the beam by a toothed rack, at the upper end of the rod, which wrought in a toothed arch, which replaced the arch head at the end of the beam, and the irregularities of this action were equalized by a fly-wheel placed near the top of the piston rod. This was, however, soon laid aside, and the contrivance adopted which is now in universal use. The following are the parts of this engine (See Plate DVIII. Fig. 1.):

A The cylinder 34 inches in diameter.
B The piston which makes a stroke eight feet long.
C The piston rod.
D The stuffing box or the cover of the cylinder.
E The steam-case or jacket of the cylinder.
  e The syphon which empties the steam-case of water.
  f The pipe which supplies the steam-case.
G The upper steam nozzle and valve, or regulator-box and regulator.
H The upper exhaustion nozzle and valves.
I The perpendicular steam pipe.
J The eduction pipe.
K The lower steam nozzle and valve.
L The lower exhaustion nozzle and valves.
M The condenser immersed in a cistern of cold water.
N The injection cock which is always open during the working of the engine.
O The blow valve.
P The air pump.
Q The lower valve and air pump.
R The bucket and rod of the air pump.
S The upper valve of the air pump.
T The hot water pump with its bucket and rod.
U The cold water pump.
V The pump for supplying the boiler.
W The governor turned by a belt from the shaft of the fly wheel.

X The lever and rod which connects the governor with the throttle valve at *t*.
Y The working gear of the nozzle valves.
Z The plug tree which drives the working gear.
a The main lever or working beam.
b Its main gudgeon.
c The perpendicular links of the parallel motion.
d The parallel bars.
e The regulating radiuses.
f The small perpendicular links.
g The secondary parallel motion for the air pump.
h The connecting rod.
i The planet-wheel fixed to the connecting rod.
j The iron wheel.
k The shaft of the fly-wheel on which the sun-wheel is fixed.
l The connecting link which retains the planet-wheel in its orbit.
m The fly-wheel.
n The boiler.
o The tube through the boiler and the flues around it.
p The grate.
q The feeding mouth.
r The damper.
s The chimney.
t The feed pipe.
u The guage pipes with their cocks.
v The safety valve.

The boiler *n*, in which the water is converted into steam by the furnace *p q*, is most frequently made of iron though sometimes of copper. Its bottom is concave, and the flame is made to circulate round its sides in the flue *o o*, and is sometimes conveyed through the very middle of the water by a tube *o*, in order that a great surface may be exposed to the action of the fire. In some of Mr. Watt's engines, the fire contained in a vessel of iron was introduced into the very middle of the water.

Before proceeding to describe the operation of Mr. Watt's double engine, we must first give an account of the construction of the regulating valves, and the manner in which the plug-tree acts upon their levers in opening and shutting them. A section of the regulator box is shown in Fig. 2. Plate DVIII, by the letters HHJJ. The opening into the cylinder is shown at HH. A spindle A passes through one side of the box, and upon this as an axis moves a toothed sector B, which works into the toothed rack C fixed to the brass valve D, fitted by grinding to its seat EE, F being the guide for the stem D *d* of the valve. On the spindle A is fixed a lever LA, jointed at L to the rod LM, which is again jointed at M to the arm MN of a bent lever MNO, movable round the axis N. Part of the plug-tree is shown at QR, and P is one of its pins. From this description it is obvious that the valve D will be opened or shut by the ascent or descent of the plug-tree QR, the pins of which act upon the lever NO. When the pin P pushes down the spanner NO, the arm MN rises to the right hand, and pulls down the spanner AL by means of the uniting rod ML; these parts are so arranged that when the cock is shut, LM and MN form one straight line as in the figure. Hence when the spanner begins to raise the valve, its mechanical energy is almost infinitely great, and from the same cause, if any thing should try to open the valve it would be ineffectual.

Operation of Mr. Watt's Double Engine.

By means of the steam pipe F, Plate DVIII. Fig. 1, the steam is conveyed from the boiler *n* to the cross pipe or upper steam nozle G, and by the perpendicular steam pipe I, to the lower steam nozle K. In the nozle G there is a valve (D. Fig. 2.) which, when open, admits steam into the cylinder above the piston B, through the horizontal square pipe at the top of the cylinder, and in the lower steam nozle K there is another valve like that at D, which, when opened by the pin of the plug-tree, admits steam into the cylinder below the piston. In the *upper* exhaustion nozle H there is a similar valve, which, when open, allows steam to pass from the cylinder *above* the piston into the eduction pipe J, which conveys it to the condensing vessel M, where it meets the jet of the injection from the cock N, and is reduced to water; and in the *lower* exhaustion nozle L there is also a valve, which, when open, allows the steam to pass out of the cylinder *below* the piston into the condenser M.

The engine, says Mr. Watt, being at rest, the cylinder quite cold, and the condenser cistern full of water, when the water in the boiler begins to boil, steam will enter by the small pipe *f* into the space between the cylinder and the heating-case E, which will expel the air contained in that space, and between the two bottoms of the cylinder, at a cock fixed in the outer bottom, which, when all the air is expelled, and the cylinder thoroughly warmed, is to be shut, and the water which may be formed in these spaces during the working of the engine, will issue by the inverted syphon *e*.

Things being in this situation to produce a commencement of motion, the first operation is to open all the four valves, G, H, K, L; (the injection cock being shut) the steam will drive the air out of the steam and exhaustion-pipes I and J, and out of the condenser M, through the blow-pipe and its valve O, and as soon as this is succeeded by a sharp crackling noise in the little cistern O, the valves are to be shut until it is thought that the steam which has entered is mostly condensed.

The same operation is to be repeated, giving a longer time to cool between the times of blowing, until it is found that, upon opening the injection-cock, some water will enter, and the barometer shall show some degree of exhaustion, after which, the repetition of blowing will soon empty the cylinder of air.

The piston being then at the top of its stroke, the valves G and L are to be opened, and the fly-wheel *m* turned by hand about one-eighth of a revolution, or more, in the direction in which it is intended to move; the steam which is then in the cylinder will pass by L into the condenser, when, meeting the jet of water from the injection-cock, it will be converted into water, and the cylinder thus becoming exhausted, the steam, entering the cylinder by the valve G, will press upon the piston and cause it to descend, while, by its action upon the working-beam through the piston-rod, &c., it pulls down the cylinder end of the beam, and raises up the outer end and the connecting rod *h*, which causes the planet-wheel *i* to tend to revolve round the sun-wheel *j*; but the former of these wheels, being fixed upon the connecting-rod so that it cannot turn upon its own axis, and its teeth being engaged in those of the sun-wheel, the latter, and the fly-wheel, upon whose axle or shaft it is fixed, are made to revolve in the desired direction, and give motion to the mill-work.

As the piston descends, the plug-tree Z also descends, and a clamp, or slider *q*, fixed upon the side of the plug-tree, presses upon the handle 1 of the upper Y-shaft, or axis, and thereby shuts the valves G and L, and the same operation, by disengaging a detent, permits a weight suspended to the arm of the lower Y-shaft to turn the shaft upon its axis, and thereby to open the valves K and H. The moment previous to the opening of these valves, the piston had reached the lowest part of its stroke, and the cylinder *above* the piston was filled with steam; but as soon as H is opened, that steam rushes by the eduction-pipe J, into the condenser, and the cylinder *above* the piston becomes exhausted. The steam from the boiler entering by I and K, acts upon the *lower* side of the piston, and forces it to return to the top of the cylinder. When the piston is very near the upper termination of its stroke, another slider *a* raises the handle 2, and, in so doing, disengages the catch which permits the upper Y-shaft to revolve upon its own axis, and open the valves G and L, and the downward stroke recommences as has been related.

When the piston descends, the buckets R, T of the air-pump P and hot water pump T also descend. The water which is contained in these pumps passes through the valves of their buckets, and is drawn up and discharged by them through the lander or trough *t*, by the next descending stroke of the piston. Part of this water is raised up by the pump V, for the supply of the boiler, and the rest runs to waste."

The engine now described was one of fifty horse power, and was erected along with another of the same power, to drive twenty pair of mill stones, of which twelve or more pairs, with all the machinery for dressing the flour and other purposes, were generally kept at work.

Although Mr. Watt's double engines were chiefly employed in producing rotatory motions, yet in the case of very deep mines they may be applied with very great advantage to work pumps, by a reciprocating motion.

For this purpose one set, or half of the pump rods, are suspended by means of a sloping rod from the working beam near the cylinder, and the other half of these rods are suspended directly from the outer end of that beam, so that the ascending motion of the piston pulls up one half of these rods, and works the pumps to which they belong, while the descending motion of the piston pulls up the other half of the rods and works their pumps.

A double engine of this kind was erected at Wheel Maid Mine in Cornwall in 1787. It had a cylinder of sixty-three inches diameter, and nine feet stroke; but the stroke in the pumps, which were eighteen inches in diameter, was only seven feet. When it was inconvenient to divide the pump rods into two sets, the ascending motion of the piston was employed to raise a weight equal to one half the column of water in the pumps, and this weight acted in addition to the power of the engine during the descending stroke of the piston.

Such is a general description of the new engine as improved by Mr. Watt, but some of its individual parts still remain to be noticed.

The first of these contrivances is the *Sun and Planet Wheel*, which is shown in Fig. 1, Plate DVIII, where the wheel *j* is called the *Sun* Wheel, and *i* the *Planet* Wheel. The sun wheel *j* is fixed in a horizontal axis, to which it is required to communicate a continuous rotatory motion by the reciprocating motion of the rod *h*, suspended from one extremity of the great beam. The planet wheel *i* is fixed to the lower end of the rod *h*, so that it cannot turn round its axis. The sun and planet wheels are of the same size, move in the same vertical plane, and have the same number of teeth; and their centres are connected together by an iron strap, which prevents them from quitting each other. If we suppose the rod *h* to rise with the end of the beam which carries it, the teeth on the inner or left hand side of the planet wheel *i* will obviously work in the teeth of the inner or left hand side of the sun wheel *j*. When the centre of the planet wheel comes on a level with the centre of the sun wheel, it will then have performed one-fourth of a revolution, so that the two wheels will have made one quarter of a revolution in respect to one another; but the planet wheel will also have made one-fourth of a revolution in its orbit round the sun wheel, and have carried the sun wheel along with it, so that the latter will have completed *half* a revolution. In like manner when the centre of the planet wheel is above the centre of the sun wheel, the former will have completed half a revolution, and the latter a whole revolution. This double velocity of the sun wheel arises from the motion of the planet wheel around it. If the planet wheel were twice the size of the sun wheel, the latter would perform three revolutions for one of the former. See Mechanics, Vol. XII., p. 660.

The following is the history of this beautiful contrivance as given by Mr. Watt himself:

"Having made my reciprocating engines very regular in their movements, I considered how to produce rotative motions from them in the best manner; and amongst various schemes which were subjected to trial, or which passed through my mind, none appeared so likely to answer the purpose as the application of the crank in the manner of the common turning lathe, (an invention of great merit, of which the humble inventor, and even its æra, are unknown). But, as the rotative motion is produced in that machine by the impulse given to the crank in the descent of the foot only, and behoves to be continued in its ascent by the momentum of the wheel which acts as a fly, and being unwilling to load my engine with a fly heavy enough to continue the motion during the ascent of the piston, (and even were a counter-weight employed to act during that ascent, of a fly heavy enough to equalize the motion), I proposed to employ two engines acting upon two cranks fixed on the same axis at an angle of 120 degrees to one another, and a weight placed upon the circumference of the fly at the same angle to each of the cranks, by which means the motion might be rendered nearly equal, and a very light fly would only be requisite. This had occurred to me very early, but my attention being fully employed in making and erecting engines for raising water, it remained in petto until about the year 1778 or 9, when Mr. Wasbrough erected one of his ratchet-wheel engines at Birmingham, the frequent breakages and irregularities of which recalled the subject to my mind, and I proceeded to make a model of my method, which answered my expectations; but having neglected to take out a patent, the invention was communicated by a workman employed to make the model to some of the people about Mr. Wasbrough's engine, and a patent was taken out by them for the application of the crank to steam-engines. This fact the said workman confessed, and the engineer who directed the works acknowledged it, but said, nevertheless, the same idea had occurred to him prior to his hearing of mine, and that he had even made a model of it before that time, which might be a fact, as the application to a single crank was sufficiently obvious. In these circumstances I thought it better to endeavour to accomplish the same end by other means, than to enter into litigation, and, if successful, by demolishing the patent, to lay the matter open to every body. Accordingly, in 1781, I invented and took out a patent for several methods of producing rotative motions from reciprocating ones, amongst which was the method of the sun and planet wheels.

"This contrivance was applied to many engines, and possesses the great advantage of giving a double velocity to the fly; but is perhaps more subject to wear, and to be broken under great strains, than the crank, which is now more commonly used, although it requires a fly-wheel of four times the weight, if fixed upon the first axis. My application of the double engine to these rotative machines rendered unnecessary the counter-weight, and produced a more regular motion; so that, in most of our great manufactories, these engines now supply the place of water, wind, and horse mills; and instead of carrying the work to the power, the prime agent is placed wherever it is most convenient to the manufacturer."

But whether the rotatory motion is produced by the simple crank,* or by the sun and planet wheel, there is an irregularity in its action, which it is necessary to correct. The force of the planet wheel to drive the sun wheel is constantly varying. In the position shown in Fig. 1, Plate DVIII, and also in the position when the planet wheel is exactly above the sun wheel, it is nothing. It then gradually increases till the centres of the two wheels are in the same horizontal line, and from that point it again diminishes. In the two positions when the force is nothing, we might expect that the engine would stop, as the action of the steam tends only to press the axis of the planet wheel against that of the sun wheel. But as the planet wheel, when once put in motion, has a tendency to go on, it never can stop at these two positions of minimum force, and the instant it passes them it acquires fresh power to continue its motion. It is obvious, however, that such a motion must be irregular, being slow in one position and quick in another.

In order to remedy this evil, a large and heavy *fly-wheel m* is fixed on the axis of the sun wheel *j*. This heavy wheel, when once put in motion, equalises the irregular motion of the planet wheel in the manner which we have already fully explained in our article MECHANICS, (Vol. XII. p. 666.)

The other contrivances invented by Mr. Watt we shall describe in his own words.

"The Parallel Motion, in the single engines, serves in place of chains, and in the double engines, supplies the place of the rack and sector. It has been mentioned, that the racks and sectors were very subject to wear, and that, when perfect, they did not move with that smoothness that was wished; and to chains there were many objections. It occurred to Mr. Watt, that if some mechanism could be devised moving upon centres, which would keep the piston-rods perpendicular, both in pushing and pulling, a smoother motion would be attained; and, in all probability, that the parts would be less subject to wear. After some consideration, it occurred to him, that if two levers of equal lengths were placed in the same vertical plane, nearly, as shown in Fig. 3 of plate DVIII, moveable on the centres B and C, and connected by a rod A D, the point E, in the middle of that rod, would describe nearly a straight and perpendicular line, when the ends A and D of the levers, and of that rod, moved in the segments of circles FG, and IH, provided the arch FG did not much exceed 40 degrees, and consequently that if the top of the piston-rod were attached to that point E, it would be guided perpendicularly, or nearly so.

It necessarily followed, that if for convenience the lever CD (which represents what he called the regulating-radius) were made only half the length of the lever AB (which represents the half length or radius of the working-beam) a point situated at one-third of the length of the rod AD, from the joint A, would then move in a perpendicular line. These were first ideas, but the parallel motion was soon moulded into the form in which it appears in all Boulton and Watt's engines, and in which it is seen in Plate DVIII, Fig. 1, of the second engine at the Albion Mill. A patent for the protection of this, and some other of Mr. Watt's invention, passed the seals in April 1784, but the invention was made in the latter end of 1783.

The regulation of the speed of the rotative engines, is a matter essential to their application to cotton spinning, and many other manufactories.

It is performed by admitting the steam into the cylinder more or less freely, by means of what is called a *Throttle-valve*, which is commonly a circular plate of metal A, Fig. 4, having a spindle B fixed across its diameter.

This plate is accurately fitted to an aperture in a metal ring CC, of some thickness, through the edgeway of which the spindle is fitted steam-tight, and the ring is fixed between the two flanches of the joint of the steam-pipe which is next to the cylinder. One end of the spindle, which has a square upon it, comes through the ring, and has a spanner fixed upon it by which it can be turned in either direction.

When the valve is parallel to the outsides of the ring, it shuts the opening nearly perfectly; but when its plane lies at an angle to the ring, it admits more or less steam according to the degree it has opened; consequently the piston is acted upon with more or less force. For many purposes engines are thus regulated by hand at the pleasure of the attendant; but where a regular velocity is required, other means must be applied to open and shut it, without any attention on the part of those who have the care of it. For this purpose Mr. Watt had various methods, but at last fixed upon what he calls the *Governor*, (shown at W. Plate DVIII, Fig. 1.) consisting of a perpen-

* See MECHANICS, Vol. XII.—p. 661.

dicular axis, turned by the engine: To a joint near the top of this axis are suspended two iron rods, carrying heavy balls of metal at their lower ends, of the nature of pendulums. When this axis is put in motion by the engine, the balls recede from the perpendicular by the centrifugal force, and by means of a combination of levers fixed to their upper end, raise the end of a lever which acts upon the spanner of the throttle-valve, and shuts it more or less according to the speed of the engine, so that as the velocity augments, the valve is shut, until the speed of the engine and the opening of the valve come to a maximum and balance each other.

The application of the centrifugal *principle* was not a new invention, but had been applied by others to the regulation of water and wind-mills, and other things; but Mr. Watt improved the mechanism by which it acted upon the machines, and adapted it to his engines.

From the beginning, Mr. Watt applied a gage to show the height of the water in his little boiler, which consisted of a glass tube communicating at the lower end with the water in the boiler, and at the upper end with the steam contained in it. This gage was of great use in his experiments, but in practice other methods are adopted. He has always used a barometer to indicate the degree of exhaustion in his engines. Sometimes that instrument is, as usual, a glass tube 33 or 34 inches long, immersed at bottom in a cistern of mercury, and at top communicating by means of a small pipe and cock with the condenser. The oscillations are in a great degree prevented by throttleing the passage for the steam by means of the cock.

But as glass tubes were liable to be broken by the workmen, barometers were made of iron tubes, in the form of inverted syphons, one leg being about half the length of the other. To the upper end of the long leg a pipe and cock were joined, which communicated with the condenser; a proper quantity of mercury was poured into the short leg of the syphon, which naturally stood level in the two legs: A light float with a slender stem was placed in the short leg, and a scale divided into half inches applied to it, which (as by the exhaustion the mercury rose as much in the long leg as it fell in the short one) represented inches on the common barometer.

The steam-gage is a short glass tube with its lower end immersed in a cistern of mercury, which is placed within an iron box screwed to the boiler steam-pipe, or to some other part communicating freely with the steam, which, pressing on the surface of the mercury in the cistern, raises the mercury in the tube, (which is open to the air at the upper end) and its altitude serves to show the elastic power of the steam over that of the atmosphere.

These instruments are of great use where they are kept in order, in showing the superintendant the state of the engine; but slovenly engine-tenders are but too apt to put them out of order, or to suffer them to be so. *It is the interest, however, of every owner of an engine to see that they, as well as all other parts of the engine, are kept in order.*

The barometer being adapted only to ascertain the degree of exhaustion in the condenser where its variations were small, the vibrations of the mercury rendered it very difficult, if not impracticable, to ascertain the state of the exhaustion of the cylinder at the different periods of the stroke of the engine; it became therefore necessary to contrive an instrument for that purpose, that should be less subject to vibration, and should show nearly the degree of exhaustion in the cylinder at all periods. The following instrument, called the *Indicator*, is found to answer the end sufficiently. A cylinder about an inch diameter, and six inches long, exceedingly truly bored, has a solid piston accurately fitted to it, so as to slide easy by the help of some oil; the stem of the piston is guided in the direction of the axis of the cylinder, so that it may not be subject to jam or cause friction in any part of its motion. The bottom of the cylinder has a cock and small pipe joined to it, which, having a conical end, may be inserted in a hole drilled in the cylinder of the engine near one of the ends, so that by opening the small cock, a communication may be effected between the inside of the cylinder and the indicator.

The cylinder of the indicator is fastened upon a wooden or metal frame, more than twice its own length; one end of a spiral steel spring, like that of a spring steelyard, is attached to the upper end of the piston-rod of the indicator. The spring is made of such a strength, that when the cylinder of the indicator is perfectly exhausted, the pressure of the atmosphere may force its piston down within an inch of its bottom. An index being fixed to the top of its piston-rod, the point where it stands, when quite exhausted, is marked from an observation of a barometer communicating with the same exhausted vessel, and the scale divided accordingly.

Mr. Watt very early found that, although most kinds of grease would answer when employed to keep the piston tight, yet that beef or mutton tallow were the most proper, and the least liable to decompose; but when cylinders were new and imperfectly bored, the grease soon disappeared, and the piston was left dry; he therefore endeavored to detain it by thickening it with some substance which would lubricate the cylinder, and not prove decomposable by heat and exhaustion. Black-lead dust seemed a proper substance, and was therefore employed, especially when a cylinder or the packing of a piston was new; but it was found in the sequel that the black-lead wore the cylinder, though slowly; and by more perfect workmanship, cylinders are made so true as not to require it, or at least, only for a very short time at first using.

The joints of the cylinder, and other parts of Newcomen's engines, were generally made tight by being screwed together upon rings of lead covered with glazier's putty, which method was sufficient, as the entry of small quantities of air did not materially affect the working of these engines where only a very imperfect exhaustion was required. But the contrary being the case in the improved engines, this method would not answer Mr. Watt's purpose. He at first made his joints very true, and screwed them together upon pasteboard, softened by soaking them in water, which answered tolerably well for a time, but was not sufficiently durable. He therefore endeavoured to find out some more lasting substance; and observing that at the iron founderies they filled up flaws by iron borings or filings, moistened by urine, which in time became hard, he improved upon this by mixing the iron borings or filings with a small quantity of sulphur, and a little sal-ammoniac, to which he afterwards added some fine sand from the grindstone troughs. This mixture, being moistened with water and spread upon the joint, heats soon after it is screwed together, becomes hard, and remains good and tight for years, which has contributed in no small degree to the perfection of the engines.

Mr. Murdock, much about the same time, without communication with Mr. Watt, made a cement of iron borings and sal-ammoniac, without the sulphur. But the latter gives the valuable property of making the cement set immediately.

The following is an account of the actual performance of some of Mr. Watt's engines, as given by himself:

The burning of one bushel of good Newcastle or Swansea coals in Mr. Watt's reciprocating engines, working more or less expansively, was found, by the accounts kept at the Cornish mines, to raise from 24 to 32 millions of pounds of water one foot high: the greater or less effect depending upon the state of the engine, its size, and rate of working, and upon the quality of the coal.

In engines upon the rotative double construction, one having a cylinder of 31½ inches diameter, and making 17½ strokes of 7 feet long per minute, called 40 horses' power,* meaning the constant exertion of 40 horses (for which purpose, supposing the work to go on night and day, 3 relays, or at least 120 horses, must be kept) consumed about 4 bushels of good Newcastle coal per hour, or 400 weight of good Wednesbury coal. A rotative double engine, with a cylinder of 23¾ inches in diameter, making 21½ strokes of 5 feet long per minute, was called 20 horses' power; and an engine, with a cylinder of 17½ inches diameter, making 25 strokes of 4 feet long per minute, was called 10 horses' power; and the consumption of coals by these was nearly proportional to that of the 40 horses' power.

A bushel of Newcastle coals, which thus appears to be the consumption of a 10 horse engine for one hour, grinds and dresses about 10 bushels, Winchester measure, of wheat.

The quantity of water necessary for injection may be determined on principle for engines having a separate condenser. Having found the contents of the cylinder in cubic feet (that is, the area of the piston multiplied by the length of the stroke + $\frac{1}{10}$ to allow for the vacuities at top and bottom through which the piston does not pass,) it is to be considered that every cubic foot of steam produces about a cubic inch of water when condensed, and contains about as much latent heat as would raise 960 cubic inches of water one degree. This steam must not only be condensed, but must be cooled down to the temperature of the hot well: therefore as many inches of cold water must be employed as will require all this heat to raise it to the temperature of the hot well.

Therefore let c be the quantity of steam to be condensed in cubic feet;

a = the temperature of the cold water (per Fahrenheit);

b = the proposed temperature of the warm water, or hot well;

1172 = the sensible and latent heat of steam;

x = the cubic inches of cold water required to condense c.

Then $c \times \overline{1172-b} = x + \overline{b+a}$:

Therefore $c \times \frac{1172-b}{b-a} = x$.

Thus, if the proposed temperature of the hot well be 100° (and it should not be higher to obtain a tolerable vacuum in the cylinder), and that of the injection be 50°, we have $a = 50°$, $b = 100°$; hence $\frac{1172-100}{100-50} = 21.44 = x$. That is, for every foot of the capacity of the stroke in the cylinder $+\frac{1}{10}$, calculated as has been directed, or for every cubic inch of water evaporated from the boiler, about 21½ cubic inches of water at 50° will be required to condense the steam.

But as the injection water may not be obtained so cold as 50°, and other circumstances may require an allowance, a wine pint of water for every inch boiled off, or for every cubic foot of the contents of the stroke in the cylinder, may be kept in mind as amply sufficient. This greatly exceeds the quantity necessary in a good Newcomen's engine, and by showing the more perfect condensation, points out the superiority of the new engine; for the Newcomen's engine, if working to the greatest advantage, should not be loaded to more than 7 pounds upon the inch, whereas Watt's engine bears a load not much less than 11 pounds, exclusive of friction, when making twelve 8-feet strokes per minute.

What has been now said is not a matter of mere curiosity: it affords an exact rule for judging of the good working order of the engine. We can measure with accuracy the water admitted into the boiler during an hour without allowing its surface to rise or fall, and also the water employed for injection. If the last be above the proportion now given (adapted to the temperatures 50° and 100°), we are certain that steam is wasted by leaks, or by condensation in some improper place.

It is evident that it is of great importance to have the temperature of the hot well as low as possible, because there always remains steam in the cylinder of the same or rather higher temperature, possessing an elasticity which balances part of the pressure on the other side of the piston, and thus diminishes the power of the engine. This is clearly seen by the barometer which Mr. Watt applies to his engines, and is a most useful addition to the proprietor. It shows him the

* "When Boulton and Watt set about the introduction of the rotative steam-engines, to give motion to mill-work, they felt the necessity of adopting some mode of describing the power, which should be easily understood by the persons who were likely to use them. Horses being the power then generally employed to move the machinery in the great breweries and distilleries of the metropolis, where these engines came first into demand, the power of a mill-horse was considered by them to afford an obvious and concise standard of comparison, and one sufficiently definite for the purpose in view.

"A horse going at the rate of 2½ miles an hour raises a weight of 150 lbs. by a rope passing over a pulley, which is equal to the raising 33,000 lbs. one foot high in a minute. This was considered the horse's power; but in calculating the size of the engines, it was judged advisable to make a very ample allowance for the probable case of their not being kept in the best order, and therefore the load was only assumed at about 7 lbs. on the square inch of the piston, although the engines work well to 10 lbs. on the inch, exclusive of their own friction." W.

state of the vacuum, and, with the height of the mercury in the steam-guage, points out the real power of the engine.

Mr. Watt finds that, with the most judiciously constructed furnaces, it requires 8 feet of surface of the boiler to be exposed to the action of the fire and flame to boil off a cubic foot of water in an hour, and that a bushel of Newcastle coals so applied will boil off from 8 to 12 cubic feet, and that it requires about a cwt. of Wednesbury coals to do the same.

Having thus given a general view of the inventions of Mr. Watt, we shall proceed to give an account of the labours of his contemporaries and his successors. The variations, however, which the steam engine has undergone are so numerous, that it would be impossible in a work like this, intended for general readers, to embrace all those contrivances which have been published; so that we must confine ourselves to those which have been regarded as combining ingenuity with practical utility.

Description of Mr. Hornblower's Engine with two Cylinders.

As this engine is now in more extensive use than any other variety excepting Mr. Watts, and notwithstanding its similarity in principle to Mr. Watts, displays much ingenuity, it is necessary to give a full description of it. Hornblower does not seem to have published any account of his own engine, excepting the one which he sent to Dr. Robison, so that we have no alternative but to lay this before our readers.

Mr. Hornblower had erected his engine for different manufactories, and for winding up coal at collieries, and in 1796 he erected one at Messrs. Meux's brewery in London. Messrs. Boulton and Watt raised an action against Messrs. Hornblower and Maberly for an infringement of the patent, and a decision was given in the Court of Common Pleas in favour of Mr. Watt.

The principal parts of Mr. Hornblower's engine are two cylinders, A, B, Plate DIX, Fig. 1, the largest of which is A. A piston moves in each, having their rods C and D moving through collars at E and F. These cylinders may be supplied with steam from the boiler by means of the square pipe G, which has a flanch to connect it with the rest of the steam-pipe. This square part is represented as branching off to both cylinders. *c* and *d* are two cocks, which have handles and tumblers as usual, worked by the plug-beam W. On the fore-side (that is the side next the eye) of the cylinders is represented another communicating pipe, whose section is also square or rectangular, having also two cocks *a*, *b*. The pipe Y, immediately under the cock *b*, establishes a communication between the upper and lower parts of the small cylinder B, by opening the cock *b*. There is a similar pipe on the other side of the cylinder A, immediately under the cock *d*. When the cocks *c* and *a* are open, and the cocks *b* and *d* are shut, the steam from the boiler has free admission into the upper part of the cylinder B, and the steam from the lower part of B has free admission into the upper part of A; but the upper part of each cylinder has no communication with its lower part.

From the bottom of the great cylinder proceeds the eduction-pipe K, having a valve at its opening into the cylinder, which bends downwards, and is connected with the conical condenser L. The condenser is fixed on a hollow box M, on which stand the pumps N and O for extracting the air and water; which last runs along the trough T into a cistern U, from which it is raised by the pump V for recruiting the boiler, being already nearly boiling hot. Immediately under the condenser there is a spigot valve at S, over which is a small jet pipe, reaching to the bend of the eduction-pipe. The whole of the condensing apparatus is contained in a cistern R of cold water. A small pipe P comes from the side of the condenser, and terminates on the bottom of the trough T, and is there covered with a valve Q, which is kept tight by the water that is always running over it. Lastly, the pump-rods X cause the outer end of the beam to preponderate, so that the quiescent position of the beam is that represented in the figure, the pistons being at the top of the cylinders.

Suppose all the cocks open, and steam coming in copiously from the boiler, and no condensation going on in L; the steam must drive out all the air, and at last follow it through the valve Q. Now shut the valves *b* and *d*, and open the valve S of the condenser. The condensation will immediately commence. There is now no pressure on the under side of the piston of A, and it immediately descends. The communication between the lower part of B and the upper part of A being open, the steam will go from B into the space left by the piston of A. It must therefore expand, and its elasticity must diminish, and will no longer balance the pressure of the steam above the piston of B. This piston, therefore, if not withheld by the beam, would descend till it is in equilibrio, having steam of equal density above and below it. But it cannot descend so far; for the cylinder A is wider than B, and the arm of the beam at which its piston hangs is longer than the arm which supports the piston of B: therefore when the piston of B has descended as far as the beam will permit it, the steam between the two pistons occupies a larger space than it did when both pistons were at the tops of their cylinders. Its density, therefore, and its elasticity, diminish as its bulk increases. It is therefore not a balance; for the steam on the upper side of B, and the piston B, *pulls* at the beam with all the difference of these pressures. The slightest view of the subject must show the reader, that as the pistons descend, the steam that is between them will grow continually rarer and less elastic, and that both pistons will pull the beam downwards.

Suppose now that each has reached the bottom of its cylinder. Shut the cock *a* and the eduction cock at the bottom of A, and open the cocks *b* and *d*. The communication being now established between the upper and lower part of each cylinder, nothing hinders the counter weight from raising the pistons to the top. Let them arrive there. The cylinder B is at this time filled with steam of the ordinary density, and the cylinder A with an equal absolute quantity of steam, but expanded into a larger space.

Shut the cocks *b* and *d*, and open the cock *a*, and the eduction cock at the bottom of A; the condensation will again operate, and the pistons descend. And thus the operation may be repeated as long as steam is supplied; and one full of the cylinder B of ordinary steam is expended during each working stroke.

Let us now examine the power of this engine. It is evident, that when both pistons are at the top of their respective cylinders, the active pressure (that is, the difference of the pressure on its two sides) on the piston of B is nothing, while that on the piston of A is equal to the full pressure of the atmosphere on its area. This, multiplied by the length of the arm by which it is supported, gives its mechanical energy. As the pistons descend, the pressure on the piston of B increases, while that on the piston of A diminishes. When both are at the bottom, the pressure on the piston of B is at its maximum, and that on the piston of A at its minimum.

Mr. Hornblower saw that this must be a beneficial employment of steam, and preferable to the practice of condensing it while its full elasticity remained; but he has not considered it with the attention necessary for ascertaining the advantage with precision.

Dr. Robison then proceeds to an investigation of the effect of this engine, and he finds it to be exactly the same with the accumulated pressure of a quantity of steam admitted in the beginning, and stopped in Mr. Watt's method, when the piston has descended through the *m*th part of the cylinder. In considering, says he, Mr. Hornblower's engine, the thing was presented in so different a form that we did not perceive the analogy at first, and we were surprised at the result. We could not help even regretting it, because it had the appearance of a new principle and an improvement; and we doubt not but that it appeared so to the ingenious author; for we have had such proof of his liberality of mind as permit us not to suppose that he saw it from the beginning, and availed himself of the difficulty of tracing the analogy. And as the thing may mislead others in the same way, we have done a service to the public by showing that this engine, so costly and so difficult in its construction, is no way superior in power to Mr. Watt's simple method of stopping the steam. It is even inferior, because there must be a condensation in the communicating passages. We may add, that if the condensation is performed in the cylinder A, which it must be unless with the permission of Watt and Boulton, the engine cannot be much superior to a common engine; for much of the steam from below B will be condensed between the pistons by the coldness of the cylinder A; and this diminishes the downward pressure on A more than it increases the downward pressure on B. The disposition and connection of the cylinders, and the whole condensing apparatus, are contrived with peculiar neatness. The cocks are very ingenious; they are composed of two flat circular plates ground very true to each other, and one of them turns round on a pin through their centres; each is pierced with three sectoral apertures, exactly corresponding with each other, and occupying a little less than one half of their surfaces. By turning the moveable plate so that the apertures coincide, a large passage is opened for the steam; and by turning it so that the solid of the one covers the aperture of the other, the cock is shut. Such regulators are now very common in the cast iron stoves for warming rooms.

Mr. Hornblower's contrivance for making the collars for the piston rods air tight is also uncommonly ingenious. This collar is in fact two, at a small distance from each other. A small pipe, branching off from the main steam pipe, communicates with the space between the collars. This steam, being a little stronger than the pressure of the atmosphere, effectually hinders the air from penetrating by the upper collar; and though a little steam should get through the lower collar into the cylinder A, it can do no harm. We see many cases in which this pretty contrivance may be of signal service.

But it is in the framing of the great working beam that Mr. Hornblower's scientific knowledge is most conspicuous; and we have no hesitation in affirming that it is stronger than a beam of the common form, and containing twenty times its quantity of timber. There is hardly a part of it exposed to a transverse strain, if we except the strain of the pump V on the strutt by which it is worked. Every piece is either pushed or pulled in the direction of its length. We only fear that the bolts which connect the upper beam with the two iron bars under its ends will work loose in their holes, and tear out the wood which lies between them. We would propose to substitute an iron bar for the whole of this upper beam. This working beam highly deserves the attention of all carpenters and engineers."

Before concluding this account of Mr. Hornblower's engine, we shall describe a very ingenious skeleton valve of his invention, which has been found of great advantage. It is shown in Plate DIX. Fig. 2, 3, where AAAA is the box containing the valves, BB is an inverted valve firmly fixed to the bottom of the socket S; this socket serves as a guide to the part of the valve which is to be lifted by a short cylindrical rod as in common cases. The part which is to be lifted is DDEE, and the lifting is to be performed by any of the usual methods attached to the eye F, which is part of the cross bar EE in Fig. 3, which is a plan of the upper surface of the valve and its upper seat. The valve has two seats, and the principal passage for the steam is at the lower seat, for the steam in its passage goes through the body of the valves, having always access to the lower seating, as the body of the valve is entirely open, excepting what is taken up by the cross bar EE; so that in this sense we lift the thickness of the metal only, of which the body of the valve is constructed. In order to understand the operation of the valve better, we must conceive the upper space in the box to be always full of steam, and consequently the inner part OO of the valve also full; then the lower space of the box will be a vacuum, when upon lifting the valve (which is a cylinder open at both ends) the steam will pass through it and into the lower space at the inverted lid BB. The cylindrical part is raised a little in the figure to show how it separates from the lower lid BB. An improvement in this valve has been suggested by Mr. Tredgold. The practical difficulty being to make it fit steam tight on two seats, he proposes to make the outside of the cylinder to slide in a stuffing box, or in an elastic packing of metal. When this is done, the largest valves will present no other resistance to being opened than the pressure on the seat, and the friction of the surface of the cylinder. "It is simply," says Mr. Tredgold, "the common conical valve inverted, and that which formed the seat in the common valve moves instead of the plate, and should obviously slide in a steam-tight case."

Account of Trevithick's High Pressure Engine.

We have already described the high pressure engine invented by Leupold. Without knowing what had been done by Leupold, Mr. Watt conceived the same idea, but his views were never put in practice, and it was reserved to Mr. Trevithick of Camborne in Cornwall, to bring the high pressure engine into general use. In conjunction with Mr. Vivian of the same place, he took out a patent in 1802, for a high pressure engine. His principal object was to form an engine so compact and portable that it could be applied to the moving of carriages on rail roads. This great object he completely attained, and it was first applied as the moving power of carriages on a railway at Merthyr Tydvil in 1805. Since that time it has been employed in various collieries near Leeds, Wigan, and Newcastle upon Tyne.

This engine is represented in Plate DIX. Fig. 4., where AA is a cylindrical boiler of cast iron from three to four feet in diameter, and from nine to twelve feet long. The fire is made in a double wrought iron tube of the form of a syphon (one of the legs is shown at D) lying horizontally within the large cylinder AA. The two ends of the double tube are attached to the plate *d*. One of the ends is occupied with the fire door and ash pit, and the bars on which the fire is made, while its other end contracts into the iron chimney or flue T, having a door Z below for removing the soot. The boiler is filled with water above the surface of the double tube D, as shown in the figure. The steam cylinder A is almost wholly inclosed within the boiler, so as to be kept at the same heat as the water. The piston rod H attached to the piston G is fixed to the middle of a cross bar I at right angles to the length of the boiler. At the extremity of the cross bar are two connecting rods L, the lower ends of which are jointed to two cranks which drive the axis of the fly-wheel M. When a vertical reciprocating motion is required, it is attained at once from the cross bar I. The *fourway cock* for admitting the steam into the cylinder, and already represented in Leupold's engine, is shown at *i*, *f*, *g*, *k*. The steam from the boiler passes directly through the passage *g*, and brings steam to the cock, so that it can be admitted either above or below the piston, according to the position of the cock, *f* being the passage that carries it above the piston, and *k* that which carries it below the piston. The fourth passage *i* allows the steam to fly off into the flue T after it has exerted its expansive force upon the piston. The method of opening and shutting the cocks is similar to that used in other engines. The safety valve *n* is kept down by a lever *p v* with a weight *p*. The cold water is carried to the boiler by a pipe *r* enclosing the waste-pipe IF which is kept hot by the discharged steam, and which, therefore, gives out its heat to the cold water.

In the engines which Mr. Trevithick erected in Cornwall, he introduced the cylindrical tube boiler which is now generally used in that part of England. It is shown in Plate DIX. Fig. 5, where *aa* represents the part containing the water. The fire place is at the end of the tube A, and the heated air, after passing through A, returns through the flue B, which passes horizontally beneath the boiler to the end at which the fire is situated. Here it divides into two branches which pass along *c c*, into the flues DD, by which it is conveyed along the sides of the boiler, and thence escapes to the chimney.*

Woolf's Engine.

The engines introduced by Mr. Woolf were founded on an erroneous law of expansion, which, having been given by so respectable an engineer as the direct result of experiment, misled many writers into the belief of its correctness. But though the law which he assumed was erroneous, yet the engines which he introduced had considerable merit. They were nothing more indeed, than the application of high pressure steam to the double cylinder engine of Hornblower, in which Mr. Watt's condensing apparatus was employed in consequence of the expiry of his patent.

When Mr. Woolf went into Cornwall he erected some engines of this kind, and by having them made and fitted together with much more accuracy than had hitherto been the practice in that neighbourhood, he obtained from them a much better performance than had yet been obtained from Mr. Watt's engines. One of these at Huel Abraham mine was found, during a trial of twenty-four hours, to lift *seventy million of pounds* one foot high by the combustion of one bushel of coal (Mr. Henwood in Dr. Brewster's *Journal*, No. xix, p. 36.) Their effect was very far beyond that of any of Mr. Watt's engines which were then at work in the neighbourhood, as appears from a statement of their performance which was published periodically; but this arose not from any superiority in the principle of Woolf's engine, but solely from the great attention which he paid to the joints, and the fitting together of the parts.

In 1820 when Mr. Woolf was appointed engineer of the consolidated mines, he was anxious to erect some double cylinder engines; but this proposal met with opposition, and some very large engines of Watt's construction were made. Every attention was paid to proportion and workmanship, and from a performance of twenty and twenty-five millions of pounds lifted one foot by the combustion of a bushel of coal, they rose to forty and even forty-eight millions. The sufficiency of Mr. Watt's engines was now placed beyond a doubt, and only one of Mr. Woolf's has been since erected. Mr. Woolf, however, has great merit in having introduced that accuracy of workmanship and niceness of fitting by which Mr. Watt's engines obtained their superiority.

Mr. Woolf made some improvements on the boilers of steam engines which merit notice. His boilers consisted of a horizontal cylinder or reservoir for containing steam and water, having a series of horizontal tubes below it crossing it at right angles, and connected by short necks with the reservoir. Between these tubes, and over and above them alternately, the flame and heated air traversed in its passage to the chimney. He proposed another ingenious plan of having an upper and a lower boiler connected by short tubes; but though this exposes much surface, it is troublesome to execute; but, as Mr. Henwood † remarks, being usually made of cast iron, and continually

* Dr. Brewster's *Journal of Science*, No. XVII. p. 159.

† Dr. Brewster's *Journal of Science*, No. XIX, p. 36.

exposed to the intense action of the fire, the water was frequently driven out of them, and their temperature became considerably elevated; by the readmission of water at a comparatively low temperature, they were rapidly cooled, and the consequent contraction occasioned frequent fracture, not only of the joints, but also of the tubes themselves. Frequent trials demonstrated their inferiority to those of Trevithick, in favour of which they were soon relinquished.

Account of Mr. Grose's Improvements on the Steam Engine.

About the end of the year 1826, Mr. Grose was called upon to superintend the manufacture of some steam engines at Huel Towan, and the average duty (performance) of the one which was first worked was nearly 50 millions of pounds. Mr. Grose now applied a coating of saw dust about ten inches thick to the steam-pipes, nozle, cylinder, &c., and a stratum of ashes of nearly the same depth to the top of the boiler. By this means the duty was raised to about 65 millions. As there was still, however, a considerable loss of heat, another coating of the same material of the same thickness was applied on the outside of the first coating, and the result of this was an increase of the duty to *eighty-seven* millions, which was the average of a trial made in the presence of Mr. Henwood and several engineers and scientific individuals. Pursuing Mr. Grose's idea, Mr. Woolf has brought one of his engines to a duty of nearly 70 millions, as already mentioned.

The gradual improvement which has taken place in the steam-engines in Cornwall, may be seen from the following table drawn up by Mr. Henwood.

	No. of Engines in Cornwall.	Average duty in millions of pounds.
1823	55	26.9
1824	57	28
1825	62	28.97
1826	63	28.36
1827	62	31.9
1828	60	34.85
1829	56	40.9

The details respecting these engines are given by Mr. Henwood in Dr. Brewster's *Journal*, No. XIX, p. 45; and the same gentleman publishes regularly in the same Journal quarterly reports of the performance of the steam-engines in Cornwall.

Mr. Perkins' Steam Engine.

Although the high expectations which were entertained from Mr. Perkins' labours on the steam engine have not been realized, our readers will still look for some account of the method from which so much was anticipated.

The general construction of the apparatus is represented in Plate DIX, Fig. 6, where *a a a* represents the section of the *Generator* or boiler. It is a strong cylindrical vessel made of metal, about three inches thick in every part. This vessel is filled with water and heated in a cupola furnace fed by a blast, which almost entirely surrounds it. On the top of the generator there is an escape valve *b* pressed down by the loaded lever *c*, the pressure being capable of adjustment by placing the weight at different distances from the fulcrum. This valve admits the steam to the steam-pipe *d* which leads to the working cylinder. A lateral pipe *e*, intended merely for safety, is connected with the generator, and has an apparatus *f* attached to it for indicating the pressure. A forcing pump *h*, wrought by the engine, feeds the generator with water by the pipe *g*, which terminates near the bottom of the generator.

In order to generate steam, the generator is filled with water by the forcing pump *h*. When the heat of the surrounding furnace has raised the water to a temperature of 400 or 500 of Fahrenheit, an additional quantity of water is pumped into the generator, sufficient to force a portion of that which is already heated from under the loaded valve *b* at the steam-pipe *d*, where it instantly *flashes* into strong steam, which proceeds to the piston of the cylinder. The valve *b* is shown on an enlarged scale in Fig. 7. It is a spherical bulb falling into a concave seat in the lower part of the square chamber. The upper part of the valve is a cylindrical rod, on the top of which the weight of the pressing lever *e* is exerted. The lower part of the valve is a triangular stem sliding up and down in the cylindrical passage. When the additional quantity of water is injected into the generator as above described, the bulb of the valve rises from its seat, and a corresponding quantity of heated water passes up between the cylindrical passage, and the sides of the triangular stem into the square chamber, where, from the pressure no longer operating on that portion of the water, it becomes steam, as already mentioned.

For the renewal and the regular continuance of the operation, an adjusting weight *i* is placed on the handle of the pump, which is a small single stroke forcing pump with a weight *w* performing the office of an air-vessel. At the end of the pump handle is a chain *m* which is connected with a single crank movement, and thus by a corresponding adjustment between the escape valve *v*, the throttle valve (which is not shewn in the figure) and the weight *i*, a certain quantity of water is forced into the generator at every stroke of the pump, and a corresponding quantity forced from beneath the loaded valve *d* to become steam.

From the difficulty, we presume, of constructing generators of sufficient strength, Mr. Perkins has more recently substituted a numerous series of very thick and strong cast iron tubes of small bore, and all connected with each other, in place of his cylindrical generator.

Such is a brief account of Mr. Perkins's method of generating powerful steam. Among the practical difficulties which Mr. Perkins encountered was the difficulty of constructing generators of the requisite strength; but it is probable that the real causes of his failure were the great force which was lost by the injection of the cold water into the generator, and the loss contained by the passage of heat up the chimney.

Account of Mr. Scott's Engine without a Boiler.

In the year 1823, our ingenious countryman Mr. Alexander Scott of Ormiston, constructed a model of a steam-engine without a boiler, with which experiments were made in presence of several persons in his neighbourhood. Owing to accidental causes, the engine itself was not completed till 1829. The following account of it transmitted to the editor of this work by Mr. Scott, and published in the *Edinburgh*

Journal of Science, New Series, No. III, p. 21, will convey a clear idea of this important invention.

When water of a low temperature is forced by a pump into a small generator placed over a fire, every stroke of the pump tends to lower the temperature of the whole body of water. This led to devise a generator by which water of a low temperature can be forced into it without lowering the temperature of the hottest part of the water. In constructing a generator with that property, two truly flat circular patterns of wood were made, having each corresponding projecting parts. In one pattern a continued spiral groove was cut from the centre to nearly its circumference; the other pattern was left plain. Fig. 8, Plate DIX, represents the one, and Fig. 9 the other. Both these patterns were made twenty-one inches in diameter, exclusive of the projecting parts. The spiral grooved pattern was one inch and three quarters in thickness, and the plain pattern one inch and a quarter thick, as also were the projecting parts of both patterns. The spiral groove was cut half an inch in depth, half an inch wide at bottom, and seven-eighths of an inch at top. The ridge between the grooves was left half an inch in depth, half an inch in breadth at top, and seven-eighths of an inch at bottom. From these two patterns iron casts were taken. The faces of both these cast-iron plates were made truly flat, and a very small chiseled groove was cut along the middle of the ridge between the grooves, and a corresponding chiseled groove was cut in the inch and quarter thick plate. These two plates were then cemented together by means of well prepared iron cement, part of it filling the chiseled grooves in both plates; the projecting parts *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, Figs. 8 and 9, were bolted together by screw bolts, five-eighths of an inch square, made of the best iron; in all fifteen bolts, as marked by the small square bolt holes in Figs. 8 and 9; the projecting parts of Fig. 8 being all, except that marked *h*, one and a quarter of an inch in thickness, which leaves a space of half an inch between the projecting parts of the two plates, for the more effectually screwing the plates close together. These two plates when thus joined form only the one-half of the generator, as there is another half almost in every respect similar to be placed perpendicularly over the one described : having a strong cast-iron pillar with flanges, as represented by Fig. 10, placed in the centre between the halves : These flanges are strongly secured by four screw bolts to each of the halves of the generator. The centre pillar is twelve inches in height and four and a half inches in diameter, with a bore up its centre of one inch and a quarter in diameter.

Fig. 4 represents a section of the generator answering to the description already given, placed in a furnace, of which a section is also given.

The generator is supported in the furnace by cast-iron brackets represented by Figs. 12 and 13, built into the sides of the furnace for the projecting parts of the generator to rest on, where F, Fig. 11, is the fire place, A the ash-pit, and C part of the chimney. R represents part of the pipe that leads from the force pump to the generator, whence the water circulates round and round the spirals from the circumference to the centre of the under half of the generator, ascends the centre pillar P, then circulates outwards from the centre of the upper half of the generator to its circumference, and escapes by the pipe S, that leads to the cylinder of the engine. The pipe T is the one that conveys part of the escape steam from the cylinder into the chimney. This generator works a small high pressure engine, of which the following is a short description :

The frame of it is of cast-iron, of the form of the upper part of Mr. Maudslay's portable engine with its parallel motion. The piston of the cylinder is six inches in diameter, and the length of the cylinder permits the piston rod to make a stroke of seventeen inches. The steam is permitted to enter the cylinder alternately above and below the piston by means of a spring slide valve wrought by the engine, and has a stroke of one and two-eighths of an inch. The axis of the fly-wheel cranks, &c. is two inches and a quarter square ; the rounded parts two and one-eighth inches in diameter. The fly is seven hundred weight. and six feet in diameter. In the steam-pipe that leads from the generator to the cylinder, there is a three-way cock introduced, with a branch proceeding from it to the hot well of the engine, by which the steam may be permitted either to pass the cylinder, or by one-third turn of the cock into the hot well of the engine. This three-way cock answers for stopping or starting the engine. As there is no space in this kind of generator, as in common engine-boilers, for the steam to condense or expand, the common throttle valve is not applicable to this kind of generator ; but in place of it, a spring slide valve is introduced in the steam-pipe between the three-way cock and generator, with a branch from it communicating with the branch pipe that leads between the three-way cock and hot well. This slide valve is raised and lowered against a very acute angled aperture by means of centrifugal balls, so as to permit a necessary regulating quantity of steam to escape into the hot well. In the pipe by which the steam escapes from the cylinder into the chimney, there is a branch to the hot well ; in this branch there is a cock by which the temperature of the water in the hot well is regulated. The forcing pump is wrought by the engine, and supplies the generator with water from the hot well. In a side vessel that communicates with the hot well, there is a forcing pump wrought by hand for starting the engine. Into this vessel additional water enters to supply the engine, and where the height of the water in the hot well is regulated. As the engine is intended to work different kinds of machinery, either together or separately, different powers are required.

To produce these several powers, there is a short branch from the steam-pipe near the generator, that reaches to a convenient place, where a steel yard safety valve is placed. On the lever of this safety valve, the safety valve weight is to be hung at divisions marked on it answering to the power required, and a corresponding length of stroke is also to be given to the forcing pump of the engine.

The engine was first publicly tried in January 1828, before it was connected with machinery of any kind ; but that it might meet with some resistance, a friction bar of iron with a considerable pressure was applied to the periphery of the fly-wheel, when the engine made eighty-eight double strokes per minute.

The engine was lately tried connected with grinding and turning-lathe machinery, and at the same time it wrought cast-iron rollers bruising bleas for fire clay.

Although the bleas were very irregularly fed into the rollers, yet the engine continued to make sixty-four double strokes per minute. A greater number might have been obtained; but from the irregular manner the bleas was fed in, there was reason to fear that the main axis of the engine might give way.

On the bottom and sides of vessels that have been long used for boiling fresh water, a calcareous crust is generally formed more or less in thickness.

It is proposed, if it shall be found that the spiral grooved generators are liable to be incrusted in this manner, that a water-tight cistern be placed somewhat higher than the generator. This cistern is to be connected with the upper part of the generator by a pipe and stop-cock. There is also to be a branch pipe from the steam-pipe close to the under part of the generator, with a particular stop-cock, that when open, it shall cut off the communication between the generator and the slide valves. Let this cistern be filled brimful with water, and the cock at the bottom of the generator left open. If the cock of the cistern be opened, the whole water of the cistern will escape through the generator; and if the time it takes to escape be observed by a pendulum or stop-second watch, the repetition of this experiment at any time will show if the passage through the generator be contracted since last experiment. Should it be found to be so, it is then proposed to fill the generator with diluted muriatic acid, taking care to cut off the communication between it and the slide valves. After letting it remain in the generator a sufficient time, it is then to be washed out with warm water poured into the above-mentioned cistern. If the cistern be filled brimful it will serve to ascertain if the passage be clear, by observing the time it takes to pass through the generator. Repetitions of these experiments will undoubtedly free the generator of all calcareous matter. But as none of the strong acids act on the crust formed by sea water, it is therefore proposed to proceed in the same manner with diluted sulphuric acid, taking care never to give time for much crust to form by sea water, so that by the diluted sulphuric acid partly acting on the iron, it shall effect the removing of an imperfect crust produced from salt water; the generator to be always thoroughly washed out with warm water.

The length of time that this engine has been in constructing, gave ample time to devise improvements. Several were proposed, but few of them were thought of in time to be introduced without making material alterations on the parts made; such as improvements in the manner of constructing generators of greater strength, but of which it is unnecessary to lengthen this paper with a description. However, one thing may be mentioned, as it would add to the improvement of the engine. In place of working the escape steam slide valve by the immediate action of the centrifugal balls, it was proposed that the axis of a bevelled wheel should be turned by the machinery of the engine, and which is to turn other two bevelled wheels on one axis. These two last mentioned wheels are neither of them to be fixed to the axis, but both to slip round freely upon it, turning in contrary directions as they receive motion from the opposite sides of the first mentioned wheel. A locking stub box is fitted upon the axis between the two wheels, and can, by moving it one way or the other, be made to lock either of the wheels to the axis at the same time that it leaves the other disengaged. It is proposed that the centrifugal balls shall shift this stub box back or forward as their centrifugal motion shall be affected by the velocity that they receive from the engine. The axis of these two wheels is proposed to be so connected with the escape steam slide valve, that, on its turning one way round it shall raise the valve to let the steam escape, and by turning the contrary way, it shall depress the valve that less may escape; and it is further proposed, that there shall be spring sockets on the axis of the first wheel, to prevent any part giving way when the valve is fully wrought up or down. In like manner it is proposed to work the furnace damper for regulating the heat of the fire.

The engine, as now completed, is a handsome piece of well finished accurate workmanship, and performs its part admirably. The young man who made all the principal parts of the engine is a self-taught mechanic, and merits the highest praise for the ingenuity, elegance, and perfect workmanship which he has displayed upon it.

Account of Mr. G. Gurney's Tube Boiler.

Various attempts have been made to construct boilers with tubes, but practical difficulties occurred which the ablest engineers sought in vain to remove. These difficulties arise from the water being carried off along with the steam, which left the containing vessel dry, oxidated the metal, and produced hydrogen, the heat of which destroyed the packings of the joints in the pipes and the working cylinder;—from the deposition of earthy concretions in the tubes,—and from the destruction of the joints by the sudden and unequal expansion of the metal composing the boiler.

Mr. Gurney's boiler is constructed with the view of obviating this objection. It is shown in Plate DIX, Fig. 14 and 15, Fig. 14 being a section, and Fig. 15 a front elevation of the boiler. A section of one of the tubes is shown in Fig. 14 surrounding the flame. Each end of every tube opens into two cylindrical chambers *c c*, and these chambers communicate by pipes with the vertical chambers *a a*, which receive the steam and water generated in the pipes. Here the steam and water are separated, the steam rising to the top, and the water falling to the bottom. Hence these chambers are called *separators*. These separators are united with the top of a tube *b*, in the centre of which the safety-valve is placed. The injection pipe of the forcing pump is inserted into either of these chambers, *d* is a small well to receive any extraneous matter which may pass into the boiler, *e e* are the guage cocks for steam and water, the lower cock being the water level of the boiler. The fire-door is shown at *f*. Fig. 15 and 17 and 18, show the manner in which the tubes are fixed to the chamber *c*.

The incrustation of salt and its corrosive action on the tubes appeared at first hostile to the use of the boiler at sea; but Mr. Gurney has removed this objection by condensing the high pressure steam instead of blowing it off, and returning the water thus procured by means of a forcing pump into the boiler, so that by beginning with pure rain or distilled water, steam is continually generated without any great expenditure of fresh water, as the steam from the engine is not only condensed, but also a part of this procured from the fresh water which is successively employed in condensing it, and which without loss of power in a steam vessel can be led from the water thrown up by the paddle wheels to a cistern for the purpose. The following is the condenser employed by Mr. Gurney.

Description of Mr. Gurney's Condenser.

Mr. Gurney's Condenser is shown in Plate DIX, Fig. 19, 20, where *a* is a bent pipe joining the eduction pipe of the engine to the cone I of the condenser, which is a cylindrical vessel 3½ feet long, and 7 inches diameter inside, for a 10 horse engine. Within this cylinder 40 copper tubes five-eighths of an inch in diameter, are arranged in circles, and are inserted in plates at each end by steam tight joints as shown in Fig. 20. The nozle *c* is connected with a cold water pump which discharges about two gallons per minute for every horse power. In steam boats this is not necessary, as the water can be procured from the paddles. This water will rise in the cylinder so as to surround the tubes until it is ejected from the nozle *d*, from which it may return to the well or cistern. The steam which passes from the engine into the tubes is condensed before it reaches the lower cone *e* and falls into the close chamber below, from which it is carried by the suction pipe *g* to the injection pump of the boiler. When there is too little water in this chamber the ball of the cock falls and admits the proper quantity from the cylinder through the tube *i*. By the tube *k* air or vapour may be drawn out. Captain Ross, who saw this condenser in operation, is of opinion that it makes Mr. Gurney's boiler quite perfect for naval purposes.

Having thus described the most important improvements on the Steam Engine, we shall now give an account of some miscellaneous contrivances connected with it.

Miscellaneous contrivances connected with the Steam Engine.

Murray's Sliding Valve.—The idea of a sliding valve has been long ago suggested, and seems to have been first applied to the air pump by Lavoisier or some of his associates. Mr. Murray of Leeds, however, has the merit of having applied it with great ingenuity to the steam engine, and may be regarded as its real inventor. This valve is represented in section in Plate DIX, Fig. 21, and the object of it is to cover alternately the passages *a c*, *e b*. The sliding cover is put in motion by the rod *o*, which passes through a stuffing box. The steam from the boiler is introduced at S, passes through the opening *a* to the top of the cylinder, when the slide is down as shown in the figure, while the passage *c* to the condenser is open through the interior portion of the slide. When the slider is up the passage *b* to the bottom of the cylinder is open, and the passage *a* from the top, to *c*, the passage to the condenser is open. Owing to the pressure of the steam against the box, the friction of the valve is considerable. This disadvantage, however, has been remedied by Mr. Murdoch, who packs the slide, and this keeps out the steam. Messrs. Taylor and Martineau have substituted for the slide, pistons sliding in a pipe, which is a valuable improvement.

Sim's Valve.—This valve is shown in Plate DIX, Fig. 22, and has been extensively used in large engines. The seat is shown at *a a a*, *a′ a′ a′*, and is solid at *a a a*. Apertures are cut in its sides at *a′ a′ a′* for the passage of the steam, and at *a″ a″* is the beat, into which it is ground with emery. The valve *b b* is a plain cylinder very accurately bored, and packed at *d d* with the usual materials, the packing being kept in its proper place by the ring *e e*. A second ring *f f* rests on *e e*, and is kept in its place by the screws *g g*, which help also to keep the packing in a proper state of compression. The valve is lifted by the bar *c*. It is evident that the steam can exert no pressure to prevent the valve from being lifted, and when it is closed, the vapour has no power to open it. This valve answers its purpose so completely, that an infant might lift the valves of a 90 inch engine. It would be desirable to dispense with the packing, as it increases the dimensions of the valve. See Dr. Brewster's *Journal of Science*, No. XIX, p. 42.

Cartwright's Metallic Piston.—Mr. Cartwright took out a patent in 1797 for the method of using metal in place of elastic substances for the packing of pistons. This method is shown in Fig. 23, where *a a a* are six or more segments of rings made to fit the internal surface of the cylinder, with a second series *b b b* crossing the joints of the former. Each series of segments were pressed against each other, and against the cylinder with V springs, and by having two sets with the junction of the rings in the one, set opposite to the solid parts of the rings in the other set, any escape of steam out of the joints was prevented. The upper and under sides of the sets of segments were connected by plates to which the piston rod was united, as shown in the section.

Jessop's expanding Coil Piston.—This very ingenious contrivance was secured by patent in 1823, and is shown in Fig. 24. It consists of an elastic expanding coil of metal AA which winds round the body of the piston in a spiral form, as shown in the section at AA. BB is a bed of hemp packing which prevents the steam from passing at the joints, and presses the springs against the surface of the cylinder. The piston is kept tight by the pressure of the steam on the upper and under plates. Mr. Barton's metallic expanding piston is very ingenious, and has been improved by Tredgold; but we must refer for an account of it to the work of the latter on the Steam Engine, p. 228. Perkins' metallic piston, from which much has been expected, is considered inferior to those described. See the *Repertory of Patents*, vol. i, p. 224.

On the Application of the Steam Engine.

The Steam Engine is, of course, applicable to every purpose where mechanical power is required, but some of its applications have been of such vast importance to the progress of the useful arts, that they require to be specially noticed. The most important of these are as follows:

1. Raising of water.
2. Drawing ores and coals.
3. Driving cotton machinery.
4. Paper mills.
5. Thrashing mills.
6. Corn mills.
7. Iron manufactures, &c.

1. *Raising of Water.*—By means of a single steam engine acting expansively 280,000 cubic feet of water can be raised one foot high by one bushel of coals;

and an engine of one horse power working eleven and a half hours daily will raise 280,000 cubic feet of water one foot high in a day. It will cost 8*l.* per annum, for each horse power, to return the first cost and repairs. In raising water the stroke of a pump should not exceed eight feet, nor its diameter fourteen inches, and the velocity of the piston should not be greater than ninety-eight times the square root of the length of the stroke.

The quantity of water in cubic feet delivered at one stroke of a pump in the best order is $.00518\ l d^2$, l being the length of the stroke, and d the diameter of the pump in inches. The following table will show the quantity of work performed in 1826, at Wheel Hope, by one of the best Cornish engines made by Mr. Grose. The numbers are taken from a monthly report.

Diameter of cylinder	60 inches square.
Load per square inch on piston	8.37 lbs.
Length of stroke in cylinder	9 feet.
Number of strokes per minute	$5\frac{1}{2}$
Number of lifts, 1st 1 through 46 fathoms	5 feet.
——— 2d 1 — 11 —	2 —
——— 3d 1 — 11 —	2 —
Diameter of pump for 1st lift	15 inches.
——— 2d —	$12\frac{1}{3}$ —
——— 3d —	11 —
Consumption of coals	1.242 bushels.
Number of strokes	261,890
Length of stroke in pump	8 feet.
Number of pounds lifted one foot high by one bushel of coals	46,838,246

2. *Drawing Ores and Coals.*---The engines used for this purpose are double engines from twenty to thirty horse power. From three to seven cwt. is generally raised at once; and as the work is irregular, from stoppages and changes of motion, *one pound of coals* raises only about 70,000 pounds of ore.

3. *Driving Cotton Machinery.*---Double acting engines working expansively are best fitted for cotton mills. One horse power will drive one hundred spindles with cotton yarn and the preparatory machinery. The same power will work twelve power looms with preparation. If the day's work is eleven hours, ninety pounds of the best caking coal will be required for each horse power.

4. *Paper Mills.*---A beating machine requires a seven horse power, and the new machines for making paper a two or a two and a half horse-power.

5. *Thrashing Mills.*---Engines from 4 to 6 horse power are generally used. The feeding rollers perform from 35 to $47\frac{1}{2}$ revolutions per minute, their diameter is $3\frac{1}{2}$ inches, and their length from 4 to 5 feet. The straw rollers revolve 30 times per minute, and their diameter is $3\frac{1}{2}$ feet. The drum revolves 300 times in a minute, and is $3\frac{1}{2}$ feet in diameter. The quantity of wheat thrashed by a machine with feeding rollers 4 feet broad, varies according to its quality from 12 to 24 Winchester bushels per hour, and the quantity of oats per hour from 16 to 30 bushels. The power required is 100,000 pounds raised one foot per minute for thrashing alone, and 183,000 when winnowing machinery is also wrought. Each inch of the straw receives three strokes of the beaters. The stroke should be made with a velocity of 55 feet per second, or the beater should move 3300 feet per minute.

6. *Corn Mills.*---The double expansive engine is best fitted for corn mills. With low pressure steam it should grind 14 bushels of wheat for each bushel of coals when working in the best manner. The average however, will be $11\frac{1}{2}$ bushels. The power required to grind and dress a Winchester bushel of wheat per hour is 31,000 pounds raised one foot in a minute. The velocity of the circumference of the mill-stone should be 23 feet per second, and with that velocity a pair of 5 feet stones should grind 4 or 5 bushels per hour, according to the state of the grain.

7. *Iron Manufactures.*---In the iron manufactures the steam engine is applied to blowing machines, forge hammers, rolling, flatting and slitting mills. See our Articles Blowing *Machinery* and Iron.

Many of the other applications of steam will be learned from the following table given by Mr. Cleland, and showing the quantity of steam power used in Glasgow in April 1825.

	Horse Power.		Horse Power.
Spinning cotton,	893	Twisting yarn,	18
Weaving,	681	Smith work,	18
Raising water,	262	Drug grinding,	14
Bleaching & dyeing, Washing & dischars	206	Coach making,	12
		Glass grinding,	12
Calendering,	160	Grinding malt and pumping wash,	20
Corn grinding,	153		
Founding,	124	Grinding colours,	14
Distilling,	119	Veneer sawing,	10
Engine making,	68	Tambouring,	10
Chemical operations,	39	Wool-carding,	8
Machine making,	37	Pottery,	7
Snuff making,	22	Singing muslins,	6
Fire-brick making,	19	Tanning,	6
Sugar refining,	18	Gas,	4
Cutting wood,	18	Coppersmiths,	4
Lamp-black making,	18	Total,	3000

Besides these there are in the vicinity of Glasgow,
Collieries, 18, with 58 engines, of horse power, 1411
Quarries, 7, --- 7 ——— ——— 39

General Abstract.

	No. of Engines employed.	Horse Power.	Average Power of Engine.
In Manufactories,	176	3000	$16\frac{9}{10}$
In Collieries,	58	1417	$24\frac{3}{10}$
In Stone Quarries,	7	39	$5\frac{6}{10}$
In Steam Boats,	68	1926	$36\frac{3}{10}$
In Clyde Iron works,	1	60	
	310	6436	$20\frac{7}{10}$

In 1824 upwards of 200 steam engines were used in Manchester.

Mr. Cleland has added to the above interesting documents, the following comparison of the price of coals consumed by steam engines and the keep of horses.

A heavy horse working 10 hours will consume 15 lbs. avoirdupois of oats, and 14 lbs. of hay per day. An engine of 30 horse power, working 10 hours per day in a mill, will consume, on an average of summer and winter, about 4 tons of coal dross. The steam-boat Toward Castle, from Glasgow to Rothsay, and back again, a distance of about 80 miles, consumes $5\frac{1}{2}$ tons of hard coal in 12 hours.

These are some of the principal applications of the steam engine; but the most important of all is its application to Carriages and vessels, which is treated of in the separate Articles Steam-Boat and Steam-Carriage. For farther information on the subject of this section, see Tredgold on the *Steam-Engine*, sect. ix.

As the preceding article is intended only for the perusal of general readers, those who wish to prosecute the subject farther may consult the following works:—Switzer's *System of Hydrostatics;* Belidor's *Architecture Hydraulique;* Desagulier's *Experimental Philosophy;* Ferguson's *Lectures on Mechanics*, vol. i. p. 312; Smeaton's *Reports;* Prony's *Nouv. Architecture Hydraulique*; Robison's *Mechanical Philosophy*, vol. ii.; Stuart's *Descriptive History of the Steam Engine*, Lond. 1824; Montgery's *Notice Historique sur l' Invention des Machine-à-Vapeur;* Farey's *Treatise on the Steam Engine, Historical, Practical, and Descriptive*, Lond. 1827; Partington's *Historical and Practical Account of the Steam Engine;* Tredgold's *Steam Engine*, Lond. 1827; Lardner's *Popular Lectures on the Steam Engine*, Lond. 1828; Birkbeck and Aldcock *on the Steam Engine*.

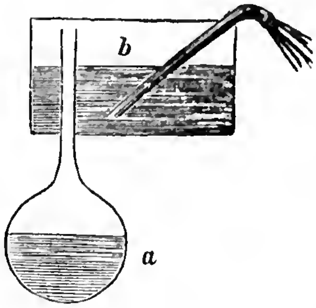
An account of the most recent improvements on the steam engine, as made in Cornwall by Mr. Henwood, will be found in Dr. Brewster's *Journal of Science*, No. XVIII. and No. XIX.

It is not only agreeable to know the gradual progress which all arts, sciences, and improvements have made, from the first rude attempts to perfection; but proper, in a work of this kind, to detail them. The author of the preceding article makes no mention of Hero of Alexandria, or of Porta the Italian, both of whom may be said to have invented steam engines, or at least to have demonstrated the elastic force and moving power of steam. The first lived about 130 years before the Christian era; and in his work entitled *Spiritalia,* describes a machine to which motion is to be given by the force of steam. It consisted of a hollow globe, having tubular arms extending in opposite directions, and having openings at different sides near their extremities. The globe was suspended upon centres, fixed upon pillars, one of which and one of the centres was hollow. Steam was introduced from a cauldron, and issuing through the hollow column and centre into the globe, passed through the arms into the open air, producing a rotary motion.

In the year 1560, Mathesius, a German, suggested the practicability of a plan by which steam could be employed. In Leipsic, a machine upon a similar plan to that of Hero was proposed to be substituted for the turnspit-dog, then in use.

Porta, a Neapolitan, published the account of his apparatus in 1606, in an Italian translation of Hero's work. The boiler *a* has a long neck, which passes through the bottom of the close cistern *b*, containing water. A bent pipe or syphon *c* is closely fitted into the top of the cistern, and descends nearly to the bottom. When the fire is lighted under *a*, the steam ascends into the cistern, presses upon the water, and forces it up the syphon *c*, whence it runs in a stream.

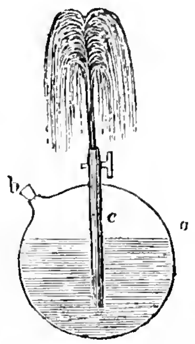
Mr. Ainger observes that this was an extraordinary suggestion, and it is surprising that the project was not sooner reduced to practice, than is found to be the case.



The contrivance is a great improvement on that of Hero (who proposed to use solar heat), because the steam from heated water in one vessel is made to drive up cold water from another vessel, instead of driving up the heated water from which the steam is produced. With this important modification, the apparatus resembles that of the Marquis of Worcester, in 1663, excepting only in the extent of its power.

In the year 1615, according to M. Arago, De Caus, a native of Normandy, published at Frankfort a work entitled *Les Raisons des forces mouvantes avec diverses Machines tant utiles que plaisantes,** &c., and dedicated it to Louis the XIII. The fifth theorem is thus headed: "*L'eau montera par aide du fous plus haut que son niveau;*"† and the explanation of this with a diagram exhibits a real steam engine, capable of producing a vacuum. This was forty-eight years prior to the appearance of the Marquis of Worcester's Century of Inventions, which was written in 1655, and first appeared in print in 1663.

The announcement forms the third of five modes of raising water. "Let there be a globe," he says, "*a*, having a valve *b*, to introduce water, and a tube *c*, soldered into the upper part of the ball, and descending nearly to the bottom: after having filled the ball with water, and well closed the valve, place it on the fire; then the heat, acting on the ball, will cause the water to ascend through the tube *c*."

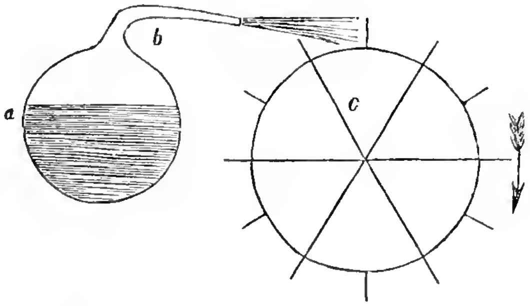


Mr. Angier says that this apparatus is so obviously inferior to that of Porta, which had appeared only nine years before, that it would be an insult to the reader to say why; and yet Mr. Arago rests his claim for the invention of the steam engine in France, on the part of De Caus, to this simple contrivance, and gives a diagram of it, not exactly like the one figured by De Caus, from whose work Mr. Angier faithfully copied the annexed figure.

Brancas published an account of his apparatus in 1629, in a work entitled "*Le Machine.*" The boiler *a* terminates with a bent tube *b*, from which the steam issues, and impinges upon the vanes of a wheel *c*, which receives motion in the direction of the arrow. This principle does not differ from the first

* The *proofs* or *account* of *moving forces with different machines equally useful* as *amusing.*
† *Water will show,* by *the aid* of *fire,* a *greater height than its level.*

apparatus of Hero, and the practical effect would probably be inferior.



The Marquis of Worcester, Newcomen, Savary, and others followed: an account of whose inventions is given in the preceding pages, and numerous other works.

Moreland's work referred to, p. 399, consists of thirty-eight pages in MS., written on vellum, richly illuminated, but the part which has reference to the steam engine occupies only four pages. It is also accompanied by a table of the sizes of cylinders, and the amount of water to be raised by a given force of steam. Moreland was presented to the French monarch in 1682, and the next year, his machine is said to have been exhibited at St. Germains. He can not however be entitled to the merit of an original, his apparatus having been evidently suggested by the work of the Marquis of Worcester.

The ingenious Papin then follows, who is noticed in p. 399: M. Arago, in the "Annuaire du Bureau des Longitudes" for 1829, gives a paper on the early history of the steam engine, and claims for his countryman the honor of completing the invention: but Mr. Ainger has critically analyzed that paper, and asserts that the apparatus, upon which he founds the claim for Papin, was never made as a working machine; and does nothing more than illustrate a well known physical fact. That a vacuum was left by condensed steam, was known from the time of Hero at least. That the air, or some other power, would force a liquid or solid body into a vacuum, was equally well known. Mr. Ainger farther asserts that Papin never experimented on such an apparatus as Mr. Arago ascribes to him; never even suggested such a one: and that the two diagrams, given by him of Papin's invention in 1690, are portraits of the apparatus of Newcomen, made fifteen years afterwards, viz. in 1705;* yet notwithstanding this unfair conduct, Mr. Arago complains of professor Robinson, who in his account of the steam engine, merely refers to a work of Papin's published in 1707,† nine years after Savary's patent, describing it as his first publication, and actually denies the existence of those of 1690 and 1695, although he might have found an analysis of the latter in the Philosophical Transactions of the Royal Society of London, for March 1697, a whole year before Savary's engine was heard of. In another instance he is said to have post-dated a little work of Papin's seventeen years, in order to attribute the merit of his observations to Dr. Hooke of England. These misstatements and errors have been copied, by professor Millington, Dr. Lardner (the author of the article on Steam Engines in Rees's Cyclopœdia) and the writer of the preceding article, who acknowledges, p. 400, that he also had been led, upon the authority of Dr. Robinson, to do injustice to the genius of Papin, when he had occasion to discuss the subject in another work. He however most unaccountably omits to notice the invention of a Safety Valve by Papin, to be attached to his digester; without which, as Mr. Galloway truly remarks, "steam would 'ere this, long have been abandoned, as a most dangerous and ungovernable agent, and entitles him to universal admiration; since it has contributed more than any single addition or improvement to the maturity of the steam engine."

In the preceding article of the Encyclopedia, no mention is made of American steam-engines, although Dr. Thornton's account of Fitch's early and successful experiments in navigating the Delaware with a steam boat was published in the London Monthly Magazine for October 1815;‡ and the history of Oliver Evans's progressive knowledge of the powers of steam; his various propositions for its use in driving carriages and boats; and the description, with a plate of his Columbian steam engine, was published by Elijah Galloway, in his "History of the Steam Engine," London 1827; a work, by the way, which is overlooked in the reference to those recommended for consultation at the close of the foregoing paper. The great merit of our ingenious countryman Evans, for his numerous mechanical improvements, and for the benefits which he has conferred upon the United States by his steam engine, entitle him to the gratitude of the present and future generations, and to a republication in this work of the record he has left of them.

His inventive genius has done more for the United States than any other, living or dead, and his improvements would have greatly added to the riches of our country, long before they began to operate, had he not been prevented from bringing them into use by his narrow circumstances, and the want of a liberal patron, to enable him to force them on the public, without waiting for the slowly acquired confidence of a people beyond whose intellects, on the subject of steam, he was full half a century in advance.

Evans could not have heard of the first high pressure engine constructed by Leupold the German in 1720, for there was not one in the United States to give him any advice; and it is known, that the work of that mechanician has only been recently introduced into the country by a German artist. The merit of Evans was therefore his own. His claim was for the "application of high elastic steam, the great advantage of which, he says, I had discovered, demonstrated, explained, and made known. I have dispensed with the heavy beam, condenser, and air pump, and simplified

* Franklin Journal, 4 vol. 1829, p. 363.

† In this publication Papin abandoned his cylinder and piston, and proposed another plan, copied unquestionably from Savary, and altered, as is universally admitted (according to Mr. Arago), for the worse.

‡ See p. 258, of this volume.

the construction of the boiler, cylinder, piston, and working gears: my plan requires a small forcing pump to supply the boiler. Thus, I have produced an engine ten times as powerful, more governable, and easier varied to suit any taste assigned to it, than that of Bolton and Watt: it can be constructed at half the price, and will expend only one third the fuel to do as much work as theirs."* His patent was taken out in 1801, one year before the date of Messrs Trevithick's and Vivian's, for a high pressure steam engine in England.

No man can pretend to compete with Evans, except Fulton, and even the wealth produced by his successful use of steam in navigation, cannot exceed that arising from the improvements on milling by Evans. In point of originality there can be no question as to the one to whom the honour is due; for while Fulton was a child, Evans, from the mere force of his genius, after hearing of the immense power of steam exhibited in a boyish frolic, with a gun barrel, followed up the principle, and in 1792 he filed in the patent office drawings and specifications of his principles, with a view to secure to himself at a future time the right to his discoveries, when he should be enabled to put them to the test, and perfect them. Twenty-one years before Fulton applied Bolton and Watts' low pressure engine to boats, he pronounced upon the extensive utility of steam, not only in navigating boats, but in propelling land carriages, and the driving of machinery, and actually demonstrated the truth of his theory in Philadelphia, in respect to the last mentioned object in 1801, and in reference to the two first, he proved it three years before Mr. Fulton had his first boat in operation in the North River, which was in the summer of 1807. Thus, in the opinion of Mr. Galloway the British engineer, "he fully established his claim to the first contrivance of a practicable steam boat."†

About the year 1772, being then an apprentice to a wheel-wright, or wagon-maker, I laboured to discover some means of propelling land carriages, without animal power. All the modes that have since been tried (so far as I have have heard of them) such as wind, treadles with ratched wheels, crank tooth, &c. to be wrought by men, presented themselves to my mind, but were considered as too futile to deserve an experiment; and I concluded that such motion was impossible for want of a suitable original power.

But one of my brothers, on a Christmas evening, informed me that he had that day been in company with a neighbouring blacksmith's boy; who, for amusement, had stopped up the touch-hole of a gun barrel, then put in about a gill of water and rammed down a tight wad—after which they put the breech in the smith's fire; when it discharged itself with as loud a *crack* as if it had been loaded with powder.

It immediately occurred to me that here was the power to propel any wagon, if I could only apply it; and I sat myself to work to find out the means. I laboured for some time without success. At length a book fell into my hands describing the old atmospheric *steam engine.* I was astonished to observe that they had so far erred as to use the steam only to form a vacuum to apply the mere pressure of the atmosphere, instead of applying the elastic power of the steam for original motion; the power of which I supposed irresistible.

I renewed my studies with increased ardour, and soon declared that I could make *steam wagons*, and endeavoured to communicate my ideas to others; but however practicable the thing appeared to me, my object only excited the ridicule of those to whom it was made known. But I persevered in my belief, and confirmed it by experiments that satisfied me of its reality.

In the year 1786 I petitioned the legislature of Pennsylvania for the exclusive right to use my improvements in flour mills, as also *steam wagons, in that state.* The committee to whom the petition was referred heard me very patiently while I described the *mill* improvements, but my representations concerning *steam wagons* made them think me insane. They, however, reported favourably respecting my improvements in the manufacture of flour, and passed an act granting me the exclusive use of them as prayed for. This act is dated March ——, 1787. But no notice is taken of the steam wagons.

A similar petition was also presented to the legislature of Maryland. Mr. Jesse Hollingsworth, from Baltimore, was one of the committee appointed to hear me, and report on the case. I candidly informed this committee of the fate of my application to the legislature of Pennsylvania, respecting the steam wagons—declaring at the same time, without the encouragement prayed for, I would never attempt to make them; but that, if they would secure to me the right as requested, I would, as soon as I could, apply the principle to practice; and I explained to them the great elastic power of steam, as well as my mode of applying it to propel wagons. Mr. Hollingsworth very prudently observed, that the grant could injure no one, for he did not think that any man in the world had thought of such a thing before: he therefore wished the encouragement might be afforded, as there was a prospect that it would produce something useful. This kind of argument had the desired effect, and a favourable report was made, May 21, 1787, granting to me, my heirs and assigns, for 14 years, the exclusive right to make and use my improvements in flour mills and the steam wagons, in that state. From that period I have felt myself bound in honour to the state of Maryland to produce a steam wagon, as soon as I could conveniently do it.

In the year 1789, I paid a visit to Benjamin Chandlee and sons, of Nottingham, Chester county, Pennsylvania, clock-makers, men celebrated for their ingenuity, with a view to induce them to join me in the expense and profits of the project. I showed to them my draughts, with the plan, of the engine, and explained the expansive power of steam; all which they appeared to understand, but fearful of the expense and difficulties attending it, declined the concern. However they certified that I had shown to them the drawings and explained the powers, &c.

In the same year, I went to Ellicott's mills on the

* Steam Engineer's Guide, p. 173.

† During this application to the legislature of Maryland, while Mr. Evans was explaining the principles of his intentions to several gentlemen, a person present asked him "how he could get out of the way of other wagons?" Mr. E. replied, "why sir, if you were the wagoner, and did not give me room to pass, I would crush you and your wagon to the earth," which so completely turned the laugh, that the would-be-wag was silent afterwards.—*Patent Right Oppression Exposed, Philadelphia*, 1813, p. 26.

Patapsco, near Baltimore, for the purpose of persuading Messrs. Jonathan Ellicott and brothers, and connections (who were equally famous for their ingenuity) to join me in the expense and profits of making and using steam wagons. I also showed to them my drawings, and minutely explained to them the powers of steam. They appeared fully to comprehend all I said, and in return informed me of some experiments they themselves had made, one of which they showed me. They placed a gun-barrel, having a hollow arm, with a small hole on one side at the end of the arm, similar to Barker's rotary tube-mill, as described in the books; a gill of water put into this barrel, with fire applied to the breech, caused the steam to issue from the end of the arm with such force as, by re-action, to cause the machine to revolve, as I judged, about one thousand times in a minute, for the space of about five minutes, and with considerable force, for so small a machine. I tarried here two days (May 10 and 11, 1789) using my best efforts to convince them of the possibility and practicability of propelling wagons, on good turnpike roads, by the great elastic power of steam. But they also feared the expense and difficulty of the execution, and declined the proposition. Yet they heartily esteemed my improvements in the manufacture of flour, and adopted them in their mills, as well as recommended them to others.

In the same year I communicated my project and explained my principles to Levi Hollingsworth.* He appeared to understand them; but declined a partnership in the scheme, for the same reasons as the former.

From the time of my discovering the principles and the means of applying them, I often endeavoured to communicate them to those I believed might be interested in their application to wagons or boats. But very few could understand my explanations, and I could find no one willing to risque the expense of the experiment.

In the year 1785 or 6, before I had petitioned the legislatures, I fell in company with Mr. Samuel Jackson, of Redstone; and learning of him that he resided on the western waters, I endeavoured to impress upon his mind the great utility and high importance of *steam boats*, to be propelled on them; telling him that I had discovered a steam engine so powerful, according to its weight, that it would, by means of *paddle wheels* (which I described to him) readily drive a vessel against the current of those waters with so great speed as to be highly beneficial. Mr. Jackson proves that he understood me well, for he has lately written letters, declaring that about twenty-six years before their date, I did describe to him the principles of the steam engine that I have since put into operation to drive mills, which he has seen—and that I also explained to him my plan for propelling boats by my steam engine, with *paddle wheels*, describing the very kind of wheels now used for this purpose; and that I then declared to him my intention to apply my engine to this particular object, as soon as my pecuniary circumstances would permit.

In the year 1800 or 1801, never having found a man willing to contribute to the expense, or even to encourage me to risque it myself, it occurred to me that though I was then in full health, I might be suddenly carried off by the yellow fever, that had so often visited our city (Philadelphia), or by some other disease or casualty to which all are liable, and that I had not yet discharged my debt of honour to the state of Maryland by producing the steam wagon. I determined, therefore, to set to work the next day and construct one. I first waited upon Mr. Robert Patterson, professor of mathematics in the university of Pennsylvania, and explained to him my principles, as I also did to Mr. Charles Taylor, steam engineer, from England. They both declared these principles to be new to them, and highly worthy of a fair experiment, advising me without delay to prove them; in hopes I might produce a more simple, cheap and powerful steam engine than any in use. These were the only persons who had such confidence, or afforded me such advice. I also communicated my plans to B. H. Latrobe, at the same time, who publicly pronounced them chimerical, and attempted to demonstrate the absurdity of my principles, in his report to the *American Philosophical Society* on steam engines;† in which same report he also attempts to show the impossibility of making steam boats useful, on account of the weight of the engine; and I was one of the persons alluded to, as being seized with the *steam mania*, conceiving that wagons and boats could be propelled by steam engines. The liberality of the members of the society caused them to reject that part of his report which he designed as demonstrative of the absurdity of my principles; saying they had no right to set up their opinion as a stumbling block in the road of any exertions to make a discovery. They said, I might produce something useful, and ordered it to be stricken out. What a pity they did not also reject his demonstrations respecting steam boats! for notwithstanding them, they have run, are now running, and will run: so has my engine, and all its principles completely succeeded—and *so will land carriages as soon as these principles are applied to them, as explained to the legislature of Maryland in* 1787, *and to others long before.*

In consequence of the determination above alluded to, I hired hands and went to work to make a steam wagon, and had made considerable progress in the undertaking, when the thought struck me that as my steam engine was entirely different in form as well as in its principles from all others in use, that I could get a patent for it, and apply it to mills more profitably than to wagons; for until now I apprehended that as steam mills had been used in England, I could only obtain a patent for wagons and boats. I stopped the work immediately, and discharged my hands, until I could arrange my engine for mills, laying aside the steam wagon for a time of more leisure.

Two weeks afterwards, I commenced the construction of a small engine for a mill to grind plaister of Paris—the cylinder six inches in diameter, and stroke

* I certify that OLIVER EVANS did about the year 1789 communicate a project to me, of propelling land carriages by power of steam, and did solicit me to join him in the costs and profits of the same. LEVI HOLLINGSWORTH.
Baltimore, November 16, 1812.

I do certify that some time about the year 1781, 31 years ago, OLIVER EVANS, in conversation with me, declared, that by the power of steam he could drive any thing—wagons, mills or vessels forward, by the same power, &c. ENOCH ANDERSON.
November 15, 1812.

† Mr. Latrobe's paper is in the 6th Vol. of the Society's Transactions, page 89.

of the piston eighteen inches—believing that with $1000 I could fully try the experiment. But before I was done with experiments, I found that I had expended $3,700—all that I could command. I had now to begin the world anew at the age of forty-eight, with a large family to support. I had calculated that if I failed in my experiment, the credit I had would be entirely lost; and without money or credit, at my advanced age, with many heavy encumbrances, my way through life appeared dark and gloomy indeed. But I succeeded perfectly with my little engine, and preserved my credit. I could break and grind 300 bushels of plaister of Paris, or 12 tons, in 24 hours; and to show its operations more fully to the public, I applied it to saw stone in Market-street, where the driving of twelve saws, in heavy frames, sawing at the rate of 100 feet of marble stone in 12 hours, made a great show, and excited much attention. I thought this was sufficient to convince the thousands of spectators of the utility of my discovery: but I frequently heard them inquire if the power could be applied to saw timber as well as stone, to grind grain, propel boats, &c. and though I answered in the affirmative, I found they still doubted. I therefore determined to apply my engine to all new uses, to introduce it and them to the public.*

This experiment completely tested the correctness of my principles, according to my most sanguine hopes. The power of my engine rises in a geometrical proportion, while the consumption of fuel has only an arithmetical ratio; in such proportion that every time I added one fourth more to the consumption of fuel, the powers of the engine were doubled; and that twice the quantity of fuel required to drive one saw would drive 16 saws, at least; for when I drove two saws the consumption was 8 bushels [coal] in 12 hours, but, when twelve saws were driven, the consumption was not more than 10 bushels; so that the more we resist the steam the greater is the effect of the engine. On these principles, very light, but powerful engines, can be made, suitable for propelling boats and land carriages, without the great incumbrance of their own weight, as mentioned in Mr. Latrobe's demonstrations.

In the year 1804. I constructed at my works, situate a mile and a half from the water, by order of the board of health of the city of Philadelphia, a machine for cleansing docks. It consisted of a large flatt, or scow, with a steam engine of the power of five horses on board, to work machinery to raise the mud into flatts. This was a fine opportunity to show the public that my engine could propel both land and water carriages, and I resolved to do it. When the work was finished, I put wheels under it, and though it was equal in weight to *two hundred barrels of flour*, and the wheels fixed with wooden axletrees, for this temporary purpose, in a very rough manner, and with great friction, of course, yet with this small engine I transported my great burthen to the Schuylkill with ease; and, when it was launched in the water, I fixed a paddle wheel at the stern, and drove it down the Schuylkill to the Delaware, and up the Delaware to the city [14 or 15 miles, leaving all the vessels going up, behind me, at least half way, the wind being a-head, and in the presence of thousands of spectators, a sight which I suppose would have convinced them of the practicability of both steam carriages and steam boats. But in this I was sadly disappointed, for they made no allowance for the disproportion of the engine to its great load, nor for the temporary manner in which the machinery was fixed, nor the great friction, ill form of the boat, &c., but supposed that it was the utmost I could do. Had I been patronised as Mr. Fulton was by the state of New-York, with the exclusive right for thirty years, and by a Mr. Livingston, with thirty thousand dollars to make the experiment, I might have showed steam boats in full operation long before Mr. Fulton began his boat, which was finished in 1807, twenty years after I petitioned the legislature of Pennsylvania, and three years after the above mentioned experiment.]†

Some wise men undertook to ridicule my experiment of propelling this great weight on land, because the motion was too slow to be useful. I silenced them by answering, that I would make a carriage, to be propelled by steam, for a bet of $3000, to run upon a level road against the swiftest horse they would produce. *I was then as confident, as I am now, that such velocity could be given to carriages.*

Having no doubt of the great utility of steam carriages on good turnpike roads, with proper arrangements for supplying them with water and fuel, and believing that all turnpike companies were deeply interested in putting them into operation, because they would smooth and mend the roads, instead of injuring them, as the narrow wheels do, on the 26th of September 1804, I submitted to the consideration of the Lancaster turnpike company, a statement of the costs and profits of a steam carriage to carry 100 barrels of flour, 50 miles in 24 hours—tending to show, that one such steam carriage would make more nett profits than 10 wagons drawn by five horses each, on a good turnpike road, and offering to build such a carriage at a very low price. My address closed as follows:

"It is too much for an individual to put in operation every improvement which he may invent.

"I have no doubt but that my engines will propel boats against the current of the Mississippi, and WAGONS ON TURNPIKE ROADS, WITH GREAT PROFIT. I now call upon those, whose interest it is, to carry this invention into effect. All which is respectfully submitted for your consideration."

In the year 1805 I published a book‡ describing the principles of my steam engine, with directions for working it, when applied to propel boats against the current of the Mississippi, and carriages on turnpike roads. And I am still willing to make a steam carriage that will run 15 miles an hour, on good level

* While Mr. Evans was exhibiting the little steam engine, he discovered the chairman of the committee of the Pennsylvania legislature, to whom his petition had been referred in 1786, and thus addressed him. "Sir, this steam engine works on the principles with which I had intended to propel my steam carriages when I petitioned the legislature, and which I endeavoured to explain to the committee. If you had granted me then the exclusive right for twenty-five years, it might have been driving wagons, boats, and mills, many years ago." His reply was "to tell the truth, Mr. Evans, we thought you were deranged, when you spoke of making steam wagons."

† Patent Right Oppression Exposed, p. 168. Philadelphia, 1813.

‡ Steam Engineer's Guide.

rail ways, on condition that I have double price if it shall run with that velocity, and nothing for it, if it shall not come up to that velocity. What can an inventor do more than to insure the performance of his inventions? Or, I will make the engine and apparatus, at a fair price, and *warrant* its utility for the purpose of conveying heavy burthens on good turnpike roads.

I feel it just to declare that, with Mr. Latrobe, I myself did believe, that with the ponderous and feeble steam engine, now used in boats, they could never be made useful in competition with sail boats, or to ascend the Mississippi, esteeming the current more powerful than it is. But I rejoice that, with him I have been mistaken; for I have lived to see boats succeed well with those engines; and I still hope to see them so completely excelled and out-run by using my engines, as to induce the proprietors to exchange the old for the new; more cheap and more powerful principles.

When we reflect upon the obstinate opposition that has been made by a great majority to every step towards improvement; from bad roads to turnpikes, from turnpikes to canals, from canals to rail-ways for horse carriages, it is too much to expect the monstrous leap from bad roads to rail-ways for steam carriages, at once. One step in a generation is all that we can hope for. If the present shall adopt canals, the next may try the rail-ways with horses, and the third generation use the steam carriages.

But why may not the present generation, who have already good turnpikes, make the experiment of using steam carriages upon them? They will assuredly effect the movement of heavy burthens, with a slow motion, of two and a half miles an hour; and as their progress need not be interrupted, they may travel fifty or sixty miles in the 24 hours. This is all that I hope to see in my time, and though I never expect to be concerned in any business requiring the regular transportation of heavy burthens (on land), because if I am connected in the affairs of a mill it shall be driven by steam, and placed on some navigable water, to save land carriage---yet I certainly intend, as soon as I can make it convenient, to build a steam carriage that will run on good turnpike roads, on my own account, if no other person will engage in it; and I do verily believe that the time will come when carriages propelled by steam will be in *general use*, as well for the transportation of passengers as goods, travelling at the rate of fifteen miles an hour, or 300 miles per day.

It appears necessary to give the reader some idea of the principles of the steam engine which is to produce such novel and strange effects; and this I will endeavour to do in as few words as I can, by showing the extent to which the principles are applied already.

To make steam as irresistible or powerful as gunpowder, we have only to confine and increase the heat by fuel to the boiler. A steam engine with a working cylinder only nine inches in diameter, and a stroke of the piston three feet, will exert a power sufficient to lift from 3,000 to 10,000 pounds perpendicularly, two and a half miles per hour. This power applied to propel a carriage on level roads or rail-ways, would drive a very great weight with much velocity, before the friction of the axletree or resistance of the atmosphere would balance it.

This is not speculative theory. The principles are now in practice, driving a saw-mill at Manchacks on the Mississippi; two at Natchez, one of which is capable of sawing 5000 feet of boards in 12 hours; a mill at Pittsburgh, able to grind 20 bushels of grain per hour; one at Marietta of equal powers; one at Lexington, Ky. of the same powers; one, a paper mill, of the same; one of one fourth the power at Pittsburgh; one at the same place of three and a half times the power, for the forge, and for rolling and splitting sheet iron: one of the power of 24 horses at Middletown, Conn. driving the machinery of a cloth manufactory; two at Philadelphia of the power of five or six horses; and many making for different purposes: the principles applying to all purposes where power is wanted.

OLIVER EVANS.

Nov. 13, 1812.

Columbian Steam Engine.

EXPLANATION.---Plate 510. No. 2.

A, the boiler; B, the working cylinder; C, the lever beam; D, the fly-wheel; E, the condenser; F, the water-pump; G, the supply pump; H, the furnace; I, the chimney flue; K, the safety-valve, which may be loaded with 100 or 150 *lbs.* to the inch area; it will never need more, and it must never be fastened down.

OPERATION.

The boiler being filled with pure water as high as the dotted line, and the fire applied, the smoke enters the centre flue, which passes through the centre of the water to ascend the flue I, and thus acts on a large surface.

When the steam lifts the safety-valve, it is then let into the cylinder by opening the throttle-valve, to drive the piston up and down, which, by rod 1, gives motion to the fly-wheel, and wheel 2 gives motion to a shaft, passing through the posts, to turn the spindle of the rotary-valves 3, 8, which lets the steam both off and on the cylinder at the proper time.

The steam escaping by pipe 4, curved and immersed in the water in box E, which is supplied by pump F, it is condensed, and the water formed descends by pipe 5 into supply pump G, and is forced into the boiler again by pipe 6.

But boiling decomposes water, slowly changing it into air incondensible. Therefore the shifting valve 7 is necessary. This valve lifts at every puff of steam, and a small quantity of air escapes; and it shuts, and a vacuum is instantly formed, as the crank passes the dead points.

The small waste of water may be supplied by condensing part of the steam rising from the condensing water, to run down the pipe 9, through a hole in the key of a stop-cock, $\frac{1}{32}$ parts of an inch diameter. A small hole indeed to supply a boiler of twenty horses power.

No sediment can accumulate in the boiler, it being supplied by distilled water. Therefore it will last much longer, and require less fuel than others. Muddy, limestone, or salt water, or the juice of the sugar cane, &c. &c. may be used to condense; and as the engine works equally well while we boil away the condensing water, we may boil for salt, sugar, &c. in working the engine,—thus using the fuel for double purposes.

If the steam be confined by the load on the safety-valve, to raise its power to 100 pounds to the inch, area of the piston and the cylinder be nine inches in diameter, and the stroke of the piston three feet, the power will equal that of twenty horses, and will grind 20 bushels of grain per hour, or saw 5,000 feet of boards in 12 hours. If the steam be confined by 150 pounds, the power of the engine will be equal to 30 horses, when the steam is shut off at one third of the stroke, and striking thirty-six strokes per minute.---Double strokes double the power.

The more the steam is confined, and the shorter it be shut off by the regulator 8, the greater will be the power obtained by the fuel. For every addition of 30 degrees heat to the water doubles the power. So that doubling the heat of the water increases the power about 100 times. On these principles fuel may be lessened to one third part consumed by other engines. This engine is not more than one fourth the weight of others; is more simple, durable, and cheap, and more suitable for every purpose; especially for propelling boats and LAND CARRIAGES. It requires no more water than the fuel will evaporate in steam, and this steam may be employed to warm the apartments of factories; or the condenser E could be used as a still to distil spirits; or a vat for paper making, boiler in a brewery, dye factory, &c. &c.

To the preceding account of Mr. Evans, the following may be added, taken from the preface to "the Steam Engineer's Guide."

In the year 1787, Mr. Evans explained to Captain Masters at Annapolis, Maryland, at his request, the principles of his Columbian Steam Engine, that he might communicate them to the people of England, to propel carriages and boats: and in 1794 or 1795, he sent drawings and descriptions to England by Joseph Stacey Sampson, of Boston, to endeavour to get some one to take out a patent there on shares with him; but he wrote from London that he could find no one to believe that the scheme would prove useful. Mr. Sampson died in London. In 1803 he entered into a contract with Mr. Edwards, engineer from England, and spent two months in furnishing him with complete drawings and descriptions of his engine, inexhaustible steam engine, and volcanic steam engine, all of which he said he could set up with his own hands. His Columbian high pressure engine was erected in Philadelphia in 1801, and in 1802 Messrs. Trevethick and Vivian took out their patent in England for a high pressure engine, which Mr. Galloway says, "has been found the most compact, simple, and effective engine perhaps ever known."

The following handbill was published by Mr Evans as a circular, and it will be useful to insert it on the present occasion. He may unduly estimate the economy of his engine, but if he is wrong, as much may be said for several philosophers who have undertaken to give tables of the expansive power of steam, no two of whom agree as to the results of their experiments or calculations.

Philadelphia, October 28th, 1817.

The subscriber continues to manufacture his Columbian Steam Engines, containing the following peculiar properties: viz.

1. It operates on the great advantageous principle of nature. As the heat is increased arithmetically, the elastic power of the steam is increased geometrically; every addition of about thirty degrees heat in water doubles the elastic power of the steam. Or, in other words, very little increase of heat produces great increase of power; doubling the consumption of fuel in a given time, produces about sixteen times the power and effect in the same engine. Thus it enables the small, simple and light steam engine, to do work equal to the large, complex, expensive and ponderous one, with about half the consumption of fuel.

2. It is constructed on the true principles of nature. All its parts are of a circular form, that cannot be bent and changed so as to break and explode, by the elastic power. It will therefore bear greater elastic power than boilers of other forms, in the proportion that a bar of iron will bear more pulling straight endwise, than it will on its middle, to bend and break it, when laid horizontally, supported at the ends; above one hundred times the power that any other form will bear.

3. The boiler being constructed of sheets rivetted together, of circular forms, it is impossible to make every part of equal strength. And the pressure of the steam, acting equally on every part, the weakest part will yield first, by a very small opening, to let the power of the steam or water escape, which will extinguish or check the fire, and stop all danger. It is therefore impossible to explode the boiler in so dangerous a degree as others do, by bending and breaking, in changing their form to a circle, by the elastic power of steam, which rises gradually.

4. The greater the elastic power, and the hotter the water in the boiler, the less will be its heat at the small distance of two or three feet, issuing from one of these small apertures, that will first yield; because the very instant it issues, the elastic power in the hot water explodes, and disperses the steam in mist so thin, and mixing with the air, that it instantly gives out its heat, and is reduced below the scalding degree, at the distance of three feet.* No injury has been done in any of the numerous instances where such leaks have yielded, in boilers worn by use, or burnt out; yielding so often that new ones have been made. Nor need any danger be apprehended, as it is evident that the boiler cannot be exploded.

5. It requires no more water than is boiled into steam. And the boiler may be made inexhaustible, by letting the steam that escapes from the engine pass into a tight vessel; there to be condensed into water again, by its own pressure, and the water may be returned to the boiler to supply it. This vessel may be a tight tube, passing through all the apartments of a manufactory to warm them, or to heat water. And thus the fuel may be applied to double purpose in many instances.

6. The boiler generates more steam than others, being so formed, that sediment does not adhere to its bottom, to form a non-conductor, and cause it to burn out; and it is well planned to receive the heat and retain it in the water, until a great elastic power is obtained.

7. It is less complex, and more easily kept in order, repaired, understood, and attended.

Those who may want a steam engine for any use,

* This may be tried and proved, by opening the water-guage cock.

are not expected to believe implicitly, but are requested to hold in suspense, *assertions* made by persons ignorant of the principles and properties of the engine, until they inquire for themselves, respecting some of the many Columbian Steam Engines now in use; or visit one personally, and they will find it to contain all those properties; and to be preferable for the following purposes; viz.

Steam Boats. It being lighter, more powerful, more governable; to vary the power, to stem the various currents, consuming and carrying less fuel and water; will carry *more* freight or passengers; and ascend currents, or perform any passage in *less* time.

And for salt or turbid waters, such as bays, and the Mississippi, the inexhaustible principle may be used; the boiler may be filled with pure fresh water, and a pure supply be obtained from steam, arising from the salt or turbid water used outside, to condense the steam in the tight vessel. Iron boilers will then suit better than copper, and there will be no danger from explosion, nor of being scalded by the small leaks.

The difference in the expense of fuel, of the profits of passengers, freight and time, will amount annually, to more than the whole price and expense of the engine, on many waters, or for many purposes.

Manufactories. As the steam may be applied to heat the water, and to warm all the apartments.

Paper Mills. The steam may be applied to heat the vats, and warm the drying rooms.

Saw or *Grinding Mills*, *Furnaces*, or *Forges*. As so little water is necessary, that it can be set at the ore banks, or in any convenient place, where a well can be had.

For every other purpose where power may be wanted, there is a difference between this and the low pressure engines, equal to its full price, in a few years use.

Several persons have begun to infringe my rights, having found that what I had published was true; viz. That as the elastic power of steam should be increased, the power of the engine and speed of the boat would be increased, without a proportionate increase of the consumption of fuel.

Some construct and use my specified boiler, in whole, or in part, by using high pressure steam to a condensing engine, to evade my rights. *Others have constructed boilers of different forms*, which they believed to be equally safe and strong: and attempting to use high pressure steam, until they exploded their boilers; neither of which can succeed perfectly. And they unitedly proclaimed, that it was the invention of high pressure, which caused the injury; to my very great damage, by depriving me of the profits of my invention, and to the injury of the public, by depriving people of the benefits of the useful discovery. And I am constrained to put the engine of the patent laws of the United States in force and motion, which will probably overtake them.

OLIVER EVANS.

It would be unpardonable to omit noticing the steam engine of our ingenious countryman Jacob Perkins, which has excited so much interest in London. "Mr P.'s original idea of substituting pressure for surface, in generating steam (which appears to be the basis of his invention) if satisfactorily established, must certainly be considered as of the utmost importance, particularly in its first feature, *absolute safety.* From the mode of constructing the compound generator (of steam) as now adopted, it becomes a safety valve of itself: for the pressure is divided into so many compartments, that any one of them may explode with impunity, without even disturbing a brick of the furnace."* Mr. Perkins says "the piston was 8 inches in diameter, with a 20 inch stroke engine, a good 70 horse power, and consuming but one fourth of the coal of a condensing engine. The weight on the end of the lever was 300*lbs.* To prove the safety of the engine, he says, he has worked it under a pressure of 1400*lbs.* to the square inch, or at 100 atmospheres, and cut off the steam at one twelfth of the stroke. The usual pressure is 800*lbs.* per inch, cutting off at one eighth, and letting the steam expand to below 100*lbs.* per inch. He lets off at the dead point, at one flash." As this engine has not yet been introduced into practice by any one except the inventor, those who are desirous of a more full account of it are referred to the Franklin Journal, Vol. III. pp. 354, 407; to Galloway on Steam Engines, p. 185; Silliman's Journal, Vol. VII. The two last contain plates of the engine, and in Silliman is an account of the application of Mr. P.'s invention to engines of the old construction.

* Remarks of the editor of the London Journal of Arts.

STEAM-BOAT.

The subject of steam-boats has already been so amply treated in a separate chapter of our article Shipbuilding, in p. 244* of this volume, that very little remains to be done under the present head.

The action of impelling boats by mechanical power was suggested and put in motion more than three centuries ago;† but the proposal to employ steam as the first mover of vessels was first made by Mr. Jonathan Hulls in the year 1736, as we have already stated in the article Shipbuilding. The contrivance by which he proposed to produce this effect is shown in Plate DX. Fig. 1, which the author describes in the following words.

"Whereas several persons concerned in navigation, have desired some account of my invention for carrying ships out of and into harbours, ports and rivers, when they have not a fair wind;

But I could not fully describe this *machine*, without writing a small treatise of the same, in which I shall endeavour to demonstrate the possibility and probability of the matter undertaken.

There is one great hardship lies too commonly upon those who propose to advance some new, though useful, scheme for the public benefit; the world abounding more in rash censure than in a candid and unprejudiced estimation of things, if a person does not answer their expectation in every point; instead of friendly treatment for his good intentions, he too often meets with ridicule and contempt.

But I hope that this will not be my case; but that they will form a judgment of my present undertaking only from trial. If it should be said, that I have filled this tract with things that are foreign to the matter proposed, I answer, there is nothing in it but what is necessary to be understood by those that desire to know the nature of that machine which I now offer to the world: *and I hope that, through the blessing of God, it may prove serviceable to my country*.

In some convenient part of the tow-boat, there is placed a vessel about two-thirds full of water, with the top close shut. This vessel being kept boiling, rarifies the water into steam. This steam being conveyed through a large pipe into a cylindrical vessel, and there condensed, makes a vacuum, which causes the weight of the atmosphere to press on this vessel, and so presses down a piston that is fitted into the cylindrical vessel, in the same manner as in Mr. Newcomen's engine, with which he raises the water by fire.

In Plate DX. Fig. 2, *P* is a pipe coming from the furnace to the cylinder. *Q* the cylinder wherein the steam is condensed. *R* the valve that stops the steam from coming into the cylinder, whilst the steam within the same is condensed. *S* the pipe to convey the condensing water into the cylinder. *T* a cock to let in the condensing water when the cylinder is full of steam and the valve *p* is shut. *U* a rope fixed to the piston that slides up and down the cylinder. *Note.*—This rope *U*, is the same rope that goes round the wheel *D* in the machine, fig. 1.

It hath been already demonstrated, that a vessel of 30 inches diameter, which is but two foot and a half, when the air is driven out, the atmosphere will press on it to the weight of 4 tons 16 hundred and upwards. When proper instruments for this work are applied to it, it must drive a vessel with a great force.

Note.—The bigness of the machines may be proportioned to the work that is to be performed by them; but if such a force as is applied in this first essay, be not sufficient for any purpose that may be required, there is room to make such addition as will move an immense weight with tolerable swiftness.

It is my opinion, it will not be found practicable to place the machine here recommended, in the vessel itself that is to be taken in or out of the port, &c. but rather in a separate vessel, for these reasons: 1. This machine may be thought cumbersome, and to take up too much room in a vessel laden with goods, provisions, &c. 2. If this machine is put in a separate vessel, this vessel may lie at any port, &c. to be ready on all occasions. 3. A vessel of a small burthen will be sufficient to carry the machine to take out a large one. 4. A vessel will serve for this purpose for many years, after she is thrown off, and not safe to be taken far abroad.

The Explanation of the Machine. (See Plate DX. Fig. 2.)

A, Represents the chimney coming from the furnace.

B, The tow-boat.

C C, Two pieces of timber, framed together, to carry the machine.

D a, *D* and *D b*, are three wheels on one axis to receive the ropes, *M F b* and *F a*.

H a and *H b* are two wheels on the same axis with the fans *I I I I I*, and move alternately in such a manner, that when the wheels, *Da*, *D* and *Db* move backward or forward, they keep the fans *I I I I I* in a direct motion.

Fb is a rope going from *Hb* to *Db*, that when the wheels *Da*, *D* and *Db* move forward, moves the wheel *Hb* forwards, which brings the fans forward with it.

Fa is a rope going from the wheel *Ha* to the wheel *Da*, that when the wheels *Da*, *D* and *Db* move forward, the wheel *Ha* draws the rope *F*, and raises the weight *G*, at the same time as the wheel *Hb* brings the fans forward.

When the weight *G* is so raised, while the wheels *Da*, *D* and *Db* are moving backward, the rope *Fa* gives way, and the power of the weight *G* brings the wheel *Ha* forward, and the fans with it, so that the fans always keep going forward, notwithstanding the wheels *Da*, *D* and *Db* move backwards and forwards, as the piston moves up and down in the cylinder.

LL, are teeth for a catch to drop in from the axis, and are so contrived, that they catch in an alternate manner, to cause the fans to move always forward, for the wheel *Ha* by the power of the weight *G*, is performing its office, while the other wheel *Hb* goes back, in order to fetch another stroke.

Note.—The weight *G* must contain but half the weight of pillar of air pressing on the piston, because the weight *G* is raised at the same time as the wheel *Hb* performs its office, so that it is in effect two ma-

* See also Navigation, Inland, Vol. XIV p. 416.

† See Robertus Valturius *De Re Militari*. Verona, 1472.

chines, acting alternately by the weight of one pillar of air of such a diameter as the diameter of the *cylinder* is.

If it should be said that this is not a new invention, because I make use of the same power to drive my machine that others have made use of to drive theirs for other purposes. I answer, the application of this power is no more than the application of any common or known instrument used in mechanism, for new invented purposes.

Answers to some Queries that have been made, concerning the Possibility and Usefulness of this undertaking.

Query I.—*Is it possible to fix instruments of sufficient Strength to move so prodigious a Weight as may be contained in a very large Vessel?*

"*Answer.*—All mechanics will allow it is possible to make a machine to move an immense weight, if there is force enough to drive the same; for every member must be made in a proportionable strength to the intended work, and properly braced with laces of iron, &c. so that no part can give way or break. If the braces, &c. necessary for this work, had been put in the draught, it would have been so much crowded with lines, that the main instruments could not be so well perceived.

Query II.—*Will not the force of the waves break any instrument to pieces that is placed to move in the water?*

Answer.—1*st*, It cannot be supposed that this machine will be used in a storm or tempest at sea, when the waves are very raging; for if a merchant lieth in harbour, &c. he would not choose to put out to sea in a storm if it were possible to get out, but rather stay until it abated.

2*dly*, When the wind comes a-head of the tow-boat, the fans will be protected by it from the violence of the waves; and when the wind comes sideways, the waves will come edgeways of the fans, and therefore strike them with the less force.

3*dly*, There may be pieces of timber laid to swim on the surface of the water on each side of the fans, and so contrived as they shall not touch them, which will protect them from the force of the waves.

Up inland rivers, where the bottom can possibly be reached, the fans may be taken out, and cranks placed at the hindmost axis to strike a shaft to the bottom of the river, which will drive the vessel forward with the greater force.

Query III.—*It being a continual expense to keep this machine at work, will the expense be answered?*

Answer.—The work to be done by this machine will be upon particular occasions, when all other means yet found out are wholly insufficient. How often does a merchant wish that his ship were on the ocean, when, if he were there, the wind would serve tolerably well to carry him on his intended voyage, but does not serve, at the same time, to carry him out of the river, &c. he happens to be in, which a few hour's work of this machine would do. Besides, I know engines that are driven by the same power as this is, where materials for the purpose are dearer than in any navigable river in England; therefore, experience demonstrates, that the expense will be but a trifle to the value of the work performed by those sort of machines, which any person that knows the nature of those things may easily calculate.

Thus, I have endeavoured to give a clear and satisfactory account of my new invented machine, for carrying vessels out of and into any port, harbour, or river, against wind and tide, or in a calm; and I doubt not, but whoever shall give himself the trouble to peruse this essay, will be so candid as to excuse or overlook any imperfections in the diction or manner of writing, considering the hand it comes from; if what I have imagined, may only appear as plain to others as it has done to me, viz. that the scheme I now offer is practicable, and, if encouraged, will be useful. J. H."

The contrivance for converting the reciprocating motion of the piston into a rotatory motion, which does great credit to the ingenuity of Mr. Hulls, will be better understood from the enlarged drawing given in Fig. 3.

Although the invention of this steam-boat was thus distinctly laid before the public, yet it does not seem to have been put in practice till the year 1782, when the Marquis de Jouffroy constructed a steam-boat to ply on the Saone at Lyons. It was 140 feet long 15 feet wide, and drew $3\frac{1}{5}$ feet of water. He seems to have made several experiments with it, and it is said to have been in use fifteen months.*

In 1785, Mr. James Rumsey, of Virginia, and Mr. John Fitch of Philadelphia, made experiments on the propulsion of boats by steam, but though their labours were patronized by General Washington, and though they received patents from some of the States, yet no satisfactory results were obtained.

In the year 1785, Mr. Patrick Miller of Dalswinton, conceived the idea of propelling vessels by paddle wheels driven by men or horses. A twin vessel for this purpose was put on the stocks at Leith on the 7th January 1786, and launched on the 14th October 1787. He published an account of his plans in February 1787, and in that publication he stated that he "had reason to believe that the power of the steam-engine may be applied to work the wheels so as to give them a quicker motion, and to increase that of the ship, and that in the course of the summer of 1787 he intended to make the experiment." The suggestion of applying the steam-engine seems to have been make to Mr. Miller by Mr. Taylor, then living as tutor in his family, and this gentleman also recommended his school-fellow, Mr. William Symington of the Wanlockhead mines, who had recently contrived a method of applying the force of steam to wheel carriages, as a proper person to construct the steam-engine. In the spring of 1788, Mr. Symington began the steam-engine for Mr. Miller, and in October it was placed in a pleasure-boat in the lake of Dalswinton, and on the 14th October 1788, this boat was moved by steam in the presence of several spectators.† After several trials, however, it was found that the engine and wheel, which were of the same description as Hull's, required the aid of manual labour with a windlass. Another experiment was made with a larger engine (constructed at the Carron works,) on board a Gabard, but the machinery does not seem to have answered Mr. Miller's expectations, and all farther trials were discontinued.

* Dictionnaire de Physique, Art. *Chaloupe à Vapeur.*

† Scots Magazine, Nov. 1788.

In 1794 the Earl of Stanhope constructed a steam vessel with paddles below her quarters, but the result of the experiment was not satisfactory.

Lord Dundas, while governor of the Forth and Clyde navigation, employed Mr. Symington to construct a steam-vessel for that canal. An engine with a cylinder of 22 inches was accordingly made, and put on board a boat called the Charlotte Dundas. In March 1802, an experiment was made in presence of Lord Dundas, and his son-in-law, the present Mr. Spiers of Elderslie, and other gentlemen. This steam-boat towed two loaded sloops, the Active and Euphemia, of 70 tons burden each, from Lock No. 20 to Port Dundas, a distance of 19½ miles, in six hours, against a head wind. Some of the canal proprietors, however, were of opinion that the agitation of the water would destroy the banks of the canal, and the boat was laid up in a creek near Bainsford Bridge, where it lay as a wreck for many years.

Hitherto we may safely say that steam navigation had no real existence. Various individuals had proposed it as a national benefit, while others, supported by capital and influence, had entirely failed in all their attempts to reduce their plans to practice. In this state of things Mr. Henry Bell, a house carpenter in Glasgow, who had retired from his profession to the baths of Helensburgh on the Clyde about 1808, after making several experiments on the propulsion of boats by steam, and overcome some of the obstacles which at first beset his progress, employed Messrs. Wood and Co. of Port Glasgow to construct a boat for him on a particular plan. This boat had a 40 feet keel, and was 10½ feet on the beam, having a paddle wheel on each side. Mr. Bell made the steam-engine himself, and having completed his steam-boat in 1811, he gave it the name of the Comet, by which that year was distinguished. In January 1812 this boat began to ply on the Clyde between Glasgow and Greenock, and though the engine was only a three horse power, yet the boat went against a head wind at the rate of five miles an hour, and by merely increasing the power of the engine, her rate was increased to seven miles an hour. It appears from a letter addressed to Mr. Cleland by Mr. James Cooke, steam-engine maker, "that there was very little difference in the principle or construction of the impelling machinery of steam-boats in general use at present (April 4, 1825,) from that applied by Mr. Henry Bell in his steam-boat Comet, erected by him in 1811 or 1812. * * * The best possible proof," he continues, "that I can adduce in support of this observation, is the Glasgow steam-boat, built by Mr. Bell's direction in 1812 or 1813. The engine and impelling machinery were made and put into the vessel by me in 1813 or 1814. The vessel was, I believe, lengthened a little since, to give accommodation; the engine and machinery are still the same, and there are not many boats on the river at this day, that exceed her far in point of speed in still water. I do not recollect now what kind of speed the *Comet* went at, but if it was slow, I am inclined to think the cause of that was the want of a proper proportion betwixt the size of the vessel, and the power of the engine and impelling machinery, and not owing to any defect in the principle or construction of the machinery, those being nearly the same then as at this day."

But though Mr. H. Bell was undoubtedly the first person who introduced steam navigation into Great Britain, we must in justice to our American brethren admit, that this did not take place till four years after steam navigation had been introduced into America. In the month of October 1807, Mr. Robert Fulton of New York launched a steam-boat, which soon after plied with perfect success between New York and Albany, a distance of 160 miles. It is no doubt true that Mr. Fulton, when in England, derived great information from Mr. Symington, and afterwards received plans from Mr. Henry Bell, but this can never diminish his merit, or deprive him of the high honour of being the first individual who saw the vast importance of steam navigation to his country, and who collected all the information which he could procure, and, aided by his own original powers, at last triumphed over every difficulty, by constructing the first steam vessel that sailed upon the deep. Fulton was honoured and rewarded by a grateful country; but Henry Bell, a subject of Great Britain, the land ever famed for its science and its arts, and still the mistress of the ocean—has been allowed to spend his old age unhonoured and unrewarded.*

The history of steam navigation in America and in England has been so fully detailed in our article SHIPBUILDING, that it is unnecessary to pursue it any farther at present. The steam-boat has crossed the Atlantic, and has forced its way even to our territories in the East, where its utility has been recognised in the enterprises both of peace and of war.

The following table given by Captain Ross will convey an idea of the comparative lengths of voyages made in steam boats and sailing vessels.

	Steam Vessels.	Sailing Vessels.	Distance.
From Holyhead to Dublin,	8 hrs	70 hrs	55 miles.
Portpatrick to Donaghadee,	3	8	19½
† London to Leith,	55	5 days	429
London to Dublin,	84	16	610
Dublin to Liverpool,	14	36 hrs	131
‡ Greenock to Liverpool,	24	3 days	224
London Bridge to Calais,	12	36 hrs	120
London to Margate,	8	20	84
—— Plymouth, -	38	10 days	315
—— Belfast, -	110	18	725
—— Ostend, -	12	21 hrs	90
—— Texel, -	22	54	170
—— Scarborough,	25	68	255
—— Portsmouth, -	29	8 days	255
—— Hull, -	23	50 hrs	215
Brighton to Dieppe,	9	30	73
Southampton to Havre,	18	36	120
—— Guernsey, -	16	37	25
Milford to Waterford,	11	25	81
Greenock to Belfast,	13	30	90
—— Glasgow, *up*,	3	12	} 24
—————— *down*,	2½	6	}
—— Dublin, . -	25	52	200
—— Ayr, - -	6	12	48

* The Town of Glasgow, by an act of well judged liberality, saved this meritorious individual from poverty by settling upon him a small annuity.

† This voyage was once performed by the United Kingdom in 42 hours.

‡ This voyage was once made by the Majestic in 21 hours, including 1 hour's delay at the Isle of Man.

From Greenock to Largo,	2 hrs	4 hrs	18 miles.
—— Port Patrick, -	9	20	90
—— Isle of Man, -	18	40	135
—— Campbelltown,	16	18	67
Edinburgh to Aberdeen,	12	25	90
——— Stirling, -	4	8	36
Harwich to Helvoetsluys,	13	28	90

Having thus given a general and brief sketch of the progress of steam navigation, we shall proceed to describe the construction of a steam ship, and of the engine by which it is propelled.

The external form of a steam boat is shown in Plate DX. Fig. 4; and Fig. 5 represents the section of the two engines in the Royal George steam ship, as executed by Mr. Gutzmer, civil engineer, Edinburgh. At the two extremities of the two horizontal axles, A P, A′ P′, passing across the steam boat, are fixed the paddle wheels, one of which is shown at W W. The cylinders of the engines are placed behind the steam chests F, F′, and by the alternate ascent and descent of the piston rods B B, attached to the cranks C C′, a rotatory motion is communicated to the horizontal axles A P, A′ P′, and consequently to the paddles W W, which are fixed to them. The cranks which work the steam valves are shown at K K′. The air pump E is wrought by the crank D, which is driven by the inner branch H of each of the cranks. The boiler G G extends quite across the ship. The top frame *i i i i* of the engine, and the machinery are supported by the pillars *h*, *h*, *h*, *h*. The sides of the ship are shown at *l*, *l*, *l*, *l*, the deck at *m*, *m*, *m*, *m*, and the funnel at *k*.

As the object of the preceding figure is principally to convey an idea of the manner in which the steam engines are arranged on board of a steam-boat, we must refer to Fig. 6 for a distinct view in isometrical perspective of one of the engines for a boat, as arranged by Boulton and Watt. This arrangement, however, was adopted by Boulton and Watt, in common with others, from the engines erected on board the Clyde steam-boats. A section of a steam boat engine, but not exactly the same as that shown in Fig. 5, is shown in Fig. 7, and as we have put the same letters of reference to both, we shall describe them together, so as to give a perfect idea of the construction of the most approved steam-boat engines. The steam from the boiler is introduced into the top or bottom of the cylinder A by the steam pipe S S, after passing through the slide valve already described in p. 423. When it has acted upon the piston, it passes from the slide valve to the condenser B, where it is condensed into water by a rose jet in constant play. The air pump shown at C receives the condensed water from B, and forces the air and water into the cistern D, from which it flows out by a pipe. The reciprocating motion of the piston is conveyed to the crank by means of the beams or levers, one of which is shown at E F moving round G as an axis. These beams are connected with the T-piece L L, or cross head of the piston, by the side rods *m n o p*, forming part of the parallel motion, the guiding bars of which are M N, M′ N′. The working end of the lever E is united with the crank *i* H *i′* by the connecting rod H H. The air pump C is also wrought by side rods *c c* connected with the beams E F, and the hot water pump from the same T-piece or cross head. The slide valve is on Murdoch's plan, and is moved by a wheel on the shaft I of the crank, with a sliding frame P, and it may also be moved by hand by means of the lever T, the slide rod being moved by slings from the arm R. The steam passes into the condenser by the valve O, when the engine is set to work, and the air and water are driven into the cistern D at the discharge valve.

Two of these engines are generally placed on board every steam boat, a passage being left between them, and space being reserved for working the fires between the cylinder and the boiler. The coals are kept in iron tanks in the engine room.

The weight of an engine of this kind of 40 horse power, with suitable duplicate parts, water, &c. is about 100 tons.

The steam-engine of Mr. Gurney, as applied to steam-boats, is so very unlike those in common use, that we have given a representation of it in Fig. 7, from the engraving published by Captain Ross. The figure represents it as placed between the two decks of a vessel. Its boilers are exactly similar to those already described. (See p. 422, and Plate DIX. Fig. 14). The right hand boiler and fire place is shown open with the flame acting upon one of the tubes of its boiler, while the left hand boiler, represented shut, is shown with a case *g*, as it appears when in use. In the open boiler the direction taken by the flame to the chimney pipe or flue *s*, is pointed out by arrows. The flue *s* is common to the two boilers. The ash pit is shown at *d*, and *v* is the bridge for directing the passage of the flame. The extremities of the chambers which receive the ends of all the bent tubes that form the boiler, are shown at *c*, *c*, the separators at *a*, *a*, with their safety valves *b*, *b*, and guage cocks *e*, *e*, formerly described.

The engine has neither beam nor parallel motion. The cylinders *h*, *k*, are suspended like guns on trunnions at *p*, so that they can vibrate up and down. The steam is brought from the separators by pipes in the direction *w*, *w*, which introduce the steam through the trunnions. The opening and shutting of the valves is effected by a series of levers *g*, *r*, which act like hand gear. The piston rod of each cylinder is attached to cranks *m*, *n*, rising from the main shaft *o*, which carries the paddles, and are placed at right angles to each other, that when the one is in the position of producing a maximum force, the other is in the position of producing no effect at all. The main shaft *o*, the trunnions of the cylinders, and the working parts of the machinery, are supported on a frame work marked *i i i*, *u u u*.

Mr. Gurney is said by Captain Ross to have succeeded in contriving a modification of the centrifugal blast, as a substitute for the chimney, by which a current of air is diffused below the whole furnace over a large body and surface of fire, at a very low and constant pressure, sufficient merely for the perfect ignition of every part of the fuel. In this way the smoke is nearly consumed, the awkward funnel is rendered unnecessary, and the fuel is economised.

Mr. Gurney has added a small separate cylinder for working the supply pump, and also the blower. The price of a boat engine of 10 horse power, with one cylinder, is £400, and £100 for collateral expenses, such as paddles, wheels, shaft, fixing, &c. For higher or lower powers £30 must be added for every horse power. Captain Ross states, that, though Mr. Gurney's engine has not made its way in this country, yet it has in France. He ascribes this to its never having had a fair trial in England, in consequence of the inventor not having capital to bring it forward against the opinion of those who have an interest in keeping up the low pressure engine, which is the most profitable to the manufacturer.

The following table has been given by Captain Ross, as calculated to show the crews which are proper for steam vessels employed in conveying goods and passengers, and which each should be obliged to have on board.

Table of the Crews of Steam-Boats.

Class.	Tonnage.	Horse Power Engines.	Captain.	Mate.	Pilot.	Servants.	Female Servants.	Seamen.	Engineers.	Stokers.	Coal Trimmers.	Carpenters.	Total.
1	1000	200	1	1	1	8	2	14	2	6	5	2	42
2	500	150	1	1	1	5	2	8	2	5	4	2	31
3	300	100	1	1	1	4	1	6	2	4	3	1	24
4	200	60 to 80	1	1	1	3	1	4	2	2	2	1	18
5	100	30 to 50	1	0	1	2	0	3	2	2	1	1	13
6	boats	under 30	1	0	1	1	0	2	1	1	1	0	8

The following are the dimensions of the United Kingdom and Majestic, which are said to be the fastest packets that have yet been built.

Dimensions of the United Kingdom *Steam-Boat.*

Length on deck,	175 feet
Length of keel,	147
Extreme breadth,	45½
Depth of hold,	12
From the upper deck of keel,	18
Three feet of water fore and aft,	9½ *f* 10 *a*
Three feet of water with coals,	11 *f* 12½ *a*
Nature of engine,	low pressure
Power of engine,	200 horse power
Tons by law,	561 tons
Actual tonnage, besides engine,	350
Number of boilers,	160
Main mast,	81 6 1 8
Main top mast,	52 0 1 0
Fore mast,	76 0 1 8
Fore yard,	72 0 1 8
Fore top mast,	50 0 1 2
Mizen mast,	60 0 1 5
Quantity of coals stowed,	170 tons
Coals used per hour,	17 cwt.
Crew,	48
Velocity in miles per hour,	11
——— against a gale,	3

Dimensions of the Majestic *Steam-Boat.*

Length on deck,	144 feet.
Length of keel,	125
Extreme breadth,	39
Breadth between paddles,	22½
Depth of hold,	11
From upper deck of keel,	16
Three feet water fore and aft,	7 0*f* 8 0*a*
Three feet water with coals,	8 6*f* 9 9*a*
Nature of the engine,	low pressure.
Power of engine,	100 horse.
Tons by law,	270
Actual tonnage besides engines,	254
Number of births,	76
Main mast,	68 0 1 4
Main topmast,	45 0 0 9
Foremast,	60 0 1 4
Foreyard,	62 0 0 11
Fore topmast,	40 0 0 9
Mizen mast,	56 0 0 11
Quantity of coals stowed,	100 tons.
Coals used per hour,	15 cwt.
Crew,	31
Velocity in miles per hour,	10
——— against a gale,	3

Mr. Tredgold has given the following table of the dimensions of one of the best American steam-boats, and one of those lately constructed.

Dimensions of the North American *Steam-Boat*

Length of deck,	178 feet.
Depth of hold, from under side of beam to keel,	9
Breadth moulded,	28 feet.
Breadth extreme, above water,	58
Draught of water,	4½
Diameter of paddle wheels,	21
Breadth of paddle wheels,	13½
Depth of paddles,	2
Two engines, with cylinders, whose diameter is,	45 inches.
Length of stroke,	8 feet.
Number of strokes per minute,	22 to 26.

The average force of the steam is 9 inches of mercury above the atmosphere, and the maximum force, 14 inches. The distance from New-York to Albany is nearly 160 miles, and the voyage is performed, at an average, in 12 hours. The boilers are placed before, and the machinery abaft the paddle wheels. The two engines consume two cords of wood in an hour and 25 cords of wood during the above voyage. A cord of wood weighs about 3826 lbs. and the ratio of coal to wood is about 22 to 26.6, so that the equivalent quantity of coal per hour would be 16½ cwt. nearly.

In our article Shipbuilding, p. 247, 249, the reader will find very copious tables of the dimensions of the earlier steam-boats.

One of the most important desiderata in the construction of steam-vessels is the proper formation of the paddle wheels. Hitherto they have almost universally resembled common undershot wheels, in which the float boards are a continuation of the radii of the wheel, and though such wheels have theoretical disadvantages, yet their firmness and strength have given them a superiority over other contrivances, which, consisting of numerous parts and movable float-boards, are very liable to be broken.

There is, perhaps, no branch of the mechanical arts that has called forth so many inventions as the subject of paddle wheels, and yet, so far as we know, no modification of them has appeared which is likely to supersede those of the common form.

One of the latest and most ingenious of these is the invention of Mr. John Oldham, engineer to the bank of Ireland. By a simple and elegant mechanism the float-boards revolve on axes, independent of the axis of the wheel. and each float-board revolves once, during every two revolutions of the wheel, and in an opposite direction.

The following account of the principal of these paddle wheels is given by Dr. Lardner, who has instituted experiments with them, compared with the common wheel, and has found the results to coincide satisfactorily with those which he has deduced from mathematical calculation:—

"The consequence of the combination of the motions of the paddle boards and the wheel is, that the edge of every paddle board is always presented to the highest point of the wheel, as shown in Plate DX. Fig. 9. The entire action of each board, perpendicular to its surface, being revolved into two actions, one horizontal and the other vertical, the proportions, quantities, and directions of these actions will be seen at once, by observing the sides of the several parallelograms in the figure and the directions of the arrows. One peculiarity which this presents, and in which it differs most strikingly from other wheels, is, that all the horizontal arrows point in the same direction, indicating that all the horizontal elements of the forces of the boards act in the same direction, and that they, therefore, can be made to propel without any back action whatever. It will also be observed, that the vertical elements, which, on the one side of the vertical diameter *lift*, and on the other side *depress*, are much smaller in proportion to the whole force than in the common wheels, see Fig. 10. and therefore the force expended without any useful effect is much less in proportion to the whole force in these than in the common wheel.

A wheel of this kind having no back action, might be totally immersed, and would still continue to propel. In consequence of the diminution of the lifting and depressing efforts, or what is the same, of the degree of the *feathering* principle with which it is endowed, its motions through the water is smooth, and attended with but little agitation, and is, therefore, the more effectual as an impellent power."

Among the ingenious contrivances for propelling steam-boats, we must mention that of Mr. Gladstone's of Castle Douglas, who has proposed to have two wheels on each side, with a chain of float boards between them, as shown in Hydrodynamics, Plate CCCXX. Fig. 6, float boards or paddles being substituted in place of the buckets C, F. The two wheels A, B, are of course placed so that the line joining them or the direction of the line of paddles is a little inclined to the horizon. Such a construction has great theoretical advantages; but the looseness of all the parts has, we believe, been the cause of its failure in practice.

A method of propelling steam-boats without wheels was proposed and carried into effect in 1820 by J. B. Fraser, Esq. and G. Lilly, Esq. who took out a patent for the invention. The method consists in forcing out from the stem of the boat a small jet of water by means of compressed air. M. Bernouilli was, we believe, the first who suggested the idea of propelling boats by this means. He proposed to fix on the boat an upright bent tube like the letter L, the vertical part having a sort of funnel top convenient for filling the tubes with water, which, descending through the horizontal part, and issuing at the middle of the stern, and below the surface of the water, propels the boat by the reaction of the effluent stream. Dr. Franklin* proposed an improvement upon this method, which consisted in adding another tube of the form L. "The two standing back to back, the forward one being worked as a pump, and working in the water at the head of the boat, would draw it forward while pushed in the same direction by the force of the stern. And after all, he adds, it should be calculated whether the labour of pumping would be less than that of rowing. *A fire engine might also in some cases be applied in this operation with advantage.*" Dr. Franklin next proceeds to show how the boat might be propelled by the use of air in place of water, and he suggests the use of an air vessel with proper valves to permit the force to continue while a fresh stroke is taken by the lever.

The apparatus described in Mr. Fraser and Mr. Lilley's patent consists of a cistern or condensing reservoir placed near the bow. From this cistern there descends a main tube, with a plug that may be opened and shut at pleasure. Two tubes, each of them having a plug, branch off from the main tube, and extend to a point rather nearer the bow than the centre of gravity of the vessel. From these two tubes the water issues in propelling the vessel. The main tube, however, continues to extend till it reaches a point about one-third of the length of the boat from the stern, and then divides into two tubes, which are bent back so as to open towards the bow of the vessel. The water is made to issue from these tubes in order to repel the vessel or give it stern way; other four tubes branch off from the main tube before the two first, two going to the bow and two to the stern of the vessel, and they are put at right angles to the keel, one of each pair being directed to one side, and the other to the opposite side of the vessel. The plugs of these tubes are united transversely, so that either pair being opened the water may issue near the bow on one side of the keel and near the stern on the opposite side of the keel for the purpose of turning the boat. A pump wrought either by men or by steam is then connected with one side of the condensing reservoir. A boat thus fitted up and wrought by two men, who pulled at separate levers in the same manner as in rowing. went at the rate of three miles in an hour, though the two apertures which discharged the water was only one-fourth of an inch in diameter each. A full account of this apparatus, with engravings, was given by the editor of this work in the *Edinburgh Philosophical Journal*, Vol. V. p. 120.

Many different contrivances have been invented, and some of them secured by patent, for rendering steam-boats fit for a tempestuous navigation. Messrs. Redhead and Parry have proposed to extend two horizontal channels through the whole length of the vessel, with apertures at the stern and the bow at which the water can enter and escape. The water rises nearly to the top of these channels, and two or more pair of paddle wheels are mounted, having their paddles immersed about one foot beneath the water in the channel. In very stormy weather the apertures of the channels may be closed by the shutters, and the water

* Memoirs of the Life and Writings of Benjamin Franklin, vol. vi. p. 451. Lond. 1819.

pumped out. In this condition the ship may be navigated by sails.

The fine American steam ship the *Savannah*, which crossed the Atlantic, and arrived at Liverpool on the 20th June 1827,* after a passage of 21 days, had its paddle wheels constructed so that they could be taken to pieces; and removed in bad weather, except two principal arms of each, which being of cast iron and firmly fastened, are placed in a horizontal position in high seas. The engines were in use during 18 days of the 21 that the passage lasted.

For farther information on the subject of steam navigation, see Jonathan Hulls's *Description of a new invented machine*, &c. 1737. Buchanan *on Steam Navigation*, Glasgow, 1816. Marestier, *Memoire sur les Bateaux a Vapeur*, Paris, 1824. Cleland's *Historical Account of the Steam Engine, and its application in Propelling Vessels*, 1825. *Memoire sur la Navigation a Vapeur*, par M. Seguin. Aimé Paris, 1828. Dr. Lardner's *Lectures on the Steam Engine*. London, 1828. And Dr. Brewster's Edition of *Ferguson's Lectures*, Vol. II, p. 112-117.

It is only of late that the world has been informed of the first attempt made to use the powerful agency of steam in propelling vessels. Blasco de Garay, a sea captain, in the presence of Charles the Fifth of Spain and sundry officers of state, in the year 1543, made an experiment upon a ship of 200 tons at Barcelona with an engine, all of which was not exposed, but it was observed to consist in part of a large caldron or vessel of boiling water, and a movable wheel attached to each side of the ship. The emperor, prince and the other spectators applauded the engine, and especially the expertness with which the ship could be tacked: and Garay was munificently rewarded. The exhibition being finished, he took the engine from the ship, and having deposited the woodwork in the arsenal of Barcelona, kept the rest himself.† This account is given in a note to the first volume of a work lately published in Spain, containing original papers relating to the voyage of Columbus. It was communicated to the author by Thomas Gonzales, dated Samancas, August 27, 1825, and said to have been taken from the Royal Archives of Samancas for 1543.

In page 258 some account was given of John Fitch's steam-boat, which was built in Philadelphia, and made several experimental excursions on the Delaware. In plate DX. Fig. 2, its form may be seen. The following account of it is given by the unfortunate inventor in the Columbian (Philadelphia) Magazine, Vol. I. for December 1786. "The cylinder is to be horizontal, and the steam to work with equal force at each end. The mode by which we obtain what I term a vacuum, is, it is believed, entirely new, as is also the method of letting the water into it, and throwing it off against the atmosphere without any friction. It is expected that the cylinder, which is of 12 inches diameter, will move a clear force of 11 or 12 cwt. after the frictions are deducted; this force is to be directed against a wheel of 18 inches diameter. The piston is to move about three feet, and each vibration of it gives the axis about forty evolutions. Each evolution of the axis moves twelve oars or paddles $5\frac{1}{2}$ feet; they work perpendicularly, and are represented by the strokes of a paddle of a canoe. As six of the paddles are raised from the water, six more are entered, and the two sets of paddles make their strokes of about 11 feet in each evolution. The crank of the axis acts upon the paddles, about one third of their length from their lower ends, on which part of the oar the whole force of the axis is applied. The engine is placed in the bottom of the boat, about one third from the stern, and both the action and reaction turn the wheel the same way."

Fitch gives a particular account of the progress of his operations in steam, from the first time that the thought occurred to him of using it, to the completion of the boat, so far as to make numerous experiments on the Delaware: the subsequent alterations made in it, and the final abandonment of the scheme by the original subscribers. This account shows him to have been a strong minded, but unlettered man, with a perseverance almost unexampled, and a determination to let no difficulty in the execution of his plan prevent him from endeavouring to bring it to perfection, so long as the share-holders furnished the means of defraying the experiments. As stated, p. 258, they refused to advance more funds. This they did after interfering with his views, and attempting expensive plans of improvements, which failed of success. The conviction of Fitch, however, respecting the power of steam continued firm; and in June 1792, when the boat was laid up, he addressed a letter to Mr. Rittenhouse, one of the share-holders, on the subject, in which he says "it would be much easier to carry a first-rate man of war by steam, than a boat, as we would not be cramped for room, nor would the weight of machinery be felt. *This, Sir, will be the mode of crossing the Atlantic in time*, whether I bring it to perfection or not, for packets and armed vessels. I mean to make use of wind when we have it, and in a calm, to pursue the voyage at the rate of seven or eight miles an hour." He further suggests the use of steam to conquer the cruisers of Barbary, by which several American vessels had been taken about that time. He says, "a six foot cylinder could discharge a column of water from the round top 40 or 50 yards, and throw a man off his feet, and wet their arms and ammunition." He complains of his poverty, and to raise funds, he urges Mr. Rittenhouse to buy his land in Kentucky, that he "might have the honour of enabling him to complete the great undertaking. His enthusiasm on the subject never diminished one moment, and steam was the constant theme of his discourse, whenever he could prevail upon any one to listen to him. Upon one occasion he called upon a smith who had worked at his boat, and after dwelling for some time upon his favourite topic, concluded with these words: "Well, gentlemen, although I shall not live to see the time, you will, when steam-boats will be pre-

* This is an error: the voyage here referred to was made by the Savannah in 1819. It appears by reference to her Log-book that she left New York for Savannah on Sunday, March 28, 1819, and arrived there on Tuesday, April 6th. Left Savannah on Tuesday, May 25th, and came to anchor at Liverpool on Sunday, June 20th 1819, at 6 P.M. Friday, July 23d 1819, at 1 P.M., left Liverpool for St. Petersburgh, and on Thursday Sept. 9th at 4 P.M. moored off Cronstadt. Sunday October 16th, at 9 o'clock, left Cronstadt, and on Tuesday, 30th November, at 5 P. M. anchored off Savannah. On the 5th December she left Savannah for Washington, and arrived on the 14th, where she was sold.—Editor Am. Edition.

† North American Review for 1826, p. 489.

ferred to all other means of conveyance, and especially for passengers, and they will be particularly useful in the navigation of the river Mississippi." He then retired, when a person present observed, in a tone of deep sympathy, "Poor fellow, what a pity he is crazy."* The prediction of the benefits which this country would one day derive from steam navigation, are made in sesevera places in the course of his manuscripts left to the library company. The distress of mind, and mortification he suffered, from the failure of his protracted exertions, and his povery, were too much for him, and to drown his reflexions, he had recourse to the common, but deceptive remedy, strong drink, in which he indulged to excess, and retiring to Pittsburgh, he ended his days by plunging into the Alleghany.

James Rumsey was a native of Virginia, and resided at Shepard's Town. He proves by affidavit that he had conceived the idea of propelling a boat by steam in 1783, and actually made two experiments with a small one in the Potomac in December 1784, in the first of which she went three miles an hour against the current, and in the last her speed was increased to four miles. His plan was to admit water through a trunk on the kelson of the boat, and by means of steam to discharge it at the stern, calculating that the power of reaction would propel her forward. The boat however was not made practically useful. Leaving the United States to his opponent Fitch, he sailed for London, where he made another experiment on the Thames, but whether on his former principle, or on some other, is not known. His death put an end to his operations. A controversy was carried on between Fitch and Rumsey for the honour of the first discovery of the power of steam for navigation, and two pamphlets were published by them, in defence of their respective pretensions, in 1788.

But for one of those unfortunate accidents which so often totally defeat the best contrived plans, Mr. Evans would have had the satisfaction of seeing one of his steam engines propelling a boat in the Mississippi two years before steam boats were seen on the Hudson. In the year 1802, having informed gentlemen in Kentucky that he had his engine in motion, which he had long before invented for propelling boats and carriages, Captain James M'Keever, formerly of Philadelphia, and Mr. Louis Valcourt agreed to build a steam boat to ply between New Orleans and Natchez, and Mr. V. came to Philadelphia to order the engine. Two of Mr. Evans's workmen went with the engine to meet the boat at New Orleans, and set it up. She was of the burthen of 150 tons, and built in Kentucky. Soon after her arrival at New Orleans, she was sunk and destroyed during a hurricane. The engine was then applied to sawing timber, and when fairly in operation, the mill was destroyed by fire. Capt. M'Keever died in 1810, and the engine was then sold to press cotton, and was worked with success.†

From the report of the late Mr. Stackhouse, one of the engineers who was sent to put up Captain M'Keever's engine, it appears that "in twelve months and fifteen days, with three saws (but with power for four) he sawed 367,000 feet of boards and scantling; that nothing relating to the engine broke, or got out of order, so as to stop the mill one hour. They sawed by day only, and the three saws cut from 2,500 to 3,000 feet per day of twelve hours, with the consumption of about one and a half cords of wood per day. The engine was of 20 horse power; the cylinder was only nine inches diameter, and the stroke of the piston three feet, making thirty-six strokes per minute, and working without a condenser; the fire place was outside of the boiler.‡

In 1812 there were ten of Mr Evans's engines in use in different parts of the United States; ten were made, making, or engaged.§ After that time, several were erected in boats; but owing to the explosion of the Ætna at New York, in the year 1824, such a prejudice was created against them, that the proprietors were forced to take them out of all the boats plying on the North River and Delaware, and to substitute those on the low pressure principle, although fully as liable to explosion as the boilers of those on the high pressure principle.

In page 256 of the present volume, ample justice is done to Mr Fulton, to whom the United States and the whole world are under everlasting obligations, for showing the possibility of doing effectually, what had been only partially accomplished in Europe, in respect to the power of steam in navigating boats; no more need be said upon the present occasion on his great merits.

Mr Stevens, of Hoboken, New Jersey, had been for many years making experiments upon steam to no purpose, and at an immense expense; but it was not until the memorable year 1807 that he had been able, with the assistance of one of his sons, to set a boat in motion. Being prevented by the monopoly of Livingston and Fulton from sailing in the waters of New York, she was sent round to the Delaware, and plied in it for about two years.

Since that time the improvements in steam boats have gradually progressed, and there is now no question about the superiority of the speed of the American boats over those of Europe. The common rate of going, in the North River, of the boats built by Mr Robert L. Stevens, is $13\frac{1}{2}$ miles per hour. The noble boat, the President, Captain Bunker, plying between New York and Providence, through Long Island Sound, distance 200 miles, commonly performs that voyage in 16 hours. In page 257 of this volume, several facts on the subject of the rates of speed by the United States steam-boats are given. The two following instances were published in the newspapers in the month of April 1831.

The steam-boat De Witt Clinton, (of the North

* Hazard's Register of Pennsylvania, vol. vii. p. 92.

† Letter from *Capt. James M'Keever, United States Navy, April* 12, 1831; *and notes to Oliver Evans's Patent Right Exposed*, p. 170.

‡ Archives of Useful Knowledge, vol. ii. p. 367.

§ Archives of Useful Knowledge, vol. ii. p. 363, in which the places of their erection, and the purposes of their use are given. On the western waters, from recent private information from an authentic source, it appears "that the proportion of low to high pressure engines, both for large and small boats, is as 1 to 8, many of them over 400 tons burthen. The simple and convenient form of the cylindrical boiler for being kept clean, and the absence of valves working in water, which are the accompaniments of low pressure engines, render this kind of engine peculiarly adapted to the muddy and sandy waters of the Mississippi. Several fine large boats have come round from the Atlantic ports with low pressure engines, but have not been able to compete with the western boats, until the boilers were changed."

River Line,) left Albany at 4 minutes past 4 o'clock, Tuesday afternoon, April 1831, and arrived at the landing place in New York, at the foot of Barclay street, at 12 minutes before 3 o'clock Wednesday morning, making the entire passage, including the landings at Hudson, Catskill, Rhinebeck, Hyde Park, Poughkeepsie, Newburgh, West Point, and Caldwell's, in 10 hours and 44 minutes.

	miles.	h.	min.
From Albany to Hudson,	30	1	54
" Hudson to Catskill,	6	0	22
" Catskill to Redhook,	12	0	50
" Redhook to Rhinebeck,	10	0	48
" Rhinebeck to Poughkeepsie,	17	1	10
" Poughkeepsie to Newburg,	16	1	00
" Newburgh to New York,	60	4	20
	151	10	24
Stoppages,			20
		10	44

The steam boat Highlander left Wheeling, on the Ohio, at 12 o'clock, on the 12th of April 1831, and returned in less than 18 days. The distance to St. Louis is 1200 miles, 200 of which up the Mississippi, a river of very rapid current.

A citizen of the United States set the first example of crossing the Atlantic in a steam ship. Captain Moses Rodgers, in the ship Savannah, sailed from Savannah, in Georgia, in May 1819, to Liverpool, and thence to Russia, and returned to the United States in November of the same year: and from 1819 to 1821, the steam ship Robert Fulton plied between New York and New Orleans, calling at Havanna. The English ship Enterprise has since that time performed a voyage to India in 118 days; and steam boats are in operation between the various British ports in India, and thence to the Cape of Good Hope.

On the Explosion and Rupture of Steam Boilers.

The remark, that it is the lot of mortality to have good united to evil, has been made a thousand times, and applies with peculiar force to the case of Steam Engines. A great drawback upon the profit and convenience derived from the powerful agency of steam, and from the satisfaction consequent on the facilities and rapidity of travelling afforded by steam-boats, and the comforts enjoyed on board of them, is the fear of the explosion of their boilers, or the rupture of their steam tubes. It has been thought proper therefore on the present occasion to collect all the information possible on the subject, to examine and detail the circumstances under which they have occurred, to state the causes of the accidents, and to point out the means most likely to prevent their occurrence. The causes which are known to have produced these explosions and ruptures, are as follow:

1. The continued application of heat to a boiler, while any part of it is uncovered with water, or in which it is expended.

2. The steam being prevented from passing off, owing to, 1. The rusting of the safety valve. 2. Its adhesion to its seat. 3. Stopping the steam pipe by the valve, owing to the improper form of the pipe. 4. Overloading the safety valve, or of fastening it down, so as to increase the power of the steam beyond the maximum point which the force of cohesion in the metal of the boiler would bear, or while the engine was stopped from working. Small size of the valve.

3. Want of proper precautions to strengthen the boiler, when first made.

4. The use of internal flues in boilers.

5. The use of improper metal in the construction of the boiler.

6. The use of metals for boilers, of different expansive powers.

7. Weakness of the boilers from long use, or unequal thickness in the metal, and raising the steam to a height beyond its strength.

8. Faulty form of the boiler.

9. A collection of earthy or saline sediments on the bottom of the boiler.

10. The sudden increase of the pressure of steam on a boiler.

1. *Loss of water in the boilers.*

The cases embraced under the first cause are, the loss of water in or around the boiler or boilers, from, a. leaks; b. neglect of a supply of it; c. the heeling of the vessel from the concourse of passengers on one side, thus forcing the water from one or more of the boilers, when several are in use ; or causing the boat to heel so much to one side as to render the guage cocks useless; d. obstructions in the pipe or pipes feeding one or more boilers.

It is believed that most of the explosions of steam boilers may be ascribed to the first cause, and its several modifications. The neglect to supply boilers when leaky, or to keep those filled which are sound, admits of no excuse : and misfortunes arising therefrom, to passengers on board of boats, affords as just and legitimate grounds for an action of damages, as those that occur in stage-coaches from racing, mismanagement, intemperance in the driver, or his wilful indifference in any way, to the safety of travellers.

The explosion in one of the high pressure boilers of the Union Rolling Mill at Pittsburgh, a few years since, can be ascribed only to this cause. There were three cylinder boilers, each of thirty inches diameter, one of which had been observed for some time to be getting red hot; but as the other two had supplied a sufficiency of steam for the works, it was disregarded until it exploded, and shooting through the air, at an angle of forty-five degrees with the horizon, fell into the river two hundred yards from the works.* The over heating of the exploded boiler cannot be ascribed to any other cause than the want of water in it. Boats on the western waters are particularly exposed to danger from this cause. Many of them have several boilers connected with one

* The steam was said to be on fire, but Dr. Jones justly attributes this appearance to the boiler being at one end heated to redness, and supposes that the meteor-like appearance which it exhibited, was owing to the rapid passage of the projected boiler through the air. To the eye, this, like the whirling of an ignited coal, would present a lengthened stream of light, and apparently justify the conclusion, that there was real combustion.—*Franklin Journal*, vol. ii.

another; when one of these boats leaves port with a full cargo of passengers, goods, and a supply of wood, she sinks deep in the stream, and the boilers are all surrounded with water to the proper height. In the course of her voyage wood is consumed, passengers and goods are landed, the forward portion of the vessel rises a little from the weight of wood being removed, and when a landing place is reached, all the passengers invariably rush to the side next the land, and thus cause the boat to heel, and the water to run out of the boilers on the opposite side. The same effect is produced by 400 or 500 passengers sometimes sitting on one side of the boat in summer, to avoid the sun. In the meantime the fire is kept up, the empty boiler becomes red hot, and when the boat recovers her trim, the heated water rushes into the empty boilers, highly expansive steam is instantly generated, and when the throttle valve, or safety valve is opened, the water mounts up with the steam, and filling the boiler, presses on the weakened metal beyond its power of cohesion; an explosion therefore must take place. The awful disaster on board the Helen M'Gregor, March 1830, is a case in point. The explosion took place at Memphis in Tennessee. The engine was on the high pressure principle. She had six or eight boilers, and was full of passengers; nearly all of whom, when at the landing, came to the side near the shore, and of course caused her to heel greatly, and to drive the water from the boilers on the other side into those next the land. The fire was kept up during her stoppage, and thus must have rendered the empty boiler red hot. *The explosion instantly followed the opening of the throttle valve to set the engine in motion.* Between 60 and 80 persons were killed, scalded and wounded, and the boat was reduced to a mere wreck. The boat Chief Justice Marshall was another instance of the same kind: "the main internal flue gave way when the engine was set in motion after a stoppage at Newburgh, North River; the safety valve was either open, or had just been closed; one of the persons on board remarked a peculiar shrillness in the sound of the escaping steam, that can only be ascribed to its being intensely heated, without having a corresponding density. Another observed that it had a violet hue, which may perhaps be explained by supposing it to have been heated until it would have been luminous at night. In opposition to the opinion that the water had fallen too low, and left the flues bare, it was stated by the captain, that the guage cocks had been tried, but on examination it was found that they were situated on the side of the boiler nearest the landing; and hence the influx of passengers to that side changed the level of the boat so much as to render the guage cocks, when so situated, useless as a test of safety. It is also possible that the fireman, who was a new hand, and by no means skilful, may have mistaken the water of condensation in the tube for that coming from the boiler. This last mistake is one that ought to be carefully guarded against by leaving the cock open several seconds."*

It would appear from the following statement, that besides the probable over heating of the boiler, the steam had been permitted to collect in quantity beyond the cohesive powers of the boiler. The editor of the New York American vouches for the respectability of the writer.

From the New York American, April 24, 1830.

Mr. Editor,—I perceive the captain of the Chief Justice Marshall says, that the steam was blowing off continually while landing. I doubt the correctness of this statement. My own very strong impression is, that no steam was going off while she was approaching the dock, nor while she was taking in the Newburgh passengers, of whom I was one, and that it was not permitted to escape at all, till within about three minutes of the explosion. For three or five minutes before this took place, I was standing at the door of the captain's office; and having nothing else to do, directed my whole attention to the steam; it was going off at that time, but so very slowly as to make but a slight murmuring sound. This continued three or four minutes, and was exchanged for the shrillest and most piercing whistle I ever heard; so that I immediately made the reflection (whether correct or not I do not know), "The steam is excessively high!" Still it appeared to me that very little steam was escaping, and as if it passed through an exceedingly small aperture. This sound continued a few seconds; it suddenly ceased, and, almost simultaneously, the boiler exploded! My own opinion is, that the steam was suffered to accumulate in the boiler in a very improper manner; and, as all the disasters of this kind have happened while boats have been lying at or leaving the dock, is it not fair to conclude, that it is owing to this cause—the improper accumulation of steam in the boilers? Why the steam is kept there pent up, I know not; but it seems to me it cannot be done without danger. No law on this subject would probably contribute more to the safety of passengers than one which should provide, that the moment the steam ceased to be employed by the piston, it should be let off in the same proportion at the safety-valve.

A PASSENGER.

As the captain positively states that the safety valve was open, he must be believed: the doubt expressed by "a passenger," as to the fact, except until about three minutes of the explosion. may be explained by the facts discovered by Mr Perkins, viz: 1. That "steam highly surcharged with heat, when rushing from the safety valve, or any other aperture, may be known by its perfect invisibility, even in the coldest day: it is, however, he says, condensible, as may be seen by holding any cold substance in its range." 2. "The whistling" mentioned is another proof of the highly heated steam in the boiler: for, Mr Perkins found by a truly important experiment, that steam highly heated, when issuing from a small aperture, produced such a noise.†

* Renwick on Steam Engines, p. 97.

† Mr Perkins "discovered that a steam generator at a certain temperature, although it had a crack in it, would not emit either water or steam. A friend ascribed it to the expansion of the metal closing the fissure. To remove every doubt, he drilled a small hole, one fourth of an inch in diameter, through the side of the generator: after getting up the steam to a proper temperature, he took out the plug, and although he was working the engine at 30 atmospheres, *nothing was seen or heard* to issue *from*

The fatal accident on board the Oliver Elsworth in March 1827, near Saybrook, when on her passage to New York, may be ascribed to the same cause. During a "heavy sea and high wind from the S. W., the boiler burst by collapsing the main flue, and forcing out the furnace head with a tremendous report, louder than the heaviest cannon." Mr. E. Hazard judiciously asks, "supposing the water to have been at its proper height in the boiler, may not the motion of the vessel from a head sea have left portions of the boiler exposed to the fire for a length of time sufficient to make them red hot?"

A boiler about eighteen feet long at Kensington, Philadelphia county, in which the water had been greatly, if not entirely expended, owing to the fire being kept up during the absence of the fireman at dinner, collapsed from the over heating of the return flue, which was reduced from one foot in diameter to two inches.

Stoppage of the Feed-pipe. The Etna. This was the second steam-boat in which an explosion took place in the United States. It happened in May 1824, between Washington in New Jersey and New York. The Etna had three boilers below deck, and on the high pressure principle, and all new. The feed pipe of the centre one was longer than the other two, and near its internal extremity was bent; a circumstance that favoured the deposition of the solid contents of the brackish water which had been used to supply them for some weeks, and which did not take place during the several years she had previously ran in the Delaware. Hence the supply of water was cut off from this boiler, which is known to have become red hot, and must have been nearly empty. It was observed too that just before the explosion the pressure was diminished from 150 lbs. to 50 lbs., owing no doubt to a sudden projection of a limited portion of the remaining water into the hot vapour, of which the heat of temperature became latent heat, and in this condition was less efficacious in producing pressure than it had been in the free state.

It was ascertained that at the time of the explosion, the engine was making only eighteen strokes per minute, and had often made twenty-two: the common rate of working was twenty strokes. The first joint of the boiler over the fire was torn off, and driven up through the wheel-house, not in the direction of the boiler, but at a considerable angle, breaking the arms of the wheel; the body split in a spiral form, one and a half turns, and was thrown up flat on the deck, with the exception of the back end, which retained its form from the strength derived from the cast iron head.

The explanation of the mode in which the explosions take place from the loss of water is as follows: In consequence of the continued application of fire, or of highly heated steam to the upper part of a boiler, when not covered with water, it becomes red hot,* the cohesive power of the metal is greatly weakened, or destroyed, technically "*nealed*," and may be easily broken with a slight force. A boiler thus weakened would be unable to resist the pressure of the highly heated and expansive steam produced from the continued fire under the above circumstances, and might burst before it was subjected to a pressure sufficient to raise the safety valve. This effect is more certainly produced by water coming in contact with the metal when in this heated state, an event which Mr. Perkins suggests may take place "by the weight being taken from the safety valve, or by a small rent occurring in the boiler owing to the pressure of the steam, when an explosion will be sure to follow." The water would also be forced up by the opening of the throttle or safety valve, as has already been mentioned; and in any of these cases, the water being relieved from the pressure of the steam on its surface, would rise with it in proportion to the rapidity and suddenness of its escape. Such instances have been noted above. Mr. Perkins states, that in the case of the English boat Graham, twenty pounds had been taken off the safety valve just before the explosion took place. Two explosions in cotton mills in France, which are quoted by Arago, and said by him "to appear so paradoxical as to excite a doubt," may be added to the above cases. While the steam engines were working very slowly, the safety valves opened, and the boilers burst; no doubt the water in both cases had descended too low, and the upper part of the metal had become red hot. In respect to one, it is stated that the workmen "supposed it to be almost void of steam." Another similar case occurred in a low pressure engine at Lyons, and is noticed by Arago. In all these, the steam must have received an excess of heat, without acquiring a proportionate elasticity: hence the engines worked more slowly than usual, but when the water rushed up, on the overheated metal, highly elastic steam was formed, and the mischief produced. The same effect may ensue from the at-

the plughole: he next lowered the temperature by shutting the damper and opening the furnace door; a *singing from the aperture was soon observable*, and *when a coal was held before it, rapid combustion ensued: nothing however was yet visible;* but as *the temperature decreased*, the *steam became more* and *more visible*, the noise at the same time increasing, until finally the *roar was tremendous*, and might have been heard at the distance of half a mile. The iron at the aperture was red hot." Mr P. gives this experiment to illustrate the *repellent power of heat*, and to prove that caloric is matter.—*Franklin Journal*, iii. p. 413.

* "Mr. Moil informed Mr. Perkins that on going to his boiler room, he observed a ladder, the foot of which rested on the top of his boiler, to be in flames. He instantly ascertained that the top of the boiler had become red hot. The fire was quenched, and upon examining the boiler when cold, he found very little water in it." *Franklin Jour.* iii. p. 420. "On board the Dublin and Liverpool steam boat, a piece of pine wood on the top of one of the boilers was burnt to a coal, although the engine was working with steam only a few pounds above the atmospheric pressure. The leaden joints of the steam pipe once melted, when the steam guage indicated only the pressure at which the engine was usually worked. In *both these cases the water was so* low in the boilers, that the heat was communicated to the steam through a portion of the boiler which had no water in contact with it, and which of course became red hot, while the steam could not part with its heat *downwards*, to the water."—E. Hazard, *Franklin Jour.* iii. p. 421. Several instances have occurred where there was sufficient time, by the rushing of the steam from a rent or fracture, for the bystanders to escape from the injury before the explosion took place. In one case the boiler was raised from its bed into the air, by the force of the steam issuing from the rent (upon the principle of the rocket) before the water had sufficiently expanded by the removal of the steam caused by the rent or fracture, to take up the heat of the boiler and the surcharged steam; when an explosion took place after the boiler had been raised many feet into the atmosphere, and it separated with a very great report, one part rising still higher, while the other was dashed with great force on the ground."—Perkins, *Franklin Jour.* vol. iii. p. 417.

tempt to remedy the neglect to supply the heated boilers with water, by pumping in cold water, until it rise to the level of the overheated and weakened part of the boiler. To this cause may have been owing the fatal explosion that took place on board the steam-boat Tricolor at Wheeling, on the 19th April 1831. A letter states "that she had been puffing off steam in the morning, until 9 o'clock, and that the explosion happened the instant the engine was started, and *cold* water was injected into the boiler." Upon examining ruptures in boilers, they have sometimes been found to follow the water line.

The interesting discovery of the want of proportion between the temperature and elasticity of steam is due to our countryman Perkins, whose experiments to prove it are given in the Franklin Journal, vol. iii. To this cause he ascribes the tremendous explosions that suddenly take place as well in low, as in high pressure boilers. These explosions having taken place when no apparent reason could be assigned for them, have been ascribed to the formation and inflammation of hydrogen gas in the boiler. But this opinion is contrary to true chemistry. On this subject professor Hare observes, that red hot iron may decompose the steam slowly, but it can do so only by absorbing oxygen, which must lessen the quantity of elastic matter in the boiler, and render the evolved hydrogen gas inert, as by itself it cannot explode.* Dr. Jones adds, that the hydrogen would be altogether incapable of producing an explosion without admitting atmospheric air, which air must find its way into a vessel filled with vapour in a state of tension, and exciting a pressure outwards much greater than that of the external air.†

Arago admits the possible formation of hydrogen gas from the contact of steam with metal heated to redness, mixed with steam; this gas will pass into the cylinder of the engine, and not being capable of condensation, will be thence expelled at a great expense of power. He can allude here only to condensing engines. Upon the supposition that the oxygen, an admixture of which with the hydrogen is necessary to produce an explosion, would be furnished by the atmospheric air in the water of the boiler, he answers, that this water is warm, and therefore contains but a small quantity of air; and this air, as fast as it is disengaged from the water, passes in a state of mixture with the steam into the engine. Farther, the oxygen of this air would combine with the heated metal more readily than that contained in the water would do; and thus, if hydrogen gas should be produced from the water, it would find nitrogen present with which to mix, but no oxygen.‡

In connexion with the subject of explosions referred to the overheating of the boiler, through the deficiency of water, we may mention a paper in a late number of the American Journal of Science (vol. XIX. p. 294), by Mr. Walter R. Johnson, in which he details several series of experiments undertaken expressly to ascertain what effect might be produced by a known quantity of metal heated to redness, and then plunged below the surface of water at boiling temperature. As the experiments were made with all due precautions to avoid loss of temperature by the water during the process, to determine the weight of steam produced, and its relation to that of the metal employed, and to expend the whole of the surplus heat of the latter, above boiling temperature, solely in giving the elastic form, there cannot be a doubt that they furnish very accurate practical data by which to judge of the effect of an overheated boiler, when suddenly supplied with hot water.

These experiments demonstrate, that at a *dull red heat in day light*, each pound of wrought iron is capable of generating one ninth of a pound of steam; in other words, that nine pounds of metal in that state, are sufficient to give the elastic form to one pound of boiling water under atmospheric pressure. Of cast iron, it appears that $8\frac{231}{1000}$ pounds are adequate to the same effect.

The lower arch only of a cylindrical boiler 20 feet long, 30 inches in diameter, made of $\frac{1}{4}$ inch rolled iron, would, together with a returning flue one foot in diameter, and of the same thickness, weigh not far from 1500 pounds, and would consequently, if made red hot, be capable of producing more than 160 pounds of steam, with a bulk of upwards of 4400 cubic feet—more than fifty times the contents of such a boiler—and all this tremendous energy would be developed in a time not exceeding thirty seconds!

Mr. Thomas Earl has also given a neat demonstration on this subject, in the Franklin Journal, vol. vii. p. 156, and in accordance with the above theory.

2. *Obstructions to the Escape of Steam.*

The obstruction to the escape of the steam from the causes noted, are so intimately connected with the safety of the boiler, as scarcely to require any remarks to enforce the propriety of preventing it from taking place, by constant attention to the safety-valve. The only instance of the adhesion of the safety valve to its seat, that has been recorded in the United States, is one that is said to have taken place in the North River, New York, and of which the following account has been published by Mr. J. B. Calhoun.

"In the summer of 1829 I was engineer on board the steam-boat Legislator, of Hudson; and noticing that the engine was working faster than common, and not seeing any steam flow as usual from the safety valve, I went to the fire-room, and was told by the fireman that he had on twenty-one inches of steam, and that the *steam-guage* was up against the *boiler-deck*. As the safety-valve was loaded to carry only sixteen inches, I became alarmed, and taking hold of a cord that ran over a pulley, and was attached to the lever of the safety-valve, I attempted to raise the valve, but could not; on going to the top of the boiler where the safety-valve was, I found all right there; that is, there was no extra weight on the valve. I then slided the weight into the length of the lever, up to the fulcrum, where the weight was merely nominal, still the valve did not rise; I became confounded, and taking hold of the lever lifted on it pretty stoutly, and continued lifting for some seconds, when all of a sudden, with an explosion like that of a small field-piece, the valve opened, and the steam rushed out violently for some

* Franklin Jour. vol. ii. p. 142. † Franklin Jour. new series, vol. iii. p. 72. ‡ Franklin Jour. new series, vol. vi. p. 53.

time before it got down to the usual pressure, the engine being at work all the time. There was no water on the valve, nor any visible obstruction to its rising of its own accord after the steam got beyond the pressure of sixteen inches, which it had invariably done before; the valve and the valve-seat were both of the same metal. For many reasons I had not placed full reliance in the mercurial steam-guage, but had always entire confidence in the correctness and safety of the safety-valves; but in this case I was deceived, and perhaps in a few moments more an explosion might have taken place, for I had no doubt, if a small rod in the steam-guage could have had a free passage through the boiler deck, it would have denoted thirty instead of sixteen inches.

" It is usual to have the steam-guage so graduated, as to show as many inches of steam as the engine will take, and to have the safety valve loaded so as to agree with the steam-guage, believing that when the steam-guage indicated sixteen inches of steam, all the surplus steam would escape through the safety valve. Many engineers do not blow off any steam when the boat stops to make a landing, but depend wholly on the safety valve rising of itself, after the steam has risen a little above its required height. This has been considered a safe way of proceeding; but the case above stated, shows that it is wrong to depend too much on the safety valve." Mr. C. recommends that when a boat stops to land passengers, the safety-valve be raised, let the guage indicate what pressure it may. Before tne occurrence described, he believed the cause of boilers exploding was almost invariably the want of a sufficient quantity of water. He now thinks, that some explosions may be attributed to the being deceived by the safety-valve not rising as was expected by the engineer.*

The two following cases illustrate the necessity of attending to the proper form and construction of the safety-valve.

About six years since, a new copper boiler of one of the ferry boats plying between New York and Pawlus Hook, New Jersey, burst in consequence of the safety valve having been fitted too neatly, so that when heated by the steam it expanded and stuck. The boat had made several trips during the morning, and no steam had been observed to pass off for several hours.‡ The boiler was turned upside down, and flattened.

In another boat, on the Delaware, the escape pipe for the safety valve was of a conical form, the greatest diameter of which was below, so that when the valve raised, it closed the pipe, and prevented the steam from passing off. The defect was, however, observed, and an explosion prevented.

Explosions from overloading the safety valve have frequently occurred. The evidence of Mr. Richter before the committee of the House of Commons, p. 122, proves that the dreadful explosion of the sugar refinery in Wellclose Square, London, several years since, was owing to this cause. The engineer, being informed that the engine did not work well, put an immense weight upon the lever of the valve, so as to render it useless, still urging the fire, and in a few minutes it exploded, and blew the whole house to pieces. The same cause, according to Mr. Leet, produced the explosion in the tobacco manufactory at Chester, England, in July, 1822.†

Arago‖ mentions that from this cause the boiler of the steam-boat Rhone exploded on the 4th March 1827, and killed several persons. "Vexed at not being able to overcome the rapidity of the current as completely as he had hoped, the engineer fastened down the safety valves of all the four boilers; three of them burst almost simultaneously.

Another case occurred in a boiler attached to a wagon in Sunderland, England, by which several were killed.§

The Norwich (English) steam-boat exploded in part from the same cause. The attendant engineer seated himself on the safety-valve, in order to give his comrades the spectacle of the oscillating motion that he would undergo, as he said, as soon as the vapour should become strong enough to lift him. The valve did not open, but the boiler burst, and killed and wounded a great number of persons.

Arago quotes another case, of a steam-boat on the Ohio (name not mentioned), in which the explosion took place while the crew were engaged in weighing the anchor; when there was no consumption of steam, although the fire had attained its full force, and the safety valve was loaded with additional weight.

In 1803 the safety valve of a high pressure boiler in England, was fastened down by a boy, with a piece of timber, and rendered entirely useless for some time; and then the engine was stopped by another workman, who knew nothing of what the boy had done. Shortly after the boiler burst.‖

Several accidents have happened in the United States and other places, in boats from these causes. The rash conduct of the engineers or firemen was excited from an anxiety to beat other boats bound to the same places. All the particular cases in the United States cannot be mentioned, but they were stated at the time in the newspapers.

3. *Original Weakness of the Boiler.*

In the account given of the explosion of the United States steam-boat, September 1830, on the East River, New York, it was stated that in nearly all the accidents that have occurred in the New York waters, the ruptures have taken place in the same part of the boiler. In the Constitution, Legislator, Bellona, Chief Justice Marshall, and the Carolina, all low pressure boats, the rents were made in the lower part of the flues. In these boats there were no braces between the flue and the outer shell in the bottom of the boilers. The Constitution after her accident had them put in, and no explosion has since taken place. The United States boat, when the explosion happened, was going at her usual speed, with 12½ inches of steam, as had been ascertained two minutes before by the captain, who examined the guage. The boat could carry 13 inches of steam, and the boiler was so fixed that the steam blew off at 14 inches. The engineer had also just before examined the water cocks, and found that there

* Franklin Journal, vol. v. p. 355. † Philos. Mag. 1822, p. 67. ‡ Franklin Journal, new series, vols. v. vi.
§ Evidence before the House of Commons, p. 46. ‖ Philos. Mag. xvi p. 372.

was a sufficient supply of water. The part that gave way, viz. the lower part of the main flue, ten feet back of the bridge wall, had been repaired about a week before the accident, and four sheets of iron put into the flue. These were torn away, but the rivets remained in the old sheets. The boiler was of sheet iron of a cylindrical form, 22 feet long, and 8 feet in diameter, with what are called "kidney flues," forming one large cylinder, and one return flue; *and had been nine years in use.**

4. *Use of Internal Flues.*

In the United States steam boats, the fire is made under the boiler, which returns through flues passing through the boiler, and are connected with the chimney proceeding from it.† These flues, although always intended to be covered with water, often get uncovered from the causes before mentioned, and become red hot; the metal is expanded, and consequently has its cohesive power greatly diminished; and this being repeated may give rise to explosions at a time of apparently perfect safety. With careful firemen or captains there may be no danger of the water falling below these flues; but we know that the most wanton inattention has prevailed on board of steam-boats to this important point. It is therefore necessary to diminish the sources of danger to travellers, by placing them as much as possible out of the power of ignorant, obstinate, or negligent men. The four cases of collapses in Cornwall, referred to by Mr. Taylor,‡ occurred in boilers with return flues. The Chief Justice Marshall and United States, in the waters of New York, also had them; and several others that have exploded.§ They are indeed commonly introduced at present.

The Constitution (first named the Oliver Evans,) which was the first boat that exploded on the Ohio, was built with flues passing through each boiler, by Mr. Geo. Evans, who deviated from the plan adopted by his father. Having proved them with a pressure of 200 pounds to the square inch, and regulated the safety valve to 150 pounds, he thought them perfectly safe, but more might have been employed; if not, no other cause can be assigned than neglect to keep the water above the flues. He concludes by saying, "flues of this description are not safe, and ought not to be used."

On the western waters of the United States, flues are not only generally introduced into high pressure boilers, but under circumstances peculiarly dangerous. In a boiler of thirty inches diameter, the flues are from ten to sixteen inches in diameter, which often leave no more than a space of four inches between the bottom of the boiler and the lower flue, and from ten to sixteen inches for water and steam room; and hence from inattention on the part of the fireman, the water may soon fall below the flues, and by becoming red hot they are rendered liable to explosion. The flue of a boiler at Kensington, Philadelphia county, which collapsed, was sixteen inches diameter, and the two sides came close in contact. In the boiler at the distillery called Lochrin, near Edinburgh, and at the tobacco manufactory at Chester in England, the bottoms of the boilers, which were convex to the interior on the side next the fire, to allow the flame from the furnace to play in the centre almost of the liquid, were rendered convex outwards, so strong had been the pressure from within.

Mr. Taylor states that at East Crennis Mine, Cornwall, the inner tube was compressed as if the fire had softened the part above it, though there did not appear to be any other reason to think that the water was too low. At the Mold mines in Flintshire, the inner tube was not moved from its place, although it was very much flattened for a great part of its length, the sides having come together.

A writer under the signature "An Engineer," in commenting upon the cases of explosions in Cornwall, related by Mr. John Taylor, says he "considers the introduction of a tube within a high-pressure boiler to be bad under any circumstances, but it is particularly so where the furnace is placed in it. The ash-pit, also, is by necessity most objectionably small, where the furnace is inside the boiler. This is an evil of some magnitude, both as regards the draught, as well as the wear and tear of fire-bars."‖

5. *Material Composing Boilers.*

Boilers were frequently made of cast iron when steam-boats first began to run, and gave rise to many explosions, owing to internal defects of the iron, and to its liability to crack from heat. Wrought iron is therefore now generally substituted. It is also preferred to copper, from its greater tenacity. But when salt water is used, copper is preferable, because it acts less powerfully upon the deposits from it than iron. Cast iron even for the ends of boilers is objected to by O. Evans, unless the fire be kept from them, owing to their liability to crack when heated.

6. *Use of metals of different expansive powers for boilers.*

To this cause may in part be attributed the explosion of the Norwich Steam-packet. It was ascertained that the boiler, although cylindrical, had one end of cast iron, the other of wrought iron. These ends were flat. The cast iron end was only $\frac{3}{4}$ of an inch thick, and it was this end that gave way. The body of the boiler was composed of wrought iron. The propriety of only using one kind of metal for a boiler must be obvious.

7. *Weakness of the boilers from long use; unequal thickness in the metal; and raising steam too high for its strength.*

The influence of these causes is apparent to all. A boiler sent to Mr. Oliver Evans to repair, had been reduced to the thinness of paper in se-

* Poulson's American Daily Advertiser, Sept. 4, 1830, from the New York Courier.

† The high pressure boilers of Rush and Muhlenberg have no internal flues.

‡ Philos. Mag. 1827, p. 126.

§ On the authority of an experienced steam-boat navigator, it can be stated that the rent in the Chief Justice Marshall took place at the farther extremity of the main fire flue, and the water was driven through the doors toward the forward cabin, and killed and scalded all who were in the fire room The Constitution boiler had D flues; and the collapse took place on their flat sides.

‖ Philos Mag. 1827, 405

veral places, and had been used in this dangerous state for some time. It had discharged its steam in two or three instances, through a small vent, without however injuring any one. A boiler of the low pressure steam-boat Bristol collapsed, from this cause, in the spring of 1820, in the Delaware. There were two boilers, one on each side of the engine, connected with steam and water pipes. The top of the furnace was flat. The boilers were old and corroded, and the captain, who is still living, says that "they ought to have been condemned before he took charge of the boat. There was a great competition from four boats at the time, and the Bristol being ahead of a better sailing boat, belonging to another line, the engineer desired the fireman to increase her fire to preserve her distance. The fireman replied that there was as much fire as was necessary, and if he wanted more he might make it himself. He did so, and suffered for his folly. While the captain was in the fire-room, he was alarmed by the leaking of the boiler, followed speedily by a tremendous hissing of steam, and retreated in time. On inspection, it was found that the furnace or flue, in the centre of the boiler, had been forced inward, and the steam and water from both boilers had rushed into the fire of the injured flue, or inside shell of the boiler."

The boiler that exploded at the Union Rolling Mill, Pittsburgh, was worn out.

The boiler of the sugar refinery, in Well-close Square, London, was of different thicknesses. At the bottom it was two and a half inches in thickness; on the two vertical faces, an inch and a half; in the lower part of the dome, not more than seven-sixteenths of an inch; and in one place, the thickness was reduced to an eighth of an inch. It was of cast iron.*

The explosion of the Norwich was in part owing to one of the causes noted. Mr. Tilloch observes that "it was usual to raise the steam to a pressure of 70 lbs. to the inch before starting for the voyage; the end of the boiler was quite incompetent to hazard such a pressure, and the steam was urged beyond all prudence to beat a rival boat. The wonder is, that it did not explode long before, for it was more common to have steam at from 100 to 120 than even at 70 lbs. to the inch."†

The boiler of the boat Tricolor (low pressure) exploded at Wheeling on the 19th of April 1831, by which eight persons lost their lives, from the immediate effects of the explosion or by drowning; eight others were scalded very severely. A private account states, that the boiler was 13 years old, the Tricolor being the third boat on board of which it had been placed; and for several hours before the explosion a hot fire had been kept up.

8. *Form of the Boiler.*

Mr. Evans, from his first attempt to make steam-engines, was aware of the superior strength of the circular form for boilers. In his "Steam Engineer's Guide," he says, "a circular form is the strongest possible, and the less the diameter of the circle, the greater the elastic power it will contain. Therefore we make cylindrical boilers not exceeding three feet, and to increase their capacity, their length is extended to 20 or 30 feet, or their number increased."

The adoption of the cylindrical form for boilers, evinces the correct philosophical principles upon which Mr. Evans acted. Nothing can be more clear than that by this form the expansive force is equally exerted over the whole of the internal surface of the boiler, and consequently that the steam will have no effect tending to change the form. Experience has proved the justness of his theory.

To ascertain the power exerted by steam to burst one of those boilers, and the thickness of iron necessary to hold it, Mr. Evans gives a rule, example, and demonstration of the problem of a circle 36 inches diameter, the result of which is, that 54,000 lbs. weight are required to break the two sides; half of which, 27,000, are necessary to break one side in any one place. To the solution of this useful problem, which he never met with, he adds a table, showing the power exerted to burst each ring of one inch wide of the boilers of different diameters, and the thickness of iron necessary to hold steam of power equal to 1500 lbs. to the inch area.

In another publication he illustrates the strength of this form by a familiar illustration. "It will bear," he says, "greater elastic power than boilers of other forms, in the proportion that a bar of iron will bear more pulling straight end-wise, than it will on its middle, to bend and break it when laid horizontally, supported at the ends." Boilers, however, are not always made in this form, and, to compensate for the deficient strength of other shapes, stay bolts are used.

The boiler of the London sugar refinery, already referred to, was made of flat iron pan, of eight feet diameter: therefore, extending the bursting surface in proportion of four to sixteen.‡

Connected with the form of the boilers, is the mode of their construction, and applying the fire. In Cornwall the most common arrangement is to fix one tube within another; the interior one containing the fire-place, and the space between it and the exterior containing water, and in the upper part, steam. The ends of the boiler fix the tubes together, so that the interior tube is opened at both ends, at one of which is placed the fire grate, and at the other the smoke and flame pass out, and are conveyed to the stack or chimney most commonly by flues passing under and along the sides of the outer case. They are from 20 to 35 feet long, and from 3 to 4 feet in diameter; the outer one from 5½ to 6½ or 7 feet. Four accidents by collapsing, according to Mr. J. Taylor, occurred in the two or three years preceding 1827, from the use of boilers of this description: the particulars of which he gives.§ The fire is now made under the boiler. Arago mentions several more that occurred in France, in similar boilers. Boilers of this description were formerly very common in the United States, but are now entirely given up.

* Evidence before the Committee of the House of Commons, p. 122: in Dodd on Steam-Engines.
† Philos. Mag. xlix. p. 302, and the Evidence before the Committee.
‡ Mr John Taylor's Evidence before House of Commons Committee, p. 44
§ Philos. Mag, 1827, p. 126.

9. *Sediment in Boilers.*

This cause has frequently produced bursting of boilers, and the inattention to it by those who own steam-engines, or command steam-boats, is truly surprising. It is evident that a crust formed within or upon a boiler, offers a non-conducting material to the heat from fire or water; and that the bottom of a boiler, the inside of which is so coated, will require much more fuel to bring the water to the boiling point, and to keep up its temperature, than if this obstruction did not exist. Hence arises additional expence. This increased operation of the fire on the metal softens it, and allows the expansive force of the steam to push it out like a bull's-eye glass light, to the extent of several inches in diameter, thus diminishing its substance. Mr. Burr states that the protusion of the bottom of a boiler at Richmond, Virginia,* was as large and as deep as a hat crown, from sediment collected in four or five weeks. The protusion in the bottom of a boiler of an engine in a cotton mill at Kensington, Philadelphia county, from the sediment three inches thick collected on it, was about half that size. The sediment when picked off, will bring scales of the iron with it, and thus tend to lessen the thickness of the bottom plate still more. When the water is over the fire flue, the sediment will descend to the legs, and space in front of the boiler. The effect of a continued application of fire to the metal of boilers thus expanded and weakened, may easily be conceived. The fire and accumulated coals finally burn out the part, the water and steam then rush below, and the pressure from above will cause a collapse of the boiler. This was probably the case of the Legislator of New York. Several years since one of the four boilers of the high pressure engine at Fairmount Waterworks, on the Schuylkill, was burnt out from the collection of sediment in one end of it. The deposition of the sediment in that part was promoted by the position of the boiler, which, in order to favour the operation of the fire, was fixed so that the farther end was several inches lower than the door end. The boiler had been cleansed the day before the accident, but, owing to the difficulty of reaching the further end, it was neglected, and a thick hard crust, to which the grease in the water greatly contributed, was permitted to remain. The rent took place under this crust; the water ran into the ash-pit, and followed by that and the steam in the other three boilers, rushed out with a mass of ashes, closing the door of the ash-pit, which opened inwards, and filled it in an instant. Two men were severely scalded, and additionally suffered from the inhalation of ashes and hot steam, in which they were enveloped: they died within two days.

When the Etna ran in the Delaware, with a high pressure engine, a leak in the bottom of the boiler took place, owing to the collection of sediment in it, but no injury was sustained by any one: and the bursting of one of the boilers of the Bristol, already mentioned, proceeded from the same cause, according to the opinion of the captain. "The small space between the bottom of the furnace and the outside shell, was very difficult to be kept clean, and that was the spot where the rent took place." This was doubtless heated red from the accumulation of coals underneath the bars of the grate. The boats plying in the muddy and sandy waters of the western country, are particularly subject to danger from the accumulation of sediment.

10. *The Sudden Increase of the Pressure of Steam on a Boiler.*

A sudden increase of pressure of the steam on a boiler, there can be no doubt, has often occasioned explosions which could not be accounted for by any apparent defect in it, owing to the unequal expansion of the metal which ensues, on the same principle that hot water poured into a glass or china cup will cause it to crack. The bursting of the boiler in the tobacco manufactory at Chester in England, already referred to, took place from this cause. Mr. Leet relates that "it was connected with machinery requiring steam of great expansive force for its movements, and when used for the first time since its repair, the steam was speedily raised in such a powerful manner, that the boiler was perceived to have an oscillating motion for a considerable time, and finally exploded, spreading desolation all around." A greater pressure, if produced gradually, might not have been attended with any rupture.

It has been mentioned that owing to the explosion of the Etna, a prejudice arose against high-pressure engines for steam-boats, and that those in the Atlantic waters have since that time been supplied with others on the low-pressure principle. The term low-pressure is, however, most commonly, merely nominal; for there are few boats professedly working with low steam, that do not carry many more pounds to the inch than the low-pressure principle, or the strength of their boilers will warrant. On the western waters this is notoriously the case. From a well-informed and highly respectable source, it can be stated, that "many boats in those rivers run under the name 'low-pressure,' merely from the circumstance of their having the condensing apparatus, and from disposing of the steam by that means as distinguished from those which suffer it to escape in the air, although it sometimes happens that the condensing boat uses steam of a greater density than the other, called 'high steam.' Boats thus working the high steam, but condensing, are technically termed '*medium* engines.' It was formerly thought that a good vacuum could not be maintained in the condenser when working high steam, but practice as well as theory teach otherwise, for from the same boilers and fuel burnt, an equal quantity of heat passes to, and has to be overcome by the condensing apparatus, whether the steam operate through a small cylinder under high pressure, or through a large cylinder at a consequent low-pressure. It is not unfrequent for boats on the Ohio and Mississippi, which condense their steam, to work it as high as eighty to one hundred pounds per square inch; now the nett gain by condensing is not in any engine much over ten pounds to the inch, so that this little apparent increase of force is scarcely worth the expense and care of condensing;" and besides, it is lost by the reduction of temperature, which must be below one hundred and seventy degrees; whereas when supplied from a high pressure engine, the water would be two hundred and twelve degrees; but the steam is disposed of in an insensible manner, and the boat obtains the security-creating name of "Low Pressure:" how justly, let the above remarks determine.

* Franklin Journal, new series, vol. vi. p. 334.

It has already been stated, that notwithstanding the prejudices in the public mind against high pressure engines on board of boats, those propelled by low pressure, were as much liable to explosion as others driven by high steam. The following list comprises the cases of some of the accidents, which have occurred in low pressure boats.

1. Paragon of New York, built by Mr. Fulton.
2. Atalanta, running between New York and Elizabeth Town.
3. Washington, on the Ohio, June 1816.
4. Powhatan, between Norfolk and Richmond, March 1817.
5. Bellona, New York and New Brunswick, March 1822.
6. Eagle,* Baltimore and Annapolis, April 18, 1824.
7. Maid of Orleans.
8. Cotton Plant of Mobile.
9. Superior, of Charleston, South Carolina.
10. The Rariton, of New York.
11. Oliver Elsworth, March 1827, near Saybrook, Connecticut.
12. Constitution, 1825, North River.
13. Legislator, } Waters of New York.
14. Carolina, }
15. Franklin, }
16. Chief Justice Marshall, off Newburgh, North River, New York, April 22, 1830.
17. United States, Sept. 11, 1830, in the East River, New York.
18. Tricolor, at Wheeling, on the Ohio, April 19, 1831.

In all of the above cases, more or less persons were killed outright, or died soon after being scalded, or were disfigured or crippled for life. The greatest number suffered on board the Helen M'Gregor. Fifteen hundred persons, it has been computed, have *lost their lives by explosions of steam engines in American boats.*

Collapsion of boilers.

"Boilers constructed of plates of laminated copper, or iron, *low pressure boilers particularly*, are subject to accidents from collapsion." Some cases of this kind in American boats have been mentioned in the preceding pages; it not having been thought necessary to separate them from those strictly called "explosions," and which proceed from the expansive force of steam. "These boilers," says Arago [or their internal tubes], "are sometimes completely crushed; the sides bending to the pressure from without. The cities of Lyons and Etienne in France have been the theatres of several accidents of this kind. The inner cylinders of boilers having the furnace and flues within, give way occasionally, from their inability to resist the pressure of the steam in the circular space around them, and become flattened; this change of figure cannot take place without the metal giving way, and hot water thus escaping produces dreadful havoc. Four collapses took place in Cornwall, of boilers of this form, as has been already mentioned, p. 447. "An engineer" in commenting upon these accidents† says, "that as far as appearances after explosion are to be relied upon, they were such as to justify a suspicion, that the boilers were short of water;" and condemns their construction.

Arago mentions another cause of collapse. "At the time of lighting the fire under a boiler, the space within the boiler not occupied with water is filled with atmospheric air. This air mixed with steam passes by degrees into the engine fed by the boiler, and at last is completely expelled therefrom. If the machine be stopped, and the fire suffered to go down, the steam will be gradually condensed as the cooling proceeds, and after some time, the space which it occupied will be almost void. The boiler is then pressed inwards by the pressure of the atmosphere, without there being any interior force to counterbalance the action. A sudden condensation would crush the boiler. To prevent such accidents, interior valves called air valves opening inwards were invented. They are kept in place by a spiral spring within the boiler, the strength of the spring being a little more than equal to the weight of the valve; or it is suspended horizontally to the arm of a lever, placed on the outside of the boiler, so arranged that the valve exactly touches the interior face of the opening, which it is to close. With this arrangement, the elasticity of the steam within the boiler, can never become less than that of the atmosphere, without the immediate opening of the valve, which will admit the air into the boiler; thus when the engine is stopped, no vacuum will be formed within the boiler.‡ It seems that we cannot so safely conclude, that the same arrangement would prevent certainly the crushing of the boiler, for such accidents result from an abrupt diminution of elasticity in the steam. The gradual action of the valve might, to a certain degree, lessen the evil, but could not prevent it. *There is but one remedy against such accidents:* to watch carefully the means of supplying the boiler, and to prevent the reservoir of steam within the boiler from being suddenly cooled, as would happen for example, if a quantity of cold water should be thrown upon the exterior. It is important also when we use this kind of boiler, not to close the register doors until the fire is extinguished."§

* The Eagle formerly ran from Philadelphia to Bordentown, New Jersey, and at a time when there was not a high-pressure boat on the Delaware. We may judge whether a low-pressure engine can do mischief from the account of the captain of the Constitution, who assisted the people of the Eagle soon after the explosion. He says, "the after head of the starboard boiler bursted into atoms;" and, "I never saw so complete a wreck below decks." He tells us further, that one part of the boiler went aft to the ladies' cabin, and another killed a soldier who was asleep in the forward cabin. It is somewhat remarkable, that this tremendous explosion scarcely excited a remark in our newspapers; there was no clamour raised against low-pressure engines in consequence of the accident.

† Philos. Mag. 1827, p. 403.

‡ A puppet valve reversed answers the purpose; they have been long in use in stills to prevent a collapse.

§ An explosion was produced in a common close stove in Philadelphia, from covering a fire of anthracite coal with wet ashes, at night: on re-lighting the fire with shavings and charcoal the next morning, an explosion took place in a drum connected with the stove, and placed in the second story of the house, of which the stove occupied the ground floor: part of the drum was thrown with violence against the ceiling of the room. "By the heat remaining in the stove, a carburetted hydrogen gas was evolved from the shavings, and formed with the atmospheric air in the drum and stove pipe, an explosive mixture. An analogous result, upon a more limited scale, may be frequently observed, when paper or shavings are thrown upon a fire where there is no flame so situated, as immediately to ignite the gas evolved. If a piece of paper had been lighted beforehand, and thrown on the top of the mass, the explosion would have been prevented.—*Dr. Hare, Franklin Journal*, new series, vol. vi. pp. 414, 337.

A NEW SOURCE OF DANGER.

On the 30th Sept. 1830, a joint in the pipe that conveyed steam from the boiler of the steam-boat William Peacock, of Buffalo, New York, gave way, and instantly discharged the whole head of steam into the steerage cabin on deck, killing and scalding several persons. Here is another point to which a careful captain ought to direct his attention. It is truly shocking to think of the sacrifice of lives, from the sheer neglect of the captain of a boat to guard against every possible source of danger; and criminal on the part of those guilty of it.

MEANS OF PREVENTING EXPLOSIONS.

Several of the causes which have been ascertained to produce explosions, having been mentioned in the preceding pages, it follows, that the means of preventing these fatal occurrences, are to guard against their causes. It is a fact, that the greater part of these explosions have originated from the wanton folly, neglect, or inattention on the part of those, to whom the management of the fire is committed.

1. *Metal for Boilers.* The first point to be attended to is the material of which the boiler is made. The propriety of rejecting cast iron, and substituting wrought iron, has already been mentioned. Where salt water is employed, copper is preferable, as it does not decompose water at any temperature, and hence an incrustation of oxide will be less liable to be formed internally, in a boiler of copper, than in one of iron; for this metal, at a high temperature, rapidly decomposes water *per se*, and with the aid of various salts or acids, decomposes it at the ordinary temperature of the air, and still more rapidly, at, or above boiling heat.

2. *The form of the Boiler.* No other than that of a cylinder should be permitted, for reasons before given.

3. *Strength of the Boiler.* The third point would seem to be, the strength of the boiler.

It has long since been proposed, that every boiler intended to be used under steam of high pressure should be previously proved by injecting, by means of forcing pump, cold water into it, while the safety-valve is loaded with a much greater weight than is to be employed when working with steam; or Bramah's hydraulic press may be employed.

The water-proof having been performed, the boiler should be next subjected to a similar trial by steam, of twice the force that is usually to be generated in the boiler, without causing the safety-valves to act. In France it is required by law, that all high pressure boilers be subjected to a proof five times as great as the boiler is intended to bear, when in service. Arago says that this pressure is reduced to three times for boilers of rolled or hammered iron, but that even these do not afford entire security. He judiciously remarks that "these trials only show what a boiler can bear when new, not what it will be able to sustain after some weeks, or some months use; after inequalities of temperature have strained the metal in every direction; or after rust has acted upon it," &c. A boiler should therefore be proved from time to time, and occasionally examined to detect any weak part.

Mr. Bramah in confirmation of this advice may be quoted. He says, if a boiler was prepared to sustain one hundred pounds, and strained with a force of two hundred pounds, it might afterwards break at forty, the straining having injured it.* The extreme proof required in France is injudicious. A proof of double the pressure intended to be used would seem sufficient; more might defeat the object of the trial. Mr. Vivian adds, that explosions may be easily prevented by proving the boiler every time it is cleansed, which should be at least every month.† John Taylor says in proof of this, that a cast iron boiler was proved to one hundred pounds to a square inch, by the water proof, and commonly used with about forty pounds pressure, but it broke one day with less than twenty pounds pressure; the fracture being caused by the heat expanding unequally.‡ Mr. Donkin has known a boiler wear out in six months; and another used for fourteen years.§ Mr. Dodd says, that when a wrought iron boiler will not support the cold water test of twelve pounds to an inch, it is time to have a new boiler.‖

4. *Size of the Boiler.* Mr. Evans never exceeded the diameter of three feet, and to increase capacity extended their length to twenty or thirty feet, or more; or increased the number. Messrs. Rush and Muhlenberg, his successors, now make their high pressure boilers of thirty inches diameter. The "Engineer," before quoted, restricts their diameters to five feet; from which it would seem that in England high pressure boilers are sometimes of a greater diameter.

5. *Height of the Water in the Boiler.* As it has been ascertained, that the greater part of the mortality from steam explosions proceeded from inattention to the great point of keeping up the due supply of water in the boilers, this should never be lost sight of. Captains of boats ought not to trust this business solely to the engineer or fireman.

To ascertain the height of the water in the boiler, it is well known that the original expedient, and the one commonly used, consists of two stop-cocks in front of the boiler, one of which communicates with the water, the other enters the boiler above it. The issue of steam from the first indicates the deficiency of water, and the discharge of water from the last, shows that it stands too high. But these cocks do not upon all occasions answer the end intended by them. Mr. Potts observes,¶ "when an engine runs regularly, it is not difficult by this means to make the supply of water to the boiler by the hot water pump equal to the evaporation; but every variation that takes place with regard to the load with which the engine labours, or the velocity with which it runs, tends to disturb the equilibrium between the supply of water and the evaporation, attained by any previous adjustment of the pump. Again, when a temporary stoppage of an engine is necessary, as for taking in, or discharging passengers, the fire is rarely abated to such a degree

* Evidence before the Committee of the House of Commons, p. 38. † P. 163. ‡ P. 43. § P. 8. ‖ P. 213.
¶ Franklin Journal, 1830, p. 42, vol. vi. new series.

as to prevent all further evaporation. The supply from the pump being cut off, the water sinks rapidly."

Cases have even occurred in which explosions have happened in the boats of the United States, when going at their regular speed, as was shown by the steam guage, if the solemn asseverations of the captains are to be believed, and immediately after the water-cocks had been opened and indicated the supply. The boats Etna, United States, and Chief Justice Marshall, are cases in point, as has already been mentioned under the third head of the causes of explosions.

This fact shows clearly, that implicit reliance ought not to be placed for safety, upon the guage-cock emitting water. But further, " even where the water is not so far reduced in the boiler, as to be below the top of the tube, I am by no means inclined to consider this boiler in a safe state. The plates of a boiler urged by an intense fire, and covered with only a thin stratum of water, become very considerably hotter than the steam and water above them. The unequal expansion resulting therefrom, renders the parts more disposed to give way, when further stress comes upon them."* A boiler or flue therefore, repeatedly thus treated, may give way upon the occasion of an extra strain from high steam, although the guage-cocks will show water in the boiler. This deficiency in the guage-cock may be remedied in low pressure stationary engines, by the means mentioned by Mr. Farey as having been used by Mr. Smeaton, viz. " A pipe going down beneath the surface of the water in the boiler, and at the upper end of the pipe, at the top of the house, a whistle mouth-piece is formed; then, if the water sinks too low, the steam will issue at the pipe, and give the alarm."†

Professor Hare proposed that a hollow globe, swimming on the water of the boiler, should open a small cock so as to produce a jet of steam in front of the boiler, whenever the water should sink too low.‡ This contrivance is applicable to high and low pressure engines; an objection to it has been raised, viz. that by frequent expansion and contraction, the parts soldered together have opened so as to cause the vessel to fill with water and sink. A little attention may certainly obviate this difficulty. Pumice stone is used as a float, for Watt's feeder at the Globe Mill. The glass tube water-guage will afford additional means to determine the height of the water.

With the same object Mr. J. L. Sullivan has invented an *alarm bell-float*, and *phonic guage* for boilers; the object of which is to cause the water itself to give the alarm. For this purpose he uses bells or metallic triangles within the boiler, to ascertain where the surface of the water is within certain limits. The principle of their operation is founded in the fact, that bells emit a louder sound in compressed air, than in the atmosphere. Two bells are to be placed in a boiler, one an inch higher than the other, with suitable wires leading from each tongue through packing to the front of the boiler: if the lower one touch the water it will not ring, while the upper one being above the water will sound and be heard; thus making it known that the surface is between them. It is intended to ring spontaneously, whenever the water shall happen to subside so much as to make bare and expose the furnace or flue to the action of the fire within; or if a single cylindrical boiler exposing some part of the sides to the action of the fire without, or under, whereby the flue or sides unprotected by the water might become red hot, and impart great heat suddenly to the water, and causing so great an increase of high steam, that the safety-valves cannot vent it. A specification of this plan is contained in Silliman's Journal for 1831, and deserves an experiment by all those to whom passengers entrust their lives, on board steam-boats.

To insure a constant and due quantity, Mr. Watt contrived a simple plan for low pressure stationary engines, by which the engine is made to supply the boiler. One of these is in use at the Globe-mill Cotton-works, near Philadelphia. Mr. Doolittle of Vermont has invented another, and described it in the Journal of the Franklin Institute, vol. iv. This feeder, like that of Mr. Watts', has a regulating cock, or valve, between the forcing pump and boiler, and the pump must continually urge towards the boiler its maximum quantity of water, whether the boiler is in a state to receive it or not. Mr. Charles Potts of Philadelphia, has recently taken out a patent for an invention to effect the same object; an account of it may be found in the Franklin Journal for 1830, vol. vi. pp. 42 and 327, illustrated by a plate. His object is to secure the self-action of the supply pump, by the falling and rising of a float in the boiler. In the same work and volume Mr. Ewbank of the state of New York has proposed another plan, and with the exception of this principle, somewhat on that of Mr. Potts; who announces that Messrs. Rush and Muhlenberg, of Philadelphia, will attach his apparatus to engines. In vol. vii. p. 183, is a specification of another patent granted to John S. Williams, of Kentucky, for the same object, with a cut illustrative of the apparatus. Finally, Mr. Farey§ describes at length, and figures a contrivance wherewith the boiler will always feed itself as fast as its evaporation requires; the water being admitted by a feeding valve, which is opened by a float on the surface of the water in the boiler. *This is the mode adopted in England.* With all these contrivances to prevent a common cause of explosion, no admissible excuse can be offered by proprietors of boats, for deaths which may take place for want of them.

6. *To lessen Sediment in Boilers.* In the collieries in Scotland, where steam engines are applied to the drawing off the water in mines, the earthy sediment has been found very troublesome, but its deposition is prevented by the simple expedient of throwing a bushel of *comings* into the boiler once a week. This substance is the radicles of barley produced in the process of malting, which are separated before the malt is sent to market. Mr. Bald of Alloa says,‖ the effect is immediate when the steam is again raised. When sulphate of lime (gypsum) is held in solution by the water.

* An engineer. Philos. Mag. 1827, p. 406. † Farey on Steam Engines, pp. 193, 370. ‡ Franklin Journal, vol. ii. p. 148.
§ On Steam Engines, p. 453. Lond. 1827. 4to. ‖ Edinb. Philos. Mag. 1820, p. 340.

they use *peat earth* in its natural plastic state. From Silliman's Journal vol. vii., it appears from a statement of Professor Griscom, of New York, that potatoes have long been used in the United States for the same purpose. Arago says that they answer even when the deposit is saline, by which it is presumed, he alludes to the contents of salt water. The diffusion of the starchy feculæ through the water forms a viscid liquid, which envelopes the solid matters of the water, and keeps them suspended, and prevents their cohesion. After a month's service, the boiler is emptied.

To prevent the formation of sediment in the boiler, one of the experienced captains on the Delaware says, that the water should be changed while the boat is under way, as the sediment would thus be made to flow out of the legs of the boiler and space in front; and to determine whether the force pump supplies as much as is let off, and the flues are covered, one guage cock should be kept open. The superb boat, Robert Morris of Philadelphia, the works of which were made by Mr. Holloway, has not only a man-hole to clean the boiler, but additional facilities to remove sediment, consisting of a vent hole or tap in each of the three front legs of the boiler, a hand hole covered with a screw plate, in the middle front leg; two hand holes, one on each side of the further end of the boiler, and another hand hole on the side of the boiler, opposite the bridge wall.

The apparatus adopted at the mint, and formerly referred to, to lessen the deposit in a stationary engine, is as follows.

The operations of the coinage in the Mint at Philadelphia are effected with the aid of one of Oliver Evans' high pressure engines. For sometime after its erection, the grease from the cylinder, being carried into the boiler with the water of the condensed steam, united with the earth in the water of the boiler, and forming a hard sediment on the bottom plate caused it to burn out. The boiler being mended required to be cleansed once a month. To lessen this trouble, and prevent the frequent suspension of the work, Mr. Eckfeldt, chief coiner, some years since adopted the following plan. He surrounded the escape pipe with a copper cylinder twelve inches in diameter, and containing thirty gallons of water, which is let into it by means of a pipe lying on the side and near the top of the cylinder, and kept constantly hot by the steam in the pipe. The steam passes into a cast iron reservoir; the portion of it condensed flows into a sink through a hole in the side of the reservoir, with the filth from the cylinder, while the uncondensed portion of the steam is conveyed up a pipe fixed in the top of the reservoir, and leading into a chimney. When the boiler requires replenishing, the hot water in the cylinder is let into a reservoir, and forced into the boiler. Thus, while there is great economy in supplying the boiler with hot, instead of cold water, the deposition of the hard crust on the inside of the bottom plate is greatly lessened, and no sediment precipitates but that which is formed from the earth contained in the water, with which the copper cylinder is filled. This is so trilling, that the boiler does not require cleansing oftener than once in three or four months. From the great head on the Schuylkill water, the workmen are enabled to draw off the heated contents of the cylinder, by merely fixing a pipe to the aperture in its top, intended for the admission of the cold water. This heated water being in perpetual requisition for various purposes about the establishment, the constant supply of it is found a great convenience. A safety valve in the cylinder prevents all danger from the too great accumulation of steam in it.

7. *Safety Valves.* Under the tenth head of the causes of explosions, six particulars are enumerated, all tending to disappoint the expectations of security from safety valves; and in the commentary upon them, some facts in illustration are given. It seems astonishing that an error should be committed as to their diameter, and yet such is said by a careful and experienced steam-boat navigator to be often the fact. As the rules for their construction are well understood, and fully laid down, it is criminal for those who undertake to make an engine, not to avail themselves of the important knowledge in their power. This may be obtained by consulting Mr. Farey's large work, or that of Mr. Renwick, p. 86. The object of the present article is not to enter in the minute details of the mechanism of engines, but to point out the causes of the dreadful explosions that have taken place, and to suggest the general means of preventing them. The adhesion of the disk should be constantly guarded against; in the case of the Legislator already noticed, the vigilance of the engineer, and his prompt attention, probably prevented the occurrence of a most serious explosion from this cause. To prevent the possibility of an adhesion, Mr. Mausdlay, an experienced worker of steam in England, placed near his boilers a cord within reach of the fireman, by which he could raise the safety valve from time to time. But this is not enough. Supposing that the valves are properly constructed, it has often been recommended to have two to every boiler, one under the control of the fireman, to be used whenever the steam is to be let off; the other to be inclosed by a grated box, of which the engineer, or captain of the boat, proprietor, or superintendant of the engine, should have the key. Arago says, that in France a royal ordinance makes this precaution absolutely essential; and the government of the United States, or the State Governments, should follow the wise example. The preservation of 1500 lives, which may again be lost in the course of a few years, by inattention to the subject of steam-boats, is certainly of more importance than the inspection of hog's-lard and butter for exportation, for which strict laws are in force.

Mr. Dodd, an eminent British steam engineer, "disapproves of those safety-valves which have a conical seat, as they are liable to be jammed in, and also fastened by contraction: and also those that are pressed down by a weight on a lever, as accident or design, by altering the position of the weight, may increase or decrease the pressure, and they are peculiarly inapplicable to the motion of vessels at sea. With lever safety-valves even the most cautious man may, in the hurry of business, place the weight too far out on the lever, and if the lever be too short to admit this, rash men frequently put on an extra weight, and thus endanger the property and themselves, and those on board. The best inaccessible valve* is formed by fixing round the hole or orifice on the boiler, a circular brass ring flat on the upper surface. From the centre of this ring, and secured to the under side thereof, arises a spindle or pivot, passing into a cylinder closed at the top in the middle of the valve and weight. This pivot should be grooved on the sides, to allow the entrance of steam; and should not extend to the top of the cylinder, nor fit tight by the tenth of an inch. This cylinder has a *brass flat bottom resting* on the flat circular ring, and both surfaces so finely ground as to be air and steam tight: valves similar in this respect have been long and successfully used. A leaden circular weight, having a hole up the centre, is placed over the brass tube or cylinder, and rests on its base. The whole is surrounded by an iron box rivetted to the boiler, and has a lid fitting tight and locked. From the side of this box passes a pipe of sufficient bore to convey away the escape steam. The steam from the accessible or common valve is conveyed by a pipe through the vessel's side into the water, and to prevent a vacuum in this pipe, and the cold water rising up to the safety valve, connected to this steam-escape-pipe is a reverse or atmospheric valve. That it may be known when the accessible safety valve is out of order, we pass the escape-steam-pipe of the inaccessible valve into the paddle boxes, from whence the steam will be heard and seen to issue in the event of that valve being forced to act; and all on board may know that something is wrong with the other valve. Yet this circumstance should create no alarm, for however much he may urge the fire, the steam will escape by that valve, and foil his utmost effort to raise it to a dangerous strength."†

These particulars are given, as Mr. Dodd's work is not common in the United States.

8. *Steam Guage.* Ample and afflicting experience having demonstrated, that safety-valves do not on all occasions afford security against explosions, no steam-engine on shore, or in a boat, should be without a mercurial Steam Guage. For, "although the load on the safety-valve makes a sufficient regulation of the strength of the steam, to avoid any danger of bursting the boiler, it is not a sufficiently accurate indication, to enable the engine man to keep up the steam always to the same elasticity. Mr. Watt, therefore, employed a steam guage, which operates by a column of mercury. This steam guage consists of an inverted syphon, or bent tube of glass or iron; one leg of which communicates with the boiler, being joined to the steam-pipe, and the other is open to the atmosphere. A quantity of mercury is poured into the tube, to occupy the bent part which joins the two legs; and the mercury in merely being exposed to the pressure of the steam, while the external air acts upon the other, it is evident that the difference of level of the two furnaces, will express the elasticity of the steam above or below the atmospheric pressure, by the height of a column of mercury it will support. When the tube is of glass, this difference of level may be seen and measured on a scale of inches; but when an iron tube is used, a small light wooden rod, floating on the surface of the mercury in the open leg, points out the height of the column against a scale of half inches, fixed above the open end of the tube. In this case, the divisions, which are numbered for inches, must be only half inches; because the mercury will descend in one leg, as much as it rises in the other; so that the scale must be doubled, to show the real difference between the two surfaces.

"The tube is made of wrought iron, in the same manner as a gun-barrel, but with the two ends bent parallel, like the letter U: the interior of the tube ought to be bored, in order that both legs may be precisely of the same diameter, otherwise the guage will not show the pressure correctly, because the mercury will not sink so much in one leg as it rises in the other. A steam guage of this kind is usually attached by two screws to the steam pipe, or else to the end of the boiler, or at any part having open communication with the boiler, and in a convenient place for the engine keeper to see it, because this should be his constant guide for the regulation of the fire and the damper." ‡

If this steam guage be properly fixed, so as to be always kept upright, and of a diameter adapted to the size of the boiler, it can never fail to point out the elastic force of the steam within it; as by the rising of the mercury, which is shown on the scale attached to the tube, the fireman can ascertain at once, whether the pressure be greater than the boiler is calculated to bear. If the mercury becomes stationary, it would instantly point out that the tube was stopped, and give time to guard against danger. "It is also a capital counter security to the valves, for if this guage indicate a higher pressure of steam than that at which the valves ought to rise, the engineer may know that they are impeded, and rectify the error. It is the duty of the man frequently to look at this guage, that he may know when to increase the fire in the furnace, and occasionally to tap the guage, that by the excited action of the mercury, and the indicating rod (where the syphon is not of glass but of metal), he may be assured that the action of the guage is free and uninterrupted. Every steam packet on the Thames is provided with one of these guages."§ The utility of the steam guage was shown in the case of the Legislator of New York (p. 445). The rod rose as high as the deck would permit, thus proving an immense pressure on the boiler.

9. *Plates of Fusible Metal.* "As soon as it was found that the common safety-valves sometimes got out of order, and did not present a certainty of security, it was proposed to replace them by an entirely different contrivance, the action of which should never be uncertain. This was the fusible metal valve, described in the 'Annuaire du bureau des longitudes' for 1829 and 1830. To understand rightly the use of these valves, we should know, that it is possible for steam to have a very high temperature, with but little elasticity, but not possible, that a great degree of elasticity, should not be accompanied by a high temperature. Experimenters have determined the lowest temperature necessary for steam to acquire

* Inaccessible, except to the one who has the key of the box containing it.

† Dodd on Steam Engines, p. 210.

‡ Farey on Steam Engines, p. 371.

§ Dodd on Steam Engines, p. 216.

a tension of one, two, three, ten or more atmospheres. By using these results, we can know what temperature the steam must not surpass after we have fixed on the pressure. If we then cover an opening in the boiler with a plate made of an alloy of lead, tin and bismuth, in proportions such that the alloy will melt at the limit of the temperature fixed upon beforehand, this temperature can never be exceeded, for on reaching it, the plate melts and gives vent to the steam.

"In France, a royal ordinance requires that every boiler shall be provided with two fusible plates of unequal sizes. The fusing point of the smaller is 10° centigrade (18° of Fahr.) above the temperature of steam having an elasticity equal to that which the steam to be used in the engines, should have. The second plate fuses at 10° (18° Fahr.) above the first.

"The plate does not approach the point of fusion without being softened: it is therefore to be feared that it might give way under a tension much less than that which produces its fusion. At the outset this actually did take place, but the difficulty has been obviated, by covering the plate with a wire gauze with small meshes, before it is fixed by bolts to the aperture which it is to close. Even now parts of the plates yield partially, swelling out in different places as the fusing point approaches, but experience has shown that it is only very near to this point that the metal yields entirely, opening a free passage to the steam. When the fusible plate has been melted, all the steam escapes through the opening which it closed, and it may take some time to replace it, to fill anew the boiler, and to heat the water, during which the engine stands still. In certain cases, this sudden absence of the moving powers might occasion serious accidents. This is a real and a great difficulty,* and perhaps is the reason why our neighbours (the English) have not adopted the fusible valve, but give a preference to the ordinary safety valve, which never opens, except when the elasticity of the steam within has passed a certain limit, previously fixed by the engineer, and falls, closing the aperture, when the elasticity has returned within this limit without the moving power failing entirely."†

M. Gualtier directs, that "these fusible disks should be composed in such proportions, that they will melt at a temperature but little higher than that at which the steam boiler of the machine ordinarily works. 2. That they should be placed in a proper situation, as it is known that in different points of the surface of the boiler, the temperature is not perfectly equal, and that a disk which would melt at one point will remain solid in another; the best position for them is over the fire place."‡

10. *Dampers.* To enable the fireman to have full command of the fire, to increase it when necessary, and to diminish it when too intense, and more steam is generated than is wanted, *dampers*, at the junction of the flues with the chimney, should never be omitted. These dampers should be self-acting, and be connected with the safety-valve as proposed by the Chevalier Edelcrantz; for nothing should be left to the vigilance of the fireman.§ Mr. Renwick suggests that "there should be another, to be worked by hand as occasion may require; and in order to place the fuel under the control of the firemen, the passage by which the air is admitted to the ash-pit ought also to be capable of being opened and shut at pleasure. Doors and valves for this purpose should therefore be provided, and the apparatus is called a Register."‖ Too many precautions to prevent the loss of lives cannot be adopted.

11. *Attention to the working of the Engine.* As it has been mentioned in the preceding pages, that just before an explosion has taken place, the engine has been observed to labour, or work more slowly, the engineer should bear this fact in mind, and prevent the calamity by timely attention. The cause of this slow motion has already been explained, p. 443. The means of prevention therefore is, to avoid opening the safety valve, or steam guage cock, which would cause the water to rise suddenly, and come in contact with the over-heated metal; to withdraw the fire as speedily as possible; to check the draught of the chimney by the damper, and to avoid a sudden change of position of the boat.

12. *Strengthening the partitions between the Boilers and Passengers.* A great means of security to passengers in case of an explosion, is to strengthen the partition between the boilers and the passengers, and to weaken the other parts of the enclosure, so that the steam should issue out at the place of least resistance.¶ Professor Silliman recommends that this bulwark of timber should be made so strong as to resist not only water and steam, but also the fragments that may be projected, or even the entire boiler should it be thrown from its bed;** that two boilers be placed on the guards of the vessel over the water, and that the side next to it should be open. This bulwark has been many years adopted in the English steam packets.††

13. *Tow-boats.* The only infallible means of preventing danger from explosions remains to be mentioned.

As it has happened, that explosions have occurred on board of boats, when, according to the declaration of those concerned in their management, they could not be ascribed to any of the causes before enumerated, and as similar cases may again take place, the ONLY CERTAIN MEANS to insure perfect safety to travellers, is to place the machinery in one boat, and to tow another containing the passengers. This was one of the measures which the unfortunate Fitch intended to adopt, if he succeeded with his boat, and mentions it in his manuscripts bequeathed to the library company of Philadelphia. It has recently been again proposed by Mr. J. R. Sullivan, and demands the serious attention of the proprietors of steam-boats. The attempt was indeed made three years since by the owners of the Commerce, on the North River, but,

* But not so great an inconvenience as being blown up, a misfortune which these fusible plates would prevent.

† Arago, *Franklin Journal*, vol. v. 1830, p. 410.

‡ Ibid, vol. vi. p. 60.

§ Lardner on Steam Engines, Lecture 8th.

‖ Renwick, p. 94.

¶ This was recommended by a committee of gentlemen who were applied to by the councils of Philadelphia, on the subject of the prevention of explosions, in the year 1817.

** American Journal of Science, 1830. No bulwark would be able to resist the entire boiler, or a large portion of it.

†† Dodd on Steam Engines, p 214. London, 1818.

owing to the deficient power her speed was much slower than that of other boats, and therefore not much patronized. Mr. S. proposes to use the strongest form of boiler, and to have the follower of a light sharp construction, with one deck, that the resistance of the water might be small. Professor Silliman remarks that "there seems to be no objection to the plan of any weight, upon waters generally smooth. The excessive speed now aimed at is of no importance; no reasonable man will be dissatisfied if (sleeping and waking) he can go ten miles an hour. This degree of speed, and probably more, is attainable in tow boats." He adds this important consideration; "the proprietors of steam-boats must answer to their country and to God, if they neglect any practicable means of defending their fellow creatures from the most awful calamity to which the confiding traveller is exposed." But this argument will have little avail with them; the concluding one used by him will have much effect, viz. that "the *first boat which is ascertained to afford absolute security will be a fortune to its proprietors.*"*

On the Economy of using high pressure Engines acting expansively, and condensing.

In p. 431, it was intimated that Mr. Evans overrated the economy in fuel from the use of his high-pressure engines. His deductions were the result of experiments recorded in the seventeenth vol. of the Ency. Britannica. But later experiments by the French Academicians, Arago, Dulong, &c., give a different result. According to those, an increase of 30° of Fahrenheit does not double the pressure of steam. Even by the experiments of Dalton, made long since, 40° of Fahr. are required to produce this pressure. The French committee prove that the doubling of the pressure at high temperature, requires a greater augmentation of heat than at a lower temperature. Thus, while an augmentation of 21° of the Centigrade therm.=38°.5 of Fahr. increases the pressure from one to two atmospheres, it requires an addition of 31½° Cent.=56°.7 Fahr. of temperature to augment the pressure from 8 to 16 atmospheres: and to raise the pressure from 12 atmospheres to 24, the increase of temperature necessary is 61°.5 Fahr., and if we may rely on their formula† given for computing the pressures at temperatures above 24 atmospheres, it will require an increase of 71°.28 Fahr. to the temperature to augment the pressure from 25 to 50 atmospheres.

The following little table of differences, by Professor Walter R. Johnson, is derived entirely from that part of the table of the French Academicians constructed from their experiments, and shows that the fourth stage of doubling pressure, viz. from 12 to 24 atmospheres, the increase of temperature is $\frac{3}{2}$ of what it is at first, or from 1½ to 3 atmospheres.

Difference of pressure in atmosphere.	Difference Cent.	Difference Fahr.
1½ to 3	22.9	41
3 to 6	25.7	46.2
6 to 12	29.8	53.8
12 to 24	34.2	61.5

Thus although the general position of Mr. Evans is true, viz. that while the temperature is increased arithmetically, the elastic power of the steam is increased geometrically: yet the particular law of that increase, as laid down by Mr. Evans, is not sustained.

In conformity with this general position, Mr. Perkins, p. 396, considers the observation which he has made upon elastic steam generated with enormous heat, as leading to the following result: *That* while the temperature rises in an arithmetical ratio, the expansive force will be that of an increasing ratio, and the increment of fuel will be a decreasing ratio.

Mr. Henwood, an advocate of the low pressure engine, states‡ that the average duty of Mr. Watts' engines was about 25 millions lbs. lifted with one bushel of coals, and according to Mr. Farey, all the water works in London are now served by Watt's engines, working low pressure steam, acting expansively in one cylinder, and the performance of the best of them is about 25 millions. Mr. John Taylor states, that according to the official monthly report of the Mine agents in Cornwall, one engine (high pressure) of Mr Woolf at Wheal Towan, raised in 1828, on an average 77,290,000; in 1829, it was 76,235,397 lbs. with one bushel of coals. During an experiment by Mr. Rennie with the same engine, it raised 92,327,000 lbs. with the same quantity of fuel:§ and Sir H. Davy states in the Trans. of the Royal Soc. for 1827 and 1829, that this engine performed a duty in the whole month of December 1829, exceeding the average of 17 engines on Mr. Watt's construction in 1798, by a proportion of nearly 4 to 1. Finally, Mr. Farey gave his opinion before the committee of the House of Commons, that "the difference in cost, between the quantity of coals consumed by the engines now in use (which are all on Mr. Woolf's system), and by an equal force of engines such as were in use before he went to Cornwall, in 1813, would absorb the profit of all the deep mining that is now carried on in Cornwall." Nothing,

* Silliman's Journal, 1830.

† These calculations must, however, be received with some qualification. Biot, in speaking of results from other data, says, "This table, calculated after the formulæ deduced from experiments of Dalton, has not been carried beyond 135°, because it would then become defective. Indeed similar formulæ are never more than approximations, in which are comprehended only the terms, which are sensible, with the experiments, that are compared. We must not then carry them to limits beyond those which these observations would include, since the neglected terms would then acquire an influence which had not been found to belong to them, while their absence would occasion great errors.

"For example, if it were wished to carry the formula to 200°, the elastic force would be seen to cease augmenting, and even begin to diminish. But that means no more than in making the proper application of the first observations, we have neglected some terms which should have been regarded in making calculations to such high degrees. This defect could be remedied, if we possessed some data relating to the tensions of the steam observed at those degrees, for then could be applied to them the formula in adding a term in n^4, which would be insensible at lower degrees. But from the want of such observations, we have limited the formula to the extent allowed by the experiments of Mr. Dalton." Biot. Traite de Physique, vol. i. p. 530.

‡ Philos. Mag. 1830, p. 324. § Do. pp. 425, 430.

it would seem, can more fully demonstrate the superior power and economy of high pressure engines.

Mr. Thomas Lean, the professional inspector of steam engines in Cornwall, stated to a committee of the House of Commons, of England, in 1817, that "high pressure engines save at least two-fifths of the whole consumption of coals in Cornwall."

In p. 397 the discovery that steam at a very high temperature will not scald, is attributed (but erroneously) to Mr. Jacob Perkins, for it was first accidentally made (in this country) sixteen or seventeen years since, at the Fairmount Waterworks, on Schuylkill, by a workman named Kissick, who had the care of the high pressure engine which was used at the time, to raise water from the river for the supply of the city; and who has at present the charge of the powerful water wheels erected for the same purpose. Having opened the guage cock for the water, to ascertain the height of it in the boiler, he received a stream of high steam in his face, and thought himself ruined, but in a minute or two he was agreeably disappointed, on finding no inconvenience from it, except the trickling down his face and breast, of the water from the condensed steam.

The fact being thus ascertained, the workmen of Mr. Evans made no difficulty about caulking boilers, while high steam from them was pouring out on their faces and hands, through leaks. A short time after the first discovery, an occurrence similar to Kissick's happened to Mr. Eckfeldt, at the mint. The aperture of the guage-cock of the high-pressure engine, used for driving the machinery of the mint, was originally at the bottom, but in consequence of a deposition from the water in the boiler, it became closed. The place of the aperture was therefore changed to the front, in order that a wire might be easily inserted to clear the passage when necessary. Some time after, the cock was turned, and Mr. Eckfeldt, who was standing about two feet from it, received the full blast of the steam directly in his face: at the moment he was much alarmed, but in turning round, he was agreeably surprised to find he was not scalded. The writer made the experiments in the presence of Mr. Eckfeldt, on the 20th of April, 1831, while the engine was at work, with a pressure of nearly 150 lbs. to the inch, the usual extent to which it carried. He held his open hand first at the distance of 18 inches from the cock, while the steam was rushing with tremendous force from the aperture in the cock, and finding it little more than warm, he placed it within nine inches of the cock, and even then the sensation excited was not more than that of an agreeable warmth. Oliver Evans mentioned the fact, in a hand bill, on the 28th of October, 1817, that high steam does not scald, see p. 431: this was before Mr. Perkins left Philadelphia, which he did in May 1819. Mr Brunton, an experienced English engineer, gave another proof of the fact to the committee of the House of Commons, in 1817,* and Mr. Vivian also said, on the same occasion, that "the steam from low pressure scalds much worse than the steam from high pressure."†

Mr. Perkins, however, confirmed the fact in England, by a set of ingenious experiments, as related in p. 397, and explains it thus: "I have frequently observed, that when the stop cock of a high-pressure boiler was opened, whether at the water or steam cocks, the *temperature was lowered in proportion to the height of the steam.* He ascribes the phenomenon to the great force and rapidity of motion of the steam causing the atmospheric air to be driven before it, evidently tending to produce a partial vacuum, to which the surrounding atmosphere would rush in, and diminish." This explanation, however, is only in part true, because the diminution of temperature of the steam is observed in tubes when the atmospheric air is excluded. A very neat set of experiments by Mr. Ewart, of Liverpool, show that the reduction of the temperature of steam, is owing to the great expansion of it, and the recovery of its capacity for heat. He ascertained that the heat of the boiler was 292°, and that of the issuing steam 185°:‡ thus confirming a well-known law, viz: the diminution of the capacities of bodies for heat when condensed, and their increased capacity for it when expanded. This law equally applies to fluids in an aeriform state, and hence the temperature of steam condensed in a boiler is raised, and lowered if allowed to escape and expand.

The following papers may be found useful to those who are desirous to enquire into the subject of steam engines.

1. On the comparative power of steam engines, and rule (with example) to find the power of a steam engine on Watt's principle, in horse power. *Franklin Journal*, vol. iii. p. 333.

2. On the relative proportions of the various parts of the Boulton and Watts', or low pressure engines; the fuel required for working engines of different powers, and the effect produced in pumping water or grinding wheat. First published in the *Franklin Journal*, vol. iii. p. 336.

3. Specification of a patent for an improvement in the application of the escape heat from the high pressure engine, by A. Brown, Onondago county, New York. Ibid, vol. iv. new series, p. 273.

4. On the economy of using highly elastic steam expansively, by Jacob Perkins, Ibid, vol. iv. 1827, p. 24. Remarks on the same, p. 120.

5. Method of using heated air, gases, elastic fluids, and products of combustion, which are available to the increase of steam power, by M. Ward, Baltimore. Ibid, p. 49.

6. Account of Mr. Perkins' new high pressure steam engine, vol. iii. 1827, with plates vol. iv. p. 39, p. 239, p. 349, by Mr. John March, p. 414.

7. Dolittle on securing a constant and uniform supply of water in steam engine boilers. *Silliman's Journal* for 1827, vol. xiii. p. 64. Remarks on the same by Dr. Jones, *Franklin Journal*, vol. iv. p. 347.

8. On the true mode of computing the power of a high pressure steam engine, by Charles Potts. Ibid, vol. v. new series, p. 111. Remarks on the same, pp. 251, 398.

9. On the difference between the absolute efforts employed to move a locomotive engine, when the force proceeds in one case from the engine itself, and in the other from a stationary engine, supposing the place over which the motion takes place to be horizontal, by Charles Potts. Ibid, vol. v. p. 246.

10. Arago, on the explosion of boilers. Ibid, vol. v. and vi. new series.

MEASE.

* Evidence, p. 135. † Ibid. p. 161.

‡ On the phenomena attending the sudden expansion of compressed elastic fluids. Philos. Mag. 1820, p. 247.

STEAM CARRIAGE. The idea of driving carriages by means of mechanical power is of considerable antiquity, and in the older works on mechanics, we meet with drawings of carriages impelled by the action of wind upon sails, and of others driven by the action of the feet of men in the carriage. Maillard's chaise driven by winches, Brodie's self-driving chaise, and Maillard's chaise with an artificial horse, may be enumerated among carriages driven by mechanical power.

Dr. Robison seems to have first suggested the idea of driving carriages by steam, and it appears that Mr. Symington of Falkirk, so early as 1787, was occupied with a plan of applying the steam engine to carriages. These proposals, however, were never carried into effect, so that the real merit of introducing the steam carriage belongs to Messrs. Trevithick and Vivian, who invented their high pressure engine with the express view of using it in propelling carriages on railways. Although their patent was taken out in 1802, yet it was not till 1805 that it was actually applied in the experiment of moving carriages on a railway at Merthyr Tydvil, when trials were made at different times, but it was not till 1811 that the first steam carriage was actually used for practical purposes. This was done by Mr. Blinkensop (proprietor of the Middleton coal works, which supply the town of Leeds with coal), who introduced steam for the purpose of conveying coal wagons along his rail-roads. In the steam carriage which Mr. Blinkensop used, the boiler was supported by four wheels without teeth; but it was driven by a crank connected with the piston, which needed other two wheels in the centre of the carriage having teeth in their circumference. These teeth engaged in teeth on the rail-road, and in this manner the carriage was moved along followed by a train of *thirty* coal wagons.

In the year 1816 Messrs. Losh and Stephenson of Newcastle took out a patent for improvements in steam carriages and railways, which we have represented in Plate DXI. Figs. 1. 2, 3 and 4. Fig. 1. is a section of the steam carriage, Fig. 2. is a view of it dragging after it the carriage EF, containing coals at E and water at F, and the first wagon G of the train. The steam-engine shown at AB has two cylinders, whose pistons T, B, drive the crank rods AC, BD, which give a rotatory motion to the two wheels C, D, to whose axles they are fixed. The two opposite wheels, which are not seen in the figure, are driven by similar rods. The circumferences of the wheels take hold of the rail rod RR merely by friction. The middle pair of wheels receive their motion from the other two pair by means of a chain passing over two rag wheels *m*, *n*, placed in the centre of each axle as seen at *c*, Fig. 5. This chain drives a third rag wheel *c*, and thus drives the middle pair of wheels. In the steam-carriage used by Mr. Blinkensop, the engine was supported directly by the axles, but Messrs. Losh and Stephenson connect the boiler with the axle by means of *six* floating pistons *b*, *b*, &c, movable within cylinders *a*, *a*, *a*, *a*, into which the steam and the water is allowed to enter. These cylinders are best seen in Fig. 1. where *b*, *b*, are the floating pistons connected with wrought iron rods below; the ends of which rest upon the bearing brasses of the axles of the wheels C, D. These pistons press equally on all the axles, and thus make each wheel bear with equal force on the rail-rod R, R, and act upon them with equal friction, even though the rails should not be all in the same plane. This effect is produced in consequence of the bearing brasses having a certain degree of play in a groove or slide in a vertical direction; and as they carry the axles and wheels along with them, they force the wheels to accommodate themselves to the irregularities of the road. A steady motion is thus obtained, and shocks are better prevented than if the engine rested on the finest steel springs. The construction of the rail-road and the wheels is shown in Figs. 3 and 4.

The engine used in steam-carriages is the high pressure one of Trevithick, already described and represented in Plate DIX. Fig. 4; but as this subject has now become one of national importance, we have given in Plate DXI. Fig. 5, a drawing of one of the most approved steam-carriages with its engine after Mr. Tredgold.

Fig. 5 is a side elevation, and Fig. 6, a vertical section of this carriage, the same letters indicating the same parts in each. From the cylindrical boiler A, surrounded with the fire and flues, the steam passes into two large cylindrical reservoirs of steam H, H′, of the same diameter. In these reservoirs are placed the engine cylinders G, G′. The parts H, are a reservoir of water not exposed to the pressure of the steam, but warmed by the flues and chimney so as to be heated previous to its being pumped into the boiler. For distributing the heat of the fuel over a large surface there are two fire places with fire doors at B, B′, which are fed with coals by hoppers from the boxes D, D′, the doors being used only to clear the bars. The flues meet at the middle, the one from the fire B rising at F, Fig. 6, passing along the upper surface of the cylinder A round H at M, then round the end of the boiler, and returning on the opposite side to ascend the chimney in the division E′. The other flue proceeds in a similar manner but in an opposite course, and ascends at E; there are two apertures beneath each ash-pit C, C′, for admitting air, and both of them should be provided with registers, so that those may be open, which either face a strong wind, or the direction of the motion of the carriage when there is not sufficient wind. For the same reason the top of the chimney should have two mouths to assist the draught. The engine and boiler rest upon a frame supported by the axis; but in order to prevent the carriage from resting on three wheels, four spiral springs may be fixed on the boxes LL, and the cross heads must be connected to the piston rods, and all the bearings must be formed so as to accommodate the parts to the sinking of one of the wheels. The pipe K carries the waste steam to the chimney, and there should be two safety valves, one locked in a box at J, and the other at J′ for the use of the engine man.

In the year 1824, our late ingenious countryman Mr. David Gordon, to whom the arts are indebted for the invention of the portable gas lamp, took out a patent for improvements in the construction of steam-carriages. His improvements relate to the machinery by which the power of the engine is to be applied to the ground, and the principal part of the contrivance consists of rods or propellers jointed to cranks situated at different angles upon the same axis, so that the extremities or feet of the propellers will act upon the ground in succession at a time when they are moving with the greatest velocity, or nearly so. The under surfaces of the feet of the propellers are curved, being described by a circle of about the same radius as the radius of the cranks which put them in motion, in order that the feet may accommodate themselves to the ground, particularly in the act of turning. Bristles, whalebone, or other pliable materials are fixed on the under surfaces of the curved feet of the propellers, as a substance to come into contact with the ground and take sufficient hold of it. During winter, when the ground is frozen, it is proposed to furnish the under surfaces of the feet with steel points projecting sufficiently to seize the ground. Notwithstanding the ingenuity of these views, it is obvious that nothing can be gained by substituting feet for wheels, and that much power must be lost by the very action of the mechanism employed.

Great difficulties have yet to be overcome before steam-carriages can be used on common roads. On level and well formed lines there is no difficulty whatever, and the present steam carriages are perfectly capable of performing useful work under such circumstances; but unless some great invention is made by which we can increase the power of steam engines, without greatly increasing their weight, we can see no prospect of their being advantageously employed in any other way than upon rail-roads.

For farther information on this subject, see the works referred to in the two preceding articles.

From the statement given by Oliver Evans, p. 427, it is certain that he proposed to drive wagons by steam, in the year 1786, and his experiment with the scow, p. 429, shows that it is possible to do so. The writer, and a thousand others now alive, witnessed this gratifying spectacle. From the commencement of his speculations on the subject of steam, he looked forward to applying it as a moving power to carriages for the transportation of passengers and merchandize; and he never lost sight of this great object. He only wanted the assistance of a wealthy friend to enable him to succeed; but it was his lot not to find any one, who, while he had the means, had so much confidence in the ultimate success of the project, as to risk his capital in making the experiment. Had such a bold spirit been found, the state of Pennsylvania would have had the immortal honor of seeing the first trial with steam carriages, and of anticipating the example set to the world by the British engineers, and which has conferred such high and lasting honor upon them for their success.

In the Steam Engineer's Guide, p. 54, may be seen the proposition to the Philadelphia and Lancaster turnpike company, in Sept. 1804, which is referred to by Evans in p. 429, "to build a steam wagon, which should transport 100 barrels of flour 50 miles in 24 hours;" and gives the calculations and items of expense attending its first cost and maintenance, and those of common wagons, five of which, with five horses each, are required to perform the same work. He makes it clear, that the profits of the steam wagon on the journey, would be \$ 104, or \$ 52 per day, while that of the wagon is \$ 3 66 per day, or \$18 33 for the whole route; and adds the important consideration, that the steam wagon would roll and mend the roads, while the horse wagons cut them up. He concludes by observing, "I have no doubt, but that my engines will propel boats against the current of the Mississippi, and wagons on turnpike roads with great profit, and now call upon those whose interest it is, to carry the invention into effect." This call was unattended to.

From a publication in the Philadelphia Aurora of December 10, 1813, it appears that Mr. Evans made another proposition on the 8th of the preceding October (which cannot be found) to "establish a line between Philadelphia and New York, for the transportation of heavy produce, merchandize, and passengers, on *carriages to be drawn by steam engines*, on railways, or smooth roads." In this last paper he gives partially the details of the scheme, and concludes thus: "I renew my proposition, viz: as soon as either of these plans shall be adopted, after having made the necessary experiments to prove the principles, and having obtained the necessary legislative protection and patronage, I am willing to take of the stock five hundred dollars per mile, to the distance of fifty or sixty miles, payable in steam carriages, or steam engines invented by me for the purpose forty years ago; and will warrant them to answer the purpose, to the satisfaction of the stockholders: and even to make steam stages to run twelve or fifteen miles per hour, or take back the engines at my own expense, if required." This second offer met with the same fate that had attended the first. It is somewhat singular, and much to be regretted, that at this very time (1813), when such immense sums were expended in manufacturing, and often by persons totally ignorant of the business, and \$1500 were given readily for a pair of merino sheep, that none could be induced to engage with him in prosecuting the business he proposed, even after he had evinced the probability of success by his first attempt with the scow (see p. 429), through the streets of Philadelphia to the Schuylkill —a success, which, from the British experiments, we have well-grounded reason to believe would certainly have taken place. Had his valuable life been prolonged to the present day, when the whole country is engaged with rail-road projects, capital in abundance would have been at his offer, and he might have seen several of his predictions verified, to the fullest extent.*

* Predictions by Oliver Evans in 1813:

1 The time will come, when people will travel in stages moved by steam engines, from one city to another, almost as fast as birds fly, fifteen or twenty miles an hour.

2. A carriage will set out from Washington in the morning, the passengers will breakfast at Baltimore; dine at Philadelphia, and sup at New York the same day.

To accomplish this, two sets of rail ways will be laid, travelled by night as well as by day, and the passengers will sleep in these stages as comfortably as they now do in steam stage-boats.

3 A steam engine, consuming from a quarter to a half a cord of wood, will drive a carriage 180 miles in twelve hours, with twenty or thirty passengers, and will not consume six gallons of water.

4. These engines will drive boats ten or twelve miles per hour, and there will be many hundred steam boats on the Mississippi,* and other western waters, as *prophesied thirty years ago.*

Posterity will not be able to discover why the Legislatures, or Congress, did not grant the inventor such protection as might have enabled him to put in operation these great improvements sooner; he having asked neither money, nor a monopoly of any existing thing.

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* Mr. Evans lived to know, that in 1813 there were three steam boats on the Mississippi; and recent information gives the number 160' most of which have been built and completed at Pittsburg and Cincinnati.

In the Franklin Journal, Vol. I, p. 187, is a list of the numerous patents granted in England for steam carriages, all of which were taken out subsequently to the first proposition of Oliver Evans.

The following statements show in part, how well founded the predictions of the ingenious and enthusiastic inventor were. From what has been done at Baltimore, and Manchester in England, on rail roads, there can be no doubt of the possibility of accomplishing every thing predicted by him.

From the Baltimore American, of March 21, 1831.

The experiment of the transportation of *two hundred barrels of flour*, with *a single horse*, was made on the rail-road on Saturday with the most triumphant success. The flour was deposited in a train of eight cars, and made, together with the cars and the passengers who rode on them, an entire load of 30 tons; viz:

200 barrels of flour,	20 tons
8 cars,	8 "
30 Passengers,	2 "
	30 tons.

The train was drawn by one horse from Ellicot's Mills to the relay-house, six and a half miles, in forty-six minutes. The horse was then changed, and the train having set out, reached the depot on Pratt Street, in sixty-nine minutes—thus accomplishing the thirteen miles in one hour and fifty-five minutes, or at the rate of 6 and three fourths of a mile an hour. The road between the relay-house and the depot is a perfect level, except at the three deep excavations, where an elevation of seventeen to twenty feet per mile, has been resorted to, for the purpose of drainage. The horse, except at the points just alluded to, brought the train along at a moderate trot, and apparently without any extraordinary labour; he is not remarkable, and was not selected, for any peculiar powers of draft, and had performed a regular trip outwards on the morning of Saturday. It is, we believe, only about a week ago that we noticed the fact of the transportation of seventy-five barrels of flour, by one horse, as a circumstance worthy of remark in comparison with the number of horses required for the conveyance of a load of a few barrels over a turnpike road. The experiment detailed above shows, that on Saturday a single horse drew three times as large a load; and there is no doubt that horses could be found, who could with the same ease transport a load of three hundred barrels.

The following statement was furnished by a gentleman who kept the time.*

From the mills to the relay-house	46 min.
From the relay-house to the depot	69
	h. 1 55 m.

The first mile was performed in	7 m.	20 s.
Second do.	7	20
Third do.	7	20
Fourth do.	6	00
Fifth do.	6	00
Sixth do.	8	30
Seventh do.	8	00
Eighth do.	9	00
Ninth do.	10	00
Tenth do.	12	00

No account was kept of the last three miles.†

MEASE.

[*Errata.*—Page 440, line 21, for 1781, read 1787. In some copies, p. 455, the heading of the section should read, "On the economy of using high pressure engines, acting expansively, and condensing."]

STEAM GUNS. While Mr. Perkins was making experiments with the high pressure steam of his generator, he observed that all metallic substances were projected from the tube of the stop cock with very great velocity. The idea then occurred to him, that with a gun barrel properly constructed, bullets might be discharged with precision and great force: and upon constructing such a barrel, his expectations were realized. By placing musket balls in a hopper from which they fell in succession into the gun barrel, he was able to project two hundred and forty balls per minute, with a velocity greater than that of gunpowder. An ounce ball was discharged from a musket with the ordinary field charge against an iron target, while another similar ball was discharged against the same target from a six feet steam barrel, impelled by steam of forty atmospheres. The distance was the same in both cases; but it was found that the ball discharged by steam was much more flattened than that discharged by gunpowder. In another series of experiments Mr. Perkins projected balls with a force of one hundred and ten atmospheres; he found that they perforated a block of wood through a greater thickness than those impelled by gunpowder. He succeeded in throwing a shower of balls at the rate of one thousand per minute. Mr. Perkins avers that he could keep up the same force of steam without intermission for twenty-four hours, or any unlimited time. A very important result of these experiments is said to be, that *one pound weight of coal* is capable of producing a quantity of steam equal in force to *five pounds weight of gunpowder*. These experiments were the foundation of Mr. Perkins's patent in 1823, for an improved method of throwing shells and other projectiles by steam. Some farther details respecting the steam-gun will be found in our article SCIENCE, *Curiosities in.* Vol. XVI. p. 622.

[For an account of Perkins' experiments with his steam-gun, see Franklin Journal, Vol. I. p. 79, and Vol. III. p. 411.]

STEAM ROCKET, PERKINS. See SCIENCE, *Curiosities in.* Vol. XVI. p. 622.

* Baltimore Gazette, March 21, 1831.

† A late report of the directors of the Liverpool and Manchester Rail-way states, that on the 25th of February 1831, the Samson locomotive engine drew 30 wagons, carrying 107 tons of merchandize, the gross weight conveyed (besides the engine and tender) being 150 tons. She was assisted up the inclined plane by three other engines, and without further aid proceeded to Manchester, where she arrived with her train in two hours and thirty-five minutes from the time of starting:—distance 30 miles. Passengers are conveyed on the cars in one hour and a half, and even in one hour and a quarter.

STEAM DRYING MACHINE.—The mode of drying linen and other cloths by steam was first suggested by Mr. Watt, who, so early as January 1781, contrived a machine of this purpose for his relation, Mr. James Macgregor, Clober, near Glasgow. This machine was erected, but no description of the invention was ever published.

A few years before his death Mr. Watt put into the hands of Dr. Brewster several MSS. and drawings of some of his minor inventions, for the purpose of publication, either in this work or in his Journal of Science, and one of them was his account of the steam-drying machine. The following description and relative engravings are copied exactly from the MSS. and drawings of Mr. Watt.

Fig. 7. of Plate DXI. is an end view of the machine, the frame for supporting it being omitted.

A A the ends of three copper cylinders.

H H two rollers to wind the cloth on and off.

Fig. 8. is a side view. A A are two of the copper cylinders 2 feet diameter, and 4 feet long.

B B two conical bell-metal sockets fitted steam tight to a hollow axis.

C C two copper steam pipes from the boiler.

D boiler two feet diameter.

E a conical valve $1\frac{1}{2}$ inch diameter to discharge the spare steam.

F a funnel and pipe to supply the boiler with water.

G two small cocks placed 2 inches asunder, by opening which it is known if the boiler be too full or too empty.

Fig. 9. and 10. views of the box which returns the condensed water to the hollow axis. It consists of a circular box of copper B B, 4 inches deep, divided into 4 divisions. In two of the divisions are holes D D, which take in the water when they are at the bottom; and as the cylinder turns round, transmit it to the holes. E E in the hollow axis C C, by which it is returned through the steam pipe to the boiler, being directed by the partition G in the axis. In the other two divisions are holes F F to admit the ingress and egress of steam from the cylinder to the box. Mr. Watt was of opinion that the hollow tube C might consist of two separate tubes, opening into each other at their extremities.

STEATITE. See Mineralogy, *Index*.

Steatite is a kind of saponaceous stone, which is sometimes found of a white colour, at others grey or green, and but rarely red or yellow. Its specific gravity varies from 2.60 to 2.66.

This substance is composed of a mixture of silex, alumine, magnesia, oxide of iron, and water; but it differs according to the localities in which it is found. It is very common in Germany, and in Cornwall; and we have no doubt that it may also be found in the western parts of France.

As steatite is not fusible excepting at a very high temperature, and as it can be worked with the greatest facility, so it forms excellent crucibles, which harden in the fire, and which litharge penetrates with great difficulty. It also serves as a facing to protect moulds for casting iron, and other metals.

M. Viscot, of Liege, made a great number of experiments to prove that this substance might be employed by the lapidaries. He formed cameos with it, to which he gave a fine polish, after exposing it to the action of the fire; and it becomes so hard, as to give sparks like flint, when struck upon hardened steel.

By polishing it, he gave the appearance of agate, and even obtained some pieces which perfectly resembled the onyx; but this appearance was quickly destroyed by the fire, and he found it impossible to restore it.

Having a great affinity with glass, the steatite, when reduced to a very fine powder, and mixed with the colours, becomes exceedingly convenient in painting upon it. It is also used as a kind of sympathetic crayon, for drawing or writing with upon glass, and on which it leaves no apparent trace, after the drawing or writing has been wiped over with a woollen cloth. However, the marks are rendered instantly visible, by breathing upon them; but they disappear anew, when the glass becomes dry.

The embroiderers and tailors prefer steatite to chalk, to make traces with; as they are more durable, and do not affect the colours of their cloth.

As steatite has the property of combining with oil or grease, so it enters into the composition of the greater part of the balls, which are used for cleaning silks and woollen cloths from oil or grease spots. It also serves as a basis, in the preparation of certain colours for painting with.

It is employed to give a fine polish to marble, serpentine, and other gypseous stones. Mixed with oil, it is used to polish glass and metallic mirrors.

If the surface of newly prepared leather be sprinkled over with it; and if, when it has become dry, it be rubbed with a piece of horn, it will give the leather a fine gloss.

Steatite is also employed to glaze paper, upon the surface of which it is sprinkled, when it is reduced to a very fine powder; or, which is much better, when mixed with the colouring materials. To glaze the paper, it must be rubbed over with a hard brush.

The powder of steatite, owing to its unctuosity, is one of the substances employed in lessening the friction of screws, toothed wheels, and other metallic contacts.

Steatite is a mineral, which belongs to the primary or secondary formations. It often constitutes beds of great extent, but when pure, it usually forms lumps of greater or less magnitude. That variety of it termed Venice talc, abounds in the Tyrol and the Valteline. The Briancon and the Spanish chalks are found, the one in the Alps of Dauphiny, near Briancon, and the other in the mountains of Arragon. The Venice talc affords a powder, which renders the skin smooth and shining, and is employed as a cosmetic. The lard stone is also another kind of graphic talc, and is used in China, to form small grotesque figures.

Fat, and fixed oils, have long been used to lessen friction in machinery. But their bad properties, and the ill scents of these matters, ought to induce us to abandon their employment, and to substitute others for them. And we may likewise add, that the emanations which they diffuse in the workshops or mills, are frequently inconvenient; and it would, therefore, be much better to sell them to the manufacturers of oil gas. Plumbago, or the carburet of iron, has been successfully used for diminishing friction in machinery; but this material is too rare and costly to be ordinarily used. There are, however, other unctuous minerals to which we may recur, and amongst these, steatite seems to hold the first rank.

The citizens of the United States of North America, who cultivate with success the employment of machinery, as we may judge from their numerous steam boats and other machines, both for naval and other purposes, appear to be the first persons who have employed steatite in the large way. It is not, however, used alone, but mixed with a small quantity of oil, suet, or tar. They commence by reducing it to a very fine powder, and then mixing or triturating it with the material intended to render it more unctuous. The first experiments on using it were made at Lowell, in the state of Massachusetts; and the coachmen and wagoners have found it highly beneficial.

Mr. Moody, superintendent of the great iron works established upon the mill dam near Boston, has afforded us means of estimating the advantage to be derived from the use of this new mixture. In one of the works is a wheel of great size and weight, which makes from 75 to 100 revolutions per minute, and turns upon necks or gudgeons of five inches in diameter. It has moved with this speed during three, and sometimes five, weeks together, without renewing the lubrication of the gudgeons. Nevertheless, Mr. Moody thinks it best to renew it oftener. The machinery, of which this great wheel forms a part, manufactures about 200,000 pounds of iron per month.

It is to chance, that we are indebted to the discovery of this valuable employment of steatite, the use of which is now continually extending in the United States; and will also, no doubt, be speedily adopted in Europe.—*De Moléon's Recuiel Industriel.*

Additions by the Editor of the Technological Repository.—Steatite is also used in the United States to line furnaces with; a type founding machine, sent from thence, and patented here, had a furnace of this kind. And the Editor lately saw, in the hands of Mr. Lemuel Wellman Wright, engineer, a cubic mass of it, a foot square, and which had been sent to him by an American friend. He had sawn off a portion of this block, and exposed it to the heat of his fire for several hours; after which it had assumed the appearance of a mass of *mica*, still, however, cohering together. The Chinese also make small portable furnaces of steatite.

The *lapis ollaris*, or potstone, is also another variety of steatite. Bishop Burnet gives the following account, in his travels, of the mode of using it in Switzerland. "There are a sort of pots, made of stone, which are used, not only in all the kitchens here, but also in those of almost all Lombardy, called *Lavege*. The stone feels oily and scaly, so that a scale adheres to the finger of any one that touches it, and it is somewhat of the nature of slate. There are but three mines of it known in these parts; one near Chavennes; another in the Valteline; and the third in the Grisons; but the first is much the best. They generally cut it round in the mine, in masses of about a foot and a half in diameter, and a foot and a quarter in thickness; and they work it into shape in a mill, where the blocks of stone are driven about by a wheel, set agoing by water; and which is so ordered, that he who manages it, turns the outside of the stone, first, till it is quite smooth; and then separates one pot after another, by small and hooked chisels, by which means he makes a nest of pots, one within another; the outward and biggest one, being as large as an ordinary cooking pot, and the inward one, no larger than a common pipkin. These pots they arm with hooks and circles of brass; and so they are used by them in their kitchens. One of these pots heats and boils sooner than any metal pot; and yet the bottom is twice as thick as that of a metal one. It never cracks by the heat, nor gives any sort of taste to the liquor that is boiled in it; but if it falls to the ground, it breaks, as it is very brittle; nevertheless, it is soon repaired again; for they piece their broken pots so close, by sewing the broken parts together with iron wire, which completely fills the holes they make to receive it, that there is no breach made, although no cement is used. The passage to the mine is very inconvenient, for they must creep for near half a mile through a rock, which is so hard, that the passage is made not above three feet high; and so that those who draw out the stones, creep all along upon their belly, having a candle fastened to their forehead, and the stone laid upon a sort of cushion, made for it upon their hips. The stones are commonly two hundred weight."

STEEL is the name of a well known metal, consisting of iron combined with carbon, or a carburet of iron. When small pieces of fine malleable iron, surrounded with powdered charcoal, are exposed for eight or ten hours to a strong red heat, the iron is converted into steel, and is then found to have united with the 150th part of its own weight of carbon. The following are the general properties of this important metal:

Steel unites with the malleability of bar iron the fusibility of cast iron, and if immersed in a cold fluid when hot, or otherwise suddenly cooled, it becomes intensely hard, sonorous, and elastic,—these properties varying according to the heat of the steel, and the temperature of the fluid, or other substance in which it is cooled. In consequence of these properties, steel is of great use in the arts for all sorts of cutting instruments, for springs, and even for musical instruments. In general, steel is brittle, resists the file, yields sparks with flint, and retains magnetism for a very long time. The hardness, in virtue of which it possesses these properties, disappears after ignition and slow cooling. At a red heat it is malleable, but less so at a white heat. It is capable of being beat out into thinner plates than iron. It melts at 150° of Wedgewood. Its specific gravity varies from 7.78 to 7.84. By repeated ignition under exposure to the air and hammering, steel again becomes wrought iron. According to Kirwan, steel may be easily distinguished from iron by letting fall a drop of diluted nitric or muriatic acid on a plate of steel. When washed off after lying a few moments, a black spot is left, whereas on iron with nitric acid the colour of the spot is whitish green. The cause of the black spot is, that a portion of the iron is dissolved, while the carbon is left.

There are three different kinds of steel, which are obtained by three different processes. 1st, *Natural steel*; 2d, *Steel of cementation*; and 3d, *Cast steel.*

1. *Natural steel.* The *natural* or native steel of Eisenhartz in Styria, is obtained directly from the ore. The ore used is the Spathose ironstone, consisting of the carbonates of iron, manganese and lime, together with a mixture of clay, which occurs abundantly in the neighbouring hill. The fuel employed is always charcoal, and generally amounts to about one-fifth of the ore in weight. The ore is first converted into cast-iron by repeated meltings, and removals of the scoriæ, and the cast-iron thus obtained is purified in the crucible of a refinery previously lined with charcoal, particular care being taken that the carbon contained in the cast iron is not burnt away. When the natural steel is thus sufficiently purified, it is extended under the hammer, and cut into bars which are examined by their fracture, and separated into *hard steel, soft steel,* and *steely iron*, the last of which is used for pointing ploughshares, and other rough work. The other two kinds of bars are made up into packets, the hard steel being placed inside, and when drawn into bars at a lower heat than that used for iron, it becomes *natural steel.*

In this process a portion of the carbon is supposed to combine with the oxygen in the cast iron, and to escape as carbonic acid gas, while the rest of the carbon unites with the pure iron, and forms steel. In quality this steel is inferior to other kinds. It is less homogeneous, and is softer and less frangible. From the cheapness of the process, it brings a lower price.

2. *Steel of cementation.* The process of forming steel by cementation is performed in two parallel troughs constructed of fire brick, or of an open-grained siliceous free stone, unalterable by the fire. These troughs are placed upon a long grate beneath an arched vault, surrounded with a cone of masonry. Bars of the best Dannemora or oregrund (Swedish) iron, free of cracks and flaws, are then selected for the purpose of cementation. A layer of coarsely bruised charcoal, capable of passing through a quarter inch riddle, is now laid at the bottom of the cementing troughs, and above this is laid a row of bars of iron, another stratum of charcoal succeeds, and then bars of iron, and so on till the trough is nearly full, containing about eight tons of iron. The whole is then covered with clay and sand mixed, and rammed as close as possible to exclude the air. The heat of the whole is raised to a glowing red, which is kept up from seven to eleven days, according to the quantity of iron. Through a small hole in each trough a bar is allowed to project, that it may be taken out from time to time to observe the progress of the operation. When the trial bars announce the perfection of the process, the fire is extinguished. The bars retain their original shape, but their surface is covered with blisters, as if a gaseous fluid had been confined in different parts of it. Hence it is called *Blistered Steel.* The bar iron when thus converted into steel is found to have increased in weight from four to twelve oz. per cwt. or on an average 1 part in 224. The first proportion constitutes *mild*, and the second very hard steel; and if the process had been pushed much farther, the steel would have melted, and in the act of fusion would have taken an additional dose of charcoal, so as to bring it to the state of *Cast Iron*, No. 1.

Blistered steel thus made is used only for the coarsest purposes. Its texture is greatly improved by being formed into smaller bars under the tilt hammer, in which state it is known by the name of tilted steel.

In order to improve the steel still farther, the bars are broken into short pieces, and these being put up in small parcels, are welded together in a furnace, and drawn down into bars, which, by repeated welding and tilting, acquire a compactness and toughness, which fit it particularly for swords and other large articles of cutlery. This steel is called *shear steel*, or *German* steel, from its having been prepared in great perfection in Germany.

3. *Cast steel.* The finest kind of steel known by the name of cast steel was first made by Mr. Huntsman of Sheffield in 1750. At first he kept his process a secret, but it is now well known and universally practised. Blistered steel, broken into small pieces, is mixed with a certain proportion of pounded glass and powdered charcoal. It is then melted in a crucible, and cast into ingots, which, by gentle heating, under the influence of the tilt hammer, are wrought into bars. By this process it becomes more brittle and fusible than blistered steel; but though it is incapable of being welded with either iron or steel, it has acquired an uniformity of texture, and a closeness of grain, which fit it for the finest articles of cutlery.

According to M. Clouet (*Journal des Mines*, No. 49, An. vii. 3), cast steel may be formed by fusing thirty parts of iron, one of charcoal, and one of pounded glass, or even by melting iron in a crucible, when surrounded with equal parts of chalk and clay, and keeping the whole a sufficient time at a white heat. There is reason to think that the pounded glass is not essential to cast steel; and while some are of opinion that this substance differs from common steel only in having a greater quantity of carbon, others maintain that it actually contains less carbon, and therefore that the difference must have another origin. In rich cast iron the carbon is supposed by some to exist in a mechanical state, while in steel it is chemically united with the iron.

Various methods of working cast steel have been published, among which that of Mr. Mushet deserves to be studied. A method of a novel character has been recently discovered by our ingenious countryman, Charles Mackintosh, Esq. Glasgow. The principle of the method is to impregnate iron at a high temperature with carbon in a gaseous form. The gas which he employs as the most economical and convenient for this purpose is that obtained from the distillation of coal, or the common coal gas. The iron to be converted into steel is enclosed in a crucible, or melting-pot, of the usual materials, and placed in the furnace; and when it is raised to a very high degree of temperature, a jet or current of the gas is thrown into the crucible through a tube and aperture provided for that purpose. In the cover of the crucible another aperture is made to permit the escape of that part of the gas which is not absorbed by the iron.*

A series of very valuable papers on iron and steel

* See *Edinburgh Journal of Science*, vol. vii. p. 361.

by Mr. Mushet has been published in Dr. Tilloch's Philosophical Magazine. He has shown that the hardness of iron increases with the carbon which it contains, till the carbon amounts to one-sixtieth of the iron. At this point the hardness is a maximum, the metal acquires the lustre and colour of silver, loses its granulated appearance, and assumes a crystallized form. If more than one-sixtieth of carbon be added, the hardness of the compound diminishes in proportion to its quantity.

The following table by Mr. Mushet shows the proportions of carbon which combine with iron during the formation of the different carburets.

Soft cast steel, ...	$\frac{1}{120}$
Common cast steel, ...	$\frac{1}{100}$
The same steel, but harder, . .	$\frac{1}{90}$
The same, too hard for drawing, .	$\frac{1}{50}$
White cast iron, ...	$\frac{1}{25}$
Mottled cast iron, ...	$\frac{1}{20}$
Black cast iron, ...	$\frac{1}{15}$

The following are the specific gravities of steel in different states.

	Spec. Grav.
Best blistered steel, before hammering,	7.31
Do. do. after hammering	7.73
Very hard steel, ...	7.26
Melted steel wire, ...	7.5
English cast steel, hammered, .	7.82 to 7.91

On the Case-hardening of Iron.

The process of case-hardening iron is that by which the surface of articles already manufactured are converted into steel. It is chiefly used for table-knives, and particular surgical instruments, where toughness and hardness are required. The articles which are to undergo this process are laid into a pan of plate iron, and surrounded with bone shavings, pieces of horn, or old leather shoes. A forge fire of considerable size is now made up, and when the upper part of the fire has caked together, it is carefully lifted off without breaking, and the iron pan when laid upon the red coals, is covered with the caked mass. In this state it remains for two hours, without urging the fire. The progress of the operation is ascertained by small pieces of trial wire previously introduced into the pan, which are taken out, and dipped in water, then by means of the file and the character of the fracture, the condition of the articles is known. When the process is deemed complete, the fire is increased, and the articles, when brought to a proper heat, are taken out and immersed in cold water.*

On the Tempering of Steel, and the colours which accompany it.

The art of tempering steel and fitting it for various kinds of cutting instruments and other purposes, is one of the most important in the arts. The heat by which this change in its character is affected, must always be less than that which was used in hardening it. The common method of tempering consists in laying the steel articles on a clean coal fire, or on a heated bar till they receive the degree of heat which is required. They are then cooled by immersion in water. The degree of heat, the colour by which it is indicated, and the degrees of temper necessary for different instruments are shown in the following table:—

Instruments.	Colours.	Temperature Fahr.
1. Razors and instruments with a stout back and fine edge	Straw Colour	430° to 450°
2. Scalpels and Penknives	Full Yellow	— 470°
3. Scissors, small shears	Brown Yellow	— 490°
4. Pocket and Pruning Knives	First Tinge of Purple	— 510°
5. Watch Springs, Swords, and Elastic Instruments	Different Purples	550° to 560°
6. ————————		— 600°

As many articles of cutlery require to be tempered with great precision, Mr. Hartley, in the year 1789, took out a patent for a new method. This method consists in using an iron trough filled with the fusible metal, consisting of eight parts of lead, two of tin, and five of bismuth. A mercurial thermometer graduated to 600° of Fahrenheit is then immersed in it, and the fusible metal is brought to the required temperature by means of a furnace or lamp placed below the trough. In place of the fusible metal oil may be used, but as the articles are in this case immersed in the oil and out of contact with the atmosphere, the colours arising from oxidation are not produced. Mercury may be used in place of the fusible metal. No change of colour will appear on the steel till the thermometer indicates 430°, and it is so faint that it can be even then only seen by comparing it with a plate not heated. A very ingenious method of tempering very delicate steel articles was proposed by Dr. Wollaston to Mr. Stodart. The steel articles when placed in a tube were surrounded with the fusible metal. The tube with its enclosures was then heated to redness in a furnace, and afterwards immersed in a cooling fluid. The whole is then thrown into boiling water, which melts the fusible metal and leaves the steel perfectly hardened and unaltered by twisting, cracking, or suffering any change of form.

Mr. Stodart made several experiments in order to determine the best fluid for cooling the heated steel. He plunged a scalpel in a mixture of snow and muriate of lime, but without perceiving that any advantage was derived from the extreme cold. A large quantity of water brought to the temperature of about 40° of Fahrenheit he found to answer the purpose as well as any that had been tried. In tempering steel and the alloys of steel, to be afterwards described, Mr. Stodart recommends it to be performed twice, first at the usual time before grinding, and again just before the last polish is given to the blade. "This second tempering," says he, "will perhaps appear superfluous, but upon trial its utility will be readily admitted; we were led to adopt the practice by analogy, when considering the process of making and tempering watch springs."†

The following table, which is different from the one given above, is drawn up from a series of fine specimens of oxidated steel, which the late eminent Mr. Stodart presented to the writer of this article. The

* See Aikin's *Dictionary of Chemistry, &c.* vol. i. p. 602.

† *Philosophical Transactions*, 1822, p. 270.

different tints are twelve in number, and exhibit very perceptibly the progress of the oxidation :—

1.	Very pale straw yellow - -	430°
2.	A shade of darker yellow - -	450
3.	Darker straw yellow - - -	470
4.	Still darker straw yellow - -	490
5.	A browner yellow - - -	500
6.	Yellow, tinged slightly with purple	520
7.	Light purple - - - - -	530
8.	Dark purple - - - - -	550
9.	Deep blue - - - - - -	570
10.	Paler blue - - - - -	590
11.	Still paler blue - - - -	610
12.	Still paler blue, with a tinge of green	630

In the production of these colours the access of oxygen is absolutely necessary, in order that it may combine chemically with the metal. Sign. Ambrosio Fusinieri, who has made a number of curious experiments on the subject in reference to the other metals, found that these colours are produced in the same order on all metals except platinum, upon which, whether in the state of wire or plate, he never could produce any colour.*

Observations on the Hardening of Steel, addressed to the Franklin Institute, by Rufus Tyler, Mechanician, Philadelphia.

The following remarks on the subject of hardening steel, are offered to the Institute as the result of much experience in the regular course of my business, and of essays suggested by some peculiarity, accidentally noticed, and made for my own satisfaction. It is, perhaps, to be regretted, that I have not had leisure to repeat them with a view to greater accuracy of detail; by some, however, this may be deemed a favourable circumstance, as they are not fortified by any array of numbers, or formulæ, and may, therefore, be the more readily discussed, corrected, and amended, for which I am fully aware my best endeavours leave ample room.

The peculiar kind of hardening of which steel is susceptible, depends upon two conditions: first, *a sufficient degree of heat* (somewhat above the lowest red), which may be termed the hardening heat; and second, *sudden cooling*. A deficiency of only a few degrees of heat, or an excess of two or three seconds of time, beyond certain limits, will *entirely* defeat the operation.

The usual method of hardening steel for common purposes is to heat it to the proper degree (the lower the better, provided it be not so low as entirely to fail to harden), and then to plunge it suddenly into cold water. When it is requisite to protect the surface from the corroding effects of the atmospheric air, as in engravings, dies of delicate workmanship, &c. it should be imbedded in fine charcoal powder, previously heated to redness, in an iron box, to drive off the evaporable matter, and when sufficiently heated, the piece must be removed to the cooling liquid with as little exposure to the air as possible. If the contents of the box be thrown, with the steel, into oil, so as completely to exclude the air, it will preserve its polish and brightness unchanged.

All articles of steel are more or less liable to become warped, by rapid cooling, from the unequal contraction of the parts, and many, from the same cause, require the greatest dexterity and skill to prevent them from breaking in pieces during the operation.

Whenever, therefore, the nature of the case admits the use of oil, as a cooling medium, it is safer than water, being much less rapid in its operation. It is obvious, however, that as large masses of steel can with difficulty be cooled, even in water, within the hardening limit of time, only small articles, such as springs, thin blades, &c. can be hardened at all in oil. It is sometimes pretended that oil imparts a degree of toughness to steel hardened in it, just as it would to a bit of horn, or leather, by penetrating its pores; and I believe the patent obtained for the use of it, in hardening a *celebrated patent oil-hardened-spring truss*, was grounded upon such a supposition.

The danger of breaking increases with the *thickness* of the piece, whatever may be its form; and that form is least liable to break, in which there is the greatest freedom of motion, or in which a simultaneous contraction can be effected in all the parts.

In hardening a roller, say two or three inches in diameter, and about the same in length, the first tendency of the contraction of the surface is to separate it. But this strain being equally divided around the circumference, and the metal being in a yielding state, the only effect, in general, is to enlarge the surface beyond its original dimensions. The surface thus enlarged immediately becomes hard and fixed; so that the subsequent cooling of the centre reverses the strain upon the surface, tending to compress or shorten it, and that to such a degree, that a segment is often thrown off with great violence, or, when the outer portion has sufficient strength to resist the contracting force of the centre, that portion in its turn tends to separate, being prevented by the outer part (to which it adheres), from returning to its original dimensions. In this case, a separation at the centre is inevitable, unless a part of the heat be allowed to remain, until the surface be relaxed by tempering, after which it may be suffered to cool. When a rent commences at the centre, the parts generally separate with such force, as to sunder the mass, accompanied by a loud report.

It sometimes happens in the breaking of dies, rollers, &c. (in which the tempering has been omitted) that the effect does not take place until several hours, and even days, after they have been hardened.

Steel is allowed by authors to expand about $\frac{1}{8}$th of an inch to the foot, in heating to the hardening point, and to contract, on cooling, about $\frac{2}{3}$ds of what it had been expanded, provided the hardening effect takes place; otherwise it returns nearly to its original size. Accordingly, I have been in the habit of making allowances for this enlargement, which is generally found to take place, in a greater or less degree, and for many years held the opinion that it was a necessary consequence of hardening steel, and that this effect *ought* to take place, just in proportion to the degree of hardness produced.

With this doctrine, however, facts are at variance, and I believe, that the circumstance, above alluded

* *Giornale di Fisica*, vol. ii. p. 146.

to, as the cause of breaking, may also explain most satisfactorily, the phenomena in question, (to wit) that of hardening the exterior, before it can possibly be permitted to contract to its proper size, because of the expanded mass within.

I have found in a number of cases of thin hollow cylinders, or flattened rings, where there was the best chance of thorough, and almost instantaneous cooling, and of course, of producing the greatest degree of hardness, that no enlargement was perceptible.

Particular care should be observed, in the act of cooling, not to suffer any intermission, in any part, as is often done by moving the piece backward and forward, too briskly, in the water, alternately cooling, and exposing to a vacuum, the opposite sides; for a part thus exposed, after moving rapidly against the current, until fairly hardened, might be let down or tempered, as it is called, by the heat rushing from the centre, toward the side exposed to the vacuum, without being sufficiently re-heated to prepare it for hardening at the return of the current of the water. In this way, soft places are often produced, which will erroneously be attributed to uneven steel, want of sufficient heat, &c.

By dipping the end of a small bar (heated to several inches in length), and keeping it quite still, until it is hardened nearly to the surface of the water (which should be very cold); and then raising it quickly, an eighth of an inch, or more, according to the size of the bar, a portion of what was hardened will be softened by the heated part above;—as soon as this is perceived, let the bar be again sunk into the water, to where it remains of a hardening heat, which will be perhaps half of an inch lower than before, another portion of about $\frac{3}{8}$ths of an inch will thus be hardened; let the bar be again withdrawn a small distance, as before, repeating the operation, until there no longer remains sufficient heat in the bar for hardening; the result will be, a number of successive hard and soft rings.

While testing the strength of different kinds of steel, by repeatedly hardening each kind, until a fracture should take place, I was somewhat surprised to find the pieces, which were small (such for example, as were an inch square, and $\frac{3}{8}$, or $\frac{1}{2}$ an inch thick), considerably swollen, after three or four times hardening, and that every hardening increased their convexity, until they actually burst the surface, in the middle of one of the faces. Repeating the experiment, with a piece prepared perfectly flat, I found the first, second, third, and fourth time, of hardening each, to produce a small additional elevation of the surface. On the fourth attempt the piece cracked.

I have seen a thin piece of steel very beautifully hardened, by chilling in its passage through a rolling mill; this piece afterwards exhibited in its fracture an exceedingly fine grain, a probable consequence of its being hardened under immense pressure.

Small drills, and other articles of the thickness of a small needle, may be cooled, with sufficient rapidity to become hard, by moving them briskly through the air.

Water, to be active, in cooling, should be perfectly free from soap,—a small portion of that substance will cause the time of cooling to be extended beyond the hardening limit, especially if the piece of steel be not very small.

The grain of steel, though finer when hard than when soft, becomes still finer, the lower the temper be drawn, until about a medium between hard and soft, when the fineness begins to decrease.

Cast iron is capable of being hardened in the same manner as steel, except the kind which is already hardened at the time of casting. This kind possesses a superior degree of hardness, which differs materially from that obtained in the manner of hardening steel. It takes place in passing from the fluid to the solid state, and can only be changed by re-melting. As soon as time will permit, I intend offering some remarks on hard and soft cast-iron.

The most satisfactory theory of hardening steel, which also applies to cast iron, is one suggested by Mr. William Mason, of this place. He supposes, that at the hardening heat, the component parts of steel exist in a state of perfect chemical union, and that if time be allowed in cooling, that union is dissolved, or changed to a simple mechanical mixture. This he conceives to be supported by the following experiment: melt together certain proportions of zinc and quicksilver, and pour one part of the amalgam into water, and the other into a wooden or paper mould; that which is poured into water being suddenly chilled, retains its chemical union, and becomes of the consistence of paste; the other separates, the zinc forming a solid cellular body, holding the quicksilver in very minute globules, in its interstices.

On Annealing Cast Steel, so as to make it as soft as Iron.—By Jacob Perkins.

We were lately shown by an American friend, some slips of thin cast-steel, which were as soft and pliant, and as easily bent into any required shape, as though they had been tinned sheet-iron. They were of a light grey colour, perfectly free from oxidation or scales, and were still capable of hardening, on being heated and quenched in water.

On mentioning this fact to Mr. Perkins, he stated that the process was known to him, he having practised it in America with great advantage; and he had even communicated it to one intelligent engineer in this country, who had since constantly employed it.

The secret consists in inclosing the cast-steel in close cast-iron vessels, which completely exclude the external air; and in keeping them at a moderate red heat, in a proper annealing furnace, a sufficient length of time, according to the thickness of the steel; and, lastly, letting them cool very slowly.

This process is superior to the usual practice of decarbonating cast steel, and reducing it to the state of iron; which renders it necessary to restore its steely nature again, by case-hardening it, before it can be hardened as usual. [*Tech. Rep.*

On Annealing Iron and Steel Wire.—By Thomas Gill.

Although "the annealing of cast-steel in close vessels," as described to us by Mr. Perkins, and as given in the preceding article, was a new and valuable fact; yet we well knew that a similar practice had long been used both in this country, and in France, for annealing iron, and steel wire.

The late scientific M. Nicolas Paul, of Geneva, described to us, twenty years since, the practice employed in an iron wire drawing manufactory in France, to anneal their wire; which was by enclosing the large coils, in cast-iron vessels of an annular or ring shape, open in the middle, to allow the flame of the furnace to play through them; and the section of which rings was a semi-circle, having flat cast-iron rings, as covers to the flat tops of the vessels. Ears were made around the internal, and external boilers, both of the vessels and their covers, with corresponding holes in them, into which wrought-iron pins, with heads, were put, and which pins had also holes near their ends, through which iron wedges were driven, to draw the covers close to the vessels, the juncture being previously made air-tight by a luting of loam. These vessels were heated in a kind of oven-shaped furnace, having a grate of iron bars, for the fuel, and vessels, to rest upon, with doors both to the oven and ash-pit.

We also saw, about the same time, the method employed by the late Mr. John Burr, at his steel wire works, near Hales-Owen, in Shropshire. He enclosed his bundles or coils of steel wire, for needle and fish-hook making, in cast-iron vessels, with covers fitted closely to them, to exclude the air. These vessels were uniformly heated in a cylindrical furnace of brick-work, covered with a dome, and having a hole in the centre of the dome, to serve as a chimney. The furnace was strengthened by a number of projecting buttresses, which were built around it, and by iron chains surrounding the brick-work. The fire was made upon a circular grate, which ran all round the inside of the furnace, and was supported upon walls; air-holes to supply the fire being also made at regular distances through the external wall of the furnace. A door of brick-work was built up, after the coal fire had been lighted, and the vessels containing the steel-wire, had been deposited in the furnace; this of course was taken down again after the annealing was performed, and the furnace had become sufficiently cool to remove the vessels.

In Cadell's "Journey to Carniola, Italy, and France, in the years 1817 and 1818," he says, vol. i. page 243, that in the iron wire works, near to Pistoja, in Italy, "after the wire has been drawn, it is hard; and, in order to restore its flexibility, it must be heated, and suffered to cool, gradually. For this process of annealing, large cast-iron vessels are employed, four feet high, in form of a truncated cone with the base uppermost. The wire is put into the vessels, which are then covered and luted tight. The vessel is surrounded by a brick-wall, at some distance from its sides, and burning charcoal is put in, between the vessel, and the wall. These cast-iron vessels are made at the furnaces in the Maremma, and they are almost the only articles of cast-iron I observed in Tuscany."

In our first volume, page 423, we mentioned, that Mr. Corcoran, of Mark-lane, wire weaver, inclosed his wire in closed cast-iron vessels, *surrounded with ground flint*, and then exposed them to a red-heat, in proper furnaces. And that, although the wire thus became quite flexible and pliant, yet it was as bright as though it had not been heated at all. [*Ib.*

Remarks by the Editor of the Franklin Journal.—We had been so long familiar with the foregoing process, that we had supposed it to be the universal practice in wire manufactories. The Messrs. Sellers of this city have used it for many years; it was also followed by Messrs. White & Hazard, at their wire drawing manufactory, at the falls of Schuylkill, and by many other persons in this country; but as it may be new and useful to some persons who work in wire, we have re-published it.

On a new method of Colouring or Ornamenting Steel. By M. Leopold Nobili, of Reggio, in Italy.

In the *Bulletin de la Société d'Encouragement*, for January 1829, is contained a report made by M. Gualthier de Claubry, a member of that society, as follows:

"A learned foreigner, known by his ingenious researches, M. Leopold Nobili, having presented to this society the results of his experiments relative to a new art, to which he has given the name of *métallochromie;* you charged your committee of the chemical arts to examine these products; and I have, in its name, to report thereon.

"A great number of experiments, more or less successful, have been made by various persons, and at different periods, to apply, in a solid manner, paintings upon metals; but the solidity of the pictures did not equal their wishes, and the thinness of the colours applied rendered their traces vague, and greatly diminished the sharpness and finish of the designs.

"M. Nobili has lately, by his assiduous researches, and the labour of many years, produced, by a process which he has not made known, designs upon various metals, in which the brilliancy of the colours, and the harmony of the tints, leave nothing to be desired; thus these colours possess none of the inconveniences above stated; and they are developed upon the surface of the metals without being too thinly diffused; but are stable, and will not disappear unless by the application of a high red heat, which, by its action, would also destroy the surface of the metal, as well as the chemical agents employed upon it.

"Nothing can be more brilliant and singular than the colours upon M. Nobili's plates, especially by day light: and all his designs are executed with a fine taste, the regularity of their forms, and the sharpness of their outlines, being all that can be wished.

"M. Nobili has not merely manufactured these plates as objects of curiosity, but has mounted several, which have been singularly esteemed by amateurs; and we can readily believe that this pleasing art would meet with great success were it carried into effect on a proper scale: and it is, therefore, much to be desired that so new and curious an art should not be lost to France, and especially as M. Nobili appears disposed to bring it into practice. We can easily form a just idea of the extent to which it might be possible to carry this branch of manufacture, when we remark that many metals assume their colours in very different orders by the application of heat; and we can easily conceive, that in the hands of a skilful man, and one well conversant with commerce, the greatest advantages might be derived from the employment of this new branch of industry. Thus, for instance, nothing presents more harmony than gold, as its tints are very different from those afforded by heating steel. It is upon this last metal that all the designs presented by M. Nobili have been executed. Silver likewise affords different colours on applying heat; and an experienced artist cannot fail to make many fine applications of M. Nobili's process.

"This process not being exactly known, many persons have accordingly formed suppositions, and even made experiments respecting it; but it does not appear that their suppositions have been well founded; and their success has been much less happy, and their colours less perfectly developed upon the surface of the metal, than can be effected by an art which has acquired perfection in the hands of M. Nobili.

"Under the impossibility, then, of being able to speak positively as to the manner in which M. Nobili has been able to produce these curious effects, we can only applaud the incessant efforts which he must have made to bring his art into the perfect state in which we find it. All those, who have attempted new branches of manufactures, may well conceive the difficulties which every day presents, and which can only be overcome by a continued zeal and efforts to surmount unsuccessful endeavours; and M. Nobili could not otherwise have arrived at the point of perfection to which he has brought his *métallochromie*, nor can he be too much praised for the success he has obtained.

"We again repeat, that it is much to be desired that so curious an art should not be lost to France; and the committee of chemical arts, in order to forward this object, have charged me to propose, that M. Nobili be recompensed for his interesting communication, by inserting this report in the *Bulletin* of the society."

The following Letter on ornamenting Steel with Gold and Platina was addressed to the Editor of the Technical Repository.

Bridge Cottage, Camberwell, Jan. 8th, 1826.

Sir,—In a paper inserted in your Repository for November last, I suggested some inquiries respecting the various methods of gilding practised by artizans. Since that period, I have been prosecuting some experiments with success, for ascertaining the proper mode of superficial gilding upon steel: and I transmit the result to you, for the benefit of that class of artists. It is necessary, perhaps, to premise, that the instructions given, in most elementary works upon chemistry, for gilding with the ethereal solution of gold, are either erroneous, or not sufficiently explicit; and to this cause may be traced the many failures which have occurred in practising this art.

The following is the process which I used; and which answers equally well, either for gold or platina.

Dissolve any quantity of gold or platina in nitro-muriatic acid (*aqua regia*), until no further effervescence is occasioned by the application of heat. Evaporate the solution of gold or platina, thus formed, to dryness, in a gentle heat (it will then be freed from all excess of acid, which is essential): and re-dissolve the dry mass in as little water as possible: next take an instrument which is used by chemists for dropping liquids, known by the name of a separating-funnel, having a pear-shaped body, tapering to a fine point, and a neck capable of being stopped with the finger or a cork; which may contain a liquid ounce, or more: fill it with the liquid about one quarter part; and the other three parts must be filled with the very best sulphuric ether. If this be rightly managed, the two liquids will not mix. Then place the tube in a horizontal position, and gently turn it round with the finger and thumb. The ether will very soon be impregnated with the platina or gold, which may be known by its change of colour. Replace it in a perpendicular position; and let it rest for twenty-four hours; having first stopped the upper orifice with a small cork. The liquid will then be divided into two parts; the darkest coloured being underneath. To separate them, take out the cork, and let the dark liquid flow out: when it has disappeared, stop the tube immediately with the cork; and what remains in the tube is fit for use, and may be called the gilding-liquid. Let it be put into a bottle, and tightly corked. When an article is to be gilded, a vessel of glass or unglazed ware must be provided, of just sufficient size to admit the article: it must then be filled with the gilding-liquid, nearly to the top. The steel must be *very highly polished*, and be entirely free from *rust* or *grease*. A basin, full of clean water, must be ready at hand: the article must be immersed into the gilding-liquid, and allowed to remain *as short a time as possible*; then be taken out, quickly plunged into water, and well rinsed: it must next be dried with blotting-paper, and be placed in a temperature of 150° Fahr. till it be completely heated throughout: it may then be polished with rouge and a soft leather; or, which is better, be burnished.

It will be as well to observe, perhaps, that the muriate of gold or platina, formed by digesting these metals in nitro-muriatic acid, must be entirely free from all excess of acid; because it will otherwise act too forcibly on the steel, and cause the coating of gold to peel off. Pure gold must be employed. The ether must not be shaken with the muriate of gold, as is advised in chemical publications, for it will be sure, then, to contain acid: but, if the two liquids be continually brought into contact, by the motion I have described, the affinity between ether and gold is so strong, as to overcome the obstacle of gravity, and it will hold the gold in solution. The etherial solution may also be concentrated by gentle evaporation. Care must be taken not to wipe the steel until the heat has been applied. This gilding is an effectual protection against rust: and is, at the same time, very ornamental.

Thomas Gill. Nicholas Mill.

Damascus Steel.

The steel of which the beautiful sword blades of Damascus are manufactured, has hitherto baffled all attempts at imitation. It is generally supposed to be made of slips or thin rods or wires of iron and steel, bound together by iron wire, and then melted together by heat. The most skilful workmen of other countries have attempted to imitate this process, but in vain: so that there is reason to think that the secret of the manufacture has not yet transpired. The colour of the Damascus blades is a dull bluish grey, and scarcely exceeds in hardness common steel from the forge. It is difficult to bend; and when bent does not resume its shape: the principal character, however, is its *water*, or a peculiar wavy appearance running from the hilt to the point in narrow lines, the thickness of a harpsicord wire, which never cross each other. These waving lines arise from a slight difference in the degree of polish occasioned by the unequal action of acid upon the steel; any weak acid would produce this effect, but at Damascus sulphate of alumine is acid. This appearance of waving lines has been imitated by a false damasking or etching, but the genuine Damascus blade is distinguished from the false one by the obliteration of the lines in grinding, which takes place in the latter. In the real Damascus blades, grinding nearly removes the water; but it immediately reappears by rubbing the blade with lemon juice.

On Indian Steel or Wootz.

This valuable material has lately been introduced with great success into cutlery. Sir Joseph Banks was the first person who drew the attention of the public to Wootz, having received it from Dr. Scott of Bombay, and submitted some of it to the trials of skilful workmen so early as 1795. It is imported in the state of round flat cakes, about five inches in diameter, and an inch thick, each weighing more than two pounds. The following is the method of making it in India. Pieces of forged iron and wood are enclosed in a crucible, and heated together in a furnace. The fire is urged by three or more pair of bellows peculiar to the country. In this way the wood is charred, and the iron is melted and converted into steel. It crystallizes in the crucible in the state above mentioned. According to Mr. Stodart it ought to undergo a second fusion, which should be conducted with the greatest care, and when this is well done, it is so much improved as to be fit for every purpose of fine cutlery, and infinitely superior to the best cast steel of England. In forging, it requires the utmost attention. Dr. Scott informed Sir Joseph Banks, that it "cannot bear anything beyond a slight red heat;" for when this happens, part of the mass seems to run, and the whole is lost as if it consisted of metals of different degrees of fusibility. Mr. Stodart also found that it was useless when overheated, that in hardening it should be quenched at a cherry-red colour, and while tempering, it should be heated from thirty to forty degrees higher than the best English cast steel.

According to Dr. Pearson's * analysis, it seems to differ from steel only in containing a little oxide of iron. He and Mr. Moore obtained the following measures of its specific gravity.

1. Wootz - - - - - -	7.181
2. Ditto another specimen - -	7.403
3. Ditto forged - - - - -	7.647
4. Another specimen forged -	7.503
5. Wootz which had been melted -	7.200
6. Wootz quenched while quite hot	7.166

The following measure of the specific gravity of wootz in different states was obtained by Messrs. Stodart and Faraday. The results are remarkable for being so much higher than the above:

Wootz unhammered from Bombay -	7.665
Wootz tilted from Bombay - -	7.6707
Wootz in cake from Bengal - -	7.730
Wootz fused and hammered from Bengal	7.787

* *Phil. Trans*: 1775, p. 322.

Wootz has been more recently (1819) examined by Mr. Faraday.† The piece which he used was cut from the middle of the cake given by Sir Joseph Banks to Mr. Stodart, when heated cherry-red. In 460 grains he found besides the carbon and iron, 0.3 of a grain of silex, and 0.6 of a grain of alumine. The best English cast steel, submitted to the same experiments, yielded no earths. Mr. Faraday attempted in vain to imitate wootz, although he obtained specimens of iron giving abundance of silex and alumine by analysis.

On a future occasion, however, he was more successful by employing the following method. Pure steel in small pieces, and in some cases good iron when mixed with charcoal powder were heated intensely for a long time. In this way were formed carburets highly crystalline, and of a dark metallic grey colour, like the black ore of tellurium. When broken the facets of several buttons of 500 grains were about the eighth of an inch wide. This carburet consisted of

Iron - - -	94.36
Carbon - -	5.64
	100.00

This metal when reduced to powder in a mortar was mixed with pure alumine, and the whole subjected to an intense and long heat. An alumine alloy was thus obtained of a white colour, a close granular texture, and very brittle. It contained 6.4 of alumine. With 67 parts of this alloy 500 grains of good steel were fused, and formed a perfectly malleable button which forged well, and gave the beautiful damask peculiar to wootz, by the application of dilute sulphuric acid.

This specimen had all the appreciable characters of the best Bombay Wootz. Hence Messrs. Stodart and Faraday were of opinion that wootz is steel accidentally combined with the metal of the earths, the earth being either in the ore, or derived from the crucible in which the prism is made. It will appear, say these chemists, from the following experiment, that we had formed artificial wootz when it was not the object of research. In an attempt to reduce titanium, and combine it with steel, a portion of menachanite was heated with charcoal; a part of the button thus obtained was next fused with some good steel in the proportion of

Steel - - - - -	96
Menachanite button -	4
	100

The alloy thus obtained worked well under the hammer, and the bar obtained was evidently superior to steel. This was ascribed to the presence of titanium, but no titanium could be found in it, not even in the menachanite button itself. *The product was iron and carbon, combined with the earths or their bases, and was in fact excellent wootz.* On this specimen a beautiful damask was produced by the action of dilute acid.

† *Journal Royal Inst.* vol. vii. p. 288.

On the Alloys of Steel.

The curious observation of Sir Humphry Davy, that mercury is rendered solid, and experiences a diminution of specific gravity from 13 to 3 by combining with $\frac{1}{12000}$dth part of ammonium, seems to have impressed on Mr. Stodart's mind the important fact that a very minute quantity of one metal is capable of producing extraordinary effects by combining with another.

Hence he was led, in conjunction with Mr. Faraday, to perform a series of interesting experiments on the alloys of steel with small quantities of gold, silver, platinum, rhodium, iridium, osmium, and palladium.* A brief account of the results is all that our limits will permit us to give.

1. *Alloy of Steel with Silver.* When *one* part of silver and *five hundred* of steel were properly fused, a button was produced which forged well, and formed various cutting tools decidedly superior to those made of the very best steel. The metals were in a state of perfect chemical combination, and by a delicate test the silver could be detected in every part of the alloy. When more than $\frac{1}{500}$dth part of silver was used, the excess was only mixed mechanically with the steel, and a silvery dew exuded from the metal when it contracted by cold or was hammered.

2. *Alloy of Steel and Platinum.* An alloy of 100 parts steel and 1 platinum † was forged into bars remarkable for smoothness of surface and beauty of fracture. Though less hard than the preceding alloy, it was considerably tougher. This alloy is powerfully acted upon by weak sulphuric acid, the action increasing with the quantity of platinum in the alloy.

Equal parts of steel and platinum produced a beautiful alloy, which takes a fine polish, and does not tarnish. It is peculiarly suitable for specula, and its specific gravity is 9.862.

3. *Alloy of Steel with Rhodium.* Alloys of steel with from one to two per cent. of rhodium, possess the valuable property of hardness, with tenacity sufficient to prevent cracking either in forging or hardening. This superior hardness is so remarkable, that in tempering for cutting articles, Messrs. Stodart and Faraday found, that they required it to be heated fully 30° Fahrenheit higher than the best wootz, wootz itself requiring to be heated fully 400 above the best English cast steel. The great scarcity of rhodium will, however, prevent this alloy from ever getting into general use.

4. *Alloy of Steel with Gold.* This alloy is good, though it does not promise to be so valuable as the preceding ones.

5. *Triple Alloy of Steel, Iridium, and Osmium.* This alloy is also one of great value.

6. *Alloy of Steel with Palladium* resembles the preceding.

7. *Alloy of Steel with Chromium.* This alloy was first made by M. Berthier,‡ who speaks very favourably of it. Messrs. Stodart and Faraday fused 1600 grains of steel with 10 of pure chrome. The button forged well, and though hard showed no disposition to crack. Another button, made of 1600 grains of steel and 48 of chrome was harder than the first, but was as malleable as pure iron.

Tin and copper were also alloyed with steel, but they did not seem to improve it.

The editor of this work has now before him highly polished specimens of four of these alloys, viz. those of platinum, gold, silver, and rhodium, which were presented to him by the late Mr. Stodart. They have now been kept for nearly *seven* years with different specimens of highly polished steel also given him by Mr. Stodart. The specimens of steel are all rusted, while there is not a spot upon any of the alloys. The much lamented death of Mr. Stodart has, we fear, delayed for a while the introduction of these valuable alloys into the arts; but we trust the subject will be again resumed by some skilful individual, who unites great practical skill with scientific knowledge.

STEEL, Engraving on. This highly important art has been recently revived and perfected by our countryman Mr. Warren, an engraver in London. Mr. Warren unfortunately died in the middle of his labours, but the art has been generally introduced into Great Britain by Messrs. Perkins and Fairman, two American gentlemen, who, along with Mr. Heath, an eminent London engraver, formed an establishment in 1819 for printing bank notes and engravings for popular works from steel plates.

The following history of Mr. Warren's experiments and discoveries was drawn up by a committee of the Society of Arts.

"Some of the earliest specimens of engraving upon steel were produced by Albert Durer. There are four plates etched by this artist, impressions of which exist in the British Museum, which in all books of art are recorded as having been executed on steel; of these one has the date 1510 inscribed upon it. Since that time attempts have been made occasionally to employ steel instead of copper as a material to engrave upon, but apparently with little success, on account principally of the great hardness of the material, which in a short time blunted and destroyed the tools which were made use of.

Steel exists in two states, the *elastic* and the *brittle*, the former being considerably softer than the latter: of the elastic steel a saw blade may be considered as an example, and in fact pieces of saw blade were the material upon which nearly all the first attempts have been made, of late years, to revive a practice which, if successful, offered so many advantages to the artist and to the public. Mr. Reimbach, a few years ago, executed an engraving on a block or thick plate of steel, but met with so many difficulties in the execution that his experiment remained insulated, and produced no sensible effect on the art of engraving.

Mr. Warren, in his early youth, was much employed in engraving on metal for the use of calico printers and gunsmiths, and the experience thus acquired induced him afterwards to turn his mind to the subject with a view of applying it to the fine arts. It was suggested to him by Mr. Gill, that the Birmingham artists, in the manufacture of articles of ornamented steel, subjected the steel, when rolled into sheets, to the process of decarbonization,

* *Philosophical Transactions*, 1822, p. 253—271.
† The platinum was produced by heating the ammonia muriate in a crucible to redness.
‡ *Annales de Chimie*, tom. xvii. p. 55.

by which it was converted to pure soft iron. It was then made into the required instrument, the ornamental work engraved or impressed upon it, and it was then by cementation with the proper materials, again converted superficially to steel, and thus rendered capable of acquiring the highest polish.

In the attempt, however, to apply this process to plates for the engraver's use, two opposite difficulties occurred. A plate of steel of the same thickness as that of common copper plate, when thoroughly decarbonized, and thus reduced to the state of very soft iron, yields readily to the graver and other tools, and, especially, is susceptible of the process of *knocking up;* this consists of scraping out the error, and afterwards striking the under side of the plate with a punch and hammer, in order to raise the cavity to the general level, and thus allow the artist to take the error out without occasioning any unevenness at the engraved surface: it was found, however, that plates of the thinnesss requisite for this operation, and of the usual dimensions, were very liable to warp in the last, or re-carbonizing process, and were thus rendered incapable of giving perfect impressions. If, in order to avoid this disadvantage, blocks, *i. e.* plates of three or four times the ordinary thinness, were made use of, the warping indeed was prevented, but at the same time the process of knocking up became impracticable and it was necessary, in order to remove an error or defective part, to grind out the surface, or to drill a hole from the under surface almost through the plate, and then, by forcing in a screw, to raise that part of the face which was immediately above it. This latter process, however, was so tedious and difficult, as exceedingly to detract from the advantage of substituting steel for copper.

In this state of things, it became a very interesting object of inquiry to ascertain how many impressions may be taken from a plate of soft or decarbonized steel: and it was found that such a plate, prepared according to Mr. Warren's process, is capable of affording several thousand copies without undergoing any visible wear. In proof of this, impressions were laid before the committee by Mr. Warren from the plates of decarbonized steel, executed by him, the one for an edition of Mackenzie's works, published by Cadell, the other for an edition of Beattie and Collins, published by Rivington. These exhibit, both in the landscape and in the figures, the most elaborate and delicate work: five thousand impressions have been taken from one, and four thousand from the other, and yet between one of the first and one of the last impressions, it was impossible to detect any perceptible difference.

If Mr. Warren had carried on his experiments alone, working by himself till he had brought his plan to perfection, it is probable that, at the period of his death, the evidence of the great importance of his discovery would by no means have been so complete as it actually was, and the result of his exertions might have been lost, to the great detriment of the profession, and of the fair fame of this eminent artist: but selfishness and secrecy in anything, which related to the improvement of the art to which he was attached, formed no part of his character; and all his discoveries, both those relating to the preparations of the plates as well as those which have reference to the engraving upon them, were unreservedly and gratuitously communicated. The consequence of this liberality was, that besides the plates of Mr. Warren's own engraving produced before the committee, impressions were shown of portraits engraved on decarbonized steel, for the Evangelical Magazine, demonstrating that after 25,000 copies have been taken, the plates still remain in a good state, and are not yet in want of repair. Mr. Mar stated, that having made an engraving on one of Mr. Warren's plates, he did not take his own proofs till after the 8000th impression; and, in another instance, the engraving being a portrait, Mr. La Hie, the printer, certified that the artist's own proofs were not taken off till after the 20,000th impression.

Mr. Warren's original process for decarbonizing the steel plates, consisted in procuring a box; or case of iron, and covering the bottom of it with a mixture of iron turnings and pounded oyster shells: on this a steel plate is laid, another bed of the mixture is then added, and so on alternately, till the box is full, taking care that the test of the compositions shall form the upper as well as the lower layer. The box so charged is thus to be placed in a furnace, and to be kept for several hours at the highest heat which it will bear without melting, after which, being allowed to cool gradually, the plates are found to be reduced, for the most part, to the state of soft decarbonized steel.

Mr. Hughes, a copper-plate maker, having been instructed by Mr. Warren in his process, and finding that the steel did not always turn out sufficiently and uniformly soft (particularly for the purpose of engravers in mezzotinto), imagined that these occasional defects were owing to a deficiency of heat in the cementing process; accordingly, he substituted a case or oven of refractory clay, for the cast iron one, and then applying a considerably higher heat than the cast iron box would have endured without melting, was enabled to obtain plates so soft that they may be bent over the knee. Each plate requires two or more cementations; and, as the first cementation warps them more or less, Mr. Warren was in the habit of rectifying them by means of a hammer. Mr. Hughes finds that the places struck by the hammer are apt to be less softened by the second cementation than the other parts, and therefore, that plates so treated will often turn out unequal in hardness. His own practice is to use a mallet, and as little force as possible, in detaching the cement from the surface, and in rectifying the plate.

The plate, being cleaned and polished (but not too highly), is ready for the engraver. When it comes into his hands, the first operation is to lay the etching ground, in doing which the plate must be rather less heated than is usual with copper, otherwise the ground, as it cools, contracts, presenting a honey-combed surface, and leaving parts of the plate uncovered. The same defect is apt to occur if the plate is too highly polished. The ground should be laid rather thicker than on copper.

Various menstruums were made trial of by Mr. Warren, for biting in with. Nitric acid, considerably more diluted than for copper, was made use of, with, upon the whole, good success. Nitrate of mercury was found to blunt or round the edges of the lines; acetic acid, with a small portion of nitrate of copper, produced the same effects: sulphate of copper bit light tints very beautifully, but its farther action rendered the lines rough. The best menstruum, however, is half an ounce of crystallized nitrate of copper, dissolved in a pint and a half of distilled water, and a few drops of nitric acid added to the solution. This will be found to bite both deeper and clearer than dilute nitric acid.

It will be advisable for the artist, when first etching on steel plate, to keep a register of the time which he finds necessary for the menstruums to act before the parts have attained their due degrees of strength, and this will serve as a guide to him in his subsequent operations. Mr. Warren generally found about two minutes sufficient for an outline, unless it was required to be very strong; the middle tint was produced in about ten minutes, and the darkest shadows in forty minutes. The menstruums should not be more than one-sixth of an inch deep on the plate, otherwise it will be difficult to see the work, and it becomes exhausted in about ten minutes, and thus requires to be replaced. While the menstruum is acting, the work must be constantly swept with a camel-hair brush, in order to remove the precipitated copper, which, if allowed to remain in the lines; renders their edges rugged, and destroys their beauty, especial care must be taken to clear the ends of the lines, as they are most liable to bite foul. In stopping out the ground (Brunswick blacks) must be laid on very thin and even, and, instead of terminating abruptly, must be re-washed off very gradually; for the smallest ridge or prominence will retain the copper, and then the ground will infallibly be penetrated, and the biting will become foul. By attending to these directions, an etching may be obtained on decarbonized steel, as deep and quite as sharp as it can be on copper. Concerning the great superiority of steel-plate over copper-plate, for all works that require a considerable number of impressions to be taken, there can exist no doubt; for though the use of the graver, and of the other tools, requires more time on steel than on copper, and though the process of re-biting has not yet been carried to the degree of perfection in the former that it has been in the latter, yet the texture of steel is such as to admit of more delicate work than copper; and the finest and most elaborate exertions of the art, which on copper would soon wear so as to reduce them to an indistinct smeary tint, appear to undergo scarcely any deterioration on steel; even the marks of the burnisher are still distinguishable after several thousand impressions.

The improvements on the art of engraving upon steel made by Messrs. Perkins, Fairman, and Heath, are of such a nature as to give them almost the character of the first inventors of the art. The following is their process of multiplying engravings, etchings, or engine work. The steel blocks or plates which are to receive the intended engraving, have their surfaces softened or decarbonized, and thus rendered more suitable for receiving all kinds of work than on copper. When the engraving upon the block has been executed, the plate is completely hardened by a new process which does not injure in the slightest degree the most delicate work. A cylinder of steel previously softened is then placed in the transferring press, and repeatedly passed over the engraved block, by which the engraving is transferred *in relief* to the circumference of the cylinder; the press having a vibrating motion equalling that of the cylinder upon its circumference, by which new surfaces of the cylinder are presented equal to the extent of the engraving. This cylinder is then hardened, and is employed to indent copper or steel plates with engravings identically the same as the one on the original steel block, and this may be repeated *ad infinitum*, as the original engraving will remain, from which other cylinders may be impressed if required. When the engraving is of too great a size to be transferred, it is executed upon a steel block, from which when hardened, 200,000 perfect impressions may be taken.

In our pottery manufactures, in calico-printing, but particularly in preventing the forgery of bank notes, &c., this art will be found of the greatest importance.

We have already seen that Mr. Warren experienced difficulties in obtaining a good menstruum for biting in upon steel. Mr. Wilson Lowry discovered a menstruum, the composition of which he sold to Mr. Heath, by which the lines could be bitten in deep as well as broad, and the requisite fineness preserved. It is well known that some menstrua succeed well on hard steel, and yet give unsatisfactory results on soft and decarbonized steel. Nitric acid, which is the active ingredient in all these menstrua, usually reduces part of the iron to the state of that oxide which is soluble in the acid, and also converts a smaller portion to the state of peroxide which remains for the most part undissolved, adhering to the surface of the iron, and preventing that clean, deep, and uniform biting which it is the great object of the artist to obtain. The presence of carbon in a finely divided state has a tendency to interfere with the peroxidation of the iron, and this probably is the reason why it is less difficult to obtain a good effect with hard than with soft steel.*

Hence it became of consequence to have a menstruum by which these effects would not be produced, and this seems to have been obtained by Mr. Humphreys, who was rewarded by the society of arts for the discovery of the following menstruum.

Dissolve together in half a pint of hot water a quarter of an ounce of corrosive sublimate, and a quarter of an ounce of powdered alum. It is ready for use when cold. "While using it keep it stirring with a camel's hair brush, and take care to wash the plate perfectly after each boiling. As this acid, though clear before use, becomes turbid during its action on the steel, it may be prudent in fine works to throw away each portion of acid after it has been on the plate. The taste and experience of the artist must dictate the length of time he may leave it on his plate; delicate tints are obtained in about three minutes." For farther information on this subject, see *The Transactions of the Society of Arts for* 1823, vol. xli. p. 83; and Newton's *Journal of the Arts*, vol. xiii. p. 42.

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* Newton's *Journal of the Arts*, vol. ii. p. 42, March 1827.

On an improved mode of etching Steel Plates. By Mr. W. Cooke, *Jun., Engraver.*

From the Transactions of the Society for the encouragement of Arts, Manufactures, and Commerce.

Dec. 21, 1825.

Sir—As the Society of Arts have given a portion of their attention to the subject of engraving on steel plates, and as many experiments have failed, I feel great pleasure in making the following communication public through the medium of the society.

For the best mode of biting-in hitherto published, we are indebted to the great perseverance of Mr. Turrell; but the difficulty and danger of using his menstruum on a soft ground, or when the varnish is not sufficiently dry, induced me to use the acids in different proportions, and to leave out the alcohol, as the composition was found to act on the ground, causing the whole surface of the plate to be corroded; this has frequently happened.

It is necessary to mention, that all plates for landscape engraving should be made of steel not completely decarbonized.

I beg to submit a few preparatory directions previous to etching.

The steel should be carefully cleansed (before laying the ground) with turpentine only, omitting the whiting which is used in preparing the surface of copper.

The ground should be laid with as little heat as possible, steel needing not so much as copper; too high a temperature decomposes the ground, and occasions it to produce small air bubbles, or to evaporate in a light smoke from the surface of the plate; should this take place, the ground must be re-laid. It is also highly necessary that in etching the point should penetrate the surface of the steel, and the breath not be suffered to condense on the etching, as it will cause the lines to rust, and will prevent the acid from biting well. The plate being ready for biting-in, the process is as follows: mix, by gentle shaking, six parts of acetic acid, and one part of nitric acid.

This mixture, being very rapid in its action, should be taken off the plate at half a minute, and the acid well washed out of the lines with water, drying the plate well, but without the assistance of heat. Stop out the light tints with Brunswick black varnish; and then, for the purpose of washing the oxyd out of the lines, pour on the plate a mixture of six parts of water, and one of nitrous acid, letting it remain two or three seconds; take this off, and immediately repeat the former mixture without washing the plate between, with water. This process should be repeated for each tint.

The biting-in of a steel plate should be accomplished, if possible, in one day: this observation holds good in regard to other methods of biting, as the lines will sometimes attract oxygen from the atmosphere during the night, which will prevent their biting with the same degree of clearness as the day before.

When the biting is completed, and the ground taken off, with a strong tooth-brush and turpentine, clean out the remaining oxyd from the lines, using the fingers for the light tints; then rub the surface of the plate, to remove the bur, with the finest emery paper previously well used on the back of a steel plate to take off its roughness; the more this paper is used the more valuable it becomes for taking out the marks of the scraper from dry point tints.

Re-biting is performed by dipping a clean rag in a very dilute nitric acid, and rubbing it over those parts intended to be re-bitten until the surface becomes dull; clean the plate out as before mentioned, and in laying the ground the dabber should be used but little, as it is likely to take up the ground again; re-bite with a few drops of nitrous acid in four ounces of water, sufficient to make the water taste sharply of the acid.

The whole process for biting, or re-biting, should be performed in a temperature of about sixty degrees, or higher, and certainly not much below that point.

As the time required to bite-in is the principal thing to be observed, all the light tints should be tried every minute after the first biting; but the deeper ones will require a longer time. A little practice will show these remarks (apparently trifling) to be important.

Biting on very soft steel plates may be accomplished by using the following mixture:—three ounces of warm water, four grains of tartaric acid, four drops of nitric or sulphuric acid, one drachm of corrosive sublimate.

I also submit to the society a new method of graduating skies and other tints.

Incline the plate, by tilting it with two wedges, and pour the re-biting acid into a glass funnel, with a stick inserted in the tube, and kept steady by a twisted copper wire loop; drop the acid on the dark part, and according to the colour of the tint the acid should be made to drop faster or slower, which is regulated by the raising and lowering the stick in the centre, and gives to the acid a tremulous motion, until it is floated over the whole sky; this obviates the old method of sweeping or feathering, which, from the quick action of the acid, occasions streaks to appear in the tints when the ground is taken off.

It is important that engravers should make use of the best acids, and perfectly free from adulteration. From the cheapness of sulphuric acid it is sometimes used with muriatic, to adulterate the nitric acid. The following tests will discover them:—dissolve a little nitrate of barytes in distilled water, and add it to a small quantity of the nitric acid in a phial or test tube; if a white precipitate is discovered at the bottom, sulphuric acid is present; and muriatic acid will form, with a solution of nitrate of silver, a white cloudy precipitate; should either of these effects take place, the acid is not fit for use.

The purest acids are those manufactured by Mr. Remnant, Smithfield-bars, who has made them some years for the use of engravers.

Since writing the foregoing account, I have discovered means of making the ground adhere to the surface of the steel, without using acid to dull the surface.

Dissolve, by gentle heat (in a Florence flask), some powdered copal in oil of spike lavender, and evaporate to a thick consistence; then to one ball of ground, add about one drachm of the copal solution, each having been made warm previous to mixing: lay the ground as before mentioned, avoiding too much heat; the ground may then be laid with the same facility as on copper. I am, sir, &c. &c.

W. Cooke, Jun.

A. Aikin, *Esq. Secretary, &c.*

The above processes were performed on tinted steel plates, in presence of the committee of polite arts, to their entire satisfaction, and that of several engravers, who were specially invited to witness them.

On a Menstruum for Etching Plates of Soft Steel. By Mr. W. Humphrys.

From the Transactions of the Society for the Encouragement of Arts, Manufactures and Commerce.

April, 19, 1826.

Sir,—I have a communication to make to the Society for the promotion of Arts, Manufactures, and Commerce, of a menstruum for biting-in steel plates. I have for some time back communicated it to various artists, to get their opinion of its merits, and have the testimony of Messrs. Turrell, W. Finden, &c., that it is the best, cheapest, simplest, and safest in its operation of any acid yet discovered; and those gentlemen will be happy at any time to meet a committee to explain its qualities. In addition, I have specimens of its performance, from several engravers, to lay before the Society. I am, sir, &c. &c.

Wm. Humphrys.

A. Aikin, *Esq. Secretary, &c.*

The composition of the menstruum is as follows:

Take a quarter of an ounce of corrosive sublimate powdered, and a quarter of an ounce of alum powdered, and dissolve them in a pint of hot water.

Directions.—Let it cool before use. While using it, keep it stirring with a camel's hair brush, and take care to wash the plate perfectly, after each biting. As this acid, though clear before use, becomes turbid during its action on the steel, it may be prudent, in fine works, to throw away each portion of acid after it has been on the plate. The taste and experience of the artist must dictate the length of time he may leave it on his plate; delicate tints are obtained in about three minutes.

It appears from the experience of those artists who have practised engraving on steel, that several of the menstrua employed in the process technically called biting-in, will succeed with hard steel, but give results by no means so satisfactory, when employed on very soft, or nearly decarbonized steel. Nitric acid is the essentially active ingredient in all these menstrua; and the chemist well knows that when this substance is brought into contact with iron, it usually brings part of it to the state of protoxid, which is soluble in the acid, and also reduces a smaller portion to the state of peroxid, which remains, for the most part, undissolved, adhering to the surface of the iron, and thus preventing that deep, clean, uniform biting which it is the great object of the artist to obtain. The presence of carbon, in a finely divided state, has a tendency to prevent, or at least to retard, the peroxidation of the iron, and this, probably, is the reason why it is less difficult to gain a good result with hard, than with soft, or decarbonized steel.

The composition employed by Mr. Humphrys contained no nitric acid; and, from the testimony before the committee of Mr. W. Finden, Mr. Warren, Mr. Romney, and others, who have tried it, and also from the result of the experiments made in presence of the committee, appears to be superior, for biting-in on soft steel, to any menstruum that has hitherto been used.

STEELE, Sir Richard, a celebrated author, was born at Dublin in 1671 or 1676. He received his education at the Charter House and at Oxford. His principal works are *The Christian Hero*, *The Funeral*, or *Grief a la Mode*, *The Tender Husband*, *The Tatler*, *The Guardian*, *The Conscious Lovers*. He sat twice in Parliament, and was knighted by Geo. I. in 1715. Broken in his fortune and his constitution, he quitted the world and died in Wales in 1727.

STEELYARD. See Mechanics, Vol. XII. p. 603.

STENOGRAPHY, or Short-Hand, from στενος *confined*, and γραφειν to *write*, is the art of writing in small compass, or employing characters, which, by a few strokes, express many words, and enable a proficient to follow a speaker, and note his discourse with accuracy. But short-hand writing is also of great importance in those private departments of life, where much is to be composed, and many writings to be put in due form. It is of no small utility to gentlemen of the bar, who are often pressed for time, as, by means of this art, they can commit their thoughts to writing with rapidity and precision.

It is highly valuable to the clergy, who have to address the people on the most interesting subjects; and where, on that account, every thought and word should be correct. When the sentiments and expressions are properly arranged in the mind, they are easily committed to short-hand writing; and, if the characters be distinctly formed, and of an adequate size, which they ought always to be, they can be caught, by a glance of the eye, in the course of delivery, and without seeming to read much, which is sometimes disagreeable to the audience, the discourse may be given, with all the correctness and elegance with which it was composed, and this can scarcely be done, if there be a total dependence on the memory.

The history of short-hand cannot be accurately ascertained; but it may be presumed, that when the art of writing became common, certain contractions and arbitrary tokens would be contrived for private use; and attempts would soon be made to employ marks and characters, for assisting to recollect such speeches and harangues as were supposed to be worthy of remembrance.

Hieroglyphics are a kind of short-hand writing, and certain signs and emblems, as memoranda and means of reckoning, were found to be in use among the people in South America, when they were first discovered. Stenography appears to have been early in use among the Greeks and Romans, and having found its way into Britain, it has made rapid progress within these 150 years, and has now arrived at great perfection. To acquire this useful art there is less difficulty than to become master of the Greek alphabet, and the common contractions of that language.

The difficulty which a learner finds to read what he has written is the most discouraging part of the process; and it is generally on this account that so many have abandoned the pursuit after they have begun it. But most assuredly, if the rules be attended to which are given in the following system, the whole will become easy and delightful. The chief embarrassment has arisen from writing short-hand, according to some systems, altogether without vowels; but although this may be done, and read by a proficient, yet the difficulty attending it is discouraging to a beginner.

The method recommended in this system, and which I have found in practice to be completely effectual, is to express the long vowels, but to omit those which have a short sound. This is in perfect analogy to the method of reading the Hebrew language without the points. The letters *aleph*, *he*, *yod*, *ain*, and *vau*, express the vowels *a*, *e*, *i*, *o*, *and u*, when they are sounded long; and wherever they are not in use, which sometimes happens in whole words of that language, these vocables are read without difficulty, for by adding the consonants together, a short or obscure vowel sound must be heard, and the word perfectly intelligible. Thus the following sentence, "The commands of God are steadfast," could be easily read, although written without a vowel, in this manner, The commnds f Gd r stdfst; but every obscurity will be removed if, in general, at least one long vowel be expressed in every word, though in those which are of frequent occurrence, and easily read, this rule may be omitted.

Much has been done to render this short-hand expeditious as well as easily read. By using dots instead of characters for the long vowels, there is a great saving both of time and labour; for, excepting in a very few instances, the vowels occur much more frequently than the consonants. It has been the object of the author also to have all the characters as simple as possible, and to apply the more simple forms to represent those letters which more frequently occur. Thus straight lines, in perpendicular, oblique, and horizontal directions, were first adopted, then a circle, with several of its segments, and afterwards some parts of an oval and oblong figure. Lastly, a few loops were added, to represent the characters which were still wanting; but these loops frequently facilitate the joinings, and in every case are easily formed.

The object in view, in composing this system of short-hand, was to overcome some difficulties, which had been encountered in attempting to learn one of the systems which were then in use; and the end in view has been completely gained, for it is not only easily written, but the author can read that which was done many years ago, as readily as that which was written but a few days ago.

It is now made public for the first time, in the hopes that it will be extensively useful; and this expectation is encouraged by the full approbation which it has met with from several persons to whom it has been communicated, and who now use it in daily practice.

The characters are shown in Plate DXII. Fig. 1.

There is only one dot employed to express the vowels, and that is the round one which marks the period in common reading, and it denotes the different long sounds of the vowels, by a diversity in its position. A dot on a line with the top of a short hand character represents the long sound of *a* as in *shape*, one between the top and middle of the character sounds *ē* long, as in *here;* one at the middle sounds *ī* or *y* long, as in *sigh* or *by*, one between the middle and bottom sounds *ō* long, as in *bone*; and a dot on a line with the bottom of the character sounds *u* long, as in *cube*, or *ū* broad as in *full*. See Plate DXII. Fig. 3, § 1. The vowels of horizontal letters are thus expressed. See Plate DXII. Fig. 3, § 2.

Some of the dipthongs have the same sound as some of the long vowels, and these are to be expressed by the corresponding long vowels. Such as have a compound sound are to be represented by the vowel which is most prevalent in the pronunciation of the dipthong. A dot in the place of *ī* may also stand for by. K is used instead of *g* and *c* hard, and *s* for *c* soft and *z*.

It might be supposed that any of these dots, not being correctly placed in their proper situations, might occasion mistakes in the reading, but no difficulty of this kind is found in practice, as no material error of this sort happens to the expert writer, and when any mistake does occur, the sense of the passage directs the reading. A dot in the cavity of a letter expresses *son*, *sion*, *ac*. See Plate DXII, Fig. 3, § 4. Where there is no cavity either in a single letter, or in the characters combined to form a word, the terminations son, sion, tion, &c., may be written if needful. But words ending in *ation*, *ession*, *ition* or *ution* have these terminations expressed by two dots being put in the place of *ā*, *ē*, *ī*, *ō*, or *ū*. See Plate DXII, Fig. 3, § 5.

Every thing might be written, by the characters, which have already been exhibited; but the additional ones, which are subjoined, greatly shorten, and facilitate writing, and they may easily be acquired and remembered.—See Plate DXII, Fig. 2.

For examples of the following directions see Plate DXII. Fig. 3. § 6. A stroke above a word signifies over, a stroke under a word, implies a repetition of it, and for every repetition of it an additional stroke may be drawn under it; an oblique stroke through a word expresses opposition; the short-hand character for *m* under another character, stands for *dom* or *ment;* the short-hand character for *l* under another short-hand character means *full*, and when written by itself, below the line of the other words, it signifies also full, *e;* the short-hand character for *p*, written below the line, below another short hand character, signifies *ship*, or *shape*, or *shop;* a dot before the short-hand character for *b* means before, and one after signifies behind, and one both before and after, means *before* and *behind*, or *before* and *after*, *g;* a dot by itself, as a character, stands for *a*, *awe*, *O*, *oh*, *owe*. No pointing is made use of but by the comma, as the period mark is otherwise employed, and for the same reason a period is shown in this system of short-hand, by leaving space, two or three times as large as you have between the words, and without any point.

Though there is a character in this short-hand for the letter *r*, yet when immediately following a consonant, it may be more easily formed, by drawing a ray from the side of the consonant, and in cases where this cannot be conveniently done, as in horizontal characters, and the characters for *l*, an inverted touch with the pen, at the end of the character, will be sufficient. When the character for *t* follows an *r*, expressed by a ray from a consonant, it should be formed by drawing the pen upwards in a diagonal direction from the ray. In making the character for *enter*, *inter*, &c. begin with the lower part, and draw the pen upwards, and in the same manner, the character standing for *serve*, *service*, &c. is to be formed.

The long vowel sounds are to be expressed by a dot at the beginning and end of a word, but never in the middle of it; for in that case, you are to begin the next consonant in the place where the vowel should be. This rule could not be strictly complied with in the case of horizontal letters, when the vowels are to be expressed on the upper side of the characters, for this would occasion much awkwardness in the writing, and make one of the characters cut another. To avoid this inconvenience, begin the character which is to stand in the place of *a* or *e*, a little above the horizontal letter, as bearing a reference to the places of these vowels; but so placed as not to touch the other character *m*.

When a consonant is repeated, with a vowel between them, the syllable will be expressed by doubling the size of the consonant. It is oftener more easy and expeditious to denote the plural by a dot under the word, than by adding the character for the plural; but these methods are at the pleasure of the writer. In short-hand, every word is written according to the sound, without regard to the true spelling. You ought never to vary the terminations of the persons of verbs, because omitting these gives much facility to the writing, and cannot embarrass the reading. I forbear from giving many rules for contracting, as every person will form those for himself, so as to be able to follow a speaker, and then only they ought to be freely employed. But when writing such things as are to be kept for private use, and future perusal, I would recommend few contractions, and the regular or general use of the vowel marks.

EXAMPLES IN PLATE DXIII.

The 23d Psalm.

The Lord is my shepherd. I shall not want. He maketh me to lie down in green pastures; he leadeth me beside the still waters. He restoreth my soul, he leadeth me in the paths of righteousness, for his name sake. Yea though I walk through the valley of the shadow of death, I will fear no evil; for thou art with me, thy rod and thy staff they comfort me. Thou preparest a table before me, in the presence of mine enemies; thou anointest my head with oil, my cup runneth over. Surely goodness and mercy shall follow me all the days of my life, and I will dwell in the house of the Lord for ever.

On Speech, from Dr. Blair's Lectures on Rhetoric.

One of the most distinguished privileges which Providence has conferred upon mankind, is the power of communicating their thoughts to one another. Destitute of this power, reason would be a solitary, and in some measure, an unavailing principle. Speech is the great instrument by which man becomes beneficial to man; and it is to the intercourse and transmission of thought, by means of speech and writing, that we are chiefly indebted for the improvement of thought itself.

What we call human reason is not the effort or ability of one, so much as it is the result of the reason of many, arising from the lights mutually communicated, in consequence of discourse and writing. (J. W.)

The preceding article is a literal copy from the Edinburgh edition of this work; the following is furnished from the 8th or stereotype edition of *Gould's American Short-hand.* The author of that work says:

In England and some other parts of Europe, the great utility of this art is now fully acknowledged, and professional gentlemen are beginning to consider it an almost indispensable accomplishment.

In the United States, a land of legislation, public discussion, and universal interchange of thought and word, its manifold advantages are too obvious to require comment, or to demand an apology for the introduction of another article, under the same head.

Although the early history of *short-hand* cannot be traced with entire precision, still it is evident, that under different names and forms, it was practised to some extent by the most remote civilized nations of the earth. The Egyptians. who were at a very early period distinguished for their learning, represented objects, words, and ideas, by hieroglyphics. The Jews also used this species of writing, adding a number of arbitrary characters, for important, solemn, and awful terms, such as God, Jehovah, &c. A similar method was practised by the Greeks; it is said to have been introduced at Nicolai by Xenophon. The Romans adopted the same method; and Ennius, the poet, invented a new system, by which the Notari recorded the language of celebrated orators. He commenced with about 1100 marks of his own invention, to which he afterwards added many more. His plan, as improved by Tyro, was held in high estimation by the Romans. Titus Vespasian was remarkably fond of short-hand; he considered it not only convenient and useful, but ranked its practice among his most interesting amusements.

Plutarch tells us, that the celebrated speech of Cato, relative to the Catalinian conspiracy, was taken and preserved in short-hand. We are likewise informed, that Seneca made use of a system of short-hand writing, which consisted in the use of about 5000 characters.

The first publication upon the subject, of which we have any correct information, was about the year 1500, from a Latin manuscript, dated 1412. Various other publications followed in succession, without materially advancing or changing its character, till about the commencement of the 18th century; nor were the principles, till many years afterwards, settled upon a basis which could insure stability to the art.

Byrom was the first who treated the subject scientifically, and to him we are indebted for the promulgation of those fundamental principles, which will ever constitute the true foundation of every rational system of stenography. His first edition appeared in the year 1767, previous to which, many systems had been published under the name of short, or swift-hand, which were so involved in philological refinements, or superfluous arbitrary signs, as to be more tedious in the acquirement and practice, than the usual long hand, and scarcely intelligible, except to the inventors, or those who devoted their lives to practice it. Nor did Byrom rest, till he had much obscured the merits of his original plan by the introduction of numerous grammar rules, plausible in theory, but useless in practice. Much difficulty was experienced by him and later writers, in selecting appropriate characters, and assigning their respective functions; but a still greater difficulty by learners, from the too frequent introduction of arbitrary signs, and subtle theories, which have rendered useless to the world much that was otherwise valuable, in the elementary principles of Byrom and his successors.

Books upon short-hand have been rendered voluminous, intricate, and expensive, by theoretical niceties, which serve only to discourage the learner, to keep the art from schools and colleges, and thus prevent its general extension and usefulness.

Under these circumstances, few individuals have been successful in acquiring a knowledge of the subject; and while these have generally found an interest in suppressing its dissemination, the multitude have ignorantly rejected it, as a mystic and useless art. This neglect was just, while confined to some of the ponderous volumes of crude and unintelligible hieroglyphics, which appeared between the 16th and 18th centuries, but when applied to the more improved systems of a later date, it is grossly illiberal and unjust. Still, the prejudices excited previous to the publication of those scientific principles, which now characterize the art, are unjustly kept up, by those who are more ready to condemn what they do not understand, than to acknowledge their ignorance of a subject with which others are familiar.

Under these embarrassments, the subject received, comparatively, little attention in the United States, till within the last few years; and there are many yet unaware of the simplicity and practicability of the art, or of the facility with which it may be acquired.

Without descending to other particulars, it may be remarked, that since the appearance of Byrom's system, not less than one hundred treatises have been published, in the English language, besides a number of elaborate works in French, German, and other languages,—each professing superiority over all that had preceded; but, in fact, adding little to which the term improvement can be justly applied.

The most distinguished English writers upon this subject are the following, viz. Addy, Aldridge, Angell, Annet, Blandmore, Blosset, Botly, Bridges, BYROM, Coles, Cross, Dix, Everardt, Ewen, Facey, Farthing, Gibbs, Graime, GURNEY, Heath, Holdsworth, Hopkins, Jeake, Labourer, Lane, Lyle, Macauley, *Mason*, MAVOR, Metcalf, Nicholas, Palmer, *Rich*, Ridpath, Shelton, Steel, Turner, TAYLOR, Thickness, Tiffin, Webster, *Weston*, Williamson, Wills, and Willis.

The systems now principally used in England, Ireland, and Scotland, are those of Byrom, Mavor, Taylor, and Gurney. In the United States, *Gould's System* has nearly superseded all others, and may be pronounced the standard of American Stenography. This plan combines within narrow limits the practical merits of the four last mentioned systems, and appears to be peculiarly adapted, not only to the genius of our language, but to the present condition of the American people—being more concise and less expensive; and at the same time adequate to all the demands of literature, arts and sciences, so rapidly spreading through this mighty empire of independent communities.

We shall, by permission, present our readers with an abstract of the theory of this system, as taught by the author in the principal cities and colleges of the United States, practised by him in courts of justice and legislative bodies, and recently illustrated by a series of lectures published in "*The American Repertory* of arts, sciences, and useful literature," vol. i.

We shall also exhibit a fac simile of the author's hand, in an entire copy of the Declaration of American Independence (see Plate DXIII, No. 2).

In the introduction to this system the author remarks, it is his aim to adapt his work to the age in which we live; to lay aside every thing *unnecessary*, and to express in few words *all that is necessary* for a general system of short-hand.

He asks, would our common writing be more easily acquired, or its execution in any way facilitated, by increasing the number of letters in the English alphabet? Would arithmetic be improved by the introduction of arbitrary marks to represent the numbers 11, 12, 13, and so on to 100 or 1000? Would the art of printing be rendered more simple, easy, and expeditious, by the construction and use of leaden syllables, words, and sentences, instead of the letters of which they are composed?

Till these questions can be answered in the affirmative, the following theory will be found, *with practice*, amply sufficient for the purposes proposed, and *without practice* the efforts of human invention will prove abortive.

To convey a more just idea of the present state of the art, it is necessary to speak of earlier systems. This recapitulation will enable us to appreciate more fully the triumph of modern improvement over the rude attempts of former times; while it will furnish a reasonable ground of hope, that a general standard of stenography may yet be established, notwithstanding numerous attempts have proved abortive.

Short-hand formerly consisted in the use of almost innumerable hieroglyphics and arbitrary characters, which could only be learned with much time and labour, and when learned could not be retained without continual practice. This was tolerable only while words were few, and the cultivation of the human mind in its infancy. For however numerous these characters, the advancement of arts, sciences, and general knowledge, rendered a continual multiplication necessary to the representation of new words and ideas; nor could such a system, by the constant aid of human invention, even approximate perfection, while resting on this false foundation. Every appendage to the already overgrown structure, only served to make it more unwieldy, and to hasten the downfall of the whole fabric; for the characters were some of them so seldom used, that the utmost powers of human memory could scarcely retain them, and if recalled by memory, it could not be with sufficient facility to answer the end for which they were intended.

We have thus far traced the subject as an art merely—we will now proceed to unfold some of its beauties *as a science and an art*.

We are all aware, that ten simple figures, or the nine digits and cipher, have been found sufficient for all the purposes of numerical calculation. We also understand, that these ten figures are now used for nearly the same object, by every civilized nation on earth. We likewise know, that seven notes comprise the whole of written music, and that by a proper arrangement of these few notes, may be intelligibly represented all the varieties of harmony. It is also known, that, by means of these few simple, but acknowledged signs, this music is transmitted from individual to individual, and from nation to nation; requiring little interpretation but that afforded by the visible signs themselves. And though individuals are antipodes, totally ignorant of each other's language,—discordant in all their other feelings, habits, and views, yet, in the signification and use of musical signs, they have not only a perfect understanding, but hold communion, at the distance of thousands of miles, and reciprocally drink, as it were, from the same fountain, the rich melody of borrowed sounds with which the ear and heart had never before been greeted.

It is also evident, that, notwithstanding the infinite number of combinations, produced by the organs of speech, and the varied modifications of the human voice, the whole may, for all the purposes of short writing, be resolved into a few prominent sounds. Hence the practicability of assigning to each sound a particular representative, which shall be understood like arithmetical figures, or musical signs, by all people, and at all times, without regard to the language in which they are employed.

As a proof of this position, to a most satisfactory extent, let us look to the 26 letters of our common English alphabet. We all know, that with these few signs may be recorded the language of a thousand tongues for a thousand ages: nor would the object be at all facilitated were the signs 26 hundred, or as many thousands, though the modes of expression are beyond all human computation.

It is also a fact of notoriety and philosophic interest, that our alphabetic signs are now employed in common by the inhabitants of England, France, Spain, Italy, and many other countries.

By these facts we see, that the powers of arithmetical figures, musical signs, and alphabetic letters, are alike unlimited, in the extent of their application. Having established this important fact respecting the use of sounds and visible signs, we may with propriety approach the subject in question.

The system of short-hand which is about to claim our attention, *is not*, as some have erroneously imagined, an arbitrary art, necessarily confined to the indefatigable reporter of speeches—it is in fact a *science* as well as an *art*; and as such, claims a degree of attention even from those who may never employ it as an *art*.

As a science, adapted to the powers and faculties of the human voice and human ear, it determines upon the use of alphabetic characters, for the purpose of swift writing, instead of arbitrary signs for words, sentences, or ideas.

In the next place, it furnishes rules, which, if reduced to practice, will enable us to record language with the least possible time, labour, and space; compatible with legibility.

It shows the common alphabet to be totally at variance with the primary object of *short-hand*, which is *despatch*—that several of the letters are superfluous, and none of them well chosen, as they contain unnecessary crooks and curves, which tend to perplex and embarrass the learner, while they require time and space, to the sacrifice of ease and facility.

In this system, the alphabet consists of twenty characters, which are extremely simple, easily made, and readily combined, without loss of time, labour, space, or legibility, They are employed, 1st. To represent, individually, certain words, which are known to occur very frequently. 2d. As letters, or representatives of sounds, to be joined together in writing all words not denoted by individual characters. 3d. For some of the most frequent prefixes; and 4th. For the most frequent terminations of words.

There is a symmetry not only in the adaptation of these *visible signs* to each other, so as to insure the greatest brevity, perspicuity, simplicity, and beauty; but the elementary *rules* harmonize with each other and the whole, according to fixed scientific principles.

The learner should not be discouraged, though he be not able at once to record the entire language of a fluent speaker; nor should he hence infer, that the system is incomplete, or the art unattainable: for with the same propriety might the young reader condemn and abandon the use of the common alphabet, because he cannot at once read elegantly,—the musician his notes, or the Tyro in mathematics his Elements of Euclid: let him persevere in practice, and he will soon attain the object of pursuit.

To turn this necessary practice to the best possible account, he should record in a common place book from day to day such facts and other items of information, as may be considered immediately interesting, or worthy of future perusal. At first, his notes should be read while the subject is familiar, and by this course, the writing and reading of short-hand may in a few days be made easy, useful, and amusing, while the art cannot fail to become a potent labour and time-saving engine, not only for the actual accumulation and preservation of knowledge, but for the cultivation and expansion of the mind, and improvement of the memory. For by judicious exercise, this faculty can be trained to receive more and retain longer, whatever may be worthy of its attention.

This improvement, however, does not depend on the substitution of one faculty for another, but on their mutual co-operation, as auxiliary, each to the other. For though we are able by short-hand to preserve a literal copy of any particular subject, for our gratification and instruction, thereby increasing our stock of tangible knowledge; yet, if memory be left to languish in sickly inactivity, and thus gradually lose its energies or become enervated for the want of proper exercise, the loss is equal to the gain.

The memory, then, while it should not be overburdened with unnecessary verbiage, should never be released from that habitual exertion on which its own preservation and usefulness depend; the great secret of preserving and improving the memory consists in giving it a sufficient quantity of the right kind of aliment, affording due time for its digestion, and no more relaxation than is absolutely necessary to its health and vigour.

The person who can write rapidly does not consequently substitute writing for memory, but employs it as an assistant; and every person when committing words to paper for his future use and improvement, should endeavour to fix in memory, at least the leading features of the subject, depending on short-band, only for that which memory cannot recall.

When the memory is thus properly exercised, it cannot fail to be improved; and the mind, being released from the unnecessary incumbrance of words, will find more time to grow and expand, by reflecting, or comparing and analyzing the ideas which words may have infused; for the memory should be rather the repository of ideas than of words, which are the mere vehicles of thought, and always at hand.

Although the following system is in itself complete, so far as intended for correspondence and general use; yet, for the gratification of those who wish to make other abridgements, and particularly those of the learned professions, who think proper to engraft upon the established system certain technical or other abbreviations, adapted to their own respective professions, the following hints may be useful.

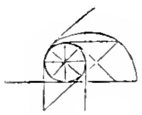
The lawyer or judge may, with much propriety, even if writing short-hand, substitute in place of certain words which occur very frequently, the initial common hand letter, as P, for plaintiff, D. for defendant, W. for witness, C. for court, T. for testimony, V. for verdict, J. for judgment, &c.

The physician may, with like propriety, use P. for patient, pulse, or perspiration, F. for fever, I. for inflammation, R. for respiration, &c.

The clergyman may find it convenient to use H. for heart, or heaven, S. for sinner or salvation, R. for redemption or resurrection, J. for judgment, C. for conscience, condemnation, &c.

Young gentlemen who attend lectures on chemistry, anatomy, or other subjects, may save much labour and time, by using the initials of certain technical terms, which occur frequently in the course of their study.

EXPLANATION OF THE SYSTEM.



This diagram exhibits at once, all the characters employed in this system; they are 20 in number, and of four distinct species, viz.

1. The right line.
2. The semicircle.
3. The circle and line combined.
4. The quarter circle and line combined.

1. The horizontal diameter is used for the letter s; the perpendicular diameter for t; the oblique diameter, drawn downwards on an angle of 45°, to the left, is d; the same line running upwards is r; the oblique diameter drawn downwards on an angle of 45° to the right, is f, or v, either, as may be required.

2. If a circle be divided horizontally, into two semicircles, the upper one is k, or q; the lower one, n: if divided perpendicularly, the left semicircle is ch, and the right g, or j.

3. If any of the right lines above described be joined to a small circle, and project as a tangent, the circle and line together form a stenographic letter of the third class, as seen upon the third limb of the tree, viz.—If it project from the top of the circle, to the *right*, *horizontally*, the circle and right line together constitute the letter m. If the same figure be turned, so that the tangent project *downward*, *perpendicularly*, from the *right side*, it will represent the letter p—if *obliquely* to the *left*, *downward*, on an angle of 45°, it is h—if *obliquely* to the *right*, *downward*, on the same angle, it is b; if *obliquely* to the *right*, *upward*, it is l; or, if the *upper* segment of a larger circle be joined to the *whole circle*, in the form of a curved tangent, projecting to the *right*, the letter w is produced.

By joining the *right line* to a *quarter*, instead of the *whole*, or *half circle*, the letters of the fourth class, are respectively produced—viz. If the right line be joined as a tangent to that segment or quadrant of the circle, lying *below* the horizontal diameter, and on the *left* of the *perpendicular*, and project to the *right*, *horizontally*, it produces the letter x;—If attached to the upper quadrant, on the *left* of the *perpendicular*, and project *horizontally* to the *right*, the character sh is formed—if attached to the other extremity of the same quadrant, and project from the *left side* of the circle, *perpendicularly down*, it is th—if attached to that segment or quadrant, contained between the lower extremities of the two *oblique diameters* in the diagram, and be extended *obliquely upward* to the *right*, on an angle of 45°, it is the character y—and if a *horizontal right line*, be drawn from *left* to *right*, till it strike the lower edge of the circle, and be joined to the *lower quadrant*, on the *right* of the *perpendicular*, the character ious is produced.

These characters have a fourfold application.

1. To represent, individually, a few common words.
2. The most frequent prefixes.
3. The most frequent terminations.
4. The alphabetic letters, for which they have been substituted.

ALPHABET AND COMMON WORDS.*

	· ☞	*a e i o u y*
1. Right Line.	— *s*	*is as us his*
	| *t*	*into unto it*
	/ *d*	*do did done*
	/ *r*	*are our or*
	\ *f v*	*of off if*
2. Semicircle.	⌒ *k q*	*know knew known*
	◡ *n*	*and an in*
	(*ch*	*such chance church*
	) *g j*	*God good give*
3. Circle and Line.	*m*	*me my many*
	p	*peace person power*
	h	*have he had*
	b	*be by been*
	l	*lord all love*
4. Quadrant and Line.	*w*	*with which who*
	x	*example except accept*
	sh	*shall shalt should*
	th	*the they that*
	y	*you your year*
	ious	*conscious judicious*

* The words above are always represented by single characters, and will constitute about one third of any common discourse; all other words are spelt according to their sound, and written with the characters of the Stenographic alphabet, having the power of letters only. The vowels a, e, i, o, u, y, are represented by a dot.

Rules for making the Characters.

1st Class.—Make s to the right, t down, d downward, r upward, f v downward.

2d Class.—Make k q and n from left to right, ch and g j downward.

3d Class.—Make the circle first in all cases.

4th Class.—Make the hook or quadrant first in all cases, except ious, this always ends with the hook. ☞ For double letters make the line longer, or the circle larger.

Rules for joining Characters.

Make one letter as if no other were to be made, and then without lifting the pen, make the next as if the first had not been made, observing to turn in that way which is most simple and easy, but let the line always take the same direction from the circle.

Rules for Spelling.

1. Use no vowels in spelling, except when distinctly sounded at the beginning and end of words. Example: entity ntt, chastity chstt, obey oba, away awa, pay pa, lay la, say sa.

2. Omit all silent letters. *Ex.* Light lit, sight sit, night nit.

3. When two letters sound like any one, use that one in their stead. *Ex.* Laugh lauf, physic fysic, Utica Utk, empty mt.

4. The letter c must be supplied by k and s. *Ex.* Comply komply, celestial selestial, receiver resciver.

5. H may frequently be omitted as follows. *Ex.* Behold beold, how ow, highway iway, heaven even, help elp.

6. Ph and gh are never written in short hand, being always sounded like f or v (when not silent), and therefore represented by these characters. *Ex.* Enough enuf, tough tuf, Philadelphia Filadelfia, philosophy filosofy, Stephen Steven.

7. When double consonants occur, use only one; but if a vowel intervene, use both. *Ex.* Restlessness restlesnes, commendation comendation, memory mmory, people pple.

8. B and w may be omitted, as follows. *Ex.* Number numer, encumber encumer, slumber slumer, answer anser.

9. The ch character is used only where it has its natural sound, as in charm, church, chapter, choice. Where ch have the sound of k or sh, let these signs be used.

10. Let z be represented by s in all cases; but to distinguish it, let the mark be made thicker than for s.

REMARKS.—Although this method of spelling may appear difficult to the beginner, he is assured, that it may be made quite familiar in a few hours, and that without injuring his common spelling. To do this, pronounce words distinctly and rapidly, retaining for short hand nothing but the most prominent sounds; as nv, for envy; ntt, for entity; ldr, for elder; flsfr, for philosopher, &c.

Rules for Writing.

1. Provide a good pencil, or fine hard pen, good ink and paper.

2. When a vowel is to be written make a small dot, and if it belong to a particular word, let it stand near that word, at the right or left.

3. Do not lift the pen in a word, except to write a prefix, termination, or vowel.

4. Make the *character* y, for the words *you*, *your*, *year;* and at the *beginning* of words, but never at the last end, as it is there a vowel and represented by a dot.

5. *Prefixes, &c.* At the beginning of words use r for *recon*, *recom;* m for *multi*, *magni;* k for *contra*, *contri*, *counter;* n for *inter*, *intro*, *enter;* s for *satis*, *super*, *circum*; t for *trans.* It must be remembered, that all these signs should be made small, and placed just before the word, but not joined to it. For *under*, *beneath*, *below*, make a small circle ₒ below the line of writing; for *on*, *upon*, *over*, and *above*, make it ° *over* the line; for *before* make it in the line °; for *up* and *down* make a small dot or touch above· or below. as the case requires.

6. *Terminations.* At the end of words a scratch through the last letter is *tive;* a dot. below is *ly*; a dot˙ above is *tion*, *sion*, *cian*; a touch′ above is *tions*, *sions*, *cians*; at the right it is *ing*, *ong*, *ung*; if below, it is *ings*, *ongs*, *ungs;* if thus` it is *ity*, *ality*, *elity*, *ility;* a horizontal touch¯above is *al*, *ial*, *tial*, *cial:* and the same touch_ below is *less*, *fess*, *ress;* and without lifting the pen, the following letters may be used for some of the frequent endings of words; viz. n for *ness*, b for *ble* or *bles*, m for *ment* or *ments*, s for *self* or *selves*, f for *full*, *ference*, w for *ward*, sh for *ship*, and ⁀ for *ious*, *eous*, *uous*, *ius.*

7. Use common figures to represent numbers, but make them larger than the other characters, that they may be readily distinguished.

8. The common marks for punctuation may all be used in short hand, except the period, which would be taken for a vowel. But the following distinction is all that is necessary in following a speaker—when a sentence is complete, leave a blank of half an inch, and let each paragraph begin a line.

9. Long words may often be represented by two or three of their leading consonants, or by their initials, when the sense is clear; and in most long sentences a number of small words may be dropped, without impairing the sense.

10. When a word or sentence is immediately repeated, write it once, and draw a line under it for the repetition. If it be a sentence, and not repeated till something else occur, write a word or two and make the ⟍ for &c.

Rules to improve Legibility.

1st. As a, I, O, are the only vowels ever used alone, they may be easily distinguished as follows, ˙a ·i .o; that is a above, I in the centre, and O below, the line of writing.

2d. At the beginning and end of words make use of the same distinctions, ˙a or e ·i or y .o or u

3d. To show certain omitted vowels in the middle of words, place a comma over the word as follows, thus: ,for a or e ———; - for i or y ———; ‘for o or u ———.

4th. For diphthongal sounds place the comma under the word, as follows, — for ou; and — for oy.

5th. In doubtful cases, let {d, v, q, g} be made heavier than {r, f, k, j}

Rule for Reading.

When a word is not known at sight, proceed to speak each letter of which it is composed, separately and distinctly, and then pronounce the whole together, as rapidly as possible—thus; n, v, when pronounced nv, would give the word envy—n, t, t, pronounced ntt, would give the word entity—l, d, r, would be elder—f, l, s, f, r, or flsfr, would be readily recognized as philosopher; and the same of all other words.

REMARK.—The characters of this system are simple and few, and may soon be known at sight, like the letters of our common alphabet, and when thus familiar, the sense of the subject will render the reading sure and easy.

Much might be said on the subject of omissions and contractions, but as these must after all depend more upon the practical experience of the writer than upon any written rules, I shall simply quote from a former edition of the Edinburgh Encyclopedia, from

Rees's Cyclopedia, and the Encyclopedia Brittannica, the rules of Byrom and Mavor. Upon this subject Byrom says, "It may be proper to advise the learner, not to embarrass himself with short-hand abbreviations, till by a competent practice of writing, according to the rules already laid down, he is become so well acquainted with the characters, as to be able to write and read them with nearly as much ease as common long hand. He will then meet with little more difficulty in reading words contracted, than he formerly did in those written more at length, provided that the rules of abbreviation be duly attended to. A summary of the principal rules and most practical methods of abbreviation is here given, and it is left to the skill and discretion of the writer, by observing their nature, and proceeding upon the same principles, to make such other advances and improvements as his occasion may require."

Before I proceed to the rules, I will subjoin another extract. "Lambinet (a French writer), in his 'Researches upon Printing,' observes, that modern stenography, which, like the telegraph, dates in France from the foundation of the republic, has neither the inconvenience, nor the obscurity, nor the danger of the ancients. The old characters varied under the hand of the copiers, and the sense changed according to the genius of the interpreters; so that their contractions are become so many enigmas, because we can refer to no other copies to ascertain the true reading, and because the authors are no longer in existence. But," continues the writer, "by the present system of stenography, the writers follow the words of the public orators, take down their speeches, the motions, the debates of the tribune, or the lectures of the professors of the Lyceum, and produce a literal translation at last, in the usual characters and in print."

A brief Summary of Byrom's Rules of Abbreviation from the Encyclopedia Brittanica.

Rule 1.—To join the auxiliary verbs, the particle *not*, and the pronouns together; as *can be, have been, must be, cannot be, he must be, ought not to be, &c.*

Rule 2.—To join the marks in an unusual manner, in order to show that each particular mark denotes a word, and not a single letter; as *in the, it is, as it is, since it is, it was, it was not to be, &c.*

Rule 3.—Derivative substantives may be very conveniently represented, by placing a point at the end of the words from which they are derived. Derivative adjectives and adverbs may be represented also by points, distinguishable by their situation, both from the substantive and the vowel points; which may be done by placing them in a line, which, if produced, would pass through the substantive point, and would also be perpendicular to the last consonant mark; one placed *before* the substantive point, signifying the adjective, one *after* it, the adverb: as, *forgetful, forgetfulness, forgetfully; reasonable, reasonableness, reasonably; sufficient, sufficiency, sufficiently.*

No great accuracy is necessary with respect to the adjective and adverb points, provided they be placed so as to be clearly distinguished from the vowel and substantive points.

Rule 4.—Such words as, either by their particular relation to the subject, or frequent occurrence, are easily discoverable, however concisely written, may be denoted by the first letter, if they begin with a consonant, if not, by the first vowel and consonant, with the adjective, substantive, or adverb point annexed; as "life and *immortality* are brought to light by the *gospel*;" the "*resurrection* of the dead, and a future state of *rewards* and *punishments*, are plainly and positively taught in the gospel." The adjectives which usually accompany such substantives may also be denoted by their first consonant, joined to the substantive; as, "with *humble submission* to your lordship."

Most writers of short-hand accustom themselves to mark such words as most frequently occur in their own particular professions, by the initial letters only, with the substantive, adjective, and adverb points, which, through custom, easily suggest those words to them at first sight. But it must not be understood, that those marks imply those words exclusively, and no other. They may stand for any other beginning with the same letters, which the sense of the passages necessarily requires.

Rule 5.—A dot placed at the point of concurrence of two consonant marks, denotes two substantives, of which those marks are the first consonants; and also that the latter is governed of, or connected to the former by some preposition, which is omitted; as, "the *love of money* is the root of all evil;" "seek ye first the *kingdom of God*, and his righteousness," &c.; "the effects of gravity are visible in every part of that system to which we belong, but the *cause of gravity* still remains undiscovered."

And if an adjective precedes either of the substantives, they may all three be represented by their first consonants joined together, with the dot always placed at the end of the first substantive: as, "the *great goodness of God* is manifest in all his dealings with his creatures;" "his majesty the *king of Great Britain.*"

Rule 6.—The substantive point, placed before a single consonant mark, denotes that the substantive is to be repeated, with some intervening preposition; as, "*day after day*;" "from *time to time*."

Rule 7.—The substantive, adjective, or adverb point, placed before two or more consonant marks joined together, denotes two or more substantives, adjectives, or adverbs, of which those marks are the first consonants, and also that they are connected by a conjunction; as, "the precepts both of *natural and revealed* religion forbid us to do our neighbours any injury:" "what doth the Lord thy God require of thee, but to live *soberly, righteously, and godly* in this present world."

Rule 8.—Many long words, especially those in which the marks for the consonants will not join neatly, may be denoted by their first syllable, with as many points annexed as there are syllables wanting; as *multitude, correspondence.* And when great despatch is required, the points may be omitted, especially if the words do not begin with prepositions; as, *signification, difficulty, negligence.*

Rule 9.—Words beginning with prepositions may be denoted by their respective prepositions, together with the next consonant and vowel, and sometimes with the next consonant only, adding, when necessary, the substantive, adjective, or adverb point; as, *deliberate, transmutation, recommendation, consanguinity*, &c.

The participles may be abbreviated after the same manner, by adding, instead of the points, the terminations *-ing* or *-ed* to the latter consonant mark; as, *considering*, *considered*.

Words beginning with double or treble prepositions, may be written after the same manner, joining the prepositions together; as, *representation*, *misrepresentation*, *incomprehensibility*. If two consonants begin the next syllable, the writing of them both will help to discover the remainder of the word; as, *misunderstanding*, *transubstantiation*.

Rule 10.—Words ending in any of the terminations, which in the alphabet are denoted by consonant marks, may be expressed by their first consonant and vowel, together with the proper mark for its termination; as, *arbitrary*, *opportunity*, *curiosity*, *lawfulness*.

Rule 11.—Such words as are easily discoverable by the particular prepositions which they require, may be denoted by their first consonant only; as, "this *belongs* to me;" "he made some good *observations* upon it;" "we must *guard* against such passions as we are most *liable* to."

As few English words end with the syllable *-to*, the preposition *to* may be joined to the preceding word, which is signified by its first consonant only; as, this *belongs to* me, *liable to*, *satisfactory to*.

Other prepositions which are denoted in the alphabet by a single consonant may, in like manner, be joined to the preceding word; as, "he made some good *observations upon* it."

Rule 12.—Prepositions generally require after them either a noun or pronoun. The pronouns being few in number, and used as substitutes for nouns, must occur very frequently, and by that means soon become familiar to the learner; pronouns, therefore, may be joined to the prepositions, without danger of creating any difficulty to the reader; as *to me*, *to my*, *to you*.

Rule 13.—The preceding word, the preposition, and pronoun, may be joined all together; as *belongs to me*, *extends to us*, *agreed with me*, *depend upon me*, *observations upon this*.

The words *some*, *any*, *none*, *which*, *each*, *both*, followed by a preposition and pronoun, may be denoted by their first consonants, and may be joined to the preposition and pronoun; as, *some of them*, *any of us*.

Rule 14.—The adverbs preceding the verbs, and the substantives following the pronominal adjectives, may be joined to the verbs and adjectives respectively, denoting both the adverbs and substantives by their first consonants, or at most by their first consonants and vowels; as, "you may *safely depend upon my word*."

Rule 15.—Many common phrases, formed by a substantive preceded by the prepositions *with*, *without*, *in*, &c., and followed by *to*, *of*, &c. may be very conveniently abbreviated; as, *with regard*, *respect*, or *reference to*, *in order to*, *in consequence*, *comparison*, or *consideration of*.

Rule 16.—Common adverbial phrases are, in like manner, often denoted by their initial consonants joined together; as, *at the same time*, *at present*, *in this manner*, *in like manner*, *in a great measure*, *in the same manner*, *in the mean time*, *in general*, *in particular*.

And when the proportion of equality is expressed, with some one word intervening, they may be all joined together; as, *so much as*, *as well as*, *as soon as*.

Rule 17.—The contractions which may be made, when *it is* or *it was*, are followed by an adjective, and *to* or *that*, are very numerous; as *it is impossible to*, *it was unnecessary to*, *it is contrary to*, *it is according to*.

I now proceed (says the American author) to give a few of the rules of abbreviation laid down by Dr. Mavor, and published in a former edition of the Edinburgh Encyclopedia; from which, with the other authorities already quoted, and the examples that I shall hereafter furnish, the learner will be prepared to make such advances in the reduction of labour as he may deem expedient, without endangering the usefulness of the previously acquired system.

"The value of stenography, says the editor, is not unknown to the learned; and the ease and success with which it has been lately cultivated in these kingdoms will, in all probability, soon render it an object of general attention. No one, however, appears to us to have simplified and improved the art so much as Dr. Mavor, author of the Universal Stenography, who has liberally permitted us to present our readers with a complete view of his scheme; which, in many schools of the first reputation, now stands a deserved class-book."

Having given an outline of his theory, Dr. Mavor proceeds :—

"Though a more concise method of writing, or more numerous abbreviations, may not be indispensably necessary, if the foregoing directions be practised for a considerable time, yet contractions will be found extremely useful and convenient to those who have attained a proper knowledge of the subject, and lead to a greater degree of expedition, at the same time that they diminish the labour of writing. It has been observed in the introduction, that abbreviations are only to be employed by proficients in this art ; because expedition is not the first, though the ultimate object in view : and that an easy legibility is of the utmost consequence to the learner, which, however, cannot be preserved, if he adopts too soon those very rules, which in time will afford him the greatest ease when applied with judgment.

"The following short and practical rules will be found, we hope, fully adequate to every purpose for which they were intended.

"Rule 1st. The usual abbreviations in long-hand are always to be followed ; as Mr. for Master, M.D. for Doctor of Physic, and Abp. for Archbishop, &c.

"Rule 2d. Substantives, adjectives, verbs and participles, when the sense will direct to the meaning, are to be expressed by their initial consonant with their distinguishing marks ; viz. a substantive must have the dot exactly over its initial consonant ; an adjective must have a dot under it ; a verb is to be expressed by a comma over its initial consonant ; and a participle by a comma under. These being the four principal parts of speech will be sufficient ; and an adept will never be at a loss to know when he can with safety apply this rule to them.

"Rule 3d. To render the writing more legible, the last letter of the word may be joined to the first, and the proper mark applied.

"Rule 4th. The constituent or radical part of words, especially if they are long, will often serve for the whole, or sometimes the first syllable; as we ought to moderate our *ex.* by our *circum.*; a man's *man.* commonly shape his *for.*

"Rule 5th. All long words, without exception, may have their prepositions or terminations expressed by the incipient consonant of such preposition or termination.

"Rule 6th. When there is a great dependence between the parts of a sentence, the initial letter will often suffice; as L. is the capital of Great B. The eldest son of the king of Great B. is styled prince of W. Every one, it is presumed, will allow this to be perfectly legible in long hand [particularly in Engand], then why should it not be in stenography?"

Although I decidedly reprobate the use of numerous arbitrary signs, as heretofore employed in short hand, still to a limited extent, they may be useful. Mr. Gurney, a celebrated reporter in the British parliament in his own work upon short-hand, when speaking of arbitrary characters, says:

"A principal advantage in this system of short-hand consists in the small number of arbitrary and contracted characters; and in their conspicuity, by which they will be soon understood, fixed in the memory, and read again at first sight."

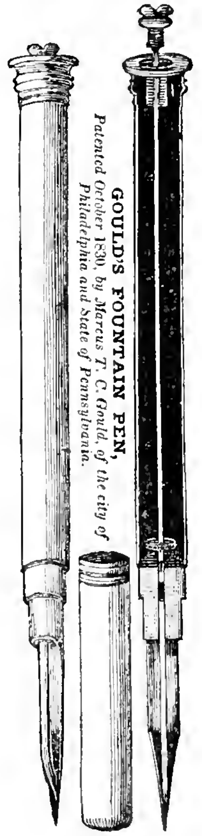
He afterwards introduces the capital letters of the common writing alphabet, as the arbitrary signs of certain words of frequent occurrence—the plan I think a good one, if confined within proper limits; and I therefore give it as prepared by him, together with remarks and additions by the editor of the last American edition of his work.

ARBITRARY CHARACTERS FORMED FROM THE WRITING ALPHABET.

☞ *The italic types are used as most convenient to represent the common writing letters.*

A Administrator, -tion	*a* accord -ing -ingly
B	*b* bankrupt -cy
C Congress, Congressional	*c* circum -stance -es
D Demonstrate -tion	*d* evident -ly, evidence
E Ecclesiastic -al	*e* establish -ed -ment
F	*f* fraud -ulent -ulently
G	*g* govern -ing -ment
H	*h* hereditary -aments
I	*j* justify -ing -able -cation
K	*k*
L	*l* legislator -ture -tive -tion
M	*m* multitude -ply -ed -cation
N	*n* notwithstanding
O Origin -ate -al -ally	*o* order -ing
P President of the States	*p* precedent -cy
Q	*q*
R Representatives	*r* represent -ed -ation
S Senate	*s* statute, spirit -ed -ual
T	*t* trespass -es, transport-
U United States	*u* unlawful -ly -ness [ation
V	*v*
W	*w* witness -es -ing
X Christianity	*x* extraordinary -ly
Y	*y*
Z	*z*

STENOGRAPHIC PEN, BY M. T. C. GOULD.



This instrument being chiefly employed in Stenographic writing, and invented by the author of the preceding system of Short-hand, may be very properly appended to this article.

The following is a full and exact description of the parts, construction and use, of the Perennial or Self-supplying Fountain Pen:

1st. A cylindrical barrel, of gold, silver, glass, or other material, about five inches in length, and one third of an inch in diameter, to be filled with ink.

2d. A shaft of metal or other substance screwed into the lower end of the barrel, and projecting downward below it, about half an inch, forming in its diminished size, a collet upon which is slid a common or metallic pen.

3d. A small tube or conductor, of gold, silver, or other material, passing upward through the collet, and communicating with the column of ink by means of a regulator, hereafter described, and at the same time extending downward, along the centre of the pen, with the lower end so bent as to open directly upon the split of the pen.

4th. A hollow wire, or rod, called the regulator, passing through the upper end of the barrel, and extending downward through the barrel and shaft, till it meets the ink tube, about midway of the shaft and collet. This regulator has a small groove or other opening near each end (and within the fastening or packing box, at each end of the barrel), for the purpose of admitting, when unscrewed, ink below, and air above—that is, ink into the tube below, and air into the barrel above; and at the same time, opening an uninterrupted channel the whole length of the instrument, through which, if the regulator be screwed down and opened above, air or water may be forced, for the purpose of cleansing the tube, without communicating with the ink in the barrel.

5th. A piece of sponge or other porous substance attached to the wire, immediately above the shaft, and filling the entire diameter of the barrel, about a quarter of an inch upward—thus forming, when the regulator is unscrewed, and the pen in use, a strainer of the ink, and a regulator of its flowing; or, when screwed down, and the pen at rest, a general valve upon which the whole column of ink may rest. Immediately above this spongy substance is attached to the rod, a thin, flat, circular plate, or follower, equal in width to the inner diameter of the barrel; this plate should be finely perforated in various places, near its circumference.

6th. A small stopper, at the upper end of the regulator, and a suitable cap at the lower end of the barrel, give a finish to the whole instrument.

When in proper order, this pen will write for hours, supplying itself with ink as fast as desired by the writer.

STEREOGRAPHIC Projection of the Sphere. See Geography, Vol. IX. p. 622.

STEREOTYPE Printing. See Printing, Vol. XVI. p. 156.

STERNE, Lawrence, a celebrated writer, was born at Clonmell in Ireland in Nov. 1713. He received his education at Halifax, from which he went to Jesus College, Cambridge. In 1759 he published his *Life and Opinions of Tristram Shandy*, in 2 vols. which were followed by seven more, the last of which came out in 1766, and in 1768 appeared his *Sentimental Journey*, in 2 vols.; he published also 4 vols. of Sermons, two in 1760 and other two in 1766. He died in March 1768 at the age of 55, leaving behind him a widow and a daughter. This daughter, who married a French gentleman, published in 1775 a collection of her father's Letters in 3 vols. 12mo., preceded by Memoirs of his Life and Family. His private and domestic character were such as might have been expected from a clergyman, who, at the age of serious thought, had published works so questionable in point of morality and decorum.

STETTIN, a town of Russia, and the capital of Pomerania, is situated on an eminence upon the left bank of the Oder, about sixty miles from the Baltic. It is connected by a long bridge over the largest of the four streams into which the Oder is here divided, with Lastadie a part of the town. It has three suburbs, five gates, and several squares. The largest of these is a fine square containing a pedestrian statue of Frederic II. by Schadow. Many of the houses in the town are very elegant, and some approaching even to palaces. The principal public buildings are the castle, the government house, the arsenal, the barracks, the exchange, the public library, the theatre, the hospitals, an academical gymnasium, a school of navigation, and five parish churches. The gymnasium is conducted by several professors, with assistants, who give lectures in theology, philosophy, medicine, law, mathematics, and languages both ancient and modern.

The principal manufactures of Stettin are woollen, linen, and cotton goods, leather, soap, tobacco, ships' anchors, ships and boats. Stettin is the outlet of the manufactures of Silesia, and also part of Brandenburg and Poland, and hence it enjoys a very considerable trade. Its exports are chiefly grain and timber. The wheat is inferior to that of Dantzic and Elbing, but it is cheaper. The oak timber and stone of Pomerania are much esteemed. The imports are coffee, sugar, dyewood, rice, rum, cotton-wool, and Buenos Ayres hides. In 1816 the number of ships engaged in the export trade were 984, and in the import trade 1311. All vessels which draw above seven feet of water are obliged to load and unload at Swinemunde, a small town situated at the mouth of that branch of the Oder, which is called the Swine.

The country round Stettin is delightful, and the lofty shore of one side of the Oder affords charming views. In the river, which now widens and now contracts its channel, are several islands both above and below the town, which increase the charms of the prospect. The population of Stettin is 26,000, and it publishes *two* Journals. East Long. 14° 45′ 45″. North Lat. 53° 25′ 36″.

STEUBEN, county of New York, bounded W. by Alleghany county in the same state; NW. by Livingston county; N. by Ontario; NE. by Yates county and Seneca Lake; E. by Tioga county of New York, and S. by Potter and Tioga counties, Pennsylvania. This county is very nearly a square of 40 miles each side; area 1600 square miles, extending in lat. from 42° to 42° 34′ N. and in long. from 0° 2′ E. to 0° 48′ W. from Washington City.

The surface of this county if not mountainous is very hilly and rocky, but possessing much excellent soil. Compared with the actually determined level of Tioga river below the eastern boundary of Steuben; the lowest part of the arable surface of that county must exceed 900 feet, and the far greater part rise above 1000 feet, relatively with the mean Atlantic tide. This elevation is equivalent to $2\frac{1}{2}$° of lat., Lake Ontario being but 231 feet above the ocean level; the higher valley of Tioga river, comprising the much greater part of Steuben, is about 800 feet, or nearly equivalent to 2° of lat. above the lake. This difference of relative height explains the true reason why a milder temperature is found along the lake border, than on any part of Steuben.

With the exception of the north-eastern part which slopes in that direction, and is drained into Seneca Lake, the body of the county is in the valley of Tioga, with a declivity to the south-eastward. As a physical section it constitutes the extreme north-western part of the basin of Susquehanna.

The Tioga or Chemung is formed by three branches: Tioga proper flowing westwardly from Tioga county, Pennsylvania; the middle branch, Canisted, having its most remote sources in Alleghany county; and the northern branch Conhoctor, rising in Livingston county. The Tioga and Canisted unite, and two or three miles below their junction receive the Conhoctor, near the Painted Post, in the south-eastern part of Steuben. It is remarkable, that though rising in so high and hilly a country, all these small rivers are navigable for down stream craft and rafts from near their sources.

The rapid and extensive settlement of this elevated and hilly county is shown by the list of Post-Offices, which amount to 49 according to the recent list now (April 1831) in the course of printing. Bath, the county seat on the left bank of the Conhocton, a little north-east of the centre of the county, is a fine thriving village, with a waving and pleasant site, N. lat. 42° 23′, long. 0° 21′ W. from, and by post road 299 miles a little W. of N. from W.C., and 216 miles NW. by W from Albany. By the census of 1820 this county contained 21,989 inhabitants.

STEUBENVILLE, post village and seat of justice, Jefferson county, Ohio, situated on the right bank of Ohio river, 40 miles SW. by W. from Pittsburgh, 82 NE. by E. from Zanesville, and 136 in a similar direction from Columbus; and by post roads 284 miles NW. by W. from W. C. It was laid out in a dense forest in 1798. The site is a bottom or plain rising by a gentle acclivity to the foot of the adjacent hills. The opposite bank on the Virginia side rises from the river margin in craggy precipices, which with high but rounded hills on its own margin gives to Steubenville the appearance of occupying the base of a deep valley, and such is the fact; the hills on both sides rise to upwards of four hundred feet above the level of the plain on which the town stands. The streets are elevated above high water, and the whole has a a romantic and pleasing effect on the eye. The dwelling houses amount to about 500, extending along streets laid out at right angles to each other in a northern and southern, and eastern and western direction, and very nearly parallel, or at right angles, to that part of Ohio river opposite the town. In 1820 the population amounted to 2539.

The public buildings are a court-house, two banks, several places of public worship, two large factories, one of woollen and the other of cotton. There are two weekly newspapers printed here, and an academy for education in operation. DERBY.

STEWART, MATTHEW, D.D. a celebrated Scottish Mathematician, was the son of the Rev. Dugald Stewart, minister of Rothsay, and was born in the year 1717. At the age of seventeen, he went to Glasgow, where he studied mathematics under Dr. Robert Simson, from whom he imbibed that love of the ancient geometry which characterized his future studies. As his views in life required his attendance at the college of Edinburgh, he went there in 1741, where he attended the lectures of Colin Maclaurin. Here he devoted himself to his favourite studies, and kept up a regular and intimate correspondence with Dr. Simson of Glasgow. In the midst of these pursuits, he was appointed to the living of Roseneath, where he completed his "General Theorems," a series of curious and interesting propositions which he published in 1746, and which, though given without any demonstrations, placed the author among the geometers of the first order.*

In the summer of 1746, the death of Mr. Maclaurin created a vacancy in the mathematical chair of the University of Edinburgh, and such was the superiority over the other candidates which the General Theorems gave to Mr. Stewart, that he was elected to the office in September 1747.

In the 2d volume of the Essays of the Philosophical Society of Edinburgh, Mr. Stewart published a very neat solution of Kepler's Problem. In 1761 appeared his *Tracts Physical and Mathematical*, which relate to the doctrine of centripetal powers, to the theory of the lunar motions, and to the determination of the sun's distance from the earth. In 1763 he brought out his *Propositiones Geometricæ more veterum demonstratæ*, and in the same year he published his *Essay on the Sun's Distance from the Earth*. In this tract he made the sun's parallax only 6″.9, and consequently his distance so much as 29,875 semi-diameters of the earth, or 118,541,428 English miles. This result was received with surprise, and brought forth two answers to the tract, the one by Mr. Dawson of Sudbury, and the other by Mr. Landen, who pointed out certain errors which had been committed by Mr. Stewart. To these animadversions Mr. Stewart made no reply. His health had now begun to decline, and with the view of restoring it he made a tour through England, and paid a visit to Earl Stanhope, from whom he received singular marks of attention. In 1772, when his son, Mr. Dugald Stewart, was able to lecture for him, he retired to the country, where he spent the greater part of his life. In 1775 he resigned his chair, and his son was elected joint professor with him. His health continued to decline, and he died on the 23d January 1785, at the age of 68.

STEWART, DUGALD, a celebrated metaphysical writer, was born at Edinburgh on the 22d November 1753, and was the only son who survived the age of infancy of the celebrated Dr. Matthew Stewart, professor of mathematics in the College of Edinburgh, and Miss Stewart, daughter of Mr. A. Stewart, writer to the signet. When a child, his health was feeble and precarious, and it was only by the greatest care that his parents succeeded in re-establishing it. At the age of seven he went to the High School, where his talents were favourably displayed, and after completing the usual routine of instruction at that academy, he was admitted a student in the University. Under the roof of his father, he was early initiated into geometry and algebra; but the peculiar bias of his mind was exhibited during his attendance on the lectures of Dr. Stevenson, then professor of logic, and of the celebrated Dr. Adam Ferguson, who filled with so much talent the chair of moral philosophy. It was this circumstance, no doubt, that induced his father to send him, at the age of eighteen, to the University of Glasgow, to attend the lectures of Dr. Reid, who was then sustaining, single-handed, the honour of that seat of learning, which had in the course of a few years been deprived of the services of Dr. Robert Simson, Dr. Adam Smith, and Dr. Black. In the session of 1771-1772, he attended a course of Dr. Reid's lectures, and was thus enabled to prosecute, under his great master, that important science which he was destined to illustrate and extend. The progress which he here made in his metaphysical studies was proportioned to the ardour with which he devoted himself to the subject; and, not content with listening merely to the instructions of his master, or with the speculations of his leisure hours, he composed during the session that admirable Essay on Dreaming, which he afterwards published in the first volume of his *Philosophy of the Human Mind*.

The health of his father had been for some time declining, and in the autumn of 1771 it had become so precarious, that Mr. Stewart was called upon to prepare for teaching the mathematical classes during the ensuing session. This duty, which devolved upon him at the age of nineteen, he discharged with great credit to himself, and, notwithstanding the high reputation of his father, the great success of his son brought an additional number of students to the class.

In the year 1774, when he had reached his twenty-first year, he was appointed assistant and successor to his father,—a situation which he continued to fill till the death of Dr. Stewart in 1785.

In the year 1778, when Dr. Adam Ferguson was appointed secretary to the commissioners for quieting the disorders which had broken out in America, Mr. Stewart undertook to supply his place during the session of that year; and this unexpected occupation was the more severe, as he had previously pledged

* The first demonstration of any considerable number of these was printed in the Edinburgh Transactions by the Rev. Dr. Small of Dundee. The demonstrations of others have been lately communicated to the Royal Society of Edinburgh, by Mr. Alexander Galloway, of the Royal Military College, Sandhurst.

himself to deliver a course of lectures on astronomy, in addition to the usual labours of his two mathematical courses. Three days after he had undertaken this difficult task, Mr. Stewart commenced his course of Ethics, and with no other preparation but that which he was able to make in the morning, he delivered a course of extempore lectures, which displayed in a remarkable degree the vigour of his mind, and the extent of his general information. Before the close of the session, his health had obviously suffered from the bodily as well as the mental fatigues to which he had been exposed, and such was the degree of his exhaustion, that it was necessary to lift him into the carriage when he set off for London at the close of the session.

The reputation of Mr. Stewart had now become so great, that several of the English and Scottish nobility were desirous of placing their sons under his superintendance; and he accordingly, in 1780, agreed to receive some pupils into his house. Among these were the late Marquis of Lothian, the late Lord Belhaven, Basil Lord Daer, the late Lord Powerscourt, Alexander Muir Mackenzie, Esq. of Delvin, and the late Mr. Henry Glassford. He accompanied the Marquis of Lothian to Paris in 1783, and on his return from the Continent, in the autumn of the same year, he married Miss Bannatine, daughter of Neil Bannatine, Esq. a merchant in Glasgow, by whom he had a son, the present Lieutenant-Colonel Matthew Stewart, who inherits no small share of the talents and acuteness of his father.

In consequence of the failure of Dr. Ferguson's health in 1784, he resolved upon giving up the duties of a public lecturer, and an arrangement was made, by which Mr. Stewart should receive the moral philosophy class, while Dr. Ferguson should be conjoined in the professorship of mathematics with Professor Playfair, and thus retain the larger salary which was attached to that chair. In 1787, Mr. Stewart was left a widower, and in the following summer he accompanied the late Mr. Ramsay of Barnton on a visit to the Continent.

In the year 1790 he married Miss Cranstoun (the youngest daughter of the Honourable George Cranstoun), a lady of congenial sentiment and talent, who contributed greatly to the happiness of his future years. In the tranquillity of domestic life, so favourable to the pursuits of science, Mr. Stewart seems to have begun with earnestness to prepare for the press the first of that series of works by which he has been so highly distinguished. In 1792 he published the first volume of his *Elements of the Philosophy of the Human Mind*. In this work he has stripped the science of the Human Mind of much of that mystery and paradox in which it had been involved; and while he has treated its most important and difficult topics with all the depth and clearness of mathematical talent, he has, at the same time, enriched his speculations with the stores of his varied learning, and adorned them with all the elegancies of his classical taste. This volume contains a review of the intellectual powers of man. On many important points, Mr. Stewart's views necessarily coincided with those of his illustrious master; but while he treated the opinions of Dr. Reid with all the veneration of a disciple, he never scrupled to examine them with the freedom of an equal, and to advocate opposite opinions, or strike into a new train of thought, into which he had been led by a more profound or a more ingenious investigation. In this, as well as the other two volumes of his work, Mr. Stewart's great aim was to vindicate the principles of human knowledge against the attacks of modern sceptics, and to lay a solid foundation for a rational system of logic.

The first volume of Mr. Stewart's work did not excite that notice to which its own merit and the high reputation of its author unquestionably entitled it. The philosophy of the mind was then a subject of comparatively little interest, and though divested of its usual repulsive aspect, it was not considered, as it is now, a necessary branch of a polite education. The long interval of twenty-one years, which elapsed between the publication of the first and the second volume, and the publication of his volume of Philosophical Essays at an intermediate period, may afford us some reason for believing that Mr. Stewart had abandoned the prosecution of his plan.

The continuity of his studies was, indeed, interrupted by a series of biographical works, which almost necessarily devolved upon him. The first of these was *An Account of the Life and Writings of Dr. Adam Smith*, the celebrated author of the *Wealth of Nations*. This memoir, which occupies 82 quarto pages, was read before the *Royal Society of Edinburgh* on the 28th January and the 18th March 1793, and is published in the third volume of their Transactions. It forms one of the finest examples of biographical composition, and, independent of the value which it derives from its luminous exposition of the principles of Dr. Smith's philosophy, it is rendered interesting by the numerous anecdotes which it contains of the great men which had a short time before adorned the literary history of Scotland.

At the request, we believe, of Dr. Robertson himself, made a short time before his death, Mr. Stewart undertook to draw up an account of the life and writings of that illustrious historian. It was read before the Royal Society of Edinburgh in March 1796, and was afterwards published in a separate volume in 1801. To the memory of Dr. Reid, Mr. Stewart felt it his duty to pay the like homage, and he accordingly completed, in 1802, his account of the life and writings of that eminent metaphysician.

In the year 1796, Mr. Stewart was again induced to receive a few pupils into his house, and at this time the present Earl of Dudley, the Earl of Warwick, the late Lord Ashburton, the son of Mr. Dunning, Lord Palmerston, his brother the Honourable Mr. Temple, and Mr. Sullivan, the present Under Secretary of War, were placed under his care. The Marquis of Lansdown, though not under Mr. Stewart's superintendance, was at this time studying in Edinburgh, and was honoured with Mr. Stewart's particular regard. Their friendship continued unabated, and Mr. Stewart had the happiness of seeing the Marquis of Lansdown, Lord Dudley, and Lord Palmerston, members of the same cabinet. Mr. Brougham and Mr. Horner were at the same time two of the public pupils of Mr Stewart.

Mr. Stewart had been long desirous to deliver a course of lectures on Political Economy, but it was generally understood that he was deterred from carrying this design into effect by the peculiar character of the times in which he lived. In 1800, however, when the effervescence of political speculation had subsided, he gave a course of lectures on Political Economy, but we believe they were not repeated more than once in subsequent sessions.

In 1806, when an accidental circumstance led the English and the French governments into an amicable correspondence, the Earl of Lauderdale was sent to Paris to adjust the preliminaries of a general peace. This nobleman requested Mr. Stewart to accompany him as a friend, and they accordingly spent some time in the French metropolis. Here Mr. Stewart had an opportunity of seeing many of the eminent individuals with whom he had formed an acquaintance previous to the Revolution, and of being introduced to some of the great men who then adorned the science and literature of France.

While individuals of inferior talent, and of much inferior claims, had received the most substantial rewards for their services, it had long been felt that a philosopher like Mr. Stewart, who derived so small an income from his professional occupations, should have been so long overlooked by his country. It fell, therefore, to be the especial duty of the administration of Mr. Fox and Lord Grenville, to correct the oversight of their predecessors. They created for Mr. Stewart the office of Gazette Writer for Scotland, a situation which, as it could be performed by deputy, required no personal labour, and which added largely to his income. The creation, or rather the revival of this office, excited a considerable difference of sentiment. It was agreed on all hands, that the distinguished individual on whom it was conferred, merited the highest recompense; but it was felt by the independent men of all parties, that a liberal pension from the crown would have expressed in a more elegant manner the national gratitude; and would have placed Mr. Stewart's name more conspicuously in the list of those public servants, who are repaid in the evening of life for the devotion of their early days to the honour and interest of their country.

In the year 1808, Mr. Stewart sustained a severe domestic calamity in the loss of his second and youngest son, who was cut off by consumption in the 18th year of his age, while pursuing his academical studies. To divert his thoughts from this deep affliction, Mr. Stewart devoted himself to the composition of his *Philosophical Essays*, a work which appeared in 1810, went through three editions, and added greatly to his reputation. As the first part of this work is a commentary on some elementary and fundamental questions which divided the opinions of philosophers in the eighteenth century, Mr. Stewart regarded it as so far a continuation of his great plan, that he recommends his younger readers to peruse it after they have completed the first volume of his *Philosophy of the Human Mind*. About a year after the death of his son, Mr. Stewart resigned the Moral Philosophy Chair, and was re-appointed joint professor along with Dr. Thomas Brown. By this arrangement, which his appointment from Government allowed him to effect, he was enabled to retire from the duties of active life, and to pursue in retirement those philosophical inquiries, of which he had yet published but a small part. He therefore quitted Edinburgh, and removed with his family to Kinneil House, near Borrostownness, a seat of the Duke of Hamilton, and about twenty miles from Edinburgh.

Although it was on Mr. Stewart's recommendation that Dr. Brown was raised to the Chair of Moral Philosophy, yet the appointment did not prove to him a source of unmixed satisfaction. The fine poetical imagination of Dr. Brown, the quickness of his apprehension, and the acuteness and ingenuity of his argument, were qualities but little suited to that patient and continuous research which the phenomena of the mind so peculiarly demand. He accordingly composed his lectures with the same rapidity that he would have done a poem, and chiefly from the resources of his own highly gifted but excited mind. Difficulties which had appalled the stoutest intellects, yielded to his bold analysis, and, despising the patient formalities of a siege, he entered the temple of pneumatology by storm. When Mr. Stewart was apprised that his own favourite and best founded opinions were controverted from the very chair which he had scarcely quitted; that the doctrines of his revered friend and master (Dr. Reid) were assailed with severe and not very respectful animadversions; and that views even of a doubtful tendency were freely expounded by his ingenious colleague, his feelings were stongly roused; and though they were long suppressed by the peculiar circumstances of his situation, yet he has given them full expression in a very interesting note in the third volume of his Elements, which is alike remarkable for the severity and delicacy of its reproof. Upon the death of Dr. Brown, on the 2d of April 1820, Mr. Stewart resigned the Chair of Moral Philosophy, and was succeeded by Professor Wilson, a man of varied and powerful intellect, admired as a poet, and distinguished as an orator.

In October 1810, our eminent countryman, Mr. James Wardrop, communicated to Mr. Stewart an account of a very remarkable youth, James Mitchell, who was born both blind and deaf, and who consequently derived all his knowledge of external objects from the senses of touch, taste, and smell. Mr. Stewart was delighted with the prospect which this case afforded of establishing the distinction between the original and the acquired perceptions of sight. This expectation was not realized; but Mr. Stewart collected all the facts regarding the remarkable youth, and embodied them in a highly interesting memoir, which was read before the Royal Society of Edinburgh in the beginning of 1812. It is entitled "*Some account of a Boy born Blind and Deaf, collected from authentic sources of information, with a few remarks and comments;*" and was published in the seventh volume of the *Transactions of the Royal Society of Edinburgh.* In consequence of the interest which was excited by this communication, Mr. Stewart was anxious that Mitchell should be brought to Edinburgh, and educated under the superintendance of persons capable of studying the development of his mental powers. He accordingly submitted this idea to the council of the Royal Society, who entered eagerly into the plan, and resolved to apply to Government for a small pension to enable Miss Mitchell and her brother to reside near Edinburgh. Lord Webb Seymour, one of the Vice-Presidents of the Society, transmitted the wishes of the council to the Earl of Liverpool, then first Lord of the Treasury. The Prime Minister of Great

Britain not only refused to science and humanity the small pittance which was craved, but ventured to strengthen the ground of his refusal, by expressing a doubt whether the object which the Society had in view was likely to add to the comfort of the unfortunate object of their patronage. The writer of these lines was one of the five members of council to whom this answer was read, and he will never forget the impression which it made upon the meeting—the suppressed feeling of mortification and shame which was visible on every countenance. The guardian of the British treasury was entitled to refuse the application which had been made to him, but he had no right to question the humanity by which that application was dictated. The character of Mr. Dugald Stewart should have been a sufficient guarantee that the personal comfort and happiness of Mitchell would be the first objects of his solicitude.

In the year 1813, Mr. Stewart published the second volume of his *Elements of the Philosophy of the Human Mind.* This volume relates entirely to *Reason* or *the Understanding, properly so called*, and as the author himself observes, the subjects of which it treats are of necessity peculiarly dry and abstruse; but he regarded them as so important, that he laboured the whole of the materials which compose it with the greatest care and diligence. In the fourth chapter he treats more particularly of the method of inquiry pointed out in the *Novum Organum* of Bacon, and he has directed the attention of his readers chiefly to such questions as are connected with the theory of our intellectual faculties, and the primary sources of experimental knowledge in the laws of the human frame.

In the month of January 1822, Mr. Stewart experienced a stroke of palsy, which considerably impaired his powers of speech, and unfitted him in a great degree for the enjoyment of general society. Unable to take regular exercise, or to use his right hand, he was reduced to a state of great dependence on those round him. The faculties of his mind, however, were in no respect impaired by this severe attack, and with the assistance of his only daughter, who acted as his amanuensis, and who understood his imperfect articulation, he was enabled to prepare his works for publication with an ardour of mind and a freshness of intellect which formed a striking contrast with his bodily weakness.

Although the progress of his great work was interrupted by his Dissertation on the progress of Metaphysical and Ethical Philosophy, which he composed for the *Supplement to the Encyclopedia Britannica*, yet he was able to complete the third volume of his *Philosophy of the Human Mind* in 1827. This volume contains a continuation of the second part, viz. two chapters, one on *Language*, and the other on *the Principles or Law of Sympathetic Imitation;* and also the third part, which consists of two chapters, one *on the Varieties of Intellectual Character*, and the other *a Comparison between the Faculties of Man and those of the Lower Animals.* To this last chapter he has added as an appendix, his account of James Mitchell, with a supplement containing a recent account of the manners and habits of this interesting individual.

In 1827 and 1828, Mr. Stewart was occupied with the fourth volume of his *Philosophy of the Human Mind*, containing his Inquiries into the Active and Moral Powers of Man, and he was fortunately able to complete it a few weeks before his death, and thus to bring to a close that great work, on which he had spent the flower of his youth, and the maturity of his more advanced years.

Mr. Stewart's health had been for some time declining, but when he was on a visit to Edinburgh in the month of April 1828, he experienced a fresh paralytic attack which carried him off on the 11th of June, in the 75th year of his age. His remains, which were accompanied to the grave by the magistrates of the city, and the professors of the university, were interred in the family burying-ground in the Canongate church-yard, already honoured as the burial place of Adam Smith. Mr. Stewart's personal friends and admirers have contributed a large sum, with which a monument will be speedily erected to his memory on some conspicuous spot in our northern metropolis.

Mr. Stewart left behind him a widow and two children, a son and daughter, whom he loved with the tenderest affection. To Mrs. Stewart and his only daughter he owed that sunshine of happiness, which, but with one cloud, Providence shed over his domestic life. They had been the ornaments of his social circle when his public station required him to mix largely with the world; and when they were called to higher duties by the infirmities of his age, they discharged the obligations of conjugal and filial love with that self-devotion and sustained tenderness, which have their residence only in the female heart. His only son, Lieutenant-Colonel Matthew Stewart, already known by an able pamphlet on Indian affairs, and who, we believe, is now occupied in a larger work on the same subject, was fortunately in Scotland at the time of Mr. Stewart's death, and was able to pay the last duties of affection to his venerable parent.

Mr. Stewart was about the middle size, and was particularly distinguished by an expression of benevolence and intelligence, which Sir Henry Raeburn has well preserved in his portrait of him, painted for the late Lord Woodhouselee before he had reached his 55th year.* Mr. Stewart had the remarkable peculiarity of vision which made him insensible to the less refrangible colours of the spectrum.† This affection of the eye was long unknown both to himself and his friends, and was discovered from the accidental circumstance of one of his family directing his attention to the beauty of the fruit of the Siberian crab, when he found himself unable to distinguish the scarlet fruit from the green leaves of the tree.

Mr. Stewart's name honoured the lists of various learned academies. He was one of the members of the Philosophical Society of Edinburgh at its incorporation with the Royal Society in 1783. He was a fellow of the Royal Society of London, an honorary member of the Imperial Academy of Sciences at St. Petersburgh, a member of the Royal Academies of Berlin and Naples, of the American Philosophical

* At a much later period Sir Henry painted another portrait of Mr. Stewart, and Mr. Wilkie still more recently executed a striking likeness of him in black lead. Mr. Joseph has also completed a bust of Mr. Stewart with his usual talent.

† See *The Edinburgh Journal of Science*, No. xix. p. 153.

Societies of Philadelphia and Boston, and honorary member of the Philosophical Society of Cambridge.

Besides the works which we have mentioned in the course of this notice, Mr. Stewart published his *Outlines of Moral Philosophy*, which appeared in 1793, and which he used as a text-book. This work has been recently translated into French; and it has been used as a text-book in several Colleges in America. He was also the author of two eloquent pamphlets on a local controversy now sunk into oblivion. He had laid down the resolution of never publishing any thing anonymously; and we believe he never deviated from so excellent a rule. See Dr. Brewster's *Journal of Science*, No. xx. p. 194, for a fuller account of the philosophy and private character of Mr. Stewart.

STEWART, county of Tennessee, bounded by Montgomery county, Tennessee, NE; Dickson SE; Humphries S; Tennessee river separating it from Henry county, Tennessee, W; and Callaway county, Kentucky, NW; and by Trigg county, Kentucky, N. Length diagonally from SE. to NW. 40; mean breadth 20; and area 800 square miles. Extending in lat. from 36° 14′ to 36° 37′ N.; and in long. from 10° 43′ to 11° 12′ W. from W. C. This county is bounded SW. and W. by Tennessee river, and traversed by Cumberland river, both streams flowing to the northwestward, at a distance apart of from 23 to 8 miles, inclining towards each other as they leave Tennessee and enter Kentucky. The surface moderately hilly, and soil productive. Dover, on the left bank of Cumberland river, is the county town. It is situated about 75 miles by the landroad NW. by W. from Nashville, at N. lat. 36° 28′, and long. 10° 49′ W. from W. C. Beside Dover there are post-offices in this county at Brunsoris, Dover Furnace, Green Tree Grove, Hamlet's and Trougdale. In 1820 Stewart contained a population of 8388.

STEWARTSTOWN, township and post village, Coos county, New Hampshire, situated on Connecticut river, opposite the mouth of Hall's river, by post-road 164 miles N. from Concord. N. lat. 44° 56′, long. 5° 31′ E. from W. C.

STEWARTSVILLE, post-village in the western part of Westmoreland county, Pennsylvania, on the main road from Greensburg to Pittsburg; 13 miles NW. by W. from the former, and 19 SE. from the latter, and by post-road 204 miles NW. by W. from W. C.

STIRIA. See STYRIA.

STIRLING, an ancient town of Scotland, and capital of the county of Stirling, is situated in a plain watered by the Forth, and on the sloping ridge of a rock, on the western and precipitous extremity of which stands Stirling castle. The town is irregular, the street on the crest of the hill is broad, but the other streets are narrow; several new streets containing elegant modern buildings have been erected on the north side of the town. At the south side of the town, several elegant villas extend along each side of the road, and a little farther south is Wellington Place, where several handsome houses have been built.

The principal public buildings are two churches, three hospitals, the town house, the jail, the school house, a public library and reading room, a military hospital and the castle. The east church, erected in 1494, is a fine building, which received some additions from Cardinal Beaton; the west church, said to have been built also in 1494, and to have constituted one building with the east church, is in the rude Gothic style, and has been lately repaired after a plan by Mr. Gillespie; it is now internally one of the most commodious and handsome churches in Scotland. The oldest of the three hospitals, built in 1530, for the support of poor tradesmen, was endowed by Robert Spittal, tailor to James IV.; the second, for twelve decayed guild brethren, was founded in 1639 by John Cowan. It is furnished with a steeple and bell and apartments for the guildry. Its annual revenue is about £3000. The third, for maintaining and educating the children of decayed tradesmen, has a revenue of nearly £500, and was founded by John Allan. The town house is a spacious building, with convenient apartments for the town courts. The jail, which has been recently built on an approved plan, contains an elegant hall for the sheriff and circuit courts. The grammar school, the academy for arithmetic and mathematics, and the English school, are commodious and good buildings. The public library and reading room is a new and elegant building, having a spire 120 feet high. The library contains several thousand volumes. The military hospital occupies Argyll's Lodging, built in 1633, and in which John Duke of Argyll lived in 1715.

The castle is situated at the precipitous extremity of the ridge on which the town stands. It is of very ancient date, and still exhibits marks of royal magnificence. James II. was born here, and the room called Douglas's room is still shown where that cruel monarch stabbed with his own hand his kinsman William Earl of Douglas. A skeleton supposed to be that of the earl was some years ago found in the cleft of the rock directly beneath the window of this room. The hall for the meetings of parliament, built by James III. is now used as a barrack. The chapel royal, built by James VII. for the baptism of Prince Henry, adjoins to the barracks, and is now a storeroom and armoury. The palace is a large building of a square form, enclosing a quadrangular court. A number of grotesque figures on pedestals adorn its exterior. It now forms barrack-wards to the garrison, a house to the governor, and apartments for the inferior officers. The apartments occupied by George Buchanan while tutor to James VI. are still shown. In one of the apartments of this quadrangle, called the king's room, the roof was covered with rich carvings in oak, which have been engraved and described in a work published in 1817, called *Lacunar Strevelinense.* Queen Anne's battery, with bombproof barracks, was erected at the beginning of the last century on the south side of the castle; the rampart is mounted with about 36 guns. On the south side of the castle is a piece of flat enclosed ground which was devoted to tournaments; and a rock whence the ladies observed them is called the Ladies' Rock. No fewer than *twelve* fields of battle are seen from the castle, the prospect from which is universally admired. Towards the east, Edinburgh and the windings of the Forth form one of the most interesting portions of it. The castle rock is basaltic. Around it is an agreeable walk, in many places cut from the solid rock.

Stirling enjoys a considerable inland trade, besides a small trade with the Baltic; vessels of about 70 tons can come up to the quay. Cotton and woollen goods, but particularly carpets, are among its chief manufactures; it has two banks and two weekly papers; it is governed by a provost, four bailies, a dean of guild, treasurer, and fourteen other counsellors; it sends a member to parliament along with Dunfermline, Inverkeithing, Queensferry and Culross. The revenue of the town from the salmon fishing amounts to £2250 per annum. The population of the burgh and parish in 1821 was

Inhabited houses - - - - -	78
Families - - - - - -	1688
Do. employed in agriculture -	18
Do. in trade - - - - - -	1138
Males - - - - - - -	3275
Females - - - - - -	3830
Total Population - - - - -	7113

See the *Beauties of Scotland*, Vol. III. and Chalmers' *Caledonia*, Vol. I.

STIRLINGSHIRE, a central county of Scotland, bounded on the north by Perthshire and Clackmannanshire; on the east by the Firth of Forth and Linlithgowshire; on the south by Lanarkshire; and on the south-west and west by Dumbartonshire; is about 36 miles in length, and from 12 to 17 in breadth; and contains an extent of about 645 square miles, or 412,800 English acres. The ecclesiastical divisions are, twenty-one parishes, besides portions of other four, parts of which are in the adjacent counties. This county contains one royal borough, viz. Stirling, which is the county town, and two large towns Falkirk and St. Ninians, besides several large and flourishing villages.

The appearance of many parts of Stirlingshire is mountainous to a considerable degree, particularly in the vicinity of Loch Lomond on the north, and in the parishes of Denny, Kilsyth, Kilpatrick, Campsie, and Baldernock on the south. Some parts of the central district are also very hilly. The principal ranges of hills are those of Lennox, Campsie, and Kilpatrick in the southern district. The Lennox hills extend from Dumbartonshire to the vicinity of the town of Stirling, and seldom exceed an elevation of 1500 feet above the level of the sea. The height of the Campsie hills is about 1500, and that of the Kilsyth hills 1368. From the highest of the last mentioned range of hills, there is one of the finest views in Scotland, which has been computed to embrace an extent of more than 12,000 square miles. The highest mountain in the county is Benlomond, in the north, which is 3262 feet high; the next highest is Bencloch in the parish of Alva, which attains the height of 2400 feet. Many of these hills, especially in the southern district, partake more of the lowland than the highland appearance, as their summits, and many parts of their sides, are covered with green sward, which affords excellent pasturage for sheep.

On the north, and especially on the east of the Lennox hills, the elevation of the country above the level of the sea is so low as 162 feet. This district is very rich and fertile, producing excellent crops of grain. The western and southern parts of the county, which are very hilly, for the most part consist of moss, and tracts of heath, and green pastures, interspersed with arable land, which is chiefly confined to the banks of the rivers.

Almost every variety of soil to be met with in Scotland occurs in Stirlingshire; but the most common is the alluvial or coarse land, which occupies an extent of about 40,000 acres on the banks of the Forth, which is the most fertile part of the county. In this soil there are beds of shells, clay, marle and moss. Small patches of rich loam occur in many parts of the county. The soil on the banks of the rivers, in the western and central districts, is chiefly of a light and gravelly description.

Stirlingshire is inferior to few districts of Scotland, in the quantity and variety of its mineral productions; the most abundant of which are coal, ironstone, limestone, and sandstone. The principal coal pits are situated in the southern base of the Lennox hills, and extend from Baldernock on the west, to Denny and St. Ninians on the east. Coal is also found in the eastern district, in the vicinity of the Forth and Clyde Canal. Stirlingshire yields this mineral in such abundance, as not only to be sufficient for home consumption, but, by means of the Union Canal, to supply the inhabitants of the metropolis at a much cheaper rate than they were formerly accustomed to pay. The ironstone, limestone, and sandstone is found in the same district with the coal, one stratum of limestone being often found above, and another below a stratum of coal. Veins of silver were discovered, and wrought about sixty years ago, but the working of them was soon discontinued. Copper, lead, and cobalt, have also been raised at different periods, but not in any considerable quantities.

The Forth is the principal river in Stirlingshire, and though not the largest, has always held the first rank among the rivers of Scotland. It has its origin in a spring near the summit of Benlomond, and after running eight or ten miles under the name of the water of Duchray, and flowing through part of Perthshire, where it is called Avendow, or the Black River, it again enters Stirlingshire, under the denomination of the Forth, and after receiving the Teith, Bannockburn, Ardoch, and Allan, it enters the Carse of Stirling, about six miles to the west of that town; a few miles further on it becomes navigable for vessels of 70 tons. Below Stirling the sinuosity of this river is very remarkable; the distance from the above town to Alloa, which is only seven miles in a direct line, is more than twenty by the course of the river, owing to its numerous windings, which are called the Links of the Forth. A little below Alloa it is joined by the Devon from the north-east, and shortly after expands into that noble estuary called the Frith of Forth, and leaves Stirlingshire a little to the south of Grangemouth. The Carron, which is the next river in size to the Forth, rises in the central district, and after flowing on in an easterly direction, joins the Forth at Grangemouth. This river is navigable for vessels of

200 tons, for about two miles from where it joins the Forth. The smaller rivers are the Bannockburn, celebrated for having been the scene of the battle between the English and the Scotch armies, in which the latter, under Bruce, completely routed the English, and established the independence of Scotland (See BANNOCKBURN), the Avon, the Enrick, the Blane, and the Kelvin, none of which are worthy of particular notice.

The manufactures of Stirlingshire are various. At Stirling there are manufactories of carpets, coarse cloths, and cottons. There are several large establishments for cotton, paper, copperas, alum, Prussian blue, soda, &c. near Campsie. There are many large distilleries in different parts of the county, in which an immense quantity of spirits is made. But the principal manufactory in the shire is one for iron-ware of every description, on the banks of the Carron, which is celebrated over all Europe, and which we have already fully described under our article CARRON WORKS.

The agriculture of Stirlingshire is subject to considerable variation, owing to the great variety of soil and situation. The carse lands which are arable are portioned out into small farms, of from 15 to 100 acres, which sometimes afford a rent of £4 an acre. But the hill farms sometimes extend to near 1000 acres. Large crops of wheat, barley, beans, pease, turnips, potatoes, &c. are raised: the use of artificial grasses has also been very generally adopted in this county. The extensive ranges of moorland, in the upland districts, are exclusively devoted to the feeding of numerous flocks of sheep. There are few cattle reared in Stirlingshire, as the county is very generally supplied by the Highland drovers. The sheep are of the blackfaced or Highland breed.

Stirlingshire, which had in 1828, 129 freeholders, sends one representative to parliament; and the town of Stirling, in conjunction with Culross, Dunfermline, Inverkeithing and Queensferry, elects another.

In this county there are several highly interesting relics of antiquity. There are still some remains of the Roman Wall, called the Wall of Antoninus, which intersected the county. At the scene of the battle of Bannockburn a stone is exhibited, in which the royal standard was pitched. In the eastern part of the county several other battles were fought between the English and Scots.

The population of Stirlingshire was 65,376 in 1821; of which 31,718 were males, and 33,658 females. The number of families employed in agriculture were 2600; and those employed in trade and manufactures, 6641; and of those in neither of the above classes, 4492. See our articles ANTONINUS'S WALL, BANNOCKBURN, CARRON WORKS, FORTH, and SCOTLAND.

STOCKBRIDGE, post village in the western part of Berkshire county, Massachusetts, situated on the Housatonick river, 12 miles S. of Pittsfield, and by post road, 127 miles W. from Boston.] DARBY.

STOCKHOLM, the metropolis of Sweden, is situated on the northern and southern shore of the lake Maelar, and embraces likewise a number of islands lying between them. The greatest part of the town stands on the continent, the part which occupies the southern shore being called Sodermalm, and that on the northern Nordermalm, these being called the suburbs of Stockholm. The city, properly so called, occupies the largest island. It is the busiest part of the town, being in reality a sea-port, having handsome quays, bordered by stately ranges of buildings, where the principal merchants reside. The houses are, however high, the streets narrow, and the general aspect of it gloomy; but it contains what was called the new palace, the great church, or that of St. Nicholas, the bank, the corn-market, the spacious custom-house, and a great number of other elegant buildings. The palace occupies a great part of this island, and towering above all the other buildings of the city, it is visible on all sides, and commands a view of every part of Stockholm. The city is connected by means of a fine granite bridge with the Nordermalm or Norr-malm. This bridge leads at once into the great square, the stately magnificence of which, according to Dr. Clarke, is very imposing, and affords a concentration of almost every thing worth seeing in Stockholm. One entire side of it is adorned with the royal palace, another is occupied with the opera-house, containing the inscription *Musis Suecicis Gustavus* III. and in which that monarch was assassinated. Opposite to the opera-house is the palace of the princess royal, and in the centre of this area, opposite to the granite bridge, is a gigantic equestrian statue of Gustavus Adolphus in armour, facing the royal residence, and having an air of great grandeur. It is of gilt bronze, and stands on a pedestal of finely polished porphyry. The principal street here is Queen's Street, stretching in a straight line for more than a mile from the observatory to the side of the lake. The streets are here at right angles to each other, but several of them are narrow. From the great square a street conducts to a quay, near which stands the Stepholm church. Between the square, the quay, and that of the city, is the port of Stockholm, where all the vessels lie.

The Nordermalm contains likewise the ancient arsenal, now a theatre, the royal gardens, the surveyor's office, the great orphan-house, the free-mason's orphan house, the workhouse on the Sabbath Mountain, the church of St. Clare, the steeple of which commands a fine view, and which has a fine altar-piece, the churches of St. James and Adolphus Frederic, the observatory, the exhibition of models, the institution for widows, the lying-in hospital, and Drotning-house.

The city is connected by a bridge with the Ritterholm towards the west. The Ritterholm contains a spacious square, near which is the church of Ribterholm, a good looking building, and the burial place of the royal family. Here also stands the senate house, and the town house, the last of which contains two halls, one for the citizens, and the other for the peasants at the diets. The old palace, with the regalia, and the chamber of models, and the academy of arts, are also situated in this island. Between the city, the Nordermalm and the Ritterholm is the island of the Holy Ghost, which contains the king's stables, an extensive and splendid building. In the city and the Ritterholm, are the great Swedish school, a synagogue, a German, a

Finlandish, and a French church;—the academy of sciences, with its library and other collections, the mint, and the college of mines, with its fine cabinet of natural history.

The other islands are Admiralty-holm, consisting of naked romantic rocks, and containing the naval arsenal;—Castleholm, containing little more than a small palace on a naked rock;—Beckholm, Langholm, and Rackningsholm, all three of little importance; and Congsholm, part of which is built upon, and the rest occupied with gardens and desert rocks, and containing a church, the glass house, and the royal hospital;—Ladugards-land, containing the Hummel Garden; also Frederickshof, with the arsenal, and a collection of artificial curiosities, the artillery house, the laboratory and the docks; Little Hessinger and Beckholm.

The last portion of Stockholm is Sodermalm, situated to the south of the city. It contains a number of good stone buildings, which gradually fall off into a village bounded with gardens, and an uncultivated country. In the Sodermalm is situated the town house (an object worth visiting), the courts, the senate house, the Greek and Roman Catholic chapels, the churches of St. Mary and St. Catharine, with the schools and work-houses, the hospital, the mad-house, and the house of correction.

The number of bridges in Stockholm amounts to twelve. The houses are founded generally on piles. In the city they are built of stone, and are four or five stories high, but a great portion of the city is composed of mean buildings, constructed of wood, and even of miserable huts, inhabited by the most indigent persons. From this cause, Stockholm is, according to Kuttner, like no other city. After leaving the principal parts of the town, " you arrive," says Kuttner, " at immense naked rocks of granite, between which you meet with gardens, windmills, tobacco plantations, and wretched huts, all of which belong to the town, and are situated within the enclosure by which it is surrounded. In those parts of the town I have met with situations in which I imagined myself among the Alps, where I saw nothing but a few miserable huts scattered among the wildest and most romantic rocks, which conceal the other part of the city so completely, that you imagine yourself in an uninhabited country. If, however, you ascend to the summit of one of these rocks, you enjoy the most romantic, and at the same time the most magnificent views of a splendid metropolis; in a word, you survey with one look, palaces, churches, islands, lakes, harbours crowded with vessels, intermingled with naked rocks. This it is that renders Stockholm perhaps *unique* in its way. I never beheld from one point of view, any thing so beautiful, so magnificent, and so sublime, nor yet any thing so mean, so rude, and so wild, within the circumference of a metropolis."

The principal public building in Stockholm is the royal palace, a large quadrangular structure, with a court in the middle. It is said to be surpassed only by that of Versailles. The lower part of the wall is of polished granite. The upper part is of brick, covered with stucco, and the roof is of copper. It contains, besides the royal apartments, a neat chapel, the hall of the states, a gallery of paintings, the museum, and the King's library. The museum is a collection of antiques, made by Gustavus III. Among the statues is the celebrated Endymion, found in the villa Adriana; it is a figure somewhat larger than life, lying asleep, and quite naked. The royal library comprehended in 1821 above 40,000 volumes, and, among other curiosities, contains the copy of the (Vulgate) Bible, used by Luther, with manuscript notes in his own hand: and also the Latin Prayer Book of the emperor Ferdinand, which in the 30 years' war fell into the hands of Gustavus II.

In Lofin, otherwise called Drotningholm, or the Queen's island, stands the most magnificent palace belonging to the kings of Sweden, exhibiting the elegance, the taste, the luxury, and the magnificence of Versailles. The cabinet of natural history, adjoining the king's private library, is remarkable as having been arranged and described by Linnæus. Among the objects of interest in the capital, is the Fredericshof, or collection of artificial curiosities and armour, otherwise called the arsenal. The clothes and arms of Charles XII. and those of Gustavus III. are carefully preserved in this collection, which contains an immense number of standards and trophies taken chiefly from the Imperialists, Poles, Russians and Danes. Here also is the stuffed skin of the horse which carried Gustavus Adolphus at the battle of Lutzen, and the boat made by Peter the Great, at Sardam in Holland, which was taken by a Swedish vessel as it was conveying by sea to St. Petersburg.

The principal societies and institutions in this Metropolis are, 1st, The Academy of sciences, founded in 1739, divided into nine classes, and comprehending 100 native and 260 foreign members. 2d, The Swedish academy, founded in 1716, consisting of 18 members, whose object is,* the improvement of the Swedish language, poetry, and eloquence. 3d, The academy of painters and statuaries, founded in 1735. 4th, A military academy, established in 1796. 5th, An academy for painting and sculpture. 6th, An academy of music, established in 1761. 8th, A statistical agricultural society, established in 1772. 9th, A medical college. 10th, A saving bank, in which 5000 workmen have deposited money.

The harbour of Stockholm is particularly commodious. It can accommodate with safety a thousand sail of shipping, and the largest can come close to the quay. The entrance, however, to the harbour, is rendered dangerous by the numerous rocks and small islands with which it is beset; the distance of the harbour from the Baltic is more than twenty miles, and in one place the passage is contracted and bounded by high rocks. There is here a regular institution called the company of divers, which is bound to have persons ready to assist at all shipwrecks on the Swedish coast; they are entitled to a proportion of the goods saved as salvage. The number of vessels that enter the harbour annually is from

* It is a curious fact that this society awarded the gold medal to Gustavus III. for the best biographical Essay on Leonard Forstensohn, without knowing who was the author.

900 to 1100, and the trade of Stockholm is equal to two-thirds of that of the whole kingdom. In 1816 Stockholm shipped

	Shippounds.
Iron, - - - - - -	257,950
Copper, - - - - - -	3,350
Lead, - - - - - -	600
Brimstone, Alum, and Vitriol,	4,520

The chief exports are the above articles, also pitch, tar and timber. The annual export of iron is about 400,000 shippounds. The imports are salt and colonial produce, wine, French and British manufactures. The vessels employed in this trade are chiefly Swedish. The inland trade of Stockholm is considerable, and is greatly facilitated by the lake Maelar, which stretches sixty miles into the interior, and by means of the lake Hielmar, which is crossed by an old stone bridge, and the canals of Arboga, it extends from Stroemsholm over the four provinces, and reaches the boundaries of Dalecarlia.

The manufactures of Stockholm are leather, silk, cotton, hats, stockings, earthenware, watches, clocks, and articles of gold and silver. There are here also iron-founderies, glass-works, sugar-refineries. The population of Stockholm has been reckoned as high as 92,000, but very recent accounts make it only 78,000.* The number of Journals published in Stockholm is estimated at thirty. E. Long. of the observatory. 18° 30′ 30″. North Lat. 59° 20′ 31″. For farther information respecting this capital, See Cox's *Travels in Poland, Russia, Sweden*, &c., vol. iv. p. 33; Kuttner's *Travels through Denmark and Sweden*, &c. in 1798 and 1799; Catteau's *Voyage en Allemagne et en Suede*, tom. ii. p. 267, Paris 1810. Dr. Clarke's *Travels*, vol. v. p. 152. Rordanz's *European Commerce*, p. 211. Schubert's *Travels in Sweden*, &c. in 1817, 1818 and 1820, in German.

STOCKING MANUFACTURE, See Chainwork, Vol. V. p. 597. chap. ii. where this subject is fully treated. See chapter on the *Manufacture of Hosiery*. See also England, Vol. VIII. p. 584.

STOCKPORT, a large market and borough town of England in Cheshire. It is situated on the river Mersy, principally on the top and sides of a hill, and the streets are very irregular and steep. The principal public buildings, &c. are the parish church of St. Mary, a large but decayed structure; a Calvinist chapel; a Roman Catholic chapel; various meeting-houses for Presbyterians, Methodists and Quakers; a free school, founded in 1487; a large Dispensary built in 1797: a subscription school erected in 1805; and several Sunday schools, one of which, conducted by the Methodists, educates 3000 children gratuitously.

The cotton trade and the manufacture of silk form the principal employment of the population of this place. In 1810 there were twenty-five large factories for cotton goods, one silk mill, and several establishments for muslin; one of these factories is on a very extended scale, and is driven by the Mersy, which is brought to it by a subterraneous tunnel. Many of the London haberdashers have establishments here. By the canal lately made to Manchester, the trade of the town has been greatly facilitated. Stockport has two annual fairs. It is a place of great antiquity, the Romans having had a camp here, and the Saxons a fortress. The following was the population of the township in 1821.

Inhabited houses, - - -	3605
Number of Families, - -	4542
Families employed in Agriculture,	24
Do in Trade, -	4256
Males, - - - - -	10,495
Females, - - - - -	11,231
Total Population in 1821, -	21,726

STOCKTON upon Tees, a market and borough town of England in the county of Durham, is situated on the north bank of the Tees, which is crossed by a handsome bridge of five elliptical arches, that cost 8000*l.*, and was built between 1764 and 1771. The centre arch is 72 feet span and 23 high. It is neat and clean, and is reckoned the most handsome town in the north of England, both for the breadth of its principal street, and the general elegance of its buildings. This street, which is formed by the road to Durham and Sunderland, is about half a mile long, and sixty yards broad, with the market place in its centre, continuing nearly as broad to both ends. Several smaller streets branch off in different directions, and there is a spacious square at the north-east side of the town, which contains some good houses, and has been recently enclosed and planted by subscription. The houses are in general built of brick and covered with tiles, and the streets are well paved, flagged, and lighted. One of the principal public buildings is the church. It is a handsome brick building, with the doors and windows faced with stone; its length is 150 feet, and the tower eighty feet high. There is a theological subscription library kept in the vestry. There are also meeting-houses for Presbyterians, Roman Catholics, Quakers and Methodists. The town-hall, which stands in the middle of the principal street, is a large square structure, with a lofty cupola and spire. It is partly used for a tavern, and comprehends an elegant suite of assembly rooms, a court room, a coffee room, and other public apartments, with warehouses, shops, and a piazza underneath. In its vicinity in the market place is a handsome Doric column, thirty-three feet high. The custom-house is a commodious building. Stockton has a neat theatre and several libraries. The charitable institutions are a charity school for twenty boys and twenty girls, to which has been added a national school with about 350 children, a school of industry for girls, two Sunday schools, a dispensary, and almshouses for thirteen poor families. The almshouses occupy an elegant Gothic building, in which is a committee-room, where the affairs of the poor, and those of a savings bank are transacted.

Stockton, from its convenient situation, enjoys a

* See *Rev. Encyclopedique*, Mars. 1828, p. 598.

great trade, which has been much facilitated by a navigable cut made in 1810 for shortening the navigation of the river. The export trade consists of lead, hams, butter, pork, cheese, leather, grain, flour, sail-cloths, huckabucks, tammies, and plain linen. The imports, which are chiefly from the Baltic, Hamburg, Norway, and Holland, consist of hemp, flax, iron, timber, linen, yarn, sheetings, hides, bark, seeds, Geneva, &c. In 1795 the number of vessels belonging to the port was 47, carrying 5733 tons.

The principal manufactures of Stockton, are two of sail-cloth, two breweries, two rope-walks, two ship-yards, two iron founderies, a soap house, also manufactories for damask, diaper, and huckaback, towelling and check linens. There is also here a large dry dock.

The town is divided into two parts, one called the borough, and the other the town. The civil government is vested in a mayor, alderman, and recorder, besides inferior officers. Stockton had once a castle, but the moat is the only remaining vestige of it.

The population of the township in 1821 was

Inhabited houses, - -	893
Number of Families, - -	1113
Ditto employed in Agriculture, -	60
Ditto - in Trades, - -	454
Total Population, - -	5006

STODDARTSVILLE, post village, on a branch of Lehigh river, and in the southeastern part of Luzerne county, Pennsylvania, 18 miles SE. by E. from Wilkes-barre, 40 miles NW. from Easton, and by post road 239 miles NNW. from Washington city.

STOKES, county of North Carolina, bounded by Rockingham NE.; Guilford SE.; Davidson S.; by Yadkin river, which separates it from Rowan, SW.; and Surry W.; by the northern part of Surry NW.; and by Patrick county, Virginia, N. Length from south to north 38; mean breadth 24, and area 912 square miles. Extending in lat. 36° 02′ to 36° 30′, and in long. from 3° 32′ W. from Washington city. This county is a table land, from which flow Dan river from the northern part; different branches of Haw river from the southeastern; and some confluents of the Yadkin from the southern and southwestern. The soil is excellent. Germantown, the county seat, is situated near the centre of the county, at N. lat. 36° 20′, long. 3° 18′ W. from Washington City, by post road, 355 miles SW. from Washington City, and 127 NW. by W. from Raleigh. Population of the county in 1820 was 14,033.

Besides Germantown, there are post offices at Belew's Creek, Bethenia, Blakely, Boyle's store, Chesnut Ridge, Dobson's Cross Roads, Frost's iron-works, LittleYadkin, Red Shoals, Salem, Waughtown, and Webb's. Darby.

STONE, a town of England, in the county of Stafford, is situated on the northern bank of the Trent. It consists chiefly of one long street, with a new market-place, and several very excellent houses. The church is a neat building. There is a free school, and an endowed almshouse, a considerable manufactory of shoes, and one of patent roller pumps. In 1821, the population of Stone was, houses, 532; families, 555; ditto in trade, 269. Total population, 2855.

[STONE RIVER of Tennessee, interlocking sources with Duck river and with Stoney Fork river, and flowing northwestward, falls into Cumberland river, 6 miles above Nashville. The valley of Stone river and Rutherford county are nearly commensurate. The county from its outline has been evidently laid out with reference to the surface drained by this stream.] Darby.

STONEHAVEN, or Stonehive, a sea-port town of Scotland, in the county of Kincardine, is situated on the east coast at the junction of the waters of Cowie and Carron. The old town lies on the south bank of the Carron, and the other is a peninsula formed by the Coure and Carron. The old town has two considerable streets, and the new town, feued by Mr. Barclay of Urie, has a square in the centre, with broad streets on a regular plan. The harbour is formed by an inland basin defended on the SE. by a high rock, which extends into the sea, and on the N.E. by a commodious quay. As the mouth of the harbour is beset with submerged rocks, it is not very safe, though capable of great improvement. The brown linen manufacture has been for some time established here, and the trade of the place is considerable. The Sheriff Court of Kincardineshire is held here. The public revenue is £.45. The population is about 2000.

STONEHENGE. See Wiltshire.

STONINGTON, post town, borough and sea port, in the southeastern part of New London county, Connecticut, 10 or 11 miles a little S. of E. from New London, and 55 SE. by E. from Hartford. N. lat. 41° 19′, long. 5° 07′ E. from Washington City. Stonington was incorporated as a borough in 1801, and in 1820, contained, independent of the residue of the township, 800 inhabitants, one cotton factory, two woollen factories, an academy, and two or three places of public worship.

STORNOWAY. See Lewis, Vol. XII, p. 17.

STOURBRIDGE, a market town of England, in the county of Worcestershire. It is situated on the river Stour, over which there is a good stone bridge. It consists of several irregular streets on the road to Kidderminster, the chief of which contains many good houses. The church is a plain building. There are also chapels for presbyterians, quakers, and methodists. A theatre was built in 1790. The free grammar school founded by Edward IV. is well endowed, and managed by eight governors. The town is governed by a bailiff, a town clerk, and other officers.

Stourbridge has been long celebrated for its manufactures. The chief one is that of glass, which is carried on in *ten* glass houses, where broad glass, flint glass, and a kind of transparent red glass are made. Owing to the number of iron works in the vicinity, nails, agricultural implements, and other articles of ironmongery are manufactured in the town. Here are also manufactories of crucibles, stovepots, bricks, and tiles. Broad and narrow cloths are likewise manufactured here, and leather from sheep skins. Coal, iron ore, and clay, are found in the neighbourhood. The clay, which is unrivalled, is found at the depth of 150 feet, beneath three different strata of coal. It occupies 200 acres, 48 of which contain clay of a very superior quality, and not less than 1000 tons of it are annually taken up. The Stourbridge canal unites that town with the great lines of inland navigation. The population in 1821 was

Number of houses, -	979
Number of Families, -	1081
Number in trade, -	1034
Total population in 1821, -	5090

STOURPORT, a market town of England, in Worcestershire which has sprung up since 1771 in a barren heath. The town is handsome, and even elegant, and the houses in it are commodious. The streets are full of shops and thronged with people. The principal objects here are a handsome chapel of ease, and the iron bridge over the Severn. It consists of one arch of 150 feet span, and 50 feet above the water. The avenues to this main arch consist on both sides of a long range of smaller ones of brick, extending on the whole between 600 and 700 feet. The toll has been farmed at £ 500 per annum. Population 3000.

STOW MARKET, a town of England, in the county of Suffolk. It is situated on the river Gipping, and is a flourishing place, with several excellent houses. The church is a handsome building, with a wooden spire 120 feet high. The house of industry for the hundred, which is an elegant building, stands about a mile from the town. There is here a manufacture of ropes and sacking. From fifteen to twenty houses are engaged in the malting trade. The population of the town in 1821 was 2250. See INLAND NAVIGATION, Vol. XIV. p. 281, for a notice of the canal to Stow Market.

STRAFFORD, county of New Hampshire, bounded, by Rockingham, S.; Merrimack SW.; Grafton W. and NW; White Mountains separating it from Coos N.; Oxford county, Maine, NE.; and York county, Maine, E. and SE. Length from Great Bay to the White Mountains 70 miles; mean width 21, and area, 1470 square miles. Extending in lat. from 43° 04′ to 44° 03′, and in long. from 5° 13′ to 6° 06′ E. from Washington City. The northern part, along and near the base of White Mountains, gives source to Saco river, which flows eastward into Oxford, Maine; southward of Saco rises Great Ossipea river, also a branch of Saco, and flowing eastward into Maine, separates Oxford and York counties. The northwestern and western border is drained into Merrimac river. The central section is occupied by Winepisseogee lake and its confluents. This curious and irregular sheet of water is about 22 miles long, with a breadth varying from one to eight miles. It is discharged into Merrimac river by Winepisseogee river. The southeastern angle toward Great Bay is drained by some creeks of Piscataqua.

The general declivity of this county is southward. The surface hilly, and rocky, and in part mountainous. Soil productive in grain and pasturage. The courts are held alternately at Dover and Guilford. Dover is situated on Concheco river, by post road 40 miles E. from Concord, the seat of government of the state. Guilford is on the left bank of the Winepisseogee river, 30 miles a little E. of N. from Concord. Besides the two county towns there are 50 other places, each having a post office. This large county in 1820, contained 54,617, or something above 34 to the square mile. DARBY.

STRALSUND, is a sea-port town of Germany, and the capital of a government of the same name belonging to Prussia. It is situated in the strait which separates the island of Rugen from the main land. From the sea it has a good appearance, but upon a nearer approach its aspect is gloomy, from the narrowness of the streets, and the lowness of the brick houses, which are pointed at the top. It contains four Protestant and one Catholic church, two of which, the cathedral and the church of St. Mary, are handsome. In the former the baptismal fonts, the altar, and the lamps, are worthy of notice; and in the latter the paintings and the organ. The principal public buildings are the government house, the governor's house, the town-house, the arsenal, and the mint. The town-house is a singularly beautiful Gothic building, in a very peculiar and remarkable style. There are here an academy, a public library, an orphan house, a poor house, and a lunatic hospital.

The harbour of Stralsund is safe and capacious. Kuttner remarks that he saw more vessels in it than in any of the ports of Sweden or Denmark, excepting Stockholm, Copenhagen, and Gottenburg. Vessels of more than fifteen feet draught of water are obliged to unload in the roads. The chief manufactures are woollen and linen goods, tobacco, soap, glass, and earthenware, with breweries and distilleries. Ship-building is also a considerable branch of trade. The principal article of export is corn, of which about 35,000 quarters are annually exported. It is, however, inferior in quality to that of Mecklenburg. The imports are principally colonial produce and foreign manufactures. From being bounded at one part by the sea, and other places by lakes and marshes, it is accessible only by bridges. Before 1807, it was a well fortified town, but since then the works have been in a manner dismantled. The town is supplied with water by hydraulic machinery, near the Gate of Kuter. The promenades are the Gardens of Westphal, of Richter, of Hagemeister, and of Wolff. Population 10,000, exclusive of the garrison.

STRANGE, SIR ROBERT, an eminent Scottish engraver, was born in the Orkney Isles in 1721. He entered into the rebel army in 1745, and after its discomfiture he went to France. Having returned to England in 1751, he became the head of historical engraving in this country. He died in 1792, leaving behind him the reputation of great talents, and a good character. See ENGRAVING, Vol. VIII. p. 641.

STRANRAER. See WIGTONSHIRE.

STRASBURG, a city of France, and capital of the department of the lower Rhine, is situated at the junction of the Brusche and the Ille, about half a mile from the Rhine. The town occupies a space of a semicircular form, and is intersected by canals crossed with bridges. The houses, built in the German fashion are high, massy, and consist of a soft red stone. The great street, and a few others, are regular and spacious, but the rest are exceedingly narrow: The number of streets are said to be 200. The *Place D'Armes*, a square, surrounded with trees, contains some good buildings. The town is defended by a regular Pentagon, composed of five bastions and five half-moons. Its citadel lies towards the east, and its outworks reach almost to the Rhine. There are six bridges across the Ille, two of stone, and four of wood, and a wooden one 3900 feet long, across the Rhine, supported in the middle by an island on which is a strong castle.

The principal public building is the Gothic cathedral, founded in 1015, and finished in 1275. Its steeple terminating in a pyramid, is 470 feet high; is ascended by a stair of 635 steps, and is the highest in the world, excepting the great pyramid, which exceeds it by about 30 feet. The tower has the openness of lacework. During the revolution many of the ornaments together with its statues were destroyed. The clock which exhibits the movements of the planets, was made in 1571. The church of St. Thomas contains the mausoleum of Marshall Saxe. The other public buildings are the town hall, the episcopal palace, the arsenal, the foundling hospital, the town hospital, the public granaries, the theatre, the observatory, and the monument to General Dessaix.

Strasburg possesses several small manufactories of common cloths, lace, skins, pens, hats, candles, hair powder, artificial flowers, cutlery, paper hangings, vermilion, &c. The articles of export are corn, beef, flax, wine and spirits, likewise linen, blankets, carpets, and hardware, leather, cotton, and tobacco.

The establishments for education, &c. of Strasburg, are the Protestant gymnasium, conducted by ten professors, the central school of the department, the school of medicine, the society of arts and sciences, the free society of agriculture, an anatomical theatre, two public libraries, the physical and natural history cabinets, cabinets of antiquities and mechanics, and a botanic garden. Strasburg is the seat of a bishop, and the capital of the department of the lower Rhine. Population in 1827, 49,708. East Long. 7° 51′ 51″, and North Lat. 48° 31′ 56″.

STRATFORD upon Avon, a market town of England, in Warwickshire, celebrated as the birthplace of Shakspeare. It stands on the west bank of the Avon, which is here crossed by a bridge of thirteen large and six small arches, and 1123 feet long. There are twelve streets, several of which meet in a point like the rays of a star. The chief buildings are the church, and the town hall, the former is the place of Shakspeare's interment, and the latter contains excellent portraits of Shakspeare and Garrick, by Wilson and Gainsborough. The town is governed by a mayor, recorder, high steward, 12 aldermen, and 252 capital burgesses. By means of the Stratford on Avon canal, large quantities of millet and corn are here exported. Population in 1821, 3069. For farther information of Stratford, see Mr. Wheler's *History of Stratford*, 1806, and his *Guide to Stratford*, 1814.

STRATFORD Stony, a town of England, in Buckinghamshire, is situated on the Avon, which is here crossed by a stone bridge. The houses which are of freestone, extend about a mile on each side of the road. The church of St. Giles is neat, and there is a good market town. The principal occupation of the people is that of lace making. The population in 1821 of the west side and east side parishes, was 1449 inhabitants.

STRENGTH OF MATERIALS.

Under the article Carpentry, we have taken a concise view of the strains to which timber and other materials are exposed in buildings and other constructions, and have promised our readers to enter upon the subject again more at large in a subsequent part of our work, a pledge which we propose to redeem in this place. At the time that article was written, we could not but regret the poverty of direct information to be obtained as to the absolute experimental strength of various materials of common application in the arts, and we expressed our hopes that something of this kind would be undertaken by some of our scientific men, in order that the practical mechanic might be furnished with principles on which he might place reliance, and not be left to the mere result of his own experience. Since that time much has been done towards obtaining the data then so much wanted, first by Mr. Barlow of Woolwich, who obtained permission from the navy board to make any selection of timber, and to avail himself of any facilities which the dockyard at that port might furnish for carrying his views into execution. These results, with a pretty general abstract from most preceding experimenters, have been published by him in his "*Essay on the Strength of Timber, &c.*" which contains also a valuable set of experiments made by Thomas Telford Esq., and another by Captain Brown (the ingenious inventor of iron cables) on the direct strength of malleable iron. Mr. Tredgold also in his *Principles of Carpentry*, and in his *Treatise on the Strength of Cast Iron*, has added much important information on these subjects, as has also John Rennie, Esq. in the Philosophical Transactions for 1818, and lastly, Mr. Hodgkinson in volume fourth of the Manchester Memoirs, has given us a detail of various experiments of this kind which cannot fail of being considered highly curious and important. From these sources we shall in the present article endeavour to make such a collection of results as to furnish the practical builder and engineer with data on which he may securely depend, and rules proper for making the requisite computation in any new case that may present itself.

The following divisions are generally made of the various strains to which materials are exposed.

1. They may be drawn asunder by a force acting endwise.

2. They may be compressed and destroyed by a force acting also endwise.

3. A bar of any substance may be strained laterally, one part being supported, and the strain applied immediately at the point of the support, as when a tenon breaks or a rafter fails at the wall. If the material is cast iron or any similar substance, viz. non-fibrous, the direction of the force with respect to the body is important, but in fibrous bodies, as timber, this strain may be considered under two distinct heads; accordingly as the force acts perpendicular to, or parallel with, the direction of the fibres.

4. A bar or beam may be strained transversely, as in the case of a girder or rafter.

5. It may be twisted, as in the axle of mills, &c.

6. It may be strained by any two or more of these forces combined.

7. A material may also be strained by an internal pressure, as in the case of hydraulic cylinders, pieces of ordnance, water pipes, &c.

We shall consider each of these strains in the order in which they are stated above, and make such additions to the results given under the article carpentry, as are supplied by the recent experiments to which we have referred, and as these have generally been made with more precautions, with better means, and on larger specimens, we beg distinctly to state, that where these results differ essentially from the former, there can, in our opinion, be no doubt that the greatest confidence is due to the latter, we shall therefore generally omit all early and doubtful results.

1. *Of the resistance to extension in length arising from the direct cohesion of the fibres or particles of matter.*

As far as the mechanism of this strain is concerned it is the most simple of any of those above enumerated, but it is by no means the easiest to submit to experiment, particularly in timber, because, if the force is not directly opposed to the fixed point, the fibres are liable to be destroyed by a twist or strain different from that we are endeavouring to estimate; it is probably to this circumstance we must attribute the discordance observed in the results obtained by different experimenters; and it is for this reason we have thought it right to inform the reader of the means employed to assure accuracy in this respect in making the following experiments. Referring to Fig. 1. Plate AB represents one of the pieces whose strength is to be determined, its whole length being twelve inches: the length of each square three and a half inches, and the side of the square one and a half inches: the intermediate part, five inches, was turned in an excellent lathe and by a good workman, and brought down in the centre to one-third or one fourth of an inch in diameter, its exact diameter being ascertained by winding a piece of silk ten times round the circumference, which length divided by ten, gave the circumference, and hence the diameter was computed. The other cylindrical parts were each three-fourths of an inch in diameter. CC, DD, Fig. 2, represent two strong iron bars brought to the form shown in the drawing, GG, are two screws which are passed through the holes HH, in the bar DD, and are there screwed fast by the nuts II; EE are two semicircular collars rivetted, one to each bar, which, when the two are screwed together, form a circular plate, as represented in Fig. 4. The circular hollow parts *ee*, are three-fourths of an inch in diameter, so as to fit exactly the larger part of the cylinder shown in Fig. 1. These bars, after being screwed together, were rested on the supports as in Fig. 4, and then *brought out of winding* and accurately adjusted to a horizontal position by a spirit level.

The two iron boxes, MNO, M'N'O', Fig. 3, were made exactly to fit the square head B of Fig. 1, having also two semi-circular holes at the top correctly fitted to the larger part of the cylinder: these were shut by passing the bolts M'N' through the holes NM, and were thus secured by the shears shown in Fig. 4. In making the experiments, the head A of Fig. 1, was placed above the collars EE, Fig. 2, the upper larger cylindrical part of Fig. 1 being placed in the hollow parts *ee* of Fig. 2, when the two parts were securely fixed together by the nuts and screws IG, IG. In the same manner, the lower end of Fig. 1, was enclosed in the two iron boxes MNO, M'N'O' Fig. 3, and fastened in that position by means of the bolts M'N', and the shears above described. The whole were then rested on the props Fig. 4, and the hook of the seals being inserted in the circular hole formed by OO' Fig. 3, the whole was ready for the experiment as shown at large in the former figure.

Every thing being thus prepared, the wedges shown in the plate were introduced under the scale to keep it steady, while the larger weights were put in. The wedges were then removed, and smaller weights added in succession till the fracture took place. As a small vibration in the scale might cause a fracture in the small cylinder submitted to the operation of the weight, four small braces were made use of, one at each corner of the scale, to prevent any such motion; and every other possible precaution was had recourse to in order to ensure accuracy in the results, which in this case was the more necessary, as these were afterwards to be introduced in order to examine some of the more complicated strains and resistances. The following are the principal results obtained in these experiments, the smaller cylinders being reduced to what they would have been on square inch bars: it being assumed that the strength or resistance is proportional to the section of fracture, of which, it is presumed, no doubt can be entertained, it should be observed that these were select specimens of timber which had been a long time in store and perfectly dry.

Experiments on the direct cohesive strength of timber.

Number of experiments	Names of the woods.	Specific gravity.	Circumference of the cylinders.	Weight in lbs. that broke the specimen.	Weight reduced to a square inch rod.	Mean result.
			inch.	*lbs.*		
1	Fir.	600	1.05	1140	12993	
2	do.	600	1.10	1260	13073	
3	do.	600	1.10	1191	12037	12875
4	do.	600	1.05	1160	13220	
5	do.	600	1.11	1213	12371	
6	do.	600	1.05	1180	13448	
7	Fir, different sorts.	581	1.10	1059	11009	
8	do.	564	1.10	1201	12472	
9	do.	601	1.10	1094	11360	11549
10	do.	611	1.10	1130	11736	
11	do.	532	1.10	1076	11180	
12	do.	500	1.10	1112	11548	
13	Ash.	594	.8800	1100	17850	
14	do.	611	.9000	1096	17003	17207
15	do.	611	.8750	1024	16770	
16	do.	600	.8375	881	15784	
17	do.	600	.8625	1025	17315	16947
18	do.	600	.8750	1081	17742	
19	Beech.	712	.880	716	11626	
20	do.	694	.890	721	11437	11467
21	do.	700	.900	731	11338	
22	Oak.	700	1.10	856	8889	
23	do.	700	1.10	887	9211	9198
24	do.	700	1.10	908	9494	
25	do.	920	.8800	740	12008	
26	do.	920	.8750	712	11660	11580
27	do.	920	.8900	698	11072	
28	Teak.	860	.8625	868	14662	
29	do.	860	.8625	900	15203	15090
30	do.	860	.8625	912	15405	
31	Box.	960	.8625	1168	19730	
32	do.	960	.8625	1160	19595	19891
33	do.	1024	.8625	1200	20348	
34	Pear.	646	.8625	683	11537	
35	do.	646	.8500	523	9096	9822
36	do.	646	.8625	523	8834	
37	Mahogany.	637	1.1125	783	7950	
38	do.	637	1.1125	783	7950	8041
39	do.	637	1.1125	810	8224	

These experiments were made, as is above stated, upon select specimens, and, therefore, exceed the general strength of wood of their respective descriptions; but, on the other hand, they were made with great care, and the general uniformity in the strengths of the similar specimens shows, that we may place great reliance on the results. These strengths, in the nearest round numbers, may be stated as below.

Box,	20,000	lbs. per square inch.
Ash,	17,000	
Teak,	15,000	
Fir,	12,000	
Beech,	15,000	lbs. per square inch.
Oak,	10,000	
Pear,	9,000	
Mahogany,	8,000	

The results, and the description of the apparatus, are taken from Barlow's *Essay on the Strength of Timber*, and they may, it is conceived, be considered perfectly satisfactory; therefore, where former results differ widely from these, they will be best omitted; for it is difficult to say whether furnishing a practical man with no information on this subject, or giving him a variety of discordant results, is most injurious? For this reason, in the following table we have omitted all those experiments given by Emerson and by Anderson, commonly found in our books: they are both clearly very inaccurate, unless they are meant to indicate the strain that may be safely borne, and not the ultimate strength, which probably is the case. In ascertaining the direct cohesive power of metals, much less delicacy of operation is required, because they are not so liable to rupture from a want of direct application of the power; but, on the other hand, they are generally made on specimens which require great force to break, and some inaccuracies are thus introduced into the results. A remarkable case of this kind occurs in the experiments reported in the preceding work, made by Mr. Telford, at Brunton's cable manufactory, and those made at Captain Brown's manufactory; the specimens of iron were the same, yet the results differed in about the ratio of 29 to 25. Mr. Barlow has shown the discrepance is most probably due to the two machines: In Brunton's experiments the machine employed was an hydraulic press, and the power exhibited by the small valve was opposed both to the friction of the piston, and to the bar, whereas it is supposed to be opposed only to the latter; this machine, therefore, overrates the power. Captain Brown's, on the contrary, was constructed on the principle of the weigh bridges, and, consequently, all the inertia was to be overcome before the exhibition took place in the register; we have, therefore, assumed the mean effect 27 as the truth, and have, accordingly, diminished the several results in Telford's experiments 7 per cent. and increased those of Brown's 8 per cent. They will thus be found to accord very nearly with some other experiments on which we have great reason to place reliance.

This being premised, the following tabulated results, will, it is presumed, be found highly valuable, and for which we are principally indebted to Mr. Tredgold, who has collected and arranged most of them in his edition of Buchanan's *Practical Essay on Mill Work*, and in his *Elementary Principles of Carpentry*.

Table of Experiments on the direct cohesive powers of various Materials.

Names of materials.	Cohesive powers reduced to a square inch rod.	Experimenters.	Quoted from
WOODS.	lbs.		
Oak	17,300	Muschenbroek	Introd. ad Phil. Nat.
Ditto	13,950	Rondelet	L'Art. de Batir, iv.
Ditto			
Ditto dry English from	12,000 / 8,000	Barlow	Essay on the Strength of Timber.
Beech	17,709	Muschenbroek	Introd. ad Phil. Nat.
Ditto	11,500	Barlow	Essay on the strength of Timber.
Alder	14,186	Muschenbroek	Introd. ad Phil. Nat.
Chesnut, Spanish	13,300	Rondelet	L'Art de Batir, iv.
Ash very dry, from	17,850 / 15,784	Barlow	Essay on the Strength of Timber.
Ditto	12,000	Muschenbroek	Introd. ad Phil. Nat.
Elm	13,489	do.	ditto.
Acacia	20,582	do.	ditto.
Mahogany	8,000	Barlow	Essay on the Strength of Timber.
Walnut	8,130	Muschenbroek	Introd. ad Phil. Nat.
Teak	15,000	Barlow	Essay on the Strength of Timber.
Poplar from / to	6,641 / 4,596	Muschenbroek	Introd. ad Phil. Nat. i.
Fir from / to	13,488 / 11,000	Barlow	Essay on the Strength of Timber.
Ditto	8,506	Muschenbroek	Introd. ad Phil. Nat. i.
Scotch Pine	7,818	do.	ditto.
Norway Pine	7,287	Rondelet	L'Art de Batir, iv.
Larch	10,224	do.	ditto.
Cedar	4,973	Muschenbroek	Introd. ad Phil. Nat. i.
METALS.			
STEEL.			
Cast Steel previously tilted	134,256	Rennie	Phil. Trans. for 1813.
Cast steel not tilted	68,110	Brown	Barlow's Essays, &c.
Blistered Steel reduced per hammer	133,152	Rennie	Phil. Trans. for 1818.
Shear Steel reduced per hammer	127,632	do.	ditto.
IRON WIRE.			
Iron Wire	113,077	Sickengen	Ann de Chimie, vol. 25.
Iron wire* one-tenth inch diameter	93,964	Telford	Barlow's Essay, p. 245, 2d ed.
Iron wire	85,797	Buffon	Œuvres de Gauthey, ii. p. 153.
MALLEABLE IRON IN BARS.			
German bar, mark B R, highest result	93,069	Muschenbroek	Introd. ad Phil Nat. i. 426.
Swedish bar, highest result	88,972	do.	ditto.
German bar, mark L, highest result	85,900	do.	ditto.
Liege bar, highest result	82,839	do.	ditto.
Spanish bar	81,901	do.	ditto.
Oosement bar, highest result	76,697	do.	ditto.
Swedish bar reduced per hammer	72,064	Rennie	Phil. Trans. 1818.
Common round iron	66,309	Telford	Barlow's Essay, p. 230.
German bar marked L	69,530	Muschenbroek	Introd. ad Phil. Nat. i. 426.
Common Staffordshire bar	64,580	Telford	Barlow's Essay, p. 230.
Common German bar	69,133	Muschenbroek	Introd. ad Phil. Nat. i. 426.
Swedish bar	68,728	do.	ditto.
Oosement bar	68,728	do.	ditto.
Welsh bar	62,079	Telford	Barlow's Essay, p. 230.
Bar of the best quality	66,000	Rumford	Phil. Mag. x. p. 51.

Names of materials.	Cohesive powers reduced to a square inch rod.	Experimenters.	Quoted from
A bar of Welsh, one of Swedish, and one faggotted scrap iron, each gave a result of	60,413	Telford	Barlow's Essay, p. 229.
The Swedish bar broke at a flaw.†			
Liege bar	62,369	Muschenbroek	Introd. ad Phil. Nat. i. 426
Staffordshire bar	57,288	Telford	Barlow's Essay, p. 229.
German bar, mark B R	61,361	Muschenbroek	Introd. ad Phil. Nat. i. 426.
Bar (mean of 33 expts.)	61,041	Perronet	Œuvres de Gautley, ii. 154.
Russian old sable, mark CCN	64,230	Brown	Barlow's Essay, p. 233.
English bar reduced by the hammer	55,872 ?	Rennie	Phil. Trans. for 1818.
Welsh bar (3 expts.)	60,238	Brown	Barlow's Essay, p. 233.
Bar of good quality	55,000	Rumford	Phil. Mag. vol. x. p. 51.
Swedish bar (3 expts.)	57,503	Brown	Barlow's Essay, p. 232.
CAST IRON.			
Bar, spec. grav. 7.807	68,295 ?	Muschenbroek	Introd. ad Phil. Nat. i. 417
Bar, cast vertically	19,488	Rennie	Phil. Trans. for 1818.
Bar, cast horizontally	18.656	do.	ditto.
Bar, Welsh pig	17,565	Brown	Barlow's Essay, p. 235.
COPPER.			
Wire	61,228	Sickingen	Ann de Chimie, xxv. 9.
Wrought copper reduced by the hammer	33,792	Rennie	Phil. Trans. for 1818.
Cast, Barbary, spec. grav. 8.182	22,570	Muschenbroek	Introd. ad Phil. Nat. i. 417.
Cast, Japan, spec. grav. 8.726	20,272	do.	ditto.
Cast	19,072	Rennie	Phil. Trans. for 1818.
PLATINUM.			
Platinum wire, spec. grav. 20.847	56,473	Morveau	Ann de Chimie, xxv. 8.
Platinum wire	52,987	Sickingen	ditto, p. 9.
SILVER.			
Silver wire	38,257	do.	ditto.
Silver cast, spec. grav. 11.091	40,902	Muschenbroek	Introd. ad Phil. Nat. i. 417.
GOLD.			
Gold wire	30,888	Sickingen	Ann de Chimie, xxv. 9.
Gold cast, spec. grav. 19.338	20,450	Muschenbroek	Introd. ad Phil. Nat. i. 417.
ZINC.			
Zinc wire	22,551	Morveau	Ann de Chimie, lxxi. 194.
Zinc sheet	16,600	Tredgold	Phil. Mag. vol. l. p. 422.
Zinc cast	2,689	Muschenbroek	Introd. ad Phil. Nat. i. 407.
TIN.			
Tin wire	7,129	Morveau	Ann de Chimie, lxxi. 194.
English block, cast	6,650	Muschenbroek	Introd. ad Phil. Nat. i. 417.
English, spec. grav. 7.295	5,322	do.	Introd. ad Phil. Nat. i. 417.
Cast	4,736	Rennie	Phil. Trans. for 1818.
Banca tin cast, spec. grav. 7.2165	3,679	Muschenbroek	Introd. ad Phil. Nat. i. 417.
Malacca tin cast, spec. grav. 6.1256	3,211	do.	ditto.
LEAD.			
Milled sheet, spec. grav. 11.407	3,328	Tredgold	Phil. Mag. vol. i. p. 422.
Wire	3,146	Muschenbroek	Introd. ad Phil. Nat. i. 452.
Wire, spec. grav. 11.282	2,581	do.	ditto.
Wire	2,547	Morveau	Ann de Chimie, lxxi. 194.
Cast lead	1,824	Rennie	Phil. Trans. for 1818.
Cast English, spec. grav. 11,479	885	Muschenbroek	Introd. ad Phil. Nat. i. 452.
BISMUTH.			
Bismuth cast, spec. grav. 9.810	3,250	do.	ditto.
Bismuth, spec. grav. 9.926.	3,008	do.	ditto.
ANTIMONY.			
Antimony cast, spec. grav. 4.500	1,060	do.	ditto.

* Wire being stronger than a bar of the same metal, it is probably proportionally stronger, as it is more reduced in diameter. The diameter therefore should be given

† The experiments by Telford and Brown were principally upon the same specimens of iron; some of them the same bars parted; they were made on bars and bolts from one inch to two inches diameter, and we conceive by far the most satisfactory.

Names of materials.		Sp. Gr.	Cohesive power reduced to a square inch rod.	Experimenters.	Quoted from
ALLOYS.					
Copper 10 Tin	1	8.351	32093	Muschenbroek	Intr. ad Phil. Nat.
8	1	8.392	36088	do.	do.
6	1	8.707	44071	do.	do.
4	1	8.723	35739	do.	do.
2	1		1017	do.	do.
Gun metal, hard			36368	Rennie	Phil. Trs. for 1818.
Brass, fine yellow			17968	do.	do.
Tin, English 10 lead	1		6904	Muschenbroek	do.
8	1		7922	do.	do.
6	1		7997	do.	do.
4	1		10607	do.	do.
2	1		7470	do.	do.
1	1		7074	do.	do.
Tin, Banca, 10 Antimony	1	7.359	11181	do.	do.
8	1	7.276	9881	do.	do.
6	1	7.228	12632	do.	do.
4	1	7.192	13480	do.	do.
2	1	7.105	12029	do.	do.
1	1	7.060	3184	do.	do.
Tin, Banca, 10 Bismuth	1	7.576	12688	do.	do.
4	1	7.613	16692	do.	do.
2	1	8.076	14017	do.	do.
1	1	8.146	12020	do.	do.
1	2	8.580	10013	do.	do.
1	4	9.009	7875	do.	do.
Tin, Banca, 10 Zinc Indian	1	7,288	12914	do.	do.
2	1	7.000	15025	do.	do.
1	1	7.321	15841	do.	do.
1	2	7.100	16023	do.	do.
1	10	7.130	5671	do.	do.
Tin, English, 8 Zinc Goslar	1		10607	do.	do.
4	1		10258	do.	do.
2	1		10964	do.	do.
1	1		9024	do.	do.
Tin, English, 1 Antimony	1	7.000	1450	do.	do.
3	2		3184	do.	do.
4	1		11343	do.	do.
Lead, Scotch 1 Bismuth	1	10.931	7319	do.	do.
2	1	11.090	5840	do.	do.
10	1	10.827	2826	do.	do.

In addition to the above table of the cohesive powers of different simple materials, we may add the following on the strength of iron and hemp, when manufactured into chain and rope.

Table of Experiments on the strength of chain made of various descriptions of re-manufactured iron (Foreign and British.) By Capt. S. Brown, R. N. from Barlow's Essay.*

Diameter of bolt.	Description of iron.	Breaking weight increased 8 per cent.†	
inch.		*tons.*	*cwt.*
$1\frac{1}{2}$	Old sable $1\frac{1}{2}$ inch square bar cut into two feet pieces, piled, and rolled into bolts,	82	14
$1\frac{1}{2}$	Ditto do.	90	0
$1\frac{1}{2}$	Gurcoft new sable, do.	79	17
$1\frac{1}{2}$	Keiolsken archangel inch square bars, cut and rolled as above,	79	17
$1\frac{1}{2}$	Old bolt taken promiscuously, piled and faggotted by hand hammers,	80	9
full $1\frac{1}{2}$	English bars piled and rolled,	96	15
bare $1\frac{1}{2}$	Ditto do.	90	0
$1\frac{1}{2}$	Old Dutch bolts faggotted by hand hammers,	79	17
$1\frac{1}{2}$	No. 1, 5-8 inch Welsh iron, hammered into bloom, and rolled into bolts at King and Queen works,	88	16
$1\frac{1}{2}$	No. 2, $\frac{3}{4}$ inch Welsh iron, manufactured as above,	82	8
$1\frac{1}{2}$	No. 4, Welsh iron faggotted and hammered at Captain Brown's works,	99	11
$1\frac{1}{2}$	No. 6, 5-8 ditto rolled but not hammered, at King and Queen works.	85	10
$1\frac{1}{2}$	King and Queen scrap iron,	90	6

The mean of these experiments give about $85\frac{1}{4}$ tons for the strength of a double bolt of $1\frac{1}{2}$ inch diameter, which is about $24\frac{1}{3}$ tons per square inch, whereas from a mean of the experiments at Messrs. Brunton's and at Capt Brown's manufactory, the strength in the simple bars is about $27\frac{1}{4}$ tons per square inch, hence the strength of iron manufactured into chain without stays to the link is to that in the simple bolt at $24\frac{1}{3}$ to $27\frac{1}{4}$, viz. it loses about 11 per cent of its strength; but when protected by stays, the loss is scarcely two per cent.

Table showing the different kinds of best bower cables at present employed in the British Navy, with the corresponding Iron Cables, their respective strengths, and Rope of different dimensions.

Rates of ships, &c.	Length 100 fathoms. Circumference.	Weight.			No. of threads in hempen cable.	Breaking strain by experiment.			Diameter and weight of bolt of iron cable substituted for hempen cable.
	inch.	*cwt.*	*qr.*	*lb.*		*tons.*	*cwt.*	*qr.*	
1st Rate large	25	114	2	7	3240				2 1-8 inch bolt 218 cwt.
middle	24	105	2	17	2983				
small	23	96	2	27	2736				
2d rate	23	96	2	27	2736	114	0	0	
3d rate large	23	96	2	27	2736				
small	22	89	0	12	2520	89	0	0	2 inch bolt 156 1-2 cwt.
4th rate 60 guns	21	80	0	22	2268				
58 do.	19	66	0	21	1872				1 7-8 inch bolt 170 1-2 cwt
50 do.	$18\frac{1}{2}$	62	1	14	1764				
5th rate 48 do.	18	58	2	6	1656	63	0	0	1 3-4 inch bolt 145 3-4 cwt.
46 do. } 42 do. }	$17\frac{1}{2}$	56	0	1	1584				
6th rate 28 do.	$14\frac{1}{2}$	33	0	21	1080	40	0	0	1 3-8 inch 87 1-2 cwt.
Ship sloop	$13\frac{1}{2}$	33	0	10	936				1 1-4 inch bolt 74 3-4 cwt.
Brig large	$13\frac{1}{2}$	33	0	10	936				
Do. small	11	21	2	5	612				1 1-8 inch 61 3-4 cwt.
Rope	4					4	19	0	
	$3\frac{1}{2}$					3	12	1	
	3					2	10	1	

The above are, we believe, the most extensive and best authenticated results relative to the strength of the direct cohesive powers of materials any where collected, and will, we are persuaded, be highly useful to persons having occasion for any reference of this kind, for by a general comparison of all that has hitherto been given on this subject, we have been enabled to detect the erroneous results, (generally arising out of the employment of too small specimens) and have not introduced them into the tables.

It will of course be seen, that in this simple strain the resistance is proportional to the area of section, and that the strength of any sized rod of any material given in the table may be found by multiplying the area of section in inches by the strength per square inch, as given in the table.

Of the Resistance of Materials to Compression, or to a Crushing Force.

The exciting force in this case acts directly the reverse of that in the preceding section, but its effect is by no means so simple and defined. There are, in fact, here two cases to be separately considered, one when the body acted upon is too short to bend, and the other when it is of considerable length with regard to its other dimensions. In the former case, the mate-

* The links of these chains were of an oval form: greatest interior diameter six inches.

† The machine underrates itself 8 per cent, see p. 497.

rial is destroyed by actual pressure; but in the latter, it generally bends in one or more directions, and is ultimately broken by a force similar to that exerted by a transverse strain; it will be better therefore to reserve the latter case till we have treated of the transverse strain, and confine ourselves here merely to the crushing force, on which subject the following valuable table of experiments have been published by John Rennie, Esq. in the Philosophical Transactions for 1818.

Experiments on the Resistance of Cast Iron to Pressure.

Size of prism.		Specific gravity.	Crushing weight.	Mean from each set.	Remarks.
Side of base.	Height.				
inch.	*inch.*		*lbs.*	*lbs.*	
1-8th	1-8th	7033	1,454	1,440	These specimens were from one block.
do.	do.	do.	1,416		
do.	do.	do.	1,449		
do.	2-8ths	6977	1,922	2,116	Iron from a block.
do.	do.	do.	2,310		
do.	3-8ths	do.	2,363	1,758	These specimens were from the same block.
do.	4-8ths	do.	2,005		
do.	5-8ths	do.	1,407		
do.	6-8ths	do.	1,743		
do.	7-8ths	do.	1,594		
do.	8-8ths	do.	1,439		
1-4th	1-4th	do.	10,561	9,773	These specimens were from the same block as above.
do.	do.	do.	9,596		
do.	do.	do.	9,917		
do.	do.	do.	9,020		
do.	do.	7013	12,665	10,114	These specimens were from horizontal castings.
do.	do.	do.	10,720		
do.	do.	do.	10,605		
do.	do.	do.	8,699		
do.	do.	7074	12,665	11,136	These specimens were vertical castings.
do.	do.	do.	10,950		
do.	do.	do.	11,088		
do.	do.	do.	9,844		
do.	do.	do.	11,096		
do.	$\frac{1}{2}$	7113	9,455	9,414	Horizontal casting.
do.	do.		9,374		
do.	do.	7074	9,938	9,982	Vertical casting.
do.	do.		10,027		
do.	3-8ths	7113	9,006		Horizontal castings.
do.	5-8ths	do.	8,845		
do.	6-8ths	do.	8,362		
do.	7-8ths	do.	6,430		
do.	8-8ths	do.	6,321		
do.	3-8ths	7074	9,328		Vertical castings.
do.	5-8ths	do.	8,385		
do.	6-8ths	do.	7,896		
do.	7-8ths	do.	7,018		
do.	8-8ths	do.	6,430		

Similar experiments on Different Metals.

Size of prism.		Name of metal.	Crushing weight.	Remarks.
Side of base.	Height.			
inch.	*inch.*		*lbs.*	
$\frac{1}{4}$	$\frac{1}{4}$	Cast Copper	7,318	Crumbled by pressure.
do.	do.	Brass	10,304	Fine yellow brass, reduced one-tenth by 3213 lbs. and one-half with 10,304 lbs.
do.	do.	Wrought Copper	6,440	Reduced one-sixteenth with 3427 lbs. one-eighth with 6440 lbs.
do.	do.	Cast tin	966	Reduced one sixteenth with 552 lbs. one-third with 960 lbs.
do.	do.	Cast lead	483	Reduced one-half with 483 lbs.

In these experiments, after the metals had been compressed to a certain extent, the resistance is stated to have been enormous.

Experiments on the Resistanee of various Materials to a Crushing Foree.

Names of materials.	Specific gravity.	Crushing weight.
		lbs.
1. Elm, cube of one inch .		1284
2. American pine, do. .		1606
3. White deal, do. .		1928
4. English oak, do. .		3860
5. Portland stone, 2 inches long		805
6. Statuary marble, 1 inch .		3216
7. Craigleith, do. .		8688
8. Chalk, cube of 1 1-2 inch .		1127
9. Brick, pale red do. . .	2085	1265
10. Roe-stone, Gloucestershire, do.		1449
11. Red brick, do. . .	2168	1817
12. Do. Hammersmith paviors' do.		2254
13. Burnt, do. do. . .		3243
14. Fire brick, do. . .		3864
15. Derby grit, do. . .	2316	7070
16. Do. another specimen, do. .	2428	9776
17. Killaly white freestone, do. .	2423	10264
18. Portland, do. . .	2428	10284
19. Craigleith white freestone, do.	2452	12346
20. Yorkshire paving with the strata, do.	2507	12856
21. Do. do. against strata, do. .		12856
22. White statuary marble, do. .	2760	13632
23. Bramley Fall sandstone, do. .	2506	13632
24. Do. against strata, do. . .		13632
25. Cornish granite, do. . .	2662	14302
26. Dundee sandstone, do. .	2530	14918
27. Portland, a two inch cube, .	2423	14918
28. Craigleith, with the strata, 1 1-2 inch cube, ...	2452	15360
29. Devonshire red marble, .		16732
30. Compact Limestone, . .	2584	17354
31. Granite Peterhead, , .		18636
32. Black compact limestone, .	2598	19924
33. Purbeck, . . .	2599	20610
34. Freestone very hard, . .	2528	21254
35. Black Brabant marble, .	2697	20742
36. White Italian marble, .	2726	21783
37. Granite, Aberdeen, Blue kind,	2625	24556

The above experiments, although they will certainly be found useful in many inquiries, are not so valuable to an engineer as those given in our first section, because we cannot in the same way establish a general rule to derive from them the resisting power of similar materials in similar blocks. In the former case, there can be no doubt that the strength varies directly as the section, but in this it varies in a much higher ratio, and we are unable from theoretical considerations alone to ascertain what that ratio is. It is obvious, that as we increase the base of our specimens, the interior particles in granulated substances, and the fibres in fibrous bodies, are protected from yielding by the lateral resistance of the exterior ones; and to what extent this proceeds as we increase our dimensions, it is impossible to estimate, because so much depends upon the internal structure of the body. By comparing the first set of Mr. Rennie's experiments on cast iron with his third, fourth, or fifth, it would appear that the resistance is as the cube of the side; but we can by no means lay this down as a general law.

When wood is submitted to this strain, its destruction takes place by separating the fibres from each other, the lateral adhesions being altogether destroyed, (the pressure being endways of the grain.) Mr. Smart, the ingenious inventor of the hollow masts, and the patentee for the compression of wood in the formation of casks, canteens, saddle-trees, &c. has several curious specimens of compressed wood, in which the fibres are reduced nearly to the state of a painter's brush, by the separation of them as above stated.

Of the Cohesive Powers of Wood resisting a force acting Perpendicular to the Direction of the Fibre.

On this subject very little new matter can be collected to add to that given under the article carpentry; for although numerous experiments have been made since that article was written, on most of the other strains to which materials are exposed, this has been almost wholly neglected. We know of nothing that has been done, except two or three experiments by Mr. Tredgold, and one by Mr. Barlow, which latter, however, was on the lateral adhesion of the fibres, but those of the former were made on their transverse strength; these are as below.

	Kind of Wood.	Resistance on a square inch.	
	Oak	2316 lbs.	Tredgold.
	Poplar	1782 lbs.	
	Larch	from 979 to 1700.	
Lateral adhesion of	Fir	600	Barlow.

If we allowed ourselves to form any general estimate from these few experiments, we might say that the resistance to the strain across the fibres is about double that of the direct cohesion, but that the lateral adhesion is only about one half of the direct strength. We cannot, however, state this as correct in all cases, nor even as approximative; a few experiments on this subject would be highly interesting.

On the Resistance of Timber and other Materials to a Transverse Strain.

We have entered at some length upon this subject, under the article Carpentry, having there examined the result of all the most common strains of this kind to which materials may be exposed; but as in the preceding cases we had not then the means of furnishing satisfactory experimental data for computing the amount of the resistance, the dimensions of the timber being given, or for computing the dimensions requisite to resist any proposed strain or load, we shall therefore principally confine ourselves in this place to laying before our readers such experimental results, as will enable them to submit the principles laid down in the article quoted to practical cases, with such few additional rules as may appear necessary.

It is shown, article Carpentry, p. 502, that the strength of a rectangular beam to resist a transverse strain varies directly as the breadth and square of the depth, and inversely as the length; consequently, if from a series of well-conducted experiments we have been enabled to determine the breaking weight on a piece of timber, of any given species and of given dimensions, we may thence compute the weight necessary to break a piece of timber of the same kind, loaded in a similar way, and of any dimensions whatever.

It has also been demonstrated in the same article, that the strains upon a beam fixed at one end in a wall, and loaded at the other, is four times greater than when the same weight is hung upon the middle of the same beam, and the latter supported at its two extremities.

It has also been shown experimentally that when a beam is fixed at both its extremities in a wall, and loaded in the middle, its strength is to that, when only supported at its two ends, as 3 to 2.

And lastly, that when a weight is uniformly distributed over a beam, its mechanical action to produce fracture is only one half of what it is when collected in the middle.

It follows, therefore, that from a series of experiments made on the resisting power of timber or other material, in any one of these cases, the resistance in any other may be found, or rather perhaps we ought to say, that the resistance in all of them is the same, it being merely the strain that is altered by the different modes of fixing and loading. Let l = the length, b the breadth, and d the depth of any rectangular piece of timber, all in inches, and W the weight in pounds, requisite to break it. Let also S be the weight requisite to break a piece of similar timber, whose length, breadth, and depth, are each one inch, then form our first rule.

$$\text{As } \frac{bd^2}{l} : 1 :: W : \frac{lW}{bd^2} = S$$

Which S will be a constant number of reference for computing the strength of any piece of timber of the same kind, under all variety of dimensions and modes of fixing and loading.

Suppose, for example, this constant is formed for the case in which the beam is fixed at one end and loaded at the other, and the weight W were required that would break any given beam, under any of the circumstances stated above, then we should have

1. Beam fixed at one end, and loaded at the other

$$W = \frac{S\,b\,d^2}{l}$$

2. Beam fixed at one end and loaded uniformly throughout $W = \frac{2\,S\,b\,d^2}{l}$

3. Beam supported at each end and loaded in the middle $W = \frac{4\,S\,bd^2}{l}$

4. Beam supported as above and loaded uniformly

$$W = \frac{8\,S\,bd^2}{l}$$

5. Beam fixed at each end and loaded in the middle

$$W = \frac{6\,S\,bd^2}{l}$$

6. Beam fixed as above and loaded uniformly

$$W = \frac{12\,S\,bd^2}{l}$$

And in the third and fourth cases, if the load be applied in any other point than the middle, then calling m and n the distance from the ends. The above results are to be respectively divided by $\frac{4\,mn}{l^2}$ for the resistance in these cases, which thus become

$$W = \frac{S\,l\,b\,d^2}{m\,n} \text{ and } W = \frac{3\,S\,l\,b\,d^2}{2\,m\,n}$$

It has been explained under Carpentry that we ought to proceed correctly to introduce into these formula the cosine of the beam's deflections, but this leads to considerable intricacy, and is of little value, because we do not generally require to know the actual but relative resisting power, and in all practical cases the deflection is too inconsiderable to be regarded. Indeed it has been asserted that our inquiry ought not to be directed to the ultimate strength; we think, however, that it is desirable in all cases to know what this is, and we may then keep as much within the limits as we please, or as the case seems to require.

The following table, containing the value of S, deduced from a variety of well conducted experiments, is taken from Tredgold's "Elementary Principles of Carpentry." We have only multiplied that author's constant by 3, to make it correspond with our constant denoted above by S, and added a few other results from Barlow's Essay on the Strength of Timber, &c.

Table exhibiting the experimental strength of various species of Timber opposed to a transverse strain.

Kinds of wood.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection at the time of fracture.	Breaking weight in lbs.	Value of constant strength.	Authorities.
Oak English young tree .	.863	2	1	1	1.87	482	2892	Tredgold.
Do. old ship timber . .	.872	2.5	1	1	1.5	264	1980	do.
Do. from old tree	.625	2.	1	1	1.38	218	1308	do.
Do. medium quality . .	.748	2.5	1	1		284	2130	Ebbels.
Ditto, green	.763	2.5	1	1		219	1741	do.
Do. do.	1.063	11.75	8.5	8.5	3.2	24812	1785	Buffon.
Beech, medium quality .	.690	2.5	1	1		271	2031	Ebbels.
Alder . .	.555	2.5	1	1		212	1590	do.
Plane tree .	.648	2.5	1	1		243	1821	do.
Sycamore .	.590	2.5	1	1		214	1605	do.
Chesnut tree	.875	2.5	1	1		180	1350	do.
Ash, from young tree . .	.811	2.5	1	1	2.5	324	2430	Tredgold.
Do. medium quality . .	.690	2.5	1	1		254	1905	Ebbels.
Ash . .	.753	2.5	1	1	2.38	314	2355	Tredgold.
Elm, common	.544	2.5	1	1		216	1620	Ebbels.
Do. weych, green	.763	2.5	1	1		192	1440	do.
Acacia, green	.820	2.5	1	1		249	1866	do.
Mahogany Spanish, seasoned	.852	2.5	1	1		170	1275	Tredgold.
Do. Honduras seasoned .	.256	2.5	1	1		255	1911	do.
Walnut, green	.925	2.5	1	1		195	1461	Ebbels.
Poplar, Lombardy .	.375	2.5	1	1		131	981	do.
Ditto, Abele	.511	2.5	1	1	1.5	228	1710	Tredgold.
Teak . .	.744	7	2	2	4.00	820	2151	Barlow.
Willow .	.405	2.5	1	1	3	146	1095	Tredgold.
Birch . .	.720	2.5	1	1		207	1551	Ebbels.
Cedar of Libanus, dry . .	.586	2.5	1	1	2.75	165	1236	Tredgold.
Riga fir, .	.480	2.5	1	1	1.3	212	1590	do.
Memel fir .	.553	2.5	1	1	1.15	218	1635	do.
Norway fir from Longsound	.639	2	1	1	1.125	396	2376	do.
Mar Forest fir	.715	7	2	2	5.5	360	945	Barlow.
Scotch fir, English growth	.529	2.5	1	1	1.75	233	1746	Tredgold.
Do. do.	.460	2.5	1	1		157	1176	Ebbels.
Christiana white deal .	.512	2	1	1	.937	343	2058	Tredgold.
American white spruce .	.465	2	1	1	1.362	285	1710	do.
Spruce fir, British growth	.555	2.5	1	1		186	1395	Ebbels.
American pine Weymouth	.460	2.0	1	1	1.125	329	1974	Tredgold.
Larch, choice specimen	.640	2.5	1	1	3.0	253	1896	do.
Do. medium quality .	.622	2.5	1	1		223	1671	do.
Do. very young wood . .	.396	2.5	1	1	1.78	129	966	do.
English oak	.934	7	2	2	8.1	637	1672	Barlow.
Canadian, do.	.872	7	2	2	6.0	673	1766	do.
Dantzic, do.	.756	7	2	2	4.86	560	1457	do.
Adriatic, do.	.993	7	2	2	5.73	526	1383	do.
Ash . .	.760	7	2	2	8.92	772	2026	do.
Beech . .	.696	7	2	2	5.73	593	1556	do.
Pitch pine .	.660	7	2	2	6.00	622	1632	do.
Red pine	.657	7	2	2	5.83	511	1341	do.
New England fir	.553	7	2	2	4.66	420	1102	do.

Table exhibiting the Strength of various descriptions of Cast Iron opposed to a transverse strain from experiments reported in Tredgold's Essay on the Strength of Cast Iron, Barlow's *Essay, &c.*

Kinds of iron	Specific gravity.	Length.	Breadth.	Depth.	Deflection at the time of fracture.	Breaking weight in lbs.	Value of constant strength.	Authorities and remarks.
Wakefield foundry, air furnace,	6012	3	1	1		971	8739	Banks supported at the ends.
Do. cupola,		3	1	1		864	7776	Do.
Old park iron,		2	1.3	.65		181	8040	Tredgold fixed at one end.
Alfricton iron.		2	1.3	.65		153	6687	Do.
Scrap iron,		2	1.3	.65		168	7341	Do.
Old park and good old iron mixed,		2	1.3	.65		174	7604	Do.
Alloy pig iron 16, copper 1,		2	1.3	.65		191	8477	Do.
Cast Bars,		3	1	1		756	6804	Supported at the ends. Banks.
Do.		2.5	1	1		100	7560	Do.
Do. mean of three experiments,		3.0	1	1		972	8748	Do.
Do. mean of three experiments,		3.0	1	1		869	7821	Do.
Cast bars,		$2\frac{1}{2}$	1	1		280	8960	Rennie fixed at one end.

Comparing the relative strength of oak and cast iron to resist a transverse strain, it appears that the latter is about five times that of the former, while its direct cohesive power is not more than one and a half times, and its weight is about eight or nine times greater than an equal bar of oak.

The application of the numbers given in the above tables to the formula preceding them, is so obvious as to require very little further illustration, we shall therefore confine ourselves to a single example.

To find the weight which, (applied at the centre of a rectangular beam supported at both ends, and of given dimensions,) is necessary to produce fracture.

The rule, in words, is here obviously as follows: Multiply the breadth by the square of the depth, and again by four times the constant value S of the particular material given in the table. Then divide the product by the length, in inches, for the weight required.

Example. What weight would it require suspended as above, to break a teak beam twenty feet long six inches broad and ten deep.

Here $\frac{4\times6\times10^2\times2151}{240}=21510$ lbs.

If the beam were fixed at one end, and loaded at the other, then the co-efficient 4 is omitted, and the weight is $\frac{6\times10^2\times2151}{240}=5377$ lbs.

If, in the former case, the beam is loaded uniformly throughout, then by the formula the weight required is $\frac{4\times6\times10^2\times2151}{240}\times2=43020$ lbs.

Of the Stiffness of Beams in Resisting a Transverse Strain.

In the preceding section our inquiry has been directed to the ultimate strength of materials, viz. the greatest weight they will support, or rather, perhaps, the least weight that will destroy the beam; but this in general is not the information a practical man most requires, although, it is obvious, if he knows the ultimate strength, he may keep as much within those limits as his case may seem to require, and thus far the tables and rules laid down in the preceding pages will be found highly useful, but commonly it is not the strength but the stiffness of his beams and rafters, that is of greatest consequence to an architect or engineer for a certain deflection, in many cases, is nearly as dangerous or injurious as an actual fracture, we should therefore leave this subject incomplete, if we did not also furnish such experimental data connected with it, as have been obtained from the sources already referred to since our article CARPENTRY was published.

When a beam is supported at its two ends, and loaded either at its middle point or uniformly throughout, the centre of the beam will sink below the horizontal line, and this sinking measured where it is greatest, is called the *deflection*.

The *stiffness* of a beam is the proportion between its length and deflection, the weight and all other things being the same, therefore, when the length is different, and the stiffness the same, the deflection must be proportional to the length. Now, it has been found from numerous experiments, as well as from theoretical investigation, (see CARPENTRY *and Barlow's Essay*,) that the deflection of beams of the same material similarly loaded, varies as the weight and cube of the length directly, and as the breadth and cube of the depth inversely, or d varies as $\frac{l^3 \times W}{bd^3}$, but the stiffness is as the length, divided by the deflection, this therefore varies as $\frac{bd^3}{l^2 W}$. Let now d be an experimental deflection found to be due to a given length l, depth d, breadth b, and weight W and d', any proposed deflection with the same beam, to find the corresponding weight w that will produce it; this is found by the simple proportion $d : d' :: W : \frac{Wd'}{d} = w$. Then this value of w being substituted in the formula $\frac{bd^3}{l^2 W}$, (instead of W,) ought to produce a constant quantity $= a$, d, being always taken proportional to the length, and from this constant the proper dimensions in any other case may be computed.

Mr. Tredgold has computed the value of the constant a, when the deflection is 1-40th of an inch to a foot, or 1-480th of the length, from the experiments reported in the following tables, consequently his constant is obtained by the formula $a = \frac{40bd^3\delta}{l^3 W}$.

Table of Experiments on the Stiffness of Oak.

Kind of oak.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection in inches.	Weight producing the deflection in lbs.	Values of a from $\frac{bd^3\delta}{l^3 W}$	Authorities.
Old ship timber	.872	2.5	1	1	0.5	137	.00298	Tredgold.
Oak from young tree, King's Langley, Herts	.85	2	1	1	0.5	257	.0145	Do.
Oak from Beaulieu, Hants	.616	2.5	1	1	0.5	78	.0164	Do.
Ditto another specimen	.736	2.5	1	1	0.5	65	.0197	Do.
Oak from old tree	.625	2	1	1	0.5	103	.0240	Do.
Oak Riga	.688	2	1	1	0.5	233	.0107	Do.
Do. English	.960	7	2	2	1.275	270	.0119	Barlow.
Do. Canada	.867	7	2	2	1.07	225	.009	Do.
Do. Dantzic	.787	7	2	2	1.26	205	.0105	Do.
Do. Adriatic	.948	7	2	2	1.55	150	.0193	Do.
Do. Green	.763	2.5	1	1	0.5	96	.0153	Ebbels.
Do. Dantzic, seasoned	.755	2.5	1	1	0.5	178	.0087	Tredgold.
Do. do.		12.3	3.19	3.19	{ 1.06 4.25	268 803	.0?8 .0105	{ Aubry.
Do. Green		6.87	5.3	5.3	.433	7.387	.005	Buffon.
Do. do.		23.18	5.3	5.3	2.7	756	.0095	Do.
Do.		8.52	5.06	6.22	0.702	4146	.0043	Girard.
Do. (bois-dis-brin)		16.06	10.66	11.75	0.67	4559	.0213	Do.
Oak		2	1	1	0.55	149	.0117	Tredgold.
Do.		2	1	1	0.55	157	.0104	Do.

Table of Experiments on the Stiffness of Fir.

Kinds of fir.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection in inches.	Weight producing the deflection in lbs.	Values of a from $\frac{bd^3\delta}{l^3 W}$	Authorities.
Fir, Riga, yellow medium		1.8	2	7	0.25	103	.0115	Tredgold.
Do. Norway	.6398	2	1	1	0.5	261	.00957	Do.
Do. Riga yellow	{ .480 .464	2.5 2.5	1 1	1 1	0.5 0.5	123 116	.0102 .0110	Do. Ebbels.
Do. Memel medium	{ .553 .544	2.5 2.5	1 1	1 1	0.5 0.5	145 145	.0089 .0088	{ Tredgold.
American pine	{ .460 .407	2 3	1 1	1 1	0.5 0.5	237 69	.0105 .0112	{ Do.
White spruce, Christiana	.512	2	1	1	0.5	261	.00957	Do.
Do. Quebec	.465	2	1	1	0.5	180	.0138	Do.
Pitch pine	.712	7	2	2	1.33	150	.0166	Barlow.
Fir, New England	.560	7	2	2	.970	150	.0121	Do.
Riga fir	.765	7	2	2	.912	150	.01137	Do.
Mar Forest, Scotland	.715	7	2	2	1.560	125	.0253	Do.
Larch, Blair, Scotland, dry	.622	2.5	1	1	0.5	93	0.137	Tredgold.
Do. seasoned medium	{ .644 .554	2.5 2.5	1 1	1 1	0.5 0.5	101 112	.0126 .0111	Do. Ebbels.
Do. very young wood	.396	2.5	1	1	0.5	45	.0284	Tredgold.
Scots fir	.529	2.5	1	1	0.5	89	.01437	Do.
Spruce, British	.555	2.5	1	1	0.5	03	.0124	Ebbels.
Fir (bois-dis-brin)		21.3	10.48	10.48	1.02	4.389	.0115	Girard.
Do. do.		10.65	10.58	10.4	0.2245	4.122	.0220	Do.

Table of Experiments on the Stiffness of different Woods.

Kinds of wood.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection.	Weight which produced deflection.	Value of a from $a = \frac{40\,b\,d\,3\delta}{l\,3\,W}$	Authorities
Ash young tree, white coloured	.811	2.5	1	1	0.5	141	.009	Tredgold.
Do. old tree, red coloured,	.753	2.5	1	1	0.5	113	.0113	Do.
Do. medium quality,	.690	2.5	1	1	0.5	78.5	.0163	Ebbels.
Ash,	.760	7	2	2	1.27	225	.0105	Barlow.
Beech,	.688	7	2	2	1.025	150	.01277	Do.
Teak,	.744	7	2	2	1.276	300	.0076	Do.
Elm, {	.510	2.5	2	2	1.42	125	.0212	Do.
	.514	2.5	1	1	0.5	99.5	.0128	Ebbels.
Cedar of Lebanon,	.486	2.5	1	1	0.5	36	.0355	Tredgold.
Maple, common	.625	2.5	1	1	0.5	65	.0197	Do.
Abele,	.511	2.5	1	1	0.5	84	.0152	Do.
Willow,	.405	2.5	1	1	0.5	41	.031	Do.
Horse chesnut,	.483	2.5	1	1	0.5	79	.0162	Do.
Lime tree,	.483	2.5	1	1	0.5	84	.0152	Do.
Walnut, green,	.920	2.5	1	1	0.5	62	.020	Ebbels.
Chesnut, Spanish,	.895	2.5	1	1	0.5	68.5	.0187	Do.
Acacia,	.820	2.5	1	1	0.5	125	.0102	Do.
Plane, dry,	.648	2.5	1	1	0.5	99.5	.0128	Do.
Alder, do.	.555	2.5	1	1	0.5	80.5	.0159	Do.
Birch, do.	.720	2.5	1	1	0.5	90.5	.0141	Do.
Wych elm, green,	.763	2.5	1	1	0.5	92	.014	Do.
Lombardy poplar, dry,	.374	2.5	1	1	0.5	56.5	.0224	Do.
Mahogany, Honduras, }	.560	2.5	1	1	0.5	118	.0109	Tredgold.
Do. Spanish,	.853	2.5	1	1	0.5	93	.0137	Do.
Sycamore,	.590	2.5	1	1	0.5	76	.0168	Ebbels.
Pear, green,	.792	2.5	1	1	0.5	59.5	.0215	Do.
Cherry, do.	.690	2.5	1	1	0.5	92.5	.0138	Do.
Beech, dry,	.696	2.5	1	1.	0.5	97.5	.0131	Do.

Table of Experiments on the Stiffness of Iron.

Kind of Iron.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection in inches.	Weight producing the deflection in lbs.	Constant a from $a = \frac{40\,b\,d\,3\delta}{l\,3\,W}$	Authorities.
Malleable Iron Swedish .		3	1	1	.25	560	.0066	Barlow.
Do. .		3	1	1	.30	560	.0078	Do.
English king & queen .		3	1	1	.25	560	.0066	Do.
Cast Iron, old park .	7.092	$2\frac{1}{4}$	1.3	.65	.27	162	.00114	Tredgold.
Cast Iron gray		3.83	1.066	1.066	.47	335	.00134	Rondelet.
Do .		3.83	1.066	1.066	.411	335	.00135	Do.
Do. .		1.915	1 066	1.066	.089	483	.00112	Do.
Do. .		1.915	1 066	1.066	.078	483	.00118	Do.

The application of the results contained in the preceding table is sufficiently obvious, at least while the deflection is intended to be $\frac{1}{480}$th of the length, and if in any case a greater deflection be admissible, or a less be requisite, it is only necessary to find a new value of a from the tabular one, by saying, as the proposed deflection, divided by the length, is to $\frac{1}{480}$, so is the tabular value of a to the value sought; with which proceed according to the following rules or formula:

When the length, breadth, and weight are given, to find the depth then

$$d = \sqrt[3]{\frac{a\,l^2 W}{b}}$$

When the length, depth, and weight are given, to find the breadth $$b = \frac{a\,l^2 W}{d^3}$$

These are the only cases which arise in practice, and the numerical operations are sufficiently evident without any numerical examples.

On the Resistance of Columns to a Vertical Pressure.

We have already given a detail of various experiments on the force requisite to crush certain materials, but in the case here to be considered the material is not destroyed by the actual crush, but by a flexure which always takes place, and after which the mechanism of the operation resembles that already considered, under the denomination of the transverse strain. The results, however, from actual experiment, are, in this case, by no means so uniform as in the former; and theory, it must be acknowledged, can assist us but very little, because theory always supposes an uniformity of result in practical cases, where all the conditions are the same, but here with two trees, of the same wood, the same specific gravity, and the same dimensions, owing to some internal and hidden cause, will give results very wide of each other; the bending will take place in different parts and in different directions, and the fracture produced by different weights. It is therefore only within certain limits that practical rules can be laid down in these cases. In pieces of timber submitted to a transverse strain, the effect of the weight is greatest in a certain and determinate point, and if the material be sound at that place, a defect in another part is seldom of any consequence; but when the whole piece is submitted to pressure endwise, every defective part has an influence in the operation; and to this cause may be principally attributed the irregular nature of results obtained in experiments of this description. Therefore, in stating the following principles of computation, the reader will be aware that the same security cannot be placed in them as in those which have preceded, and that they are only applicable when the timber is uniformly sound throughout. They may be stated as follows, viz.

The resistance to flexure varies directly as the breadth into the cube of the depth, or as the least dimension into the cube of the greater;

And the strain varies as the square of the length into the weight;

Consequently, if we have a series of experiments, showing the flexure which has been produced by certain weights in beams of given dimensions, we may hence compute the weight that would produce any other given flexure, and hence again the length and weight, in any other case, being given, we may compute the requisite breadth and depth, these being either equal, or bearing any given proportion to each other.

The two following tables are of this description, the one extracted from "Construction des Ponts, &c." of M. Gauthey, and the second from the "Traité Analytique de la Resistance des Solides," by M. Girard, as they are given by Mr. Tredgold in his Elementary Principles of Carpentry. The elasticity e, however, as deduced from these experiments, the latter author considers too strong for general practice, and he recommends in practical cases to use the mean value $e=$ for oak, and this being assumed, he has computed the mean value for the other woods stated in a preceding table for the transverse strain; this table we have also given. And since, acccording to the preceding analogies, it appears that $\frac{b\,d^3}{l^2 W} = e$ or constant quantity, we shall have at once for computing the depth or least thickness of beams (all the rest being given),

$$d = \sqrt[3]{\frac{l^2 W e}{b}} \quad \text{or} \quad b = \delta \frac{l^2 W e}{d^3}$$

when d is given, and b the greater side is sought.

It appears also to have been determined that a column or cylinder has a less power of resistance than a rectangular beam (in which $b\,d^3 = D^4$, D being the diameter of a circle) in the ratio 1: 1.7, therefore for a cylinder, the formula for the diameter is

$$D = \sqrt[4]{(l^2 W \times 1.7\,e)}$$

also a rectangular beam is said to be weakest in the direction of its diagonal, and when square to require the multiplier 4, so that in a square beam

$d' = \sqrt[4]{l^2 W \times 4\,e}$, where d′ is the diagonal.

We have, in compliance with general practice, given these rules, the investigation of some of which may be seen in Tredgold's work above quoted, and in Dr. Young's Lectures on Natural Philosophy; but we have already stated our opinion of their inadequacy, that is, they would be true provided we could assume an uniformity of texture throughout, but this is seldom to be expected in practice. The tables, however, are computed on the lowest possible resisting powers, so that the dimensions determinable by the rules will never fail in point of strength, unless the timber be very deflective, and it is much better to have our dimensions in excess than our strength in defect. For the reasons stated in the preceding section, the numerical application of these tables and formula are omitted.

Experiments on the Resistance of Seasoned Oak Beams to Forces pressing in the direction of their length.

Kind of wood.	Length in feet.	Breadth in inches.	Depth in inches.	Deflexion in inches.	Weight producing the deflection in lbs.	Proportional elasticities.	Duration of the experiment in hours.	Weight that broke the pieces.	Authority.
Oak seasoned.	2.125	2.126	2.126	.0787	7,856	.0006	4	15.631	Lamande.*
				.03937	13,525	.00033	6	21.296	
				.1181	14,119	.00032	18	19.993	
				.03937	11,750	.00042	8	21.060	
Do.	4.25	2.126	2.126	.0787	6,298	.0002	21	11.844	do.
				.1574	6,298		27	12.225	
				.1574	6,298			13.565	
				.1574	6,298		6	12.458	
Do,	6.375	2.126	2.126	.1574	3,277	.00015	6	7.244	do.
				.1574	2,860	.00018		7.484	
				.2361	2,750	.00019	5	8.492	
				.1574	2,750			7.878	
Do.	2.125	3.18	3.18	.0787	34.599	.0007	27	50.058	do.
				.03937	45,168	.0005	24	50.958	
Do.	4.25	3.18	3.18	.1574	20,317	.0003	29	43.639	do.
				.1574	18,647	.00031	5	36.865	
				.19685	20,578	.0003	9	36.205	
				.27559	21,819	.00026	17	28.182	
Do.	6.375	3.18	3.18	.1574	9,121	.00028	7	26 939	do
				.19685	9.713	.00027	19	28.987	
				.0787	11,000	.00023	4	23.929	
				.2361	10,142	.00025	18	33.048	
				.1574	12,746	.0002	6	36.902	
Do.	2.125	4.25	4.25	.0787	61,883	.00118	11	95.262	do.
				.03937	56,691	.00129	8	66.112	
				.03937	56,693		23	105.826	
				.0787	67,467	.00107	28	94.476	
				.03937	57,780	.00125	30	88.442	
Do.	4.25	4.25	4.25	.03937	63,066	.00027	8	100.755	do.
				.0787	29,695	.0006	5	85.998	
				.0787	50,525	.00035	19	73.238	
				.03937	45,201	.0004	19	96.368	
Do.	6.375	4.25	4.25	1574	21,586	.00038	7	64.090	do.
				.2361	17,331	.00047	5	59.373	
				.1574	18,517	.00044	22	54.062	
				.2361	27,599	.0003	22	65.608	

Experiments on the Resistance of Oak Beams when pressed in the direction of its length, by M. Girad.

No. of experiments.	Kinds of wood.	Specific gravity.	Length in feet.	Breadth in inches.	Thickness in inches.	Deflection in inches.	Weight which produced deflection in lbs.	Proportional elasticity.	Time in hours.	Weight that broke the piece, and remarks.
1	Oak	1.038	8.52	6.22	5.06	0.268	38,105	0.00029	0.83	Recovered its first form.
3	do.	1.010	8.52	6.22	4.00	0.09	26,381	0.0002	0.83	Retained a slight flexure.
4	do.	1.000	8.52	5.21	3.9	0.445	26,384	0.00016	6.66	ditto.
5	do.	.925	8.52	5.15	4.17	6.665	26,392	0.00019	6.66	50.448
7	do.	.973	7.46	6.22	5.06	not sensible.	38,098	0.00038	0.83	
						0.157	50,454	0.00028	2.08	Recovered its first form.
8	do.	.972	7.46	6.13	4.09	0.244	38,104	0.00019	12 08	72.865.
9	do.	.925	7.46	6.22	4 00	0 267	38.106	0.00018	12.08	62.977.
10	do.	1.038	7.46	4.97	4.00	0.312	26,397	0.00021	10.00	Retained a slight flexure.
11	do.	1.102	6.39	6.13	5.24	0.177	38,107	0.00057	7.08	ditto.
13	do.	.987	6.39	6.22	4.00	0.177	38,106	0.00025	2.08	Recovered its first form.
15	do.	1.032	6.39	5.24	4.17	0.22	38,048	0.00024	10.00	ditto.
17	do.	.920	7.46	6.22	4.25	1.114	26,396	0.00032	10.00	ditto.
19	do.	1.038	8.52	6.22	5.06	0.177	26,392	0.00042	10.00	
20	do.	9.44	8.52	7.37	6.22	0.09	26,394	0.0009	10.00	Recovered its first form.
21	do.	8.42	8.52	7.46	6.22	0.03	26,396	0.00093	10.00	

Table of the Elasticity of various Woods to be employed in the preceding rule, as computed by Mr. Tredgold.

Kinds of wood.	Elasticity =e	Kinds of wood.	Elasticity =e
English Oak, .	0.0015	Mahogany, Honduras,	0.00161
Beech, .	0.00195	Teak, . .	0.00118
Alder, . .	0.0023	Cedar, Lebanon,	0.0053
Chesnut, green,	0.00267	Riga fir, . .	0.00152
Ash, . .	0.00168	Memel fir, .	0.00135
Elm, . .	0.00184	Norway spruce,	0.00142
Acacia, . .	0.00152	Weymouth pine,	0.00157
Mahogany, Spanish,	0.00205	Larch, . .	0.0019

On the Resistance to Torsion.

Mr. Tredgold, in his Practical Essay on the Strength of Cast Iron, has the following illustration of the nature of this strain. If a rectangular plate be supported at the corner A and B, Fig. 5, and a weight be suspended from each of the other corners C, D, then the strains produced by loading it in that manner will be similar to the twisting strains which occur in shafts. In a cast iron plate, the fracture would take place in the directions AB, and CD, at the same time; but before the fracture, the ore of the strains will serve as a fulcrum for the other; and the resistance to the forces at C and D will be sensibly the same as if the plate were supported upon a continued fulcrum in the direction AB.

Hence, the strains may be considered as a transverse strain of the same kind as that already treated of with the leverage a D, or c C, acting at D or C, the breadth of the strained section being AB.

To find the breadth of the section of fracture, and the leverage in terms of the length and breadth of the plate, we have AB the breadth, and by similar triangles $\frac{AD \times BD}{AB} = D\,a$ the leverage. These values of the leverage and breadth being substituted in the equation, expressing the transverse strain, becomes

$$W \times \frac{b^6\, d}{b\, l} = \frac{f\, d^2 \times AB \times AB}{6 \times AD \times BD}$$

Or since $AB^2 = BD^2 \times AD^2$

$$W = \frac{f\, d^2}{6} \times \frac{BD^2 \times AD^2}{AD^2 \times BD}$$

But when a force acts upon a shaft, it is commonly at the circumference of a wheel, and if R be the radius of the wheel, then $\frac{2\, RW}{BD}$ = force collected at the surface of the shaft; substituting therefore this instead of W in the above equation, we have

$$\frac{2\, RW}{DB} = \frac{f\, d^2}{6} \times \frac{BD^2 \times AD^2}{AD \times BD}$$

$$\text{Or} \quad W = \frac{f\, d}{12\, R} \times \frac{BD^2 \times AD^2}{AD}$$

Experiments relating to Torsion.

The following experiments were made by Mr. George Rennie, and published in the Philosophical Transactions for 1818. The apparatus consisted of a wrought iron lever, two feet long, having an arched head of about 60°, and four feet diameter, of which the lever represented the radius: the centre round which it moved had a square hole made to receive the end of the bar to be twisted. The lever was balanced, and a scale hung on the arched head; the other end of the bar being fixed in a square hole, in a piece of iron, and that again in a vice. The following are the results of these experiments:—

EXPERIMENTS.

On Twists close to the Beaming cast Horizontal.

No's.		lbs.	oz.	
1¼	Inch bars, twisted as under with	10	14	in the scale.
2¼	ditto, bad casting	8	4	
3¼	ditto	10	11	
	Mean	9	15	

Cast Vertical.

	lbs.	oz.
4¼	10	8
5¼	10	13
6¼	10	11
Mean	10	10

On Twists of different lengths Horizontal Cast.

	Weight in Scale lbs.	oz.
7¼ by ½ long	7	3
8¼ by ¾ do.	8	1
9¼ by 1 inch do.	8	8
Vertical.		
10¼ by ½ do.	10	1
11¼ by ¾ do.	8	9
12¼ by 1 inch do.	8	5

Cast horizontal Twists at 6 Inches from the Bearing.

13¼ by 6 inches long	10	9
14¼ by do. do.	9	4
15¼ by do. do.	9	7

Twists of half an Inch Square Bars, cast Horizontal.

	qrs.	lbs.	oz.	
16½ close to the beam	3	9	12	end of the bar hard.
17½ do	2	18	0	middle of the bar.
18 at 10 inches from bearing lever in the middle	1	24	0	

On Twists of different Materials.

These experiments were made close at the bearing, and the weights were accumulated in the scale until the substances were wrenched asunder.

	lbs.	oz.
19 Cast Steel	19	9
20 Shear Steel	17	1
21 Blister Steel	16	11
22 English Iron	10	2
23 Swedish Iron	9	8
24 Hard Gim Metal	5	0
25 Fine Yellow Brass	4	11
26 Copper	4	5
27 Tin	1	7
28 Lead	1	0

It will of course be understood that these experiments give only the relative resistance to torsion, and not the actual resistance.

On the Resistance of Cylinders to Internal Pressure.

With respect to internal pressure, such as that sustained by water pipes, hydraulic cylinders, &c. we know of no actual experiments, but the amount of resistance is so directly dependent on the resistance to tension, that no experiments are in this case necessary. If we examine the force which tends to produce the rupture in this case, it will be seen immediately that it varies as the longitudinal section of the cylinder; or which is the same, the circumferential strain on any given point of the interior of the cylinder, is equal to the pressure on a square inch multiplied by the number of inches in the radius. That is, the force tending to rend the cylinder along any line parallel to its axis, is equal to a pressure on a section between the circumference and axis.

Hence it would appear at first sight that the determination of the thickness to resist this pressure would be simply to determine the sectional area of the metal requisite for this purpose, on the supposition of every part bearing an equal torsion: this, however, is not sufficient, and practice has pointed out that in presses and pipes, it is always necessary to increase the thickness in a higher ratio than the pressure. This subject has been investigated by Mr. Barlow, and the following is the result of his inquiries. If we imagine, as we ought to do, that the metal, in consequence of the internal pressure, suffers a certain degree of extension, it will be found that the external circumference participates less in this extension than the internal, and as the resistance is proportional to the extension divided by the length, it follows that the interior circumference, and every successive circular lamina from the exterior to the interior surface, offers a less and less resistance to the interior strain. The law of which it is our object to investigate.

In the first place, it is obvious that whatever extension the cylinders or ring may undergo, there will be still the same quantity of surface, independently of the small change due to compression, in the section of the ring, which area is always proportional to the difference of the squares of the two diameters.

Let D be the interior diameter before pressure, and $D + d$ its diameter when extended by the pressure.

Let also D' be the exterior diameter before pressure, and $D' + d'$, its diameter when extended by pressure.

Then from what is stated above we have

$$D'^2 - D^2 = (D' + d')^2 - (D + d)^2$$
$$\text{Or } 2\,D'd' + d'^2 = 2\,D\,d + d^2$$
$$\text{Whence } 2\,D' + d' : 2\,D + d :: d : d'$$

Or considering d' and d as very small in comparison with $2\,D'$ and $2\,D$, this becomes

$$D' : D :: d : d'$$

That is, the extension of the exterior surface is to that of the interior, as the interior diameter to the exterior,

But the resistance is as the extension divided by the length, therefore, the resistance of the exterior surface is to that of the interior, as $\frac{D}{D'} : \frac{D'}{D'^2}$ Or $D^2 : D'^2$.

That is, the resistance offered by each successive lamina is inversely as the square of its diameter, or inversely as the square of its distance from the centre; by means of which law the actual resistance due to any thickness is readily ascertained.

Let r be the interior radius of any cylinder, p the pressure per square inch on the fluid, t the whole thickness of the metal, and x any variable distance from the interior surface. Let also s represent the strain exerted, or the resistance sustained, by the interior lamina, then by the law last deduced

$(r + x)^2 : r^2 : s : \frac{r^2\ s}{(r+x)^2}$, the strain at the distance, a from the interior surface, consequently,

$$\int \frac{r^2\ s\ d\ x}{(r + x)} + cor. = \text{sum of all the strains.}$$

This, when $x = t$ becomes

$$R = r^2\ s\ \left(\frac{t}{r} - \frac{t}{r+t}\right) = \frac{s\ r\ t}{r+t}$$

That is, the sum of all the variable strains or resistances on the whole thickness t, is equal to the resistance that would be due to the thickness $\frac{r\ t}{r+t}$ acting uniformly with a resistance s.

Let us now suppose (the above law being established) the radius r, and the pressure p per square inch on the fluid, to be given, to find the thickness necessary to resist it, or such that the strain and resistance may be in equilibrio, the cohesive power of the metal being also given. Let x represent the thickness required, and c the cohesive power of the metal per square inch; then, the greatest strain the area $\frac{r\ x}{r+x}$ can sustain, is $\frac{r\ x\ c}{r+x}$, and that which it has to sustain is $p\ r$; hence, when these are equal we shall have

$$r\,p = \frac{r\ x}{r+x}\ c, \text{ or } p\ r + p\ x = x\ c$$

$$\text{Whence} \quad x = \frac{p\ r}{c - p}.$$

Hence the following rule in words at length.

To find the thickness of Metal.—Multiply the pressure per square inch by the radius of the cylinder, and divide the product by the difference between the cohesive power of the metal per square inch, and the pressure per square inch, and the quotient will be the thickness sought.

As an example, let it be required to determine the thickness of metal in two presses, each 12 inches in diameter, in one of which the pressure is $1\frac{1}{2}$ tons, and in the other, 3 tons per circular inch: the cohesive strength of cast iron being 18,000lbs. per square inch. Here $1\frac{1}{2}$ tons per circular inch = 4278 lbs. per sq. inch.
3 tons = 8556

Hence by the rule

$$\text{First } \frac{4278 \times 6}{1800 - 4278} = 1.87 \text{ inches thickness.}$$

$$\text{And } \frac{8556 \times 6}{1800 - 8556} = 543 \text{ inches thickness.}$$

It appears, therefore, that in this second case, although the pressure is only double the former, the metal requires to be nearly three times the thickness.

STROMA, see CAITHNESS, Vol. V. p. 132.

STROMBOLI, the most northerly of the Lipari Isles. It is about ten miles in circuit. The population of the island, amounting to about 1000 persons, are lodged in an irregular collection of cottages and fishermen's huts. A small portion of the island is cultivated, and the inhabitants are chiefly occupied in fishing. Rabbits are here abundant.

The island consists of a single conical mountain, having on one side of it several small craters, one of which is in ceaseless activity, having in all probability continued so during the last 2000 years. The mountain rises at an angle of nearly 40°. The crater is placed upon the slope of the precipice. The gaseous fluids escape from the volcano in successive explosions, the greater ones at intervals of about seven minutes, and the lesser ones almost continually. The lava is thrown out only as projected scoriæ, and is seldom or never discharged in any quantity. The inhabitants assured Mr. P. Scrope that in the storms of winter the side of the cone occasionally split, and discharged into the sea a current of lava which destroyed the fish.

Dr. Daubeny found that that part of the island not in the immediate vicinity of the volcano, was chiefly composed of a tuff. In one place the cavities were lined with very minute laminæ of specular iron. The tuff is in some places penetrated by dykes of a cellular description of rock approaching to trachyte.

According to Mr. Scrope, the lavas of Stromboli have a high degree of fluidity, as their cellular nature shows, and also an extremely high specific gravity, being solely augitic. East Long. 15° 55'; North Lat. 38° 58'. See Spallanzani's *Tracts*, vol. ii. and iv. Mr. Scrope's *Considerations on Volcanoes*. Lond. 1825, p. 6, 56. Dr. Daubeny's *Description of Volcanoes*. Lond. 1826, p. 183-186.

STROMNESS. See ORKNEY, Vol. XV. p. 78.

STRONSAY. See ORKNEY, Vol. XV. p. 81.

STRONTIAN, a small village in Argyleshire, situated on Loch Sunart, celebrated for its lead mines, and for having given its name to the new earth of Strontites, first analysed by Dr. Hope. The minerals found at this place will be learned from the list of Scottish minerals given in our article SCOTLAND, Vol. XVI. p. 697. See also Dr. Brewster's *Journal of Science*, Vol. I. p. 225, and CHEMISTRY, Vol. V. p. 685—706.

STROUD, a town of England, in Gloucestershire, situated near the junction of the Frome and Stroud Water. The houses stand irregularly on the bank of the river. The Church of St. Lawrence consists of a nave, chancel and side aisles, with a tower and spire. There are also chapels for the Wesleyan Methodists and Independents, a free school, and several charity schools. Stroud is the centre of an extensive trade in fine cloth, most of which is in grained colours, particularly scarlet, the water of the river being supposed particularly fitted for such purposes. All the surrounding vallies are covered with houses and villages, inhabited by those engaged in the manufacture. The Thames and Severn Canal gives great facility to the trade of the place. Population of the parish in 1821; 1419 inhabited houses; 1493 families; 1144 families employed in trade; and 7097 inhabitants.

STRUENSEE, John F. See Denmark, Vol. VII. p. 491.

STRYCHNIA, the name of a new alkali, which has been obtained from the fruit of the *Strychnos ignatia*, the *Strychnos nux vomica*, and from the *Upas*. It was discovered in 1818 by MM. Pelletier and Caventou.

The following process for obtaining it is recommended by M. Carriol. The solution of *nux vomica*, treated with successive portions of cold water, is evaporated to a syrup, and the gum precipitated by alcohol. The alcoholic solution is then evaporated to an extract by the heat of a water bath. This extract, which is the *Igasurate* of *Strychnia*, when deprived of a little fatty matter by solution in cold water, is heated and the strychnia precipitated by a slight excess of lime water, and then dissolved by boiling alcohol. By evaporating the spirit, the alkali is obtained nearly pure. It occurs in four-sided prisms. It is highly soluble in boiling alcohol, but almost insoluble in water, requiring 6000 parts of cold, or 2500 of boiling water. It is intolerably bitter, and water containing only one 600,000th part of the weight of strychnia, tastes bitter. It is united in the nux vomica with igasuric acid, the existence of which, as a separate acid, is still doubtful. This alkali affords a red colour with strong nitric acid.

It is a most virulent poison. Half a grain blown into the throat of a rabbit kills it in five minutes. It is composed of 78·22 carbon, 6·38 oxygen, 6·54 hydrogen, and 8·92 nitrogen. For farther information see Dr. Turner's *Elements of Chemistry*, 2d edition, 1829, p. 651. *Mem. de Chim.* vol. x. and xxvi. and *Journal de Pharmacie*, 1825, p. 492.

STUTTGARD, the capital of the kingdom of Wirtemberg, is situated in a valley on the banks of the Nisselbach, about two miles from the Neckar. It consists of the city, two well built suburbs adjacent to each other, and the insulated suburb of Esslingen. Some of the streets are broad, and others very narrow. The houses, which are chiefly of wood, are tolerably good. The principal public buildings are the palace, which is a splendid building, near an extensive park. It contains a fine library and collection of paintings. The library consists of above 100,000 volumes, among which is a very interesting collection of battles, and a collection of plans and military charts. Near the palace is a commodious opera house, a theatre, a museum of natural history, and an academy of paintings, sculpture and architecture. There is also at Stuttgard a gymnasium, a college, a society of physicians and lovers of natural history, founded in 1804. The collection of the old university still exists, and the natural history cabinet of Roesler now belongs to the gymnasium. The other public buildings are the old palace, the collegiate church, the hotel de ville, the barracks, the town library, the mint and the royal stables. In the environs of Stuttgard are the *Solitude*, the Hirschbad, and the palace of Ludwigsburg, with its fine collection of pictures, the park of Hohenheim, the Roman baths, the house for the orphans of soldiers, the prison and the porcelain manufactory. The chief manufactories are cotton, silk, hats, leather and snuff. Population, 18,000.

STYRIA, a large province of the Austrian empire, is bounded on the north by Austria, on the east by Hungary, on the south by Carniola, and on the west by Carinthia. It extends about 110 miles from east to west, and from 25 to 45 from north to south, and contains about 8500 square miles. It is subdivided into Upper and Lower Styria.

Upper Styria.	Lower Styria.
Circle of Iudenburgh.	Circle of Gratz.
Bruck.	Marburg.
	Cilley.

A branch of the Alps, rising in different parts to the height of 6000, 7000, 8000 or 9000 feet, extends through Upper Styria from west to east, part of them being covered with perpetual snow. The ramifications which are sent out into Lower Styria, gradually decline into small elevations. The principal rivers are the Drave, the Save, the Enns, and the Muhr. In Upper Styria, the climate is very cold, though the air is pure. The winter lasts from November till May, and as cottages are inhabited at very great heights in the mountains, the people are kept prisoners for several months when there are falls of snow. The steep declivities of these elevated regions are cultivated by the plough, and produce a fine species of wheat, which they are able even to export. The Styrians have large herds of cattle, on which they bestow much care, and they are well shaped and of a middle size. Sheep are not yet brought to great perfection, and the horses are fit chiefly for draught. There are here wild fowl, game, and the chamois, with abundance of fine fish in the mountain lakes.

In Lower Styria, wheat, barley, oats, rye, and potatoes, and, in warm exposures, maize, are cultivated. In some of the warm vallies very fine corn is successfully cultivated.

Styria abounds in valuable mines. Gold, silver, and copper occur in small quantities, but lead is scarce. Coal is wrought in some places, but not with the spirit which it deserves. The mountain of Erzeberg is a solid mass of iron ore, and yields annually 13,000 tons. The total produce of Styria in iron is from 16,000 to 20,000 tons. There are good salt works at Aussee, and mineral springs are numerous. Cobalt, arsenic, and molybdena, are found in this province.

There are in Styria 200 forges, and 30 manufactories, where about 300,000 sickles and some scythes are annually made. The other articles of manufacture are nitre, alum, gunpowder, and sulphur. Earthenware is also made, and some coarse linen. The imports are woollen and linen goods, silk, oil, tobacco, and colonial produce. The exports are iron, steel, sickles, scythes, corn, wine, flax, olive oil, and cattle. There are nearly 120 towns or little villages in the province, and 500 citadels, many of which stand on the highest summit of the rocks. Iudenburgh is the capital of Upper, and Gratz of Lower Styria. The people are principally Roman Catholics. About 15 inches of rain fall annually. Population about 840,000. See Gratz,

STYLE. See CHRONOLOGY, Vol VI. p. 252.

SUABIA. See SWABIA.

SUAKIN, or SUAKEM, a Turkish sea port town, and Island of Nubia, anciently *Theon Soter*. The town has an imposing appearance at a distance, from the effect of two minarets, but it is mean when seen nearer. The harbour is capable of holding 200 large vessels. Water and provisions are good. The town carries on a small trade with the coast of Africa, Arabia, and Egypt. East. Long. 37° 35. N. Lat. 19° 48.

SUBTRACTION. See ARITHMETIC, Vol. II. p. 357; and ALGEBRA, Vol. I. p. 403.

SUDBURY, a borough of England, in Suffolk, situated on the river Stow, which is crossed with a stone bridge, and occupying several irregular streets.

The principal buildings are the three parish churches of St. Gregory's, St. Peter's and All Saints, which are handsome, besides an ancient market house. The town has a considerable manufacture of toys, perpetuanas, buntings, and crape, and as the Stow is now navigable to Manningtree, an active trade is carried on in the produce of the neighbourhood. The town returns two members to parliament by the votes of 725 freemen. Part of the priory of St. Augustine, converted into a house, still exists.

The population of the borough in 1821.

Houses,	819.
Families,	955.
Do. in Trade,	671.
Population,	3950.

See the *Beauties of England*, vol. xiv. p. 147.

SUDERMANIA, or SUDERMANLAND, one of the middle provinces of Sweden, is about 100 miles long and about 55 broad, containing 3470 square miles. The mountainous part contains mines of lead, copper, iron and cobalt. There is much arable land, which is fertile and well cultivated. The principal lakes are the Maelar, which bounds it on the north, the Hielmar and Bawer, and many smaller ones, which abound in fish. Nykioping is the capital of the province. Population 156,000. See SWEDEN.

SUDEROE. See FAROE.

SUETONIUS, TRANQUILLUS CAIUS, a celebrated Roman author, was born A.D. 117. He was secretary to Adrian, but was banished from the court in consequence of disrespect to the empress. He enjoyed in seclusion the friendship of Pliny, and composed various works; the only one of which extant is his Lives of the Twelve Cæsars, with some fragments of his Catalogue of Famous Grammarians. One of the best editions of his work is that of Ernestus, Lips. 1775.

SUEZ, a town of Egypt, situated on the Red Sea, on the isthmus of the same name. It was the ancient Arsinoe. The town is supposed to have been built within the last 300 years. In the time of Niebhur it was as prosperous as Cairo, but it has since greatly declined, the French having destroyed one half of its houses, which then amounted only to 900. Vessels cannot approach nearer than about two and a half miles of the town. The country around is a desert; but there is still some trade with Gaza, Joppa, and Jerusalem, by caravans which bring soap, oil, and tobacco. Coffee, tea, pickled ginger and tamarinds are the chief exports. East Long. 32° 28′, and North Lat. 30° 1′.

SUFFOLK, a maritime county of England, is bounded on the east by the German Ocean, on the south by Essex, on the north by Norfolk, and on the south by the county of Cambridge. It is about 47 miles long and 27 broad, and contains 1,512 square statute miles, or 967,680 statute acres. The rental of land is £694,078 + £117,405 of tithe, and the annual value of a square mile is £537. In 1806 it paid £1,731,763 of property tax.

Suffolk is politically divided into the franchise or liberty of Bury St. Edmunds and the Geldable land; and though there is only one assize for the county, yet two grand juries are always appointed, one for the Geldable land, and the other for the liberty of Bury St. Edmunds. These are subdivided into 21 hundreds and 523 parishes. The county pays 20 parts of the land-tax, furnishes 960 militiamen, and returns 16 members to parliament, two for the county, and two for each of the towns of Aldborough, Dunwich, Eye, Ipswich, Orford, Sudbury, and Bury St. Edmunds.

The county is governed ecclesiastically by the bishop of Norwich, aided by the archdeacons of Sudbury and Suffolk. In 1803 the money levied for the poor was £149,666, or 4*s*. 10½*d*. per pound of annual rate.

Suffolk in general presents a level surface, diversified with but few eminences of any considerable height. The great chalk ridge extends from Haverhill to Thetford in the county of Norfolk.

Suffolk is bounded on the south and west by navigable rivers, and is intersected by numerous streams. The navigable rivers are the Lark which joins the Great Ouse near Mildenhall. The Waveny, which, after approaching the very sea-shore, is driven back abruptly by a rising ground, and runs due north to the Yar, the Deben, which passes Woodbridge and falls into the sea; the Gipping, which receives the name of the Orwell below Ipswich, to which it is navigable, and joins the Stour opposite to Harwich; the Blythe, which runs near Saxfield, and is navigable to Framlingham; and the Stour, which separates the county from Essex, falls into the sea, between Harwich and Landguard fort. The other rivers are the Little Ouse and the Alde. The only canal in Suffolk runs from Ipswich to Stowmarket.

The soil of Suffolk embraces almost every variety from the lightest sand to the heaviest clay; the former occurs principally in the northwest of the county, which is a dreary barren district, sustaining upon its patches of heath a few sheep and rabbits. Even here, however, by means of the free use of clay, much valuable land has been reclaimed. The interior of the county is a strong fertile loam, which rewards the skill with which it is managed by most abundant crops. The portion called High Suffolk has a very stiff and retentive soil, but yields fine wheat, oats, beans, hemp, and cabbage. The bean crops are highly productive. Turnips and carrots are extensively cultivated. Every garden rears a small portion of hemp, and a few hops are grown near Stowmarket. The seaward district is generally sandy, but it bears excellent barley when enriched with shell marl, which occurs in vast beds near Woodbridge. A small part of the county is fenny, and peat bog is in some cases found from one to six feet beneath the surface.

The farming stock of this county is highly valuable.

Suffolk furnishes an excellent breed of draught horses, which are strong, active, and capable of great exertion. The cows, which have no horns, are excellent milkers, yielding from five to eight gallons a day. The dairy district is extensive, and the quantity of butter sent annually to London is about 40,000 firkins. The sheep, which are very numerous, are chiefly of the Norfolk breed. Within the last 40 years the breed has been nearly changed by the introduction of the South Down breed, which was effected by Arthur Young. Hogs, poultry, and pigeons are numerous.

There are many rabbit warrens; one near Brandon yields 40,000 rabbits annually.

Suffolk has almost no manufactures, the woollen manufacture occupying in 1785 about 37,600 persons, having been chiefly transferred to Yorkshire. At Stowmarket coarse linen is made, at Sudbury, says, &c. (See SUDBURY) some bone lace near Eye, and at Lavenham some calimancoes. The principal exports are corn and malt. Woodbridge has a share of the coasting trade and makes some fine salt, and lime from fossil shells. Lowestoff and Southwold have a mackarel and herring fishery in which many vessels are engaged.

One of the principal objects of antiquity in Suffolk is the Roman castle of Burgh situated on an eminence near the confluence of the Yare and Waveney. It is supposed by Camden and others to be the *Garianonum* of the Romans, erected in the reign of Claudius by Scapula who conquered the Iceni. It forms three sides of a parallelogram with rounded angles. The north and south sides are each 321 feet long, and the east side 642 feet long; the walls are sixteen feet high and nine feet thick, enclosing five and a half acres, including the walls: The chief entrance was on the east side. There is a circular moat at the south-west corner. A little to the north are the remains of a monastery, built by an Irish monk. The monasteries of Bury St. Edmunds and Framlington, and several old churches are among the most remarkable of the Saxon antiquities.

The following was the population of the county in 1821:

Number of houses	42,773
Families	55,069
Families in trade	17,418
Total population	270,542

The population of the chief towns are as follows:—

Ipswich, burgh of,	17,186
Bury St. Edmunds, burgh of,	10,000
Woodbridge town and parish	4,060
Sudbury, burgh of,	3,950
Lowestoff town and parish	3,675
Beccles town and parish	3,473
Bungay town and two parishes	3,270
Mildenhall town and parish	2,974
Hadley town and parish	2,929
Framlington town and parish	2,327
Stowmarket town and parish	2,252
Halesworth town and parish	2,166
Eye burgh and parish	1,882

For farther information respecting this county, see the *Beauties of England and Wales*, Vol. xiv. Young's *Agriculture of Suffolk*, and Kirby's *Suffolk Traveller*.

SUFFOLK, county of, Massachusetts, containing only the townships of Boston and Chelsea. See BOSTON. Including the city of Boston, this county in 1820 contained 43,941 inhabitants; and in 1830, 62,162, or above 41½ per cent.

SUFFOLK, a county in the state of New York, comprising the eastern part of Long Island, bounded by Queen's county W.; Long Island sound N.; and the Atlantic Ocean northeast and east. Length from W. to E. 80 miles. The width varies from one to near eighteen miles, but is at a mean of about eight; area 640 square miles. Extending in lat. from 40° 25′ to 41° 25′ N.; and in long. from 3° 33′ to 5° 8′ E. from W. C. The general range of this part of Long Island is from NNE. to SSW., and composed of a ridge extending in a similar direction with the island, and a slope falling from the ridge towards the Atlantic Ocean. The ridge rises rather abruptly from Long Island Sound, to from one hundred to in some places three hundred feet elevation. The eastern declivity near the base of the ridge also falls rather rapidly, and thence slopes by a more gradual descent to the level of tide water. This plain is followed by a chain of shallow and narrow sounds, which are again succeeded by a series of low, long, and narrow sand islets. The sounds are from two or three miles to a quarter of a mile wide, and in no place admitting vessels of more than two or three feet draught. The eastern extremity of the island and county is broken into two long points, with an intervening intricate bay. The southern promontory is terminated by Mortaug Point, and the northern by Oyster Pond Point. The northern, and relatively to the continent, the interior peninsula is about 30 miles long, and is evidently a continuation of the central ridge, and is continued in Plumb Island, Gull Island, Fisher's Island, and Stonington Point, outside the bay of Pawcatuck. On the whole the surface of Suffolk county on Long island may be regarded as level. Soil rather sterile, and much of it wooded with pine timber. The climate is, however, more mild and agreeable than that of the continent opposite; and such are the other advantages of position, that as early as 1820 the distributive population was 38 to the square mile, nearly the whole county having an aggregate of 24,272.

Though along the Atlantic side of the island the depth of water and want of harbors is very unfavourable for shipping, that is not so much the case on the eastern and western sides. The gulf which penetrates between Mortaug and Oyster Pond points, called Gardner's to the eastward, and Peconic bay still farther down the island, affords, beside some of lesser note, the haven and town of Sagg Harbor. This is indeed a very prosperous port of entry, and had in 1820 about 150 dwelling houses, 6000 tons of shipping, two extensive rope walks, three salt works, and 1296 inhabitants. N. lat. 41°; long. 4° 38′ E. of W. C. By post road 108 miles a little N. of E. from the city of New York, and 26 miles a little W. of S. from New London in Connecticut. Beside Sagg Harbour, and Suffolk, the seat of justice, there are thirty other post offices in Suffolk county.

SUFFOLK, post town and seat of justice, Nansamond county, Virginia, situated on the right or eastern bank of Nansamond river, 28 miles SW. by W. from Norfolk, and by post road 224 miles a little E. of S. from W. C., and 102 miles SE. from Richmond. N. lat. 36° 42′; long. 0° 26′ E. of W. C. Vessels of considerable tonnage ascend Nansamond river to Suffolk. Population about 400. DARBY.

SUGAR, the name of a well known vegetable product, of the general and chemical nature of which we have given a pretty full account in our article CHEMISTRY, Vol. V. p. 747.

The art of refining sugar, however, which is not described in that article, and which has been brought in this country to great perfection, still remains to be considered.

In the common method of refining sugar, the ordinary Muscovado sugar is boiled with fresh bullocks' blood and lime water, and the scum or impurities produced by the successive additions of the bullocks' blood, is continually removed, till the sugar casts up only a clean milky froth, which indicates the removal of impurities. In order to heighten the whiteness, a little of the finest indigo is added. In this operation the heat of the fire is applied directly to the pan containing the sugar.

The next process is that of evaporating the pure saccharine solution: This is effected by a moderate fire, and the boiling is continued till the sugar has the proper degree of viscidity or ropiness, which is easily ascertained by what is called the proof stick.

When the evaporation is completed, the hot sugar liquor is removed out of the pans into coolers, and it is here gently stirred to prevent the formation of a crust. It is then granulated by an oar, the violent motion of which continued for several minutes, destroys the viscousness of the sugar, and completes the granulation. The beauty of the sugar depends on the perfection of this process.

The next step is to fill the moulds, which are earthen vessels like inverted cones, the apex of which is undermost. The clarified concentrated juice is then poured in by three different pourings. In order to prevent adhesion to the moulds, and to lay the grain of the mass even and regular throughout, the sugar is scraped from the sides of the cone by a wainscoat knife, the fluid is allowed to rest a few minutes till it has got some firmness. The moulds are then stirred round three or four times, and the process is finished.

The above is the process for single loaves, or sugar once refined. The double loaves, or those doubly refined, are made by a process in which the clarification is effected by the whites of about 200 eggs for each pan, and with fresh water in place of lime water.

The scums taken off during these processes are employed to yield an inferior sugar by methods of purification, which are not interesting to the general reader.

We had left the sugar in the conical moulds. These moulds are now placed above pots, and the stopper or rag at the bottom or apex of the moulds having been previously taken out, and a punch made with an awl, there will exude from this aperture a syrup or molasses, which in twenty-four hours will fill one half of the pot. This syrup is then removed, and the pot replaced under the apexes of the moulds. A small ladleful of wet clay is then poured on the face or base of each loaf or cone of sugar, which, after drying into a cake, in five or six days is removed and laid by for future use. On the day following the loaves are clayed a second time, and the cake when dry, is removed like the first. Each loaf is now drawn out of its mould, and irregularities and impurities brushed off. They are next left some days in the moulds to acquire hardness of surface. They are then turned out upon paper, freed from all little specks, and then dried on a stove for five, six, or seven days, when they are fit for sale.

In the preceding method of refining sugar, between twenty and thirty-five per cent. of molasses are found in the pots, and it is supposed that about two-thirds of this are produced by the intensity of the heat employed for concentrating the syrup. To remedy this evil various ingenious methods have been devised and successfully put in execution.

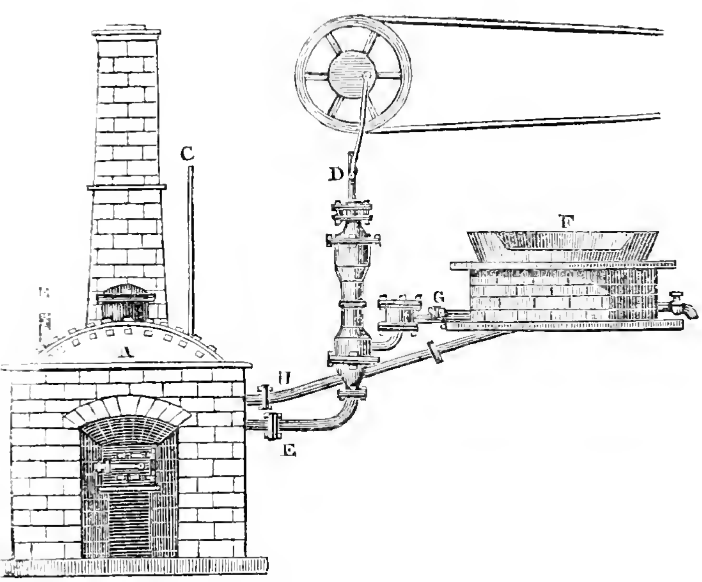
The first of these was invented by Edward Charles Howard, Esq. and was secured by patent in 1812. He brings the sugar liquor to a temperature of from 190° to 200° of Fahrenheit, by surrounding the pan with boiling water or steam, under the common pressure of the atmosphere.

A second method consists of covering the pan or boiler at top, and by creating a vacuum within the pan, to favour ebullition and rapid evaporation, at moderate heats. In these very ingenious processes Mr. Howard dispensed with the use of bullocks' blood, and he effected the clarification of the liquor by a system of ingenious canvas filters, assisted by a small quantity of pasty gypsum and alumina, formed by a saturated solution of alum in quick-lime. In the last purification, in place of covering the base of the sugar loaves with a stratum of wet clay, he covers them with a stratum of very fine saturated syrup.

In 1815, Messrs. P. and J. Martineau took out a patent for an improved method of refining sugar. It consists in employing animal charcoal, such as ivory black, bone ash or bone black, aluminous earths, ochres and lamp black. They prefer, however, the animal charcoal, and they use from two to five pounds of it for every cwt. of sugar to be refined. The usual finings of eggs, blood, or other albuminous matter, are used also in larger quantities than formerly, in order to combine the charcoal, &c. with the dirt in the sugar. The rest of the processes are the same as in common use; but the sugar thus produced has a high degree of purity and whiteness.

The most recent process for purifying sugar, and one which, from an accidental circumstance, has acquired great notoriety, is that of Mr. Daniel Wilson, who conceived the ingenious idea of boiling sugar by means of heated oil, passing through a worm or coil of copper pipe, fixed within the pan containing the sugar.

A view of this apparatus is annexed.



In the preceding elevation A is a wrought iron vessel for heating the oil, similar to the boiler of a steam engine. It is set in brick work, with a fire under it of a moderate size, and without any flues round the sides, so that the whole action of the fire is upon the bottom. It is made of an oblong form, and its length should exceed its breadth as much as the situation it is to be placed in will allow. The size depends upon the quantity of oil to be heated, or the liquor which is to be evaporated; and it is observable, that the more the surface presented to the fire exceeds the evaporating surface, the greater will be the economy of fuel. Whale oil, free from sediment, is found to answer better than any other for this purpose, and the quantity necessary to be employed is merely sufficient to cover the bottom of the vessel, to the depth of six or eight inches.

B is a thermometer for ascertaining the heat of the oil.

C is a small tube, opening at the lower end into the oil vessel, while the upper extremity passes into a long flue, called a steam vent, and communicating with the atmosphere. This pipe serves three different purposes: the first is, that before the pump begins to work in the morning, there is a quantity of air contained in it, and it is necessary there should be a vent for this when the pump is set to work, in order to prevent any compression in the inside of the vessel. The next is, that with a common suction-pump it is necessary there should be a communication with the atmosphere. Thirdly, it is designed to carry off the aqueous vapour from the fresh oil, which has a very bad smell, and such vapours would injure the sugars, if they got abroad in the sugar-house.

D is a cast iron pump, with a spring metallic piston communicating with the oil vessel A, by means of its suction-pipe E. It is set in motion in the usual manner, by some mechanical power.

F is a copper vessel, the bottom of which is covered in the inside by a coil or pipe, communicating at one of its ends with the pump at G, and at the other end with the oil vessel through the pipe H. Through this coil of pipe the heated oil circulates, and being surrounded on all sides by the liquid in the pan F, it gives out about 100° of heat in its passage, and returns to the oil vessel to obtain a fresh increase of temperature. This pan is surrounded by brick or wood work, to prevent cooling. Of course it has no fire under it.

This ingenious apparatus was erected in August 1819, by Messrs. Severn, King and Company, and one of the pans was wrought with great satisfaction and profit for nearly three months, when in Nov. 1819, a fire broke out and occasioned a loss of L. 80,000. On the ground that this new mode was more dangerous than the other one, the insurance offices refused to make good the above loss, and that celebrated trial took place in which half of the London chemists gave evidence the reverse of the other half. The point was decided against the insurance offices.

Mr. Wilson's process differed also in other respects from the common one. For every cwt. of sugar a solution of sulphate of zinc, in as small a quantity of water as possible, is added to the melted sugar in the pan. The oxide of zinc combines with the extractive matter, tannin and gallic acid, and renders them insoluble, while the sulphuric acid combined with the lime is insoluble also. When a strong grain is required, and the raw sugar contains much acid, a mixture of lime, consisting of an oz. of powdered lime in water is added about five minutes after the sulphate of zinc solution has been added. This method is used along with the patent filtering apparatus invented by Mr. J. Sutherland.

It is well known that sugar can be obtained from many vegetable substances, but particularly from the root of White Beet. In consequence of the destruction of the sugar plantations of St. Domingo, and the resolution of Bonaparte to exclude the colonial produce of Great Britain from the continent, he exerted all his means to supply the place of colonial produce by articles of indigenous growth. Chaptal, Dombasle and others, seconded his views; the Institute reported on the subject in 1800, 1810; and in 1812, the manufacture was extending rapidly. The events of the war put an end to such operations, but in 1819 they were again in considerable activity, and in 1825, there were 100 manufacturers who furnished altogether about 4 or 5 millions of lbs. of raw sugar (from 2000 to 2500 tons), which was not the twentieth part of the consumption of the kingdom.

The following table from M. Dubrunfaut shows the expense of growing the beet in ten different estates in France and Flanders, and the quantity produced in each for every hectare ($2\frac{1}{4}$ acres). The expense in the last column includes that of labour, &c

	No. of kilogrammes. Of Beet per hectare.		Expense of 500 kilogrammes.	
1	12,500	-	14 francs	56 centimes
2	30,000	-	9 —	20
3	25,000	-	7 —	50
4	30,000	-	6 —	65
5	25,000	-	8 —	40
6	16,390	-	9 —	—
7	16,500	-	8 —	66
8	18,000	-	7 —	95
9	26,625	-	6 —	25
10	37,500	-	10 —	—
Total,	237,515	Total,	88	5
Average,	23,751	Average,	8	80

According to our author about 4000 tons of roots (4,114,200 kilogrammes), cost £5600, or 136,082 francs, when manufactured into sugar.

The produce of this quantity of roots he estimates thus:—

As 70 per cent. of juice is extracted, this would leave 30 per cent. pulp, worth 15 francs per 1000 kilogrammes (12 francs per ton), or 18,514 francs.

Raw Sugar 4½ per cent. on the weight of the roots, or 185,139 kilogrammes, - - - - - - -	222,167
Molasses, 153,960 litres=201,600 kil. fit only for distillation, 10 francs per 100 kilogrammes, - - -	20,160
	260,841
Deduct cost above mentioned,	136,082
	124,759

and deducting for the expenses 135,082, and the sum of 38,674 francs, for the value of the pulp and pure molasses, we find a balance of 97,408, which, divided by the weight of the sugar, 185,138 kilogrammes, gives 58 centimes, per kilogramme, or 2½d. per lb. At the manufactory of M. Crespel, near Arras, the cost is 3½d. per lb.

Several very remarkable views and facts respecting the formation of sugar, have been lately brought to light. M. Kirchoff, a Russian chemist discovered that starch may be converted into sugar, by being boiled for some time in very dilute sulphuric acid. M. Theod. Saussure found that *one hundred* parts of starch yielded *one hundred and ten* parts of sugar, and he concluded that sugar is merely a compound of water and starch. Thus,

	STARCH.		SUGAR OF GRAPES.
Oxygen	55.87	- - - - -	56.51
Carbon	37.19	- - - - -	36.72
Hydrogen	6.84	- - - - -	6.78
	100.00		100.00

According to the analysis of M. Berzelius, starch and common sugar are thus composed:

		Starch.		Common Sugar.
Oxygen	-	49.6	- -	49.856
Carbon	-	43.5	- -	43.265
Hydrogen	-	7.0	- -	6.879
		100.0		100.000

Hence the abstraction of a little hydrogen and carbon would convert starch into sugar.

The most remarkable discovery, however, relative to sugar, is that made by M. Braconnot relative to the formation of sugar from the sawings of wood, old rags, and paper, of which a brief account will be found in our article SCIENCE, *Amusements in*, Vol. XVI. p. 610.

SULLIVAN, county of, New Hampshire, formed recently from the northern or upper towns of Cheshire county. Sullivan is bounded N. by Grafton; E. by Merrimac; SE. by Hillsborough; S. by Cheshire; and by Connecticut river separating it from Windham county, Vermont, SW.; and from Windsor county, Vermont, W. and NW. Length from S. to N. 32; mean width 18; and area 576 square miles. Extending in lat. from 43° 10′ to 43° 37′ N.; and in long. from 4° 30′ to 5° 5′ E. from W. C. This county lies entirely in the basin of Connecticut river, and has its declivity eastward from a range of hills separating the basins of Merrimac and Connecticut; and is drained by the sources of Ashmelot, and by Cold river, Sugar river, and some smaller streams. Surface very broken, but soil excellent for grasses of all kinds.

Beside Newport, the seat of justice, there are sixteen post-offices in Sullivan; the principal villages in which these offices exist are Charlestown, Claremont, Croyden, Goshen, Lempster, Plainfield, Springfield, Unity, and Washington.

Newport, the seat of justice, stands a small distance west of Sunapee lake, on Sugar river. N. lat. 43° 20′; long. 4° 52′ E. from W. C. by post road; 40 miles NW. by W. from Concord, and 467 miles NE. from W. C.

SULLIVAN, county of, New York, bounded by Delaware county of the same state, NW.; Ulster N. and NE.; Orange SE. and S.; and by Delaware river, separating it from Pike county of Pennsylvania, SW.; and from Wayne county of Pennsylvania, W. The longest line that can be drawn in this county is one very nearly due N. and S., from the southern angle at the mouth of Mongarep creek, to the most northern angle, 39 miles; and the area being within a small fraction of 819 square miles; the mean breadth is about 21 miles. Extending in lat. from 41° 26′ to 42° N.; and in long. from 1° 55′ to 2° 38′ E. from that meridian of Washington city.

The surface of this county is elevated, broken by hills, and in part mountainous, and nearly the whole drained by creeks flowing into Delaware river. The northern part has a western declivity, and gives source to Beaver Kill, a confluent of the Popachton branch of Delaware river. The central and southern part of the county declines southwardly, and is also drained into Delaware river by the Mongaret, Nevesink, and other creeks. By the levels taken on the Hudson and Delaware canal, the lowest part of Sullivan county must exceed 455 feet above the ocean level; and of consequence, from its mountainous aspect and position, the arable soil must lie between 500 and at least

1000 feet of such relative height. It is probable that the mean height of the farms exceeds 800 feet, or an equivalent to two degrees of Fahrenheit in the mean temperature of the climate. This difference is distinctly seen in the advance of spring and autumn in Sullivan, and in similar latitude on Hudson river.

The southeastern and lower part of Sullivan county has gained public importance and local advantage from affording a part of the route of Hudson and Delaware canal. This canal leaves the Delaware river at Carpenter's Point, at the mouth of Nevesink river, and in the western part of Orange county, and passes thence in a northeastern direction along the valleys of the Nevesink, Rondont, and Waalkill, to the Hudson at Eddyville, nearly opposite Rhinebeck, and passes by the villages of Essopus, or Kingston, Marbletown, Mombacus, Warwassing, &c. The rise from tide water in Hudson 535 feet, and fall from the summit level to Delaware river 80 feet.

By the post lists publishing at this time (May 1831), there are beside Monticello the seat of justice, post towns Bethel, Bloomingburgh, Cochecton, Fallsburgh, Forrestburgh, Grahamsville, Liberty, Nevesink, Philipsport, Rockland, Searsville, Thompsonville, West Brookville, White Lake, Woodbourne, and Warsborough. In 1820 the population amounted to 8900.

SULLIVAN, county of, East Tennessee, bounded by Carter's mountain separating it from Carter county, E. and SE.; by Washington county S.; Hawkins W.; Scott county of Virginia NW.; and Washington county of Virginia NE. This county lies in a near approach to a right angled triangle, longest side on Carter and Washington counties in the same state 45 miles; the perpendicular south from the Virginia line 18 miles, but a southern curve of the longest side increases the area to about 500 square miles. Extending in lat. from 36° 22′ to 36° 35′, and in long. from 4° 58′ to 5° 30′ W. from the meridian of Washington city. The entire declivity is to the southwest, and the far greatest part of the area included in the valley of the main branch of Holston river. This stream rising in Wythe county of Virginia traverses Washington county in that state, and entering Sullivan county in Tennessee, receives the Watanga from Carter county, and flowing a few miles farther to the SW. curves abruptly to NW., and receives the north branch on the boundary between Holston and Hawkins counties. The surface is elevated and mountainous, but with much good soil. In the post list of 1831 there are enumerated in Sullivan county, Tennessee, five post towns, beside Blounsville, the county seat; these are Hilton, Kingsport, Pactolus, Paperville, and Rockhold's Store. The population in 1820 amounted to 7015.

SULLIVAN, county of, Indiana, bounded by Vigo county in the same state, N.; Clay NE.; Greene E. and SE.; and Wabash river, separating it from Crawford county of Illinois SW., and Clark county, of Illinois NW. Length from S. to N. 28, mean width 20, and area 560 square miles. Extending in lat. from 38° 53′ to 39° 17′, and in long. from 10° 16′ to 11° 42′ W. from W. C. The slope is to the southwestward obliquely towards Wabash river. Surface moderately hilly, and soil excellent. In the beginning of 1831 there were but three post offices in this county; these were situated at Merom, the seat of justice, Carlisle, and Yurman's creek. Population in 1820, 3498. DARBY.

SULLY, MAXIMILIAN BELLEVUE, Duke of, was born at Rosni in 1559, and was descended from an illustrious Protestant family of the counts of Flanders. At the age of eleven, when he was in Paris, he escaped from the massacre of St. Bartholomew in 1572, by being concealed for three days. The leading events of his public life and his character will be found in our article FRANCE, Vol. IX. p. 301—307. He died in 1641, at the age of 82. The *Œconomies Royales*, or the Memoirs of Sully, written by himself, are much esteemed for the simplicity of the style, and the interesting anecdotes they contain.

SULPHATES and SULPHITES. See CHEMISTRY, *Index*.

SULPHUR. See CHEMISTRY and MINERALOGY, *Indexes*.

SULPHURIC AND SULPHUROUS ACIDS. See CHEMISTRY, *Index*.

SUMACH. See FRANCE, Vol. IX. p. 414.

[SUMASINTA, river of the republic of Mexico, as laid down on Tanner's Mexico, rises in the mountains of Guatemala, N. lat. 15°, and 15° W. long. from W. C.; and in the extreme southern part of Chiapa; flows thence northwardly, first separating Yucatan from Chiapa, and then from Tabasco, is finally lost in the Gulf Terminos, after a comparative course of about 220 miles. The gulf or bay at the mouth is shallow, admitting only small vessels.] DARBY.

SUMATRA, a large island in the Eastern Sea, and the most westerly of the Sunda Islands. It extends about six degrees on each side of the equator, and is about 1050 miles long, and 165 broad. A chain of mountains in double and treble ranges, extends through the island. Mount Ophir, under the equator, rises 13,842 feet, but snow has never been seen on its summit; or on that of any of the rest. Between the ridges of these mountains there are extensive plains of great elevation, where the inhabitants principally reside on spots cleared of the woods which clothe every part of the island. These plains abound with large lakes, from which issue rivers and streams, the largest of which is the Siak, the Indragiri, the Jambi, and the Palembang, flow to the eastern coast, while the small ones in great number discharge themselves into the western sea. The most important of these are the Kataun, the Indrapura, the Tabuyong, and the Sinkel.

The mean temperature of Sumatra is, we are persuaded, not above 81°, the average measure of the equatorial heat. According to Mr. Marsden, the thermometer fluctuates between 82° and 85° in the most sultry heats. At Fort Marlborough, he never saw it higher than 86° in the shade; though at Natal, in north lat. 0° 34′, it is not unfrequently at 87° and 88°. Now, at sunrise, it is usually as low as 70°; so that 81° will be found a full measure of the average mean temperature. Beyond the first range of hills the people light fires in the mornings. The southeast monsoon, or dry season, is between May and September inclusive, and the northwest monsoon begins about November; and the hard rains cease in March. There are a number of volcanic mountains; and earthquakes frequently occur. Thunder and lightning are also frequent.

The soil of Sumatra is generally a reddish stiff clay, burned nearly to a state of brick with the sun, but covered with a stratum of black mould. The principal article of produce is rice of various kinds, which, in some cases, gives a return of 140 for 1, though in general it is only 30 for 1. The cocoa nut, the sago tree, the sugar cane, are also cultivated, but very little sugar is made. Maize, chilly pepper, turmeric, ginger, coriander and cumin seed, are reared in gardens. Hemp is cultivated in order to obtain bang, which is smoked in pipes along with tobacco, which is also cultivated.

The principal fruits of Sumatra are the mangosteen, the pine apple, oranges, the white and red shaddock, limes and lemons, the bread fruit, the jack fruit, the mango, the papaw, the pomegranate, the tamarind, nuts and almonds, wild grapes. Among the medicinal and useful trees may be enumerated the castor-oil plant, the caoutchouc tree, the camphor tree, the coffee tree, the indigo tree, and the upas tree, which is not injurious to those who come near it.

Sumatra is rich in mineral productions. There are mines of copper, iron, and tin. Sulphur and nitre are also plentiful. Yellow arsenic is also found. Coal, washed down by the floods, is procured in many parts. There are mineral and hot springs, and springs of petroleum. Yellow, red, and white ochres, are abundant.

Gold, which is found chiefly in the interior, occurs imbedded in the rock, forming veins in quartz. The mines are generally at the foot of the mountains, and are wrought by horizontal shafts from 50 to 150 feet long. The gold is also found in smooth masses like gravel, one of which seen by Marsden weighed 9 oz. 15 grains. There are no fewer than 1200 gold mines in the dominions of Menancabow. It is said that 11,000 ounces have been annually received at Padang, 2000 at Nalaboo, 800 at Natal, and 600 at Mocomoco.

Among the articles exported from Sumatra may be enumerated the edible birds nest, the Biche de Mer, bees wax, gum Lac, ivory, pepper, cassia, aloes, gum dammer, benzoin, camphor, dragons' blood, salted roes. The imports are, from Coromandel, cotton goods, blue and white long cloth, chintz and coloured handkerchiefs, and salt; from Bengal, muslins, cotton goods, taffetas and opium; from Malabar, coarse cottons; from China, porcelain, iron-pans, tobacco, gold thread, &c.; from Celebes, the rough striped cotton which forms the dress of the natives, krises, hats, small pieces of brass ordnance, spices; and from Europe, silver, iron, steel, lead, cutlery, hardware, brass wire, and broad cloth, particularly scarlet.

The inhabitants of Sumatra have made but little progress in the useful arts. Fire arms, nails, adzes, axes, hoes are made in different parts. They are good carvers in wood and ivory; they make good cane and basket work. Silk and cotton cloths, gold and silver embroidery, earthenware, gunpowder, salt, gold and silver filagree work, are the chief objects of their industry.

The *doosoons*, or villages, are generally situated upon an eminence, on the banks of a river or a lake The houses form a quadrangle, with lanes between. The balii or town-hall stands in the centre of the square. It is a room from ninety to a hundred feet long, and from twenty to thirty feet wide, and open at the sides, unless when it is hung with mats or chintz. The houses consist of a wooden frame, lashed with split bamboos, and generally roofed with the leaf of the Neepal's palm. To secure themselves from wild beasts, the inhabitants raise their houses to different elevations, and they ascend to them by a piece of timber or stout bamboo cut in notches. The better class of houses are ornamented externally with uncouth carved ornaments: they have neither tables nor chairs, nor knives or forks. In cooking they employ an iron vessel.

Sumatra is chiefly occupied by the empire of Menancabow, and the Malays; by that of the Acheenese; the Battas, the Rejangs, and that of Lampong. The Malay language is universally spoken along the coast. It prevails also in the inland territory of Menancabow, and is understood almost throughout the island. Their written character is the Arabic. Many other languages prevail in the island, but of these the Rejang and the Batta are the chief.

Sumatra abounds with wild animals, the tiger, the elephant, the hippopotamus, the rhinoceros, the bear, deer of various kinds, sloths, squirrels, monkeys, the gigantic orang-outang,* civet-cats, tiger-cats, porcupines, hedgehogs, alligators, boa-constrictors, guanas, chameleons, flying lizards, tortoises, and turtle. Among the domestic animals are the buffalo, which affords milk, beef and broth, the cow, the horse, the sheep, the goat, the hog, the otter, the cat, the dog and the rat. Among the birds are the beautiful Sumatra pheasant, eagles, vultures, peacocks, kites, crows, &c. The island swarms with insects.

For farther information respecting this island, see *Beschreibung der insel Sumatra*, besonders in *Ansehung des Handels*, &c. von Adolph. Eschelskron, Hamb. 1781. Marsden's *History of Sumatra*, Lond. 1783. Shelbeare's *History of Sumatra*, Lond. 1787. Van Schirak's *Description of the Commerce of Sumatra*, in Dutch, Harlen, 1789: and the *Asiatic Researches*, vol. x. See also our article Acheen.

SUMNER, one of the northern counties of Ten-

* See Dr. Brewster's *Journal of Science*, No. VIII. p. 193. No. XIII. p. 162. No. XVII. p. 1. and *New Series*, No. II

nessee, bounded by Smith county in the same state E.; by Cumberland river separating it from Wilson county S.; by Manpoes creek separating it from Davidson SW.; by Robertson county NW.; and by Simpson and Allen counties in Kentucky N. This county reaches in lat. from 36° 12′ to 36° 37′; and in long. from 9° 8′ to 9° 42′ W. from W. C. The separating summit level between the vallies of Cumberland and Greene rivers traverses Sumner from E. to W., dividing it into two inclined planes. The northern and least extensive slopes to the NNW., and gives source to creeks flowing into Big Beaver branch of Green river. The largest or more extensive declivity falls southwardly, and is drained by creeks falling into Cumberland river. Surface waving rather than hilly, with an excellent soil. In the beginning of 1831 there were post offices in Sumner, at Bracken's, Cairo, Fountain Head, Gallatin, Green Garden, Hartsville, Hendersonville, Long Hollow, Montgomery, and Tyree Springs.

Gallatin, the seat of justice, is situated near the middle of the county, from east to west; but, towards the southern border, on Cumberland river, 27 miles NE. from Nashville, and as stated in the recent post office list, 699 miles from Washington city.

Cairo is on Cumberland river, five miles a little E. of S. from Gallatin. Hartsville is also situated on Cumberland river, in the extreme southeastern angle of the county, and by post road 41 miles above, and NE. by E. from Nashville.

This county is in length from east to west 38; mean width 17; and area 646 square miles.

SUMPTER, district of, South Carolina; bounded NW, by Kershaw; NE. by Lynches river separating it from Darlington; E. and SE. by Williamsburg; S. by Santee river separating it from Charleston district; SW. by Santee separating it from Orangeburg; and W. by Wateree separating it from Richland. Greatest length from the extreme southern part on Santee river to the extreme northern on Lynch's creek, 62 miles; mean width 20; and area 1240 square miles. Extending in lat. from 33° 23′ to 34° 17′, and in long. from 2° 51′ to 3° 38′ W. from Washington city. General declivity SSE. It is bounded on two sides by navigable rivers, whilst the central parts are drained by Black river, branch of Winyaw.

Sumpterville, the seat of justice, stands on a small branch of Black river, near the centre of the district, 93 miles a little W. of N. from Charleston; 44 miles a little S. of E. from Columbia; and by post road 481 miles SSW. from the city of Washington. N. lat. 33° 53′, long. 3° 22′ W. from W. C.

Beside at Sumpterville, there are post offices in this district at Bishopville, Bradford Springs, Bradleyville, Friendship, Fulton, Jacksonville, Jamesville, Manchester, Mill Grove, Mount Clio, Salem, Statesburg, and Willow Grove.

In 1790 Sumpter contained a population of 6940; in 1800, 13,103; in 1810 it contained 19,054; and in 1820, 25,369. For the population in 1830 see the general table of the counties under the head of United States.

SUNBURY, post town, borough, and seat of justice, Northumberland county, Pennsylvania, situated on the left bank of Susquehanna river, on the point immediately above the mouth of Shamokin creek, two miles below the junction of the two main branches of Susquehanna river, and a similar distance below the borough of Northumberland, with the breadth of the east branch superadded; 52 miles above and N. from Harrisburg, and by post road 162 miles a very little E. of N. from Washington city.

From Philadelphia there are two roads to Sunbury. The most direct is by Reading and Orwigsburg, 123 miles; the second by Lancaster and Harrisburg, 148 miles. Population about 1000.

SUNBURY, post town and sea port, Liberty county, Georgia, situated at the head of St. Catharine's sound, and mouth of the small river Medway, 10 miles E. from Riceborough, the county seat; 34 miles SSW. from Savannah; and by post road 212 miles a little S. of SE. by E. from Milledgeville. Lat. 31° 45′ N. Long. 4° 22′ W. from W. C.

The harbour is open to the sound, distant about eight miles from the Atlantic ocean; but the northern projection of St. Catharines island contributes to shelter vessels from southern and south-eastern winds. DARBY.

SUN. See ASTRONOMY, *Index*.

SUNDERLAND, a borough and sea-port town of England, in the county of Durham, is situated on the southwest bank of the Wear. It is united to Monk Wearmouth by the celebrated iron bridge, of which we have already given a full description and drawing, (see BRIDGE, Vol. IV., p. 479, and Plates XCI. and XCIII.) so as to form altogether a town about one and a half mile long, and one mile broad. It consists of one principal street, called the High Street, formed by the road to Durham, which contains many handsome houses. Several of the other streets, which branch off from it, are narrow and dirty. Lately, however, great improvements have been made in widening, lighting and repairing the streets. The church is large and handsome, having a light and elegant east front. A spacious and elegant chapel of ease was erected in 1767, and there are also excellent places of worship for the Presbyterians, Independents, Baptists, Quakers, Methodists and Unitarians. The Methodist chapel is a handsome building, which holds 1500 persons. The other public buildings and institutions are the exchange, a handsome edifice, a theatre, assembly room, an excellent subscription library, a dispensary, a humane society, a charity for decayed seamen and their widows, a girls' school, a blue-coat school, besides two charity-schools, one on Lancaster's plan, and the other on Bell's plan, at Bishops Wearmouth. On the moor to the east of the town, are commodious barracks capable of accommodating 1800 men.

The harbour is inclosed by two piers, one on each side of the river. The south pier is old, but the north one has been erected since 1788, and gives great security to the shipping. The tide now flows sixteen feet, and admits vessels of 300 and 400 tons burthen. An elegant circular lighthouse has been erected near the end of the northern pier.

The trade of Sunderland has been long progressively increasing. The principal imports are corn, flour, wines, spirituous liquors, timber, tar, deals, flax, iron, &c. The exports are coal, lime, glass, glass bottles, grindstones and copperas. The coal trade employs about 500 vessels, besides 492 *keels*, or flat-bottomed craft; which convey the coal from the staiths to the ships. The coal is chiefly sent to London, but also to the Baltic, France, Holland, &c. The quantity annually exported was reckoned at 315,000 Newcastle chaldrons; but in 1820 it amounted to 421,061 chaldrons. The persons employed in the coal trade on the river Wear only amounted to 26,000. The lime is sent chiefly to the coasts of Scotland and Yorkshire.

The principal manufactures here are those of cordage, bottles, flint glass, broad glass, white and brown earthenware and copperas, tar, &c. Shipbuilding is carried on to a great extent. In 1814, 8000 vessels cleared out of Sunderland harbour. The town is governed by a vestry or association of the inhabitants, having freehold estates, at the annual value of £10. They continue in office three years. A little to the south of Sunderland, on the edge of the sea, is a chalybeate spring, nearly as strong as that of Harrowgate. The following was the population of the town in 1821:

Houses	1,618
Families	4,064
Do. in Trade	949
Total population	14,725

See the *Beauties of England*, vol. v. p. 135.

SUPERIOR, LAKE. See CANADA, Vol. V. p. 233.

This greatest sheet of fresh water on the earth is itself a reservoir for a circular band of territory around it varying in width from 40 to 80 miles, and measured at about mid-distance from the lake equals in length 15 degrees of a great circle, equal to 1042 statute miles. Including the whole valley, or the lake and land surface drained into it, we find a physical section in the form of a vast triangle; base from east to west passing through St. Mary's strait to the height of ground between St. Louis and Rum rivers 500 miles. Perpendicular 350 miles. These elements give an area of 87.500 square miles. Of this expanse, lake Superior itself occupies a triangular surface; base 350 miles from the outlet of St Mary's river to the mouth of St Louis's river 350 miles. Greatest width 160 miles, but mean width about 86 miles as the area is by careful admeasurement on numerous maps, within a small fraction of 30,000 square miles. The valley of Superior lies, according to Tanner's United States, and his North America between N. lat. 46° and 51°, and between Long. 7° and 17° W. from the meridian of Washington city.

The present is a favourable opportunity to correct a prevalent error. Lake Superior has been called the American Caspian, and very frequently stated to be equal or even more extensive than the Caspian. But these comparisons are very erroneous; the Caspian is 690 miles from south to north, and the mean width at least 180 miles, giving an area of 124,200 square miles; or upwards of four fold more extensive than is lake Superior. In reality the whole five great lakes of Canada, and all the intermediate land taken together, but little exceeds the surface of the Caspian; and the actual water surface of the five Canadian lakes is to that of the Caspian as one to three very nearly.

The surface of lake Superior is elevated above the Atlantic tides 641 feet, but the utmost depth sinks below the ocean level, and of course if a strait level with the ocean connected it with the lake, the latter would still exist as an inland sea.

The immense depth of the Canadian lakes, except Erie, is indeed amongst the most extraordinary facts in their natural history. Lake Superior is perhaps the deepest of the three higher lakes, but each admits the navigation of the largest vessels. Similar to the Caspian, the lakes of Canada have shores very deficient in harbours; and lake Superior in particular has immense walls of rock stretching along much of its border.

The enormous mass of water from Superior passes over what has been very erroneously called the falls of St. Mary, but which is in reality not a very steep cataract, and is passable with boats. The entire fall determined by general Gratiot is 22 feet 10 inches. The strait of St. Mary if measured from the lower end of St. Joseph's island into the open water of lake Superior, is about seventy miles in direct length. The real narrows at the cataract, where Fort Brady now stands, is at N. lat. 46° 31'. Long. 7° 18' W. from the meridian of Washington city.

From the geographical position and the long and intense frosts so near the eastern side of a large continent, the upper lakes of Canada would be annually frozen in winter, if that phenomenon was not prevented by their prodigious depth. Their bays and rivers are annually frozen, in fact; but the great mass and depth of the open lakes prevent the formation of solid, compact, and passable fields of ice. DARBY.

SURAT, a large city of Hindostan, in the province of Guzerat, situated in a fertile plain on the south bank of the Tappi or Taptee. It is defended on one side by the river, and elsewhere by a brick rampart about twenty feet high, and a ditch, having a strong citadel, with an esplanade. The squares of Surat are spacious, but the streets are generally narrow, irregular and unpaved. Every street has its own gates, which are shut in cases of alarm. The citadel, which is the principal building, is a large quadrangular building, of hewn stone, with a circular and spacious bastion at each angle, mounted with three tiers of guns, the lowest being 36 pounders, the second 24, and the upper 18 and 12 pounders. In all, there are 200 cannon mounted, besides 24 at the saluting battery. The houses for the officers are elegant. The durban palace is about two hundred paces distant. The mint is a large pile of building, encircled with a lofty wall. There are two caravanserahs in Surat, and numerous bazaars or market places. Some of its mosques are handsome. There are here some fine water tanks.

As the Hindoos never willingly deprive any thing of life, they have here a large hospital for maimed or diseased animals, with an annual revenue of 6000 rupees, and occupying an extent of twenty-five acres. It is full of decrepid cows, sheep, rabbits, hens, pigeons, &c. who are attended by a physician. Niebuhr saw here a blind tortoise, said to be 125 years old.

The trade of Surat, once very great, has declined rapidly, both from the badness of its harbour, and the rise of Bombay. The river is full of sandbanks, and all large vessels are obliged to remain at its mouth, called Swallow roads, where there is good anchorage, but no shelter. Nearly two-thirds of the distance between the anchorage and the town, a distance of nearly twenty miles, is a continued chain of banks, with narrow channels between them. In the burial places of the Europeans in the suburbs, are many large and handsome tombs, worthy of being visited. Shipbuilding used to be carried on to a considerable extent, but much of it has been transferred to Bombay and Damaun.

From 1794 to 1796 the trade of Surat amounted annually to about 600,000 rupees, half of it being carried on with the Arabian, and half with the Persian gulf. In the year 1811 and 1812, the total imports amounted to 4,881,410 rupees, and the total exports to 3,966,523 rupees. This trade was carried on by fifty-seven vessels, whose tonnage amounted to 5318.

In 1796 the population of Surat was estimated at 800,000 souls, and by others at 600,000. It has been stated also at 400,000, and lately so low as 70,000, composed of persons of all nations and religions. East long. 73° 3′ north lat. 21° 13′. See Milburn's *Oriental Commerce*, vol. i. Hamilton's *East India Gazeteer*, and our article India, *passim.*

SURDS. See Algebra, Vol. I. p. 423 425.

SURGERY.

Surgery is that branch of the medical profession wherein manual operations form part of the occupation of the practitioner, and during certain periods of its history constituted the exclusive department of the individual who professed it; being derived from χειρ, a hand, and εργον, a work, whence it was termed chirurgery. This, however, will be better understood after we have detailed the history of surgery from the earliest ages.

History of Surgery.

Although there cannot be a shadow of doubt that surgery was coeval, if not prior to medicine, yet there is no account of any surgical operations before the siege of Troy, when that eventful strife immortalized in song the chirurgical deeds of Podalirius and Machaon, the godlike sons of Æsculapius, together with those of Patroclus, for in that memorable war, princes were as much renowned for their exploits in surgery as for those in battle.

Æsculapius lived about the beginning of the Trojan war, and was instructed in medicine and surgery by Apollo, and Chiron the Thessalian, named also the centaur. According to Diodorus Siculus, he was the inventor of medicine and surgery, which were in great repute during the Trojan war; and he carried botany to perfection as well as the use of medicines and operative surgery; at the dawn of medicine, all the departments of the medical profession were prastised by one individual, and that person frequently either a prince or a deified king.

It is supposed that the temples dedicated to Æsculapius were chiefly for his skill in surgery; and Podalirius and Machaon according to Celsus, confined themselves to the chirurgical part of physic, being the most ancient branch, as medicine, in the era of Æsculapius, 1263, before Christ, was chiefly practised by consulting the oracle at Pergamus. When we consider the restless spirit of man in the earliest ages, it is presumptive that wounds, fractures, and luxations must have existed from the creation, and that consequently many surgical remedies would originate nearly at the same period with man, for surgery and medicine must have been coeval with injuries and diseases inflicted on the human frame.

From the fall of Troy until the Peloponesian war, an interval of 700 years, and 431 before the Christian era, we have no accurate account of surgery; it is only known that the Asclepiades, descendants of Æsculapius, exercised the art. The great Hippocrates, also a lineal descendant of Æsculapius, appeared at that time, and has handed down to us works not less celebrated in surgery than in medicine. His writings, however, are more devoted to medicine than to surgery, having only composed chapters on fractures, diseases of the joints, ulcers, fistulas, hemorrhoids, wounds of the head and midwifery, the genuineness of some of which are questioned by his commentators; indeed, if we believe the singular oath which he administered to his pupils, he despised operative surgery, for in that extraordinary document he ordains, that "cutting for the stone I will not meddle with, but will leave to the operators in that way. He however used the lancet, the scarificator, the actual cautery, and the crotchet, and practised as a physician, a surgeon, an accoucheur, an apothecary and even a nurse. He is also exceedingly bold in his directions to "operators in that way," for in calculus of the kidney he thus observes, "when however there is tumefaction in the region of the kidney, an incision ought to be made, and the calculus carefully extracted; for if this operation be not performed, there are no hopes of a cure, and the disease will prove fatal." The reason, says Meibomius, why Hippocrates would not allow physicians to treat calculus in the bladder, was simply because it was too difficult.

The surgery of Hippocrates has, to the misery of the sufferers, been implicitly followed by nearly all succeeding authors; for as the great Bacon observes, authors have written, not that their works should stand as consuls, to give advice, but as dictators; and as John Bell justly states, "most unfortunately for science, Hippocrates wrote with such truth and brevity, with so sound and discerning a spirit of observation, and recited so carefully the signs of danger in all kinds of wounds and injuries, that he has been held in continual reverence, and holds an influence over the profession even to the present hour." His directions for the treatment of fractures are very unscientific, and even cruel, when we consider his extension and machines; his treatment of injuries of the head may be said to be both inert and cruel, inert as regards active blood-letting, and cruel in trephining for every fissure or crack of the skull.

In Egypt, according to Herodotus, lib. ii. c. 129, surgeons were divided, as in the present day, into oculists, capitists, dentists, &c.; and in Persia, A. M. 3483, according to the same historian, the surgeons of Egypt were held in high reputation. Democedes is mentioned as having become the principal favourite of Darius, of being loaded with honours and riches, merely for having succeeded in reducing one of his ankle-joints which was dislocated. Xenophon states, that Cyrus had an excellently appointed medical staff to his armies. In Egypt and Babylon, according to Herodotus and Strabo, the sick were exposed on the roads, in order that those passengers who had been similarly affected might give them their advice. The Egyptians considered the god Hermes the inventor of physic. About 500 years before the Christian era, the celebrated medical school of Alexandria flourished, at which Herophilus and Erasistratus had the boldness to introduce the study of human anatomy, the source of all its renown; but in consequence of the destruction of the Alexandrian library, we possess few of the writings of these great men; they were founders of particular sects; and Galen and Cœlius Aurelianus have collected all the scattered remains of their works, together with those of the other successors of Hippocrates, down to Celsus, a period of four centuries. It is presumptive that surgery was far advanced in perfection during the zenith of the Alexandrian school, when we consider the advantages then derived from a knowledge of dissection, and the many opportunities of practice which must have occurred in the celebrated campaigns of Alexander and his successors.

In Greece, during the time of Herophilus, there were dietetic, pharmaceutic, and surgical practitioners; the surgeon was restricted to the use of the knife, and was not permitted even to treat wounds, ulcers, or tumours. In this age also reigned the famous sects of empirics, dogmatists, methodists, &c.

Arcagathus, a Greek, was the first who practised surgery at Rome, U. C. 535, but he operated so frequently and rashly, and it may be presumed unscientifically, as he received the opprobrious appellation of hangman. Celsus, who lived during the reigns of Augustus and Tiberius, about the beginning of the Christian era, greatly advanced both medicine and surgery, and condensed all that was then known in one small volume; he has the merit of being the inventor of the ligature on wounded arteries, of union by the first intention or adhesive inflammation, of amputation in gangrene from external causes, of a scientific mode of performing amputation, of the operation of couching for cataract, and of performing lithotomy on the gripe, now termed the Celsian mode or operation, operations of the utmost importance in surgery, and improvements in operative surgery of the most vital consequence. It appears doubtful, however, whether Celsus really is entitled to the merit of being the inventor or discoverer of these important facts and operations, for he describes them not as his own invention, but as the practice of the day. Thus, under lithotomy he observes, "multi hic quoque scalpello usi sunt." We entertain the same opinion with Richerand concerning these ancient authors; thus, with regard to Hippocrates, he says, "Hippocrate n'est point le pere de la medicine, elle est la fille du temps et de l'experience. Ses ouvrages doivent étre regardés comme une sorte d'encyclopedie medicale." Celsus talks of Philoxenus, Gorgias, Sostratus, the two Herons, the two Apollonii, and Ammonius Alexandrinus of Egypt, having made discoveries in surgery; and of Tryphonius, Euelpistus, and Meges having made considerable additions to this art. It has been questioned whether Celsus practised as a physician and surgeon, but of this there can be no doubt, after an attentive perusal of his writings; no one who had not practised surgery could describe the operation and treatment of lithotomy as he has done; besides, he occasionally employs the first person singular. His qualifications for an operator are, "that he must be young or middle aged, have a strong and steady hand, never subject to tremble; to be ambidexter, to have a quick and clear sight, to be bold; and so far void of pity, that he may have only in view the cure of him whom he has taken in hand, and not in compassion to cries, either make more haste than the case requires, or make his cut less than is necessary, but to do all as if he was not moved by the shrieks of his patient." There is much truth in this sentence, but Celsus does not appear to be aware, that the greater part of these can be acquired, as was the case with Cheselden, who had a natural repugnance to operations; and hence also we presume does Richerand consider the firmness of mind requisite for a surgeon to be a gift of nature. Haller also confesses he could never summon up resolution or fortitude to operate. Bichat considered two things essential to form a great surgeon, genius and experience; and in his eulogium upon Desault, he thus observes, "La nécessité de l'anatomie en avoit fait naitre le goût. Son étude précède celle de notre art, ses vérités ajoutent à l'intelligence des siennes: et telle est depuis un siècle l'opinion publique, qu'elle ne sourit aux efforts du chirurgien, qu' apres avoir couronné ceux de l'anatomiste. Fabrice honora le théâtre de Padua, avant de s'immortaliser par ses œuvres chirurgicales. La science longuement méditée de nos organes, traça au lithotome de Raw et de Chesselden, la route methodique qu'ils semèrent de tant de succès. Petit, Hunter, furent applaudis dans leurs amphithéâtres, avant de briller sur la scène éspineuse de la pratique; et dans ces premières pages consacrées aux premiers travaux de Desault, je n' aurai à retracer que ceux qui firent sa reputation en anatomie." Our own opinion is, that daily dissection of the dead, combined with occasional operations on the living, is alone required for a scientific and dexterous operator; for, as John Bell observes, what are our great operations, but careful dissections on the living body. It is the habit of dissecting, with address, that fits a man for operating. An operator should be in the meridian of life, and ought to have begun his career early, both as a dissector and an operator, and must continue daily to prosecute dissection, that he may be familiarized with every part of the human body on every emergency.

Galen was the last author of distinction that practised physic and surgery at Rome, A.D. 160; he was educated at the Alexandrian school, and would have done deeds of wonder, had dissection been permitted in Rome, but being confined to the anatomy of monkeys, and the other lower animals, he was only able to add to the surgery of his day, a Treatise on Bandages; his works upon Anatomy rank high. He has entered more minutely into the different species of ruptures than his predecessors, but throughout his writings he is a contemptible dictator.

The compilation of Oribasius, who lived about the end of the fourth century, may be passed over in silence in its relation to surgery, but not so that of Ætius of Amida, who studied at the Alexandrian school, A.D. 500, in which are many observations on surgical operations, and some on the effects of the Guinea worm.

Paulus Ægineta, who lived in 640, and practised at Alexandria and Rome, wrote an excellent work on Surgery, containing all the improvements of his day; he invented some operations, of which tracheotomy was one, and improved others, particularly lithotomy. He also improved the doctrine of, and operation for aneurism, and is the first who treats of fracture of the patella; he was bold and decisive in his practice, opening the temporal or occipital artery, or external jugular vein in affections of the eyes or head, and relieving strangulated hernia by an operation.

Nothing but a chaos presents itself from this period to the beginning of the tenth century. Torrents of northern barbarians inundated the Roman empire, and swept man and civilization from the fairest provinces of Europe; and, almost in immediate succession, the hosts of Saracens, under Amrou, viceroy of Egypt, set fire to the noblest monument of antiquity, the Alexandrian library. Thus nearly three centuries were buried in oblivion, with respect to the sciences, literature, and the arts; while war, and all its attendant horrors, raged from the Euxine to the Atlantic.

The Arabians, at last contented with their conquests, requested, in 820, the Greek Emperor at Constantinople, to give them some of their best literary and scientific works; among those sent were Galen's, translated into the Syrian language, in which astrology and superstition were mingled with medicine. In the works of Rhazes, Halyabbas, and Avicenna, we have no facts or remarks concerning surgery, which are not to be found in Galen, excepting those relating to spina ventosa.

Avenzoar wrote on surgery, but apologizes for condescending to write on a subject so contemptible, for in his days, surgery was practised in Arabia by the servants of the physicians, while all operations on the female sex were performed by women.

Albucasis ranks highest of the Arabian surgeons; he has given a long list of surgical operations, and an equally formidable catalogue of instruments and machines, fit to terrify the operator himself, much more the patient. At this period they plunged amputated stumps into boiling pitch. In an Arabian work, by Abi Osbia, we have a catalogue of 300 medical writers, who have justly merited oblivion, being mutilated translations of the Greeks, adulterated with the magic and astrological fables of the Arabians.

In consequence of the tyranny and aristocratic despotism which reigned over Europe, the sciences, literature, and the arts remained in obscurity, and even in Greece, theological controversies absorbed all other kinds of literature or science until the middle of the fifteenth century, when they again began slowly to revive. The revival of literature and science is probably solely to be attributed to the crusades. In England, it was actually near the end of the fifteenth century before medicine was cultivated at Oxford as a regular science, and even at the medical schools on the Continent, the diploma of surgery was conferred after one year's study of anatomy. At the famous school of Salernum, where this law existed, and where there was compiled a system of medicine, entitled "Schola Salernitana," only one chapter is devoted to surgery, and that on fistulas. The degrees of bachelor and doctor had no doubt been conferred at Paris during the reign of Charlemagne, in 1231, but generally on the clergy and monks, who practised physic at this epoch, and who were, in consequence of the barbarous anathema pronounced by the Council of Tours, in 1163, prohibited from performing any surgical operations; in consequence of this, surgery was again formally separated from medicine, and practised only by the most illiterate of the laity. The *Ecclesia Abhorret à Sanguine* continued long a satisfactory cloak for preventing the study either of anatomy or the practice of surgery. Gilbertus Anglicus is the first who wrote on surgery in England, which was about the year 1300; he copied chiefly Rhazes. Bernardus Gordon, a native of Scotland, and John of Arden, are said to have flourished at this period; the latter wrote a work, entitled the Chirurgery. From the 11th to the middle of the 15th century, numerous works were published, but all mere compilations, or extracts from Arabian authors; from this mass we ought to except a treatise on Surgery, written by Guido de Cauliaco, or Guy de Chauliac, professor at Montpelier, who lived at Avignon in 1363, which continued for many years the sole classical work in France. For from this period until the day of the great Paré, surgery was degraded to the lowest possible degree. Paré, in his first editions of his works, styles himself 'Barbier chirurgien.' There were then bitter civil wars carried on between the clerical physicians and these unfortunate barber surgeons. Vidus Vidius, however, published a splendid Latin edition of Greek surgery in 1544. The great Paré, enlightened by the labours of Vesalius, Fallopius, and Eustachius, gave birth to an able work on surgery, founded on anatomy, in 1585, which had been previously published in separate treatises. He has been considered by some the inventor of the ligature on wounded arteries, but as that merit clearly belonged to Celsus, he must be viewed merely as the reviver of that important surgical means of stopping hemorrhage; for in the dark ages the ligature had fallen into disuse, and the boiling pitch, cautery, escharotics, and astringents had succeeded in their place; he is entitled however to the merit of discovering the curved needle. Paré, who was a military surgeon during the reigns of Henry the II., Francis the II., Charles the IX., and Henry the III. of France, is the first surgeon who gives a scientific account of gun-shot wounds, which treatise is truly valuable in consequence of its simplicity. In 1560 Botallus published a treatise "De Curandis Vulneribus Sclopetorum;" and in 1561, Pierre Franco, a celebrated lithotomist, published "Traité des heries, de la pierre, de la cataracte et autres maladies des yeux," a work of considerable merit.

In Italy, there were several surgical authors. In 1563 Fallopius, an excellent anatomist, wrote a treatise "De Ulceribus et de Tumoribus præter Naturam," and in 1597, Caspar Tagliacotius wrote his remarkable work "De Curtorum Insitione per Chirurgiam." Marcus Aurelius Severinus wrote several surgical treatises in 1613, and in the same year, Fabricius ab Aquapendente, a profound anatomist and physiologist, wrote a system of surgery. In 1616, Cæsar Magatus wrote a treatise on wounds, Felix Platerus, in 1614, published his "Observationes in Hominum Affectibus Plerisque," a work of considerable merit; he is the first who treats of the malignant nature of carcinoma. In 1644 T. Bartholimus wrote a work on aneurism.

In Germany and Switzerland, surgery was in the hands of quacks until 1641, when Fabricius Hildanus and Scultetus flourished. The former produced a voluminous work, entitled, "Opera observationum et curationum Medico-chirurgicarum," and the latter an able work, styled "Armamentarium Chirurgicum."

In Holland, the same empiricism reigned until the days of Tulpius, in 1641; J. V. Horne, in 1644, and Ruysch, in 1691. In England the College of Physicians was not founded until the reign of Henry the VIII., in the beginning of the sixteenth century, but anatomy, the foundation of both medicine and surgery, was not taught until two centuries after this. Prior to this period, the bishop of London and the dean of St. Paul's sold licenses and diplomas to the clergy, laity, and empirics, to practise physic and surgery. Bartholomew's hospital was not erected until Henry's reign. Surgery was held in contempt, and practised indiscriminately by barbers, farriers, and sow gelders. Both in Paris and London, in the sixteenth and even the beginning of the seventeenth centuries, the barbers and surgeons' companies were incorporated. In 1676 Wiseman redeemed surgery, by publishing the result of his valuable observations during the civil wars, in his work, termed "Several Chirurgical Treatises."

In France and other countries, many insulated works were published about this period; in 1640 Covillard's "Traité Methodique des principales operations de Chirurgie." In 1681 F. Tolet's Traité de la Lithotomie." Lambert of Marseilles wrote an able work on diseases of the bones, also "Commentaires et Œuvres Chirurgicales," in 1656 and 1677.

The eighteenth century opens with an era of intelligence truly astonishing when compared with the preceding. In France there were Mery, Dionis, Duverney, J. L. Petit, F. Petit, Le Dran, Garengeot, La Faye, Lecat, La Motte, Louis, Maitre, Jean, David, Frere Cosme, Portal, Ravaton, La Peyronie, Quesnay, Faure, Morand, Sabatier, Pouteau, Moreau, Deschamps, and Desault. France has just cause to boast, for having given birth to so many able men.

J. L. Petit communicated his observations on surgery to the Memoirs of the Royal Academy of Surgery in Paris, a truly valuable journal; his communications rank very high, especially that upon the diseases of the bones, and he has the honour of being the inventor of the screwed tourniquet, a most useful instrument; for "the ancients," says a historian, "previous to amputation, only made a tight ligature round the member, from which defect, amputation of a large member was too frequently fatal." Petit was the first who operated for fistula lacrymalis by an incision of the lacrymal sac, and is the inventor of the eighteen tailed bandage.

Le Dran contributed a few papers to the Memoirs of the Academy of Surgery, and published several separate treatises, "Parallele des differentes Maniers de tirer la pierre." "Supplément au parallele." "Observations de Chirurgie." "Traité ou reflexions tirées de la pratique sur les playes d'armes à feu." "Traité des Operations de Chirurgie." "Consultations sur la plupart des Maladies qui sont de resort de la Chirurgie." Some of these are translated into different languages; and his observations and consultations are translated into English, the latter of which are interesting and at the same time amusing, and the operations are well drawn out; his works throughout are replete with many valuable facts and cases.

Sabatier's medicine operatoire is considered so complete on this department of surgery, that additions have been published by Dupuytren, Sanson and Begin. The edition published in 1822, contains every modern improvement in French operative surgery, and in this light is a valuable work; he also communicated some papers to the Academy of Surgery.

Pouteau's Melanges de Chirurgie, and les Œuvres Posthumes, are consulted at the present day, as they contain many valuable facts and observations. The Melanges are translated into German.

The works of Desault deservedly stand very high in reputation. He was the first in Paris who taught surgical anatomy and gave clinical lectures on surgery, one of the most important modes of instruction. He was not less profound as an anatomist than a surgeon, and infused an ardent zeal for both sciences into his pupils, among whom were Dubois, Boyer, and Bichat, who have equalled their preceptor in reputation. He invented several ingenious apparatus for fractures, some of which retain his name, and modified the common amputating knife, converting it from the ancient curved shape to a straight one; he also improved Hawkin's gorget. He renewed the use of the immediate ligature on arteries, which had again fallen into disuse after the demise of Paré, and has the merit of proposing that scientific mode of securing arteries beyond or distant to the aneurismal tumour, in cases where the reverse is impracticable, an operation now perfectly established by the success of Mr. Wardrop and others. He is stated to have been a scientific and dexterous operator, and was the first who attempted to cure an artificial anus formed after strangulated hernia; and also the first who treated scientifically schirrous tubercles of the rectum. In France he is as much esteemed as an authority as John Hunter is in England.

In Italy there were Bertrandi, Mollinella and Moscati.

In Germany and the north of Europe, there were F. Hoffman, Heister, Platner, Bidloo, Bilguer, Callisen, Richter, Ruysch, Trew, Meckel primus, Schneider, Schmucker, and Haller.

Heister wrote an able system of surgery, which is deservedly quoted at the present day; it is a work of extensive practical experience. He appears to have been an able anatomist, a sound pathologist, and a bold operator. Callisen's Systema Chirurgiæ Hodiernæ is an excellent compilation of the day, written by a vigorous mind.

Richter's Medical and Surgical observations are deservedly valued.

Schmucker ranks high as a military surgeon; many of his observations on injuries of the head are quoted by his successors. He published an excellent work in 1774, termed "Chirurgisch Wahrnehmungen," and another entitled "Vermischte, Chirurgisch," Schriften in 1785.

Haller's Disputationes Chirurgieæ, like the other works of this great man, are extensive and elaborate dissertations on surgery.

Great Britain, during this century, produced Chesselden, Douglas, Monro, primus et secundus, Sharp, Cowper, Pott, Allanson, John Hunter, Hill, Warner, Ford, White, Broomfield, Ranby, Gooch, Park, O'Halloran, Dease, Latta, Benjamin Bell, John Bell, and a number of others.

Chesselden's great celebrity consisted in performing the lateral operation of lithotomy so scientifically, that he is said seldom to have exceeded 24 seconds in its performance, he was the greatest operator of his day, and a most profound anatomist. He published a work on the anatomy of the human body in 1713, in which several of the operations of surgery are described, and in 1733 some splendid plates on the healthy and diseased structure of the bones; also a treatise on the high operation for the stone, in 1723.

Monro primus has contributed largely to the pathology of surgery, as, for example, that of luxation of the inferior maxillary bone, of fistula parotidea, of aneurism, of the lacrymal canals, of cataract, of the knee-joint, of caries, of cancer of the mamma, and of the ovarium. He improved the operations of paracentecis abdominis, and amputation.

Monro secundus was a man of great learning, a profound anatomist, physiologist, pathologist, and a most scientific consulting physician and surgeon.

Sharp wrote an excellent treatise on the operations of surgery. Gooch's cases and practical remarks on surgery, and his practical treatise on wounds and other chirurgical subjects are extremely valuable.

Pott's chirurgical works continue the standard of reference, although the doctrine of injuries of the head, hernia, and hydrocele have undergone some modification and improvement since his time.

John Hunter's works continue the admiration and boast of English surgeons. His treatise on the venereal disease, pathological doctrines of the blood, union by the first intention, inflammation and gunshot wounds, are creations of a great and inventive mind.

John Bell's principles of surgery is a work of great merit; his observations on aneurism, especially that by anastomosis, are valuable; he has proved more than the great Haller, that the largest arteries of the human body may be freely secured, without any fear of the collateral circulation not being carried on. It is much to be regretted, that he has written in so diffuse a style, and in so elaborate a manner, as to render the work too voluminous for general reading; again, the style and manner are so peculiarly his own as not to admit of being curtailed. He was a good anatomist, an elegant scholar, and a dexterous operator. He has written on the healthy structure of the bones, ligaments, muscles, heart and arteries; and his work on gunshot wounds is highly prized by the profession. His lectures on anatomy were probably the most eloquent ever delivered in Edinburgh.

We shall now conclude this brief historical sketch, as it will be better to advert to living authors, in the accounts of the different surgical subjects concerning which they have written. We have to refer the reader who wishes further information on this interesting subject to the able article Medicine, in a preceding part of this work; also to the following treatises,—Meibomius; Hippocratis jusjurandum commentariis illustratum, 1643; Le Clerc histoire de la Medicine, 1702; Friend's history of Physic, 1725; Histoire de la Chirurgie par Peyrihle, H. Boerhavii Methodus discendi artem medicam; Halleri Boerhavii Methodus discendi artem medicam; Haller Bibliotheca Chirurgica, 1774; Keisneri Bibliotheca medica; Recherches historiques, et critiques sur l'origine, les divers états et les progres de la chirurgie en France, par Quesnay. Gesner de chirurgia scriptores optimos veterum et recentiorum. Black's historical sketch of Medicine and Surgery, 1782; Gooch's practical treatise on wounds and other chirurgical subjects, together with a short historical account of the rise and progress of surgery and anatomy, 1767; Portal, histoire de l'anatomie et de la chirurgie, 1770; Richerand Nosographie chirurgicale; Prolegomènes histoire abrégée de la chirurgie; also, Histoire des progrès récens de la chirurgie; Sprengel histoire de la Medicine, 1815.

Before concluding, it becomes necessary to make a few observations on the changes or revolutions which have taken place in the practice of the profession. At the beginning of medicine, all its departments were practised by one individual, and it is evident that it was from Hippocrates's universal knowledge he so excelled, and it could have been only from a conscientious feeling of the difficulties attendant on lithotomy, that he separated it from the surgery he wrote upon and practised. Surgery appears then to have been first partially separated from medicine, which circumstance must have contributed to degrade it, as the physicians retained whatever was scientific. It appears to have continued in the most degraded condition until the time of Celsus, who, from his writings, embracing both departments, and evidently practising both, and since he was the companion of the first men in Rome, he must undoubtedly have raised surgery to a high rank in the estimation of the public. In consequence of surgery having no natural foundation at Rome, dissection of the human body being proscribed, it gradually degenerated, and particularly after the suppression of the Alexandria school, when it was again separated from medicine. It is presumptive from the scattered fragments collected by Galen and Cœlius Aurelianus, that surgery must have arrived at great perfection, and been held in high estimation during the flourishing state of that school, when dissection was publicly sanctioned by the government. It is evident from the history of surgery, that it has only flourished according as it has been founded on anatomy, and enriched with medicine or pathological doctrines. At its dawn it was combined with medicine, and in the days of Celsus, Herophilus, Erasistratus, and Galen, it was also united with medicine and founded upon anatomy. After this period, when anatomy could only be prosecuted by stealth, surgery continued in a truly degraded and insulated condition, and in the 11th century was stigmatized by the council of Tours. In the 12th century, the school of Salernum, and also that of Naples, required only one year's study of anatomy for the diploma of a surgeon. In the 15th century we find the great Paré still a barber surgeon, and controlled frequently by the physicians. At Oxford and Edinburgh, the two first universities in Great Britain, anatomical chairs were not established until the last century, and at neither school was dissection prosecuted until this century, and that only at Edinburgh; and even yet throughout Great Britain, the study of anatomy is only prosecuted by stealth; in many schools on the continent, however, its study is sanctioned by the governments, so that it has only been at the dawn of medicine, and in the present era, that surgery has been blended with physic and rendered a respectable profession; and it is much to be regretted there exists any separation, since it only tends to degrade each department; as physicians must be occasionally consulted in accidents, the province of the surgeon; and the surgeon, again, must be acquainted with the treatment of fever occurring from operations. All, therefore, ought to have the same elementary education, and be able to practise every department. The operating surgeon ought to dissect daily. Lately the college of physicians of Edinburgh have wisely rescinded a law, which prohibited their fellows from using the lancet or the scalpel. "Etenim omnes artes," says Cicero, "quæ ad humanitatem pertinent, habent quasi vinculum communem."

Arrangement.

The arrangement of the different surgical affections nosologically, is not so essentially necessary in this place, as it has been already done under the article Medicine, for surgery ought not to be separated from Physic. "La science de l'homme malade constitue un tout indivisible."

The classification, according to the textures affected, is objectionable, on the ground that one disease affects many structures, and frequently proceeds from the one to the other, it has been founded on the healthy division of the textures which has been carried to an extreme, and such has been the baneful influence of Bichat's divisions, that his followers in the treatment of disease have conferred as many lives upon man as the vulgar attribute to the cat. The arrangements adopted by Bell, Boyer, Richerand and Allan are all arbitrary.

As Pathology, and even the doctrines of inflammation have been elaborately detailed under the article Medicine, it is unnecessary to describe them here, particularly when we take into consideration the narrow limits allowed us to include so comprehensive a system as that of surgery. The chief object which shall be kept in view shall be a practical detail of surgery, the grand aim to which all our attention ought to be directed.

We shall first treat of inflammation, a disease which more or less follows all the operations of surgery. Inflammation is a term familiar in common language, and is derived from *inflammo*, to burn or inflame, an expression applicable enough, when we consider the kind of pain excited by a very violent degree of it, and the ideas formerly entertained of the temperaments of our bodies. Inflammation is evinced by pain, increased heat, redness, and swelling, which are caused by a morbidly increased action of the nerves, arteries and veins; and in poisoned wounds, the lymphatics are also involved. The nerves are first thrown into action, which instantly excite the contiguous arteries and veins, and as inflammation increases, the excitement extends to the brain and heart. The pain and heat are more dependent upon nervous than arterial action; in very slight degrees of inflammation, arising from some trifling injury, a sensation of warmth is only felt, in which case it is not completely established, since the phenomenon resembles more an increased healthy action. When inflammation is fully developed from a more severe injury, there is a thrilling pain and intolerable sensation of heat at the moment of receiving it. And if the inflammation be so severe as to threaten mortification, the pain is insufferable. The degree of pain seems proportionate to the distribution of the nerves, and to the density or unyielding nature of the structure affected, which prevents the expansion of the nerves, as is evidenced in toothache, diseases of the bones, &c. To prove that increase of heat is also consequent chiefly on nervous action, a sensation of warmth is experienced instantly after the infliction of the pain, and if a severe blow or wound be received, the sensation of heat is intolerable at the moment of the injury; and not until the inflammation has lasted for some time, does the increased quantity of blood contribute to form the increased heat. The redness is caused by the arteries carrying red blood becoming enlarged in their calibre, and conveying more, for the contractility of the arteries is soon enfeebled by over action, and also by those arteries which previously conducted pale blood or lymph, becoming enlarged and transmitting coloured blood. The capillaries, and communicating vessels between the arteries and veins, and even the commencements of the veins themselves, are similarly dilated. The blood flows with increased velocity, which is caused by that part of the artery which is immediately contiguous, or leading to the inflamed or dilated portion, being morbidly excited.

The artery of an inflamed part therefore is at first smaller than during health, in consequence of the spasmodic action of the nerves, and the distention of the vasa vasorum, diminishing the calibre of the vessel, but it very soon becomes enlarged, from the nerves being partially exhausted and the vessel over distended with blood; while the portion leading to the inflamed part is contracted in diameter. The swelling is first caused by the increased quantity of blood circulating in the blood-vessels affected, and secondly, by a deposition or effusion of coagulable lymph, which appears to occur very early in inflammation. In what is termed the phlegmonous inflammation, of which a common whitlow is a good example, there is generally more or less throbbing present, which is solely caused by the pulsation of the inflamed arteries.

In severe inflammation, the nervous system, the heart, and the whole circulating system, are involved, and constitute inflammatory fever; sometimes the quickened pulse precedes the appearance of the inflammation, while at other times it follows. In the former, the increased circulation, from whatever cause, so excites the nerves and arteries, that they are incapable of returning to their wonted quiescence, and the inflammation may be either partial or general, according as any part of the body is feebler than another. In the latter, the nervous system, together with the heart and arteries, are excited by the diseased action of the nerves of the part affected being transmitted along the nerves to the brain and heart. Our narrow limits will not permit us to examine the humoral theories of Hippocrates, Galen and Boerhaave; the alchemical theory of Paracelsus; the spasmodic theory of Hoffman, Staahl, and Cullen; the excitability and excitement of Brown; the irritation, sensation, volition, and association of Darwin; the materia vitæ conservata, chordæ internunciæ, and materia vitæ diffusa of John Hunter; the debility of the capillaries followed by increased action of the larger vessels, or an inequality in the distribution of the blood, according to Vacca Berlinghieri of Pisa, Drs. Lubboch, Allen, W. Phillip, and Hastings; the increased action of the vessels in moderate degrees of inflammation according to Drs. Thomson, Parry, and James. For further information the reader is referred to the article MEDICINE; to the *Edinburgh Med. and Surg. Journal*, No. 60., and to Lizars's *Anatomical Plates*, part 9, Physiological and Pathological Observations. The great subject of dispute in these theories, is, whether obstruction to the circulation of the blood actually exists in inflammation. That this is the case in well formed inflammation there cannot be the least doubt: but in mild cases, especially erysipelas, there appears no ground whatever for such an obstruction.

Inflammation has been divided in a variety of ways by Hunter, Kirkland, Pearson, C. Smith, Pinel, Bichat, Burns, Thomson, and James. From these great authorities, a very simple arrangement may be formed; for inflammation, whether acute, sub-acute, chronic, phlegmonous or erysipelatous, must be identically the same. Phlegmon and erysipelas are only varieties of inflammation, while the acute and chronic are merely different stages of it. The adhesive, suppurative, ulcerative and gangrenous, are its terminations. Healthy inflammation comes under phlegmon; unhealthy, under phlegmon, erysipelas, and chronic; specific, which embraces scrofula, syphilis, cancer and fungus hæmatodes, evidently involves two diseases in each of these peculiar constitutions; thus inflammation occurring in either the scrofulous, or syphilitic constitution, may be either phlegmonous or erysipelatous, acute or chronic.

Acute inflammation, whether phlegmonous or erysipelatous, is mild or violent according to a variety of circumstances. In a healthy, temperate constitution, with a placid mind, and residing in a salubrious situation and temperature, it is natural to expect the attack will be mild, and more likely phlegmonous than erysipelatous; on the contrary, in a diseased, debauched constitution, with a fretful unhappy mind, and living in a confined filthy abode, we have every reason to expect the attack will be violent, and more probably erysipelatous than phlegmonous. We find, however, phlegmonous and erysipelatous inflammation occurring occasionally in both of these habits. Chronic frequently supervenes after the acute, as for instance, in opthalmia, and in advanced life is occasionally an idiopathic disease. It is ascertained that, according as the part affected is more or less vascular, the progress of the inflammation is more or less favourable. The phenomena of general inflammation are evidenced in acute, or chronic, whether phlegmonous or erysipelatous; and when these symptoms are confined to a small space they are said to be local, and when they extend to, or involve the nervous and circulating systems, the affection becomes general, or constitutes inflammatory fever.

The treatment of local inflammation depends much on the part affected; if a finger, it requires less promptitude than if seated in the eye; generally speaking, local blood-letting, anodyne fomentations or poultices, perfect rest, attention to the bowels, and abstemious diet, are all that is requisite. The treatment of general inflammation is by abstracting blood from the system, both locally and generally, by active purging, tobacco enemata, the warm bath, low diet, perfect quiescence, and confinement in a darkened apartment. By a diligent exercise of these remedies, the inflamed part, or inflamed constitution, may be restored to its wonted state of health; and when local, the vessels gradually become more and more quiescent, until they return to their former healthy condition; but if the inflammatory action has been so severe that the capillary arteries have effused coagulable lymph, then the absorbents are excited to remove this superabundant fluid, and the affected part is longer of returning to health. In the case of the constitution being involved, or a general inflammatory action of the system, the nervous and circulating systems progressively decrease in their excitement, until they at last resume their natural course. Either of these favourable results is termed resolution, but this name is more applicable to the local than the general affection.

A phlegmon, which is derived from φλεγω, *to burn*, is distinguished by the colour being of a dark purple hue, by the inflammation being circumscribed, by tumefaction, and by an intense pain, which soon becomes throbbing; when this tumour is pressed upon with the finger, the purple colour disappears for a moment. In the treatment of a phlegmon, leeches, anodyne fomentations or poultices, gentle laxatives, mild diet, and rest should be ordered; and after suppuration, treated as an acute abscess: it is very liable to suppurate, and when occurring in the axilla or groin is styled a bubo. When these phlegmons occur on the face or scalp, they excite the whole system, and then require the treatment recommended for general inflammation, combined with blisters to the nape of the neck.

The manner of applying leeches is familiar to all. When few leeches can be procured, it has been proposed to cut of the tail while the animal is sucking, that the blood may flow out as fast as it enters; or to incise the inflamed surface with a lancet or bistoury. In order to encourage the bleeding afterwards, the part should be fomented or poulticed, or a cupping glass applied. Leeches are preferable to cupping, in affections of the eyelids and other parts of the face, of the forepart of the neck, the scrotum, the penis, the pudenda and the anus.

Fomentations and poultices are preferable to cold saturnine lotions, in all instances of acute inflammation; heat being more natural and manageable than cold. Caloric subdues the action of the nervous and circulating systems by relaxation and exhaustion, and can be procured either in cold or hot weather; while cold does it by causing torpidity, but not until it is reduced to a very low temperature, and then it is liable to produce mortification. Many authors consider that hot and cold applications should be regulated by the feelings of the patient, but these ought never to influence the practice of the surgeon; for the reason why cold at one time, and heat at another, is more agreeable to their feelings, depends entirely upon the time or stage of the inflammatory action. Thus, for example, cold applied during the incipient stage, will be more liable to produce pain, than when applied in the chronic; again, heat in the chronic stage, is more apt to produce pain than in the acute; and whenever suppuration is established, or the inflammation becomes chronic, heat invariably increases the pain, and should be discontinued, cold then being the better remedy. When heat is employed, it must be kept constantly up by renewing the poultices and fomentations whenever they become cool. Poultices are made of turnip, carrot, linseed, barley-meal, onions, oatmeal, and bread and milk, &c., but their virtues depend more on the heat and moisture, than on the materials of which they are composed; the best probably is one made of oatmeal, in a solution of opium with acetate of lead: they ought always to be so large as to cover a great extent of the contiguous healthy surface. The best fomentation is a decoction of poppy heads and chamomile flowers, with a little opium added. Poultices and fomentations will never promote suppuration, they only appear to do so by moderating the increased action, which, if not attended to, might terminate in mortification; when applied, therefore, in inflammation, before the vessels have advanced to suppuration, they will favour resolution; but if not until the vessels are on the verge of suppurating, they merely moderate the increased action, and hence appear to promote suppuration. The practice of applying alternately cold saturnine lotions the one day, and warm poultices the next, must seem absurd to the most superficial observer.

We have already stated that this variety of inflammation has a more diffused character, and is then termed phlegmonous inflammation, which includes Paronychia, Opthalmia, Cynanchetonsillaris, Pleuritis, Pneumonia, Carditis, Peritonitis, Gastritis, Enteritis, Hepatitis, &c. The treatment of these diseases may be said to be the same as that of phlegmon, or general inflammation, and requires to be combined with external irritants, such as rubefacients, blisters, and moxas.

The causes of phlegmonous inflammation are very various, but they may be classed into mechanical and chemical. Fevers frequently give rise to it. An individual phlegmon is sometimes produced by the irritation of extracting one of the bulbs of the hair. The alternations of temperature is a very common cause, especially when the constitution is not in a healthy condition, either from irregularity of the bowels, intemperance, or distress of mind. The operation of cold on the system in producing inflammation has long been an interesting investigation. When an intense degree of cold is applied for a short period to a part of the surface of the body, it paralyses or arrests the action of the nerves for a time, and also constringes the blood-vessels, which causes a reaction of the contiguous nerves and arteries to overcome this torpidity and obstruction, and produces an effusion of the serous part of the blood between the cutis vera and cuticle. When this intense degree of cold is sustained for a length of time, both nerves and blood-vessels are so overpowered, the former rendered so torpid, and the latter so constringed, that too often they are unable to recover their vitality; and in some instances, even life is destroyed, when congelation of all the structures of the body is the result. According, therefore, to the continuance of so severe a degree of cold, will either inflammation, with recovery of the frost-bitten part be the result, or inflammation with mortification of the part; consequently, on the same principle will a more moderate degree of cold only produce inflammation. In the last case, the nerves are merely chilled or impeded in their functions, while the arteries are constringed, so that reaction is the result, or inflammation is produced. Inflammation of the throat, chest, or belly, arising from wet feet, appears to depend on those cavities being more delicate, sensitive, and vascular in their structure, cæteris paribus, than the rest of the body, or from one of these parts having been formerly attacked with inflammation; for it is a singular fact, that when any part has once suffered from inflammation, it is liable to a relapse from every exposure to cold; erysipelas of the face is probably the most familiar example. The cold must be transmitted from the feet to these organs through the medium of the nerves, and must at first produce such a commotion in the nervous and vascular systems as to threaten general fever, for it is more than probable, if inflammation of these organs did not take place, fever would ensue. This effect of cold must occur more readily when there is any irregularity of the constitution.

Phlegmonous inflammation is said to have its seat in the cellular membrane, but this is evidently incorrect, unless this texture be allowed to form the substratum of all the other structures of the body. This phlegmonous variety generally terminates in suppuration; sometimes, however, in resolution, but seldom or never in mortification.

It has already been mentioned, that phlegmonous inflammation is often so diffused as to involve both the nervous and circulating systems, and constitute inflammatory fever, or synocha, or cauma. See Article Medicine.

Its treatment consists in local and general blood-letting, active purging, tobacco enemata, warm bath, low diet, perfect rest, and the apartment kept darkened. Blood is to be abstracted from the system by the lancet, which may be employed either to open a vein or artery, and the blood should be allowed to flow until fainting ensues, or a marked effect is produced on the constitution; a check must be given to the increased action of the nervous and circulating systems; for it is of no avail in an active disease such as this, to bleed without producing a decided effect on the system. Whenever the constitution has rallied from the effects of the first bleeding, which generally happens in four or six hours, if the violent symptoms are not very materially subdued, a second bleeding should be repeated and carried also to syncope; but much depends on the period of the fever at which blood-letting was first adopted, for it is a law in acute diseases, to modify venesection according to the duration of the disease; further bleeding may be even necessary, but the quantity required then to produce fainting, will generally be very small. Syncope takes place more quickly in the erect than in the horizontal posture, but if the fever be severe, the patient is unable to be raised, even to the sitting attitude.

Besides venesection from the general system, it is generally requisite to abstract blood locally; when the head, for instance, is much affected, leeches or cupping glasses ought to be applied to the temples or nape of the neck. Immediately after the first bleeding, a brisk cathartic of calomel and jalap should be given, and if this does not operate in five hours, a tobacco enema of 15 grains to the pint of water should be administered, and afterwards a dose of the sulphate of magnesia. When the nausea of the cathartics has subsided, the patient should be immersed in a warm bath between 90° and 100° of Fahrenheit, and remain until nausea, syncope, or perspiration occurs. Effervescent draughts may be given every two or three hours. Acidulated drinks may also be allowed, and low diet, consisting of plain boiled vegetables, ripe fruits, farinaceous substances, weak tea with a little milk, and toast water. If the local injury will not admit the patient to be removed into a warm bath, a vapour one may be used while he remains in bed.

In idiopathic inflammatory fever, when all increased action has been subdued, the diet should be gradually and carefully rendered more nutritious; but in the symptomatic, it may generally be increased more quickly, particularly if suppuration has commenced.

Venesection acts upon the system by diminishing the sensibility of the heart, first by removing a portion of the stimulus to the brain, and secondly by lessening the quantity of the stimulus to the heart itself; but this does not always occur in proportion to the quantity abstracted, for some faint from the loss of a very small portion, while others are able to bear the removal of a much larger quantity, and this difference seems to depend on the firmness or flabbiness of the fabric of the individual. In the lean frame, pressure seems to be kept up between the different structures of the system; while in the loose and flabby individual, pressure or support is deficient, in consequence of which, fainting takes place sooner than when the patient is of a firm habit of body; upon the same principle, a person faints sooner from being bled in the erect, than in the horizontal posture; the blood cannot be propelled so quickly and easily to the brain, which organ being deprived of its wonted support or pressure, and also of its stimulus, is unable to perform its functions, and fainting consequently is the result; but apparently more from the want of support than stimulus, a fact which is corroborated by the phenomena in paracentesis abdominis for dropsy of that cavity, and also by leaping suddenly out of bed in the morning, or in raising a patient too quickly after fever, or long continuance in the horizontal posture.

The heart contracts or palpitates more quickly by twelve beats in the erect than in the horizontal attitude, but this varies in different constitutions, particularly in the native of a cold climate, who has resided long in a tropical one. In feeble people it is greater, and in all after eating, drinking, or exercise.

Cupping is performed with a scarificator. See Plate DXV. Fig. 1. glass cups and spirit lamp or syringe. Some art is requisite in the performance of this little operation, for the scarificator must be promptly raised during the transition of the lancets from the one side to the other, to allow them to move freely round; and they should never be set to strike too deep, as they then completely divide the skin, and reach the cellular tissue, the blood-vessels of which are not so large and numerous, and when wounded pour their contents into the cells. In some cases it is requisite to strike twice with the scarificator, crossing the wounds that were formerly made; and in other instances, the cups are applied before the scarificator, in order to determine the blood to the part. Cupping is a most valuable remedy in many diseases, being preferable to leeches in affections of the spine and joints, without being a painful remedy.

Of the two modes of abstracting blood, viz. generally and locally, the latter is on all occasions preferable to the former, as we abstract blood more directly from the diseased part, and in all complaints, even in fever, one organ is more affected than another, consequently general and local blood-letting ought to be combined almost on all occasions.

In the treatment of disease much reliance is placed on the nature and colour of the blood abstracted, and many experiments have been performed to elucidate this interesting point. The spontaneous change of the blood, in passing from the liquid to the solid state, or its coagulation, has also been frequently the object of experiment and investigation. The coagulum appears to form merely from the blood being allowed to remain at rest; and happens in the living body whenever it flows out of its natural channel, or whenever that channel is so enlarged as not to be able to circulate it with its accustomed rapidity and keep it fluid, as illustrated in aneurism, in varicose veins of the leg, and when an artery is secured either for aneurism or amputation. The nature and appearance of the coagulum or clot vary very much according to the state of the constitution, when the blood is abstracted; sometimes it is of a natural purple colour, at other times of a yellow or buff tinge, while at other times again, it is of a milky hue. The buff-coloured blood, named also sizy and inflammatory crust, is occasionally turned up at its edges, and is then termed cupped buffy blood, and not unfrequently presents an oleaginous appearance; this buff colour is in consequence of the red particles falling to the bottom of the coagulum, and leaving the fibrin pure on its surface. To convince us that these peculiarities of the coagulum of the blood, even the buffy coat, ought never to direct us in our diagnosis of disease, or influence us in the slightest degree in our practice, we have only to refer to the experiments performed by Mr. Vines, detailed in the 195, 272, and 284 Numbers of the Lancet. From these it is evident, that the conclusions hitherto drawn respecting the blood of man in disease, are incorrect. Many causes producing sudden death prevent the coagulation of the blood. During pregnancy the blood continues buffy from conception until parturition. In pneumonia, the blood, in proportion to the quantity abstracted, becomes more buffy; in many cases where only two cupfuls are taken, the last is occasionally more buffy than the first; and in some instances, when four or five are abstracted, each cupful presents a different appearance; the first has a natural purple colour, the second a buff, the third cupped and buffy, while the fourth and fifth are again purple. The buffy appearance has been attributed to the magnitude of the orifice of the vein, but this is incorrect; the cupped appearance is certainly a better test of the existence of inflammation than the buff colour, but no weight should be given to either; the milky colour is generally present in diabetic, bilious, and dyspeptic habits. For the chemical composition of the blood, See Chemistry.

In the inflammatory fever, when the head is more affected than any other part of the body, the external jugular vein, the temporal, or the occipital artery, should be opened, as the relief is greater the nearer the blood-vessel is to the affected organ; again, as arterial blood affects the system more quickly and for a longer period than venous, the temporal or occipital artery ought to be preferred to the external jugular vein, as in general one half the quantity of arterial, compared with venous blood, produces fainting.

The operation of opening an artery is termed Arteriotomy, and is now almost exclusively confined to the temporal, in consequence of its being more easily reached, although the occipital, which was preferred by the ancients, would be the most beneficial, from its direct inosculation with the vertebral artery. In the days of Galen the arteries of the hand were frequently opened. In the Medico-Chir. Trans. of Edinburgh, vol. i., a case is mentioned, where the radial artery was opened by Mr. Rhind, surgeon in India. When the temporal artery is to be opened, the patient should be in the horizontal position, with his head resting on a pillow; the operator then feeling the course of the trunk of the artery, as it runs over the zygoma, or one of its branches as it ascends along the temple, places the fore and middle fingers of his left hand on the vessel, in order to render it steady, the one above or distad, the other below or proximad, of the artery, while with his right hand he makes an oblique incision, about half an inch in length, through the integuments down to the artery, with a lancet, cutting as if it were a scalpel. When the artery is distinctly seen traversing this little wound, the surgeon is to make a similar oblique incision of the vessel, cutting it in a contrary direction, or picking it from below upwards, as if he were opening a vein of the arm. See Plate DXVII. Fig. 6. When the necessary quantity of blood has been taken, the lips of the wound are to be approximated, a firm compress made of a roller of calico, about one inch in diameter, as delineated in Fig. 12, applied over it, and a double-headed roller to encircle the head, crossing as often as possible over the compress. See Fig. 8. The wound should be dressed on the third day, either with adhesive plaster, or simple cerate, according to its appearance, and the compress and bandage reapplied. Afterwards it ought to be dressed daily, and the compress and bandage worn for at least a month, as aneurism is very liable to supervene to this little operation. Arteriotomy is preferred to phlebotomy, in inflammation of the brain or eye, especially Iritis.

The opening of a vein is termed Phlebotomy, from φλεψ *a vein*, and τεμνω *to cut*, also venesection or bleeding. Venesection is commonly applied to blood-letting at the bend of the arm, although we sometimes select the external jugular, or one of the veins on the back of the hand, foot, or ankle. It is sometimes performed on the veins of the scrotum; it has been done in the veins under the tongue and on the forehead, but these last are now abandoned. The external jugular is preferred in apoplexy and croup; the veins at the bend of the arm, in general inflammatory diseases and after accidents; those on the back of the hand, foot, and ankle, in very fat people, when a vein at the bend of the arm or external jugular can neither be seen nor felt. In many individuals, the veins at the bend of the arm can only be felt; and in such cases the surgeon should be experienced, and most careful, as a nerve, the artery, or the tendon of the biceps, might be mistaken.

When the hand or foot is selected, it should be immersed in hot water, and retained there during the flow of the blood; and the same should be done when the scrotum is the part affected, and the patient may stand before the fire, as he should be in the erect position.

The manner of opening the external jugular vein, is to place the head of the patient on a pillow, while his body reclines in the horizontal posture; then press with the thumb of the left hand on the vein after it has crossed the sterno-mastoid muscle, and when it becomes turgid, place the fore and middle fingers of the same hand above and below the point to be wounded, which should be in the region of the sterno-mastoid muscle; then with the lancet in the right hand an incision is to be made obliquely across the integuments from above downwards, using the lancet as a scalpel, and when the vein is distinctly seen, it is to be cut upwards as at the bend of the arm. See Fig. 7, Plate DXVII. Whenever the blood has begun to flow, the middle fingers of the left hand are to be removed, but the thumb is to remain until the quantity required has been abstracted, and the wound closed with adhesive plaster, as air may enter in by the wound of the vein and prove fatal; a case of which is detailed in the Lancet, No. 259. No compress or bandage is to be used, for it would check the cutaneous venous circulation of the head.

When the vein at the bend of the arm is the vessel selected, the patient should stand, sit, or lie, according to the effects to be produced. If the intention of the surgeon is to produce fainting at the least expense of blood, as in luxation or rupture, the patient should be held in the erect position, and a large orifice made in the vein in order to remove the fluid quickly. In inflammation of the bowels, the object should be to abstract as much blood as to cause syncope, but not hurriedly, the patient therefore should be placed in the sitting or horizontal attitude, and a large wound of the vein made. During pregnancy we occasionally abstract blood, in order to relieve congestion, and have then to guard particularly against producing syncope or any uterine irritation; we therefore place the patient in the horizontal posture, and make a very small wound.

When a vein at the bend of the arm is to be opened, as represented in Fig. 4 of Plate DXVII, the patient must hold it on the stretch, and have something to grasp in his hand, to keep his fingers in motion, to promote the flow of the blood. The skin must be firmly stretched upwards along the vein, in order to prevent the wounds made in the skin and vein from shifting; and this is generally done with a fillet or bandage, which should encircle the arm twice, as close as possible to the point to be wounded, and be tied with a slipping knot on the outside of the arm. The surgeon then places the fore and middle fingers of his left hand as in arteriotomy, in order to keep the vessel steady, and with his right hand holding the lancet somewhat like a writing pen, he wounds or pricks the skin and vein at once, and gradually cuts obliquely upwards; making the wound in the skin somewhat larger than that of the vein. The blood should flow at the side of the lancet before it is withdrawn; and when the necessary quantity has been removed, the fillet should be unbound, and the vein compressed beneath or distad to the wound with the thumb of the left hand, the arm washed with tepid water, the lips of the wound neatly approximated, and a square compress of linen applied, and then bound up with a bandage rolled round the elbow joint in the figure of 8. The wound should not be dressed sooner than the third day, and then treated according to appearances, either with a new compress and bandage, adhesive plaster, or simple ointment. It not frequently happens, that although the vein is compressed distad to the wound, the blood still flows, which arises from an inosculation with one of the deep-seated veins.

However simple this elegant little operation of venesection at the bend of the arm may appear, yet there are instances of individuals losing their lives, even in skilful hands, in consequence of a high division of the brachial artery into the radial and ulnar, one of which sometimes runs immediately beneath the skin, between it and the fascia of the biceps, and is thus liable to be wounded. A careless operator may transfix the vein and wound the fascia of the biceps or the brachial artery, and thus varicose and false aneurism may be produced: or extensive inflammation of the fascia of the arm, together with suppuration beneath it. Besides these formidable diseases, there are ecchymosis, inflammation of the vein, of the skin, of the cellular substance, of the lymphatics, and the wound of a nerve, which may all occur after venesection at the bend of the arm.

Ecchymosis, from εκχυω, *to pour out*, is an effusion of the blood into the cellular tissue, contiguous to the wound in the vein, occasioned by the wound in the skin not corresponding with that in the vein, or the wound of the one not being kept in apposition to that of the other during the flow of the blood, or from the integuments overlapping the wound in the vein, the skin not having been braced with sufficient firmness by the bandage ; or lastly, by not making the wound in the skin a trifle larger than that in the vein. When the blood forms a circumscribed tumour, it is termed a thrombus, from θρομβος, *coagulated blood.* The one, therefore, is a circumscribed tumour, and the other a diffused effusion of blood; they both require the same treatment, and unless the quantity of blood be profuse, either effusion is of little consequence, and requires no attention. If however the effusion be extensive and produce pain or inflammation, poultices should be applied and continued until all inflammatory tendency has subsided. The inflammation induced, seldom or never ends in suppuration, even of the lips of the wound. If the ecchymosed fluid does not disappear, and the lips of the orifice are healed, but not otherwise, it may be discussed by exciting absorption by means of stimulant embrocations. All surgical operations are followed by more or less ecchymosis, according as the parts may have been torn or bruised during the operation; but it even supervenes in a slight degree in operations most scientifically performed, especially in the face and other delicate parts of the body, as the knife cuts on the principle of a saw.

Too often from an over anxiety to heal the wound inflicted in phlebotomy, it is dressed the day following the operation, the consequence of which is, that the process of adhesive inflammation is disturbed, and too great a degree of inflammation is excited, which either spreads all over the arm, confining itself to the skin, and assuming commonly the erysipelatous type, or involves the subjacent cellular tissue, forming erysipelas phlegmonodes, or extends to the fascia of the arm, or affects the lymphatics, or the vein itself.

Inflammation of the vein is also said to arise from foul lancets, which however appears to be very seldom the case; nevertheless, a vein ought never to be opened by one which has been employed in opening a syphilitic bubo, or in performing vaccination. When a patient requires to be bled twice in the course of twenty-four hours, a common practice is to abstract the second quantity of blood from the same orifice, by applying another bandage round the arm above or proximad to the wound, until the veins become swollen, then removing the first bandage, and tearing away the compress adhering to the wound, when the blood commonly springs out; but if not, the wound is forcibly opened either with the fingers, or by squeezing the blood along the vein onwards to the orifice, or by inserting a probe or lancet; such teazing steps are even pursued in a third bleeding, if performed in twenty-four hours. If there is not much inflammatory action present, and the second bleeding is performed within twelve hours of the first, this plan may be adopted; but if otherwise, it is extremely liable to produce inflammation, as the adhesive process takes place very quickly between the lips of a vein and so small a wound in the skin. It is therefore preferable to open a vein of the opposite arm. The same vein is sometimes opened close to the first wound in the course of twenty-four hours, which is also an improper practice; and neither this, nor opening the same wound twice, should be adopted in hospital practice, particularly in thoracic inflammation, as the veins are more liable to be inflamed, when lanced in this, than any other disease.

Inflammation of the vein is characterized by tumefaction of the arm, pain in the wound darting to the axilla, and even to the thorax, accompanied with difficult respiration and inflammatory fever, which advances rapidly to typhus. The vein to the touch feels hard, is very tender, and sometimes inflamed both upwards and downwards; the lips of the wound are everted, swollen, and occasionally pus or sanies, mixed with blood, can be pressed out from it. Not unfrequently there is an œdematous boggy feeling in some parts of the arm, with more or less inflammatory discolouration of the integuments. On dissection, the vein is found so thickened in its coats, that it has all the appearance of a nerve; and coagulable lymph and pus are deposited in its cavity, sometimes to the extent of plugging it up; the internal coat is of a reddish purple colour, resembling claret. There is more or less effusion of purulent matter in the contiguous cellular tissue, and even in that entering into the formation of the muscles, and in some instances the two pectoral and the contiguous intercostal muscles are infiltrated with pus. The pleura is often found inflamed, with abscesses forming in the lungs; and sometimes the right auricle and ventricle will also be inflamed, with even pus in the pulmonary artery. Inflammation of a vein proceeds with great rapidity, and as veins circulate their contents onwards to the heart, the inflammatory action is conveyed to this viscus with alarming celerity, frequently proving fatal between the fifth and tenth day. The coagulable lymph and purulent matter effused into the veins, must also be carried onwards to the heart. From these alarming consequences, it is evident that the treatment of this disease must be very prompt. The patient should be bled to syncope by opening a vein of the neck or opposite arm, and this ought to be repeated in four hours, or whenever he rallies, and until all inflammatory tendency has been subdued; and as there is a disposition to inflammation in the venous system, the same vein ought never to be opened twice. Together with active blood-letting, should be combined tobacco enemata, brisk cathartics, warm bath, a profusion of leeches to the part affected, or scarifications with the bistoury, represented in Fig. 2, Plate DXV, followed by large anodyne poultices, or fomentations, with low diet and perfect quietness. When scarifications are made with the bistoury, the wounds should be plugged with lint, after a requisite quantity of blood has been abstracted. If these local applications do not seem to arrest the extension of the disease, large blisters should be applied. The general treatment in all these affections is the same with that recommended for inflammatory fever. John Hunter and others have recommended pressure on the vein both above and below the wound; but we should rather consider, that the compression would increase the inflammation; Mr. Abernethy proposes the division of the vein, a line of practice certainly preferable to that of Mr. Hunter.

Inflammation of the lymphatics begins by the wound appearing fretful, inflamed and suppurative, by a cord or cords being felt sometimes above or proximad, and at other times below or distad to the wound, but not precisely in the course of the vein. These cords appear of a delicate rosy red colour, are exceedingly tender to the touch, and have frequently one or more tumefied points on the inner or ulnar margin of the biceps muscle, in the course of the brachial vessels; similar tumours are also often seen on the fore-arm, between the elbow and the wrist joints. The glands of the axilla become early affected, and there is general tumefaction of the arm, with acute pain in the wound, in these corded lines and tumours, accompanied with considerable symptomatic fever. Either before or after the inflammation of the lymphatics, the contiguous cellular substance becomes very early involved, frequently producing extensive suppuration of both, which also spreads to the axillary glands, in which case there is more or less œdematous feeling. According to the extent of the affection, the treatment requires to be either entirely local, or both local and general. The same remedies, with the exception of blisters, are to be employed as in inflammation of the vein, and need not again be described.

Inflammation of the fascia of the arm commonly takes place, when the operator has carelessly transfixed the vein and wounded this membrane; but this accident may occur in the most skilful hands, for occasionally the most prominent vein at the bend of the arm, and the one any surgeon would select, runs beneath or centrad to the fascia of the biceps. The symptoms of this affection are acute pain in the arm, extending to the shoulder, whenever the fore-arm is moved, which latter is in some degree bent on the arm, with the fingers also bent and contracted. There is great tension, some degree of tumefaction in consequence of anasarca, and slight erysipelatous inflammation; there are also generally sympathetic spasms over the whole body.

As suppuration quickly supervenes, with thickening of the fascia, and consequent contraction of the elbow joint and fingers, the treatment should be extremely prompt, this affection being strictly erysipelas phlegmonodes, consequently the same means should be used as for inflammation of the vein: and in the event of contraction resulting, the fascia of the fore-arm must be divided either at its connexion with the biceps muscle, or what is preferable, immediately below or distad on the pronator and flexor muscles, avoiding the course of the veins and nerves, and even the ulnar artery in case of a high division of the brachial. When there is great tension during the inflammatory stage, accompanied with severe pain, the fascia even then should be divided.

A nerve at the bend of the arm is extremely liable to be wounded in venesection, in consequence of the twigs of the internal and external cutaneous nerves, and even some of the spiral nerve entwining the different veins. When a nerve is wounded, the patient feels acute pain the moment the lancet pierces the vein, and inflammation of the wound follows, the nervous symptoms immediately commence, and acute pains are experienced darting along the arm, to the neck and head, and even down along the fingers; convulsive twitchings ensue, accompanied with restless nights, being disturbed by frightful dreams. When inflammation of the wound does not take place it heals up, and some days, even weeks, elapse before the convulsive symptoms begin, and in this case, which is the more rare of the two, it resembles tetanus more than the other. On some occasions it assumes the appearance of neuralgia. If the convulsive symptoms have been severe, in a few days spasms occur which dart from the head along the back and bring on trismus or locked jaw, which puts an end to the patient's sufferings.

The treatment of this affection in the first noticed case, requires to be very prompt. The wounded nerve must be divided close above or proximate to the wound, the arm enveloped in an opiate poultice, having half an ounce of opium dissolved in half a gallon of water, and if this should not give relief to the patient, the actual cautery should be applied to the wound. The patient ought to be bled in the other arm, or jugular vein to syncope, put in the warm bath, have powerful cathartics given, followed by large doses of opium, and have tobacco glyster administered. The bleeding to be repeated as frequently as circumstances require; and if all these remedies fail to subdue the tetanic symptoms, a vein of the opposite arm should be opened, and a solution of opium injected into the circulating system.*

We have already mentioned the most common cause of inflammation of the skin supervening to venesection at the bend of the arm, and it may also arise from the same causes as those producing inflammation of the vein and lymphatics; and we have already stated, that the variety of inflammation which generally occurs here is erysipelas. This variety then, or type of inflammation, for it appears nothing else, has been divided by authors into a number of species, as may be seen by consulting the works of Cullen, Bateman, Pearson, Smith, Pinel, and James, for it attacks the same structure as the phlegmonous, thus the velum pendulum palati is as often affected with erysipelatous as with phlegmonous inflammation; the former named cynanche maligna, the latter cynanche tonsillaris.—We shall confine ourselves to erysipelas, and erysipelas phlegmonodes.

Erysipelas from ερυω *to draw* and πελας *adjoining*, termed in common language *rose*, or St. Anthony's fire, when it occurs after blood-letting at the bend of the arm, begins in the contiguity of the wound, and soon spreads both upwards and downwards, frequently involving the whole arm, which becomes swollen, the skin assumes a delicate rosy tinge, and is clear and shining, and when pressed gently with the finger, a white mark remains for a little. A yellowish hue is frequently observable, and there are occasionally serous vesicles which either dry up, or burst and desquamate, or ulcerate, or slough and ulcerate. The patient feels a hot burning pain in the part, and when the constitution becomes affected, which is early in the disease, there is inflammatory fever with considerable nausea. By some it is stated, that the wound of the vein often heals before the erysipelatous affection takes place, and continues so, while on other occasions it breaks out. The treatment is the same as that recommended for inflammation of the vein; for bleeding, blisters, poultices, and anodyne fomentations, are as proper remedies for the one affection as the other; but if there be any tension, incisions should be made as in erysipelas phlegmonodes. The reader is also referred to the treatment of inflammatory fever, and the Article Medicine, Vol. XIV. Page 4.

In this disease, a vein opened in the opposite arm never assumes the erysipelatous type; nor do leechbites, according to the common opinion, mortify; blisters often arrest the extension of the inflammation, and the blistered surface never assumes the erysipelatous action, but, on the contrary, limits it. Warm poultices are as beneficial in erysipelas as in phlegmon. Flour is a common but most inert application. A solution of the sulphate of magnesia, with tartrate of antimony, is found to be an excellent aperient. Emetics are pernicious remedies, particularly when the head is the seat of the disease, as they propel the blood to that organ. When erysipelas attacks the face or scalp, it ought to be treated with great promptitude, in consequence of the vicinity to the brain; and when once either of these parts have been attacked, it is peculiarly liable to return on the slightest exposure to cold. It is also very apt to move from one place to another, in this manner, extending all over the body, from the head down the back and breast to the arms and even the legs, the one part desquamating as the other makes its appearance. It is likewise subject to be translated from one part of the body to another like rheumatism, from the leg to the lungs or face, and it has been known to occur periodically. The integuments of the head are particularly prone to erysipelas after all wounds, especially punctured ones; it also often occurs after compound fractures of the leg, and occasionally in the anasarcous leg. It not unfrequently attacks the umbilical region of new born children, and extends along the umbilical vein, or downwards to the pudenda. Erysipelas is described as being confined to the skin, and when it involves the subcutaneous cellular tissue, it is termed phlegmonous erysipelas, or erysipelas phlegmonodes, or diffuse inflammation of the cellular texture. The epidermis, the rete mucosum, the cutis vera, the cellular tissue, and the cellular substance forming the aponeurosis of the muscles, have all individually and collectively been supposed by authors to be the seat of erysipelas.

We find erysipelas attacks mucous structures, as the mucous membrane of the fauces, and we feel confident that we have seen it evidenced in other textures, as the serous, namely the pleura and peritoneum, also fibrous textures, as the periosteum, and we can see no reason for its not attacking every tissue. Erysipelas phlegmonodes is distinguished from simple erysipelas, by the part affected presenting a combination of the two colours, the vermilion and purple, and often a yellow tinge, by the œdematous boggy feeling, and by the patient having rigors or shiverings. An œdematous spongy sensation is one of the best criteria of suppuration having taken place. Whenever matter can be distinguished, free incisions should be made to evacuate it, and as it is often diffused over a great extent, these require to be numerous. If much tension is present, or if the disease be severe, it will be advantageous to make these incisions even before suppuration has taken place, as they not only relieve the tension, but moderate the inflammation by the local abstraction of blood. Instead of short, or moderately sized incisions, as first

* Cauteries are divided into the potential and actual. The potential consists of the different escharotics and astringents, as the sulphates of alum and copper, and nitrates of silver and copper. The actual cautery is an iron heated to incandescence and the moxa. The irons used for cauterizing are of various shapes. The moxa is made of common cotton immersed in a solution of the nitrate of potass (of the strength of five grains to an ounce of water) and afterwards dried. A small quantity of this cotton is firmly rolled up and encircled with a piece of card half an inch broad, and three inches long, and afterwards tied round with a thread. It is then fixed in a *port-feu* (See Plate DXV. Fig. 3) the one end set fire to, and the other held firmly on the part to be chemosed. The common bellows are then employed to keep up the ignition of the cotton, which now resembles a common fuse, until it is entirely consumed. The ignition should be merely kept up, for the more slowly it burns, the more powerful is the effect.

recommended by Mr. C. Hutchison, Mr. Lawrence makes a long incision, even the length of the leg, which is evidently objectionable. Erysipelas terminates either in resolution, suppuration, vesication, or gangrene. When resolution, or an abatement of the disease is the termination, the skin assumes a pale yellow colour, and ultimately the cuticle desquamates.

When gangrene supervenes, the parts become first bluish and then black; an inflamed line of demarcation next takes place between the sound and the mortified parts, ulceration succeeds, and the gangrened parts slough or sphacelate, and sometimes leave the principal artery of a limb exposed. In dissection of the more severe cases of erysipelas, the cellular tissue of the arm is universally gangrenous, even that forming the basis of the muscles, which texture is also distended with a sanious fluid. There appear no grounds for considering erysipelas infectious, and it is even doubtful how far it is contagious; nevertheless, in this as in all other diseases, every attention should be paid to cleanliness and ventilation. The treatment will be detailed under mortification.

Paronychia, or Whitlow, named also, Panaris, Onychia, Onychia maligna, and Panaritium, is so common an infection attacking the finger, that all are familiar with it; writers, however, make out a number of species, as detailed in the Edinburgh Medical Journal, No. 95, which subdivision appears truly frivolous and unnecessary; in general, the less the finger is diseased, the more the hand, fore-arm, and arm are affected. It is usually a phlegmonous inflammation attacking the finger near the point, but sometimes is erysipelatous, and arises from a variety of causes, some of which are occasionally very obscure, or entirely unknown. The causes are commonly cold, a piece of the nail fretted, or what is vulgarly termed rag-nail, a prick or wound in the finger from a thorn, small splinter of wood, needle, hook, scalpel, forceps, spicula of bone, a broken bottle, an abrasion, or dirt getting access to the cutis beneath the nail. The finger affected generally presents a swollen inflamed appearance, and has a painful hot throbbing sensation. In some cases the malady is confined to the nail and its vicinity; in others the finger feels acutely painful, the pain extending to the hand and fore-arm, with little or no tumefaction; in others again, the pain is confined solely to the finger, unaccompanied with tumefaction. When confined to the nail and neglected, there commonly shoots forth a fungoid excrescence, and the finger becomes swollen and deformed. From what has been stated, a whitlow may be considered a disease of the finger, of an inflammatory nature, attacking one or all the structures, rapidly terminating in suppuration, and occasionally in gangrene even of the bones; and as the inflammation, suppuration, and gangrene are liable to extend upwards along the arm, fatal consequences may ensue.

As the finger is exceedingly sensitive and vascular, whitlow should be treated early and vigorously. If the finger be merely inflamed, and no degree of tension, warm poultices, with absolute rest and low diet, will be sufficient; but if there is tension, or matter apparently secreted, a longitudinal incision of some depth should be freely made in the centre of the finger, and generally on the palmar aspect, to give relief, and to extract blood locally. When the cuticle acts as a sheath, and restrains the expansion of the inflamed finger, it ought to be cut off with scissors; and when matter insulates the nail, the latter should be removed with scissors and forceps, otherwise a fungous excrescence germinates around it, forming what is termed *ulcus mali moris*, or in common language, the growth of the nail into the flesh, when the slightest motion causes exquisite pain. The nail then is more difficult to remove, produces more pain, and the excrescence requires to be removed with the scalpel and escharotics, or both. The best escharotic is the nitrate of copper. This latter variety often attacks the toes, especially the great one, and various ways have been devised to remove this source of irritation, by Paré, Dupuytren, and Wardrop, the last of which is the preferable, and is detailed in No. 209 of the Lancet.

If the hand be involved in the disease, it should be treated as recommended for inflammation of the vein, and if the inflammation still continue, one or two incisions should be made in the palm of the hand, to divide the palmar fascia so as to remove the tension and obviate permanent contraction of the hand, care being taken not to wound the palmar arch of the ulnar artery, an incision may be also necessary on the back of the hand. If the disease extend to the fore-arm or arm, the same treatment will be required as in inflammation of the fascia. In this affection the phalanges of the fingers become soon carious, proving the necessity of active treatment; and whenever the bone or bones are ascertained to be bare or rough, they should be removed either by extracting them individually or by amputation; on some rare occasions, the finger degenerates into a carcinomatous condition, and requires to be amputated.

The fascia palmaris, especially the threads extending along the fingers, is frequently so contracted from this malady as to impede the functions of the fingers or even the whole hand, and should therefore be divided by a cross incision, the fingers being afterwards held out straight by a piece of wood. From an attentive examination of such fingers in the dissecting room, we can speak with confidence of the nature of this contraction; the tendon being only gradually contracted, in consequence of this arch of the fascia palmaris being so: and from the different positions in which the fingers are held, the same derangement takes place in their joints, which progressively become dislocated.

Pure and simple whitlow, the most common affection resulting from punctures in the dissecting room, is frequently produced from the puncture of a hook, scalpel, forceps, needles, or the spicula of a rib, in the examination of the thoracic viscera. In the mildest cases, there is merely a small serous vesicle of a milky colour, from being filled with a fluid more or less purulent, and surrounded with an erysipelatous or phlegmonous blush. In the severest cases, the disease is either at once ushered in with rigors, high constitutional excitement, advancing rapidly to typhus, with a peculiar despondency of mind, or the inflammation extends along the fore-arm and arm to the axilla and thorax, involving the muscles of the axilla, those situated on the thorax, and even those on the abdomen and back, resembling erysipelas phlegmonodes, or inflammation of the fascia consequent on venesection at the bend of the arm: indeed the only difference between these affections is, that in this originating from a puncture in morbid dissection, we have frequently no chain of connection between the puncture and the muscles and cellular tissue of the axilla; but the same want of connection, or cause and effect, appears to exist in erysipelas and a wounded nerve succeeding to phlebotomy. There can scarcely be a shadow of doubt, that in one and all of these affections, some exciting cause must have existed; and that although the wound healed in either without being observed, yet nevertheless it must have inflicted irritation or excitement, or a morbid action, either in a lymphatic, a nerve, or a blood-vessel, which has not been called into action until the constitution was excited either by stimulation or by fever induced by cold. We have known many by dining out and indulging in wine, rouse to action such punctures even when healed; also if afterwards attacked with febrile symptoms induced by cold. The lymphatic vessels appear to be those which suffer, because the axilla is the most frequent seat of the first development of this affection, and yet the glands situated there are seldom affected. The greater number of individuals are affected in consequence of being punctured while labouring under some febrile attack. The mind has a powerful influence in this disease.

Assuming this view of our theory to be correct, we must next ascertain whether any poisonous matter is absorbed. The fact of the same affection being produced by clean lancets, clean needles, common skewers, delicate splinters of wood, various kinds of thorns, the spiculæ of the bones of the ox or sheep, broken glass, or an abrasion of the finger against a wall, should at once put to rest the idea that absorption has any concern in producing such a disease; for since to the same causes we are entitled to ascribe the same effects, why should we search for the unknown and fanciful, when such simple and natural causes are before us? Before the time of Paré, musket bullets were supposed to be poisonous, and there are modern authors who are so credulous as to believe, that Malaria travels, like the carrying pigeon, from Italy and Holland to London!

Some authors assert, that recently dead morbid animal matter is more poisonous than putrid, while others the reverse, and some think that the saline solution employed in injecting dead bodies is a corrective. If what has been advanced be correct, it follows that putrid dead morbid matter, and saline dead morbid matter, should be more irritative than recently dead morbid matter. We do not mean to deny, that putrid dead morbid matter may be absorbed, although it is well known that the syphilitic virus and many other living animal poisons cease to affect the living system the moment death takes place; but we do mean to deny, that absorption occurs in punctured wounds, producing erysipelas phlegmonodes or diffuse inflammation of the cellular tissue. By some a specific virus is supposed to be generated in the dead body, but this appears fallacious if we are correct in our theory. It is also imagined that this virus is absorbed even when the skin is sound in those constitutions considered to be peculiarly susceptible of the impression of dead animal matter, and that gloves, oil or lard, are excellent prophylactics; but that these are totally inert there appears scarcely a shadow of doubt. Some authors contend, that a person engaged in dissection, will resist this disease and the putrid effluvia better if his diet be nutritious; but the very reverse ought to be the case.

With regard to fever, we have already stated, that idiopathic inflammatory fever is caused by the application of cold to the body while heated. The same appears to be the cause of all other fevers with the exception of hectic, so that we are of opinion that neither putrid effluvia, marsh miasmata, nor pestilential vapours, ever give rise to fevers. These effluvia appear only to render the constitution ill-conditioned and feeble, and more susceptible of cold, and hence, when attacked with fever, make it more violent.

The treatment of this variety of erysipelas phlegmonodes, originating from punctured wounds received in morbid dissections, is as various as its theory, which must ever be the case so long as we are ignorant of the correct pathology of the disease; it equals the farcical medley of a thousand remedies as applied to ulcers, so humorously described by John Bell. When suppuration is established, all are agreed that vent should be given to the matter by free incisions. Nor has the general treatment been more consistent than the local. The treatment of this should be the same as that recommended for erysipelas phlegmonodes. See also inflamed vein and inflammatory fever. In the last stages of this fearful affection, as in other fatal disorders, hiccup, which is an inverted action of the stomach and diaphragm, is no unfrequent concomitant, and is easily checked by the patient sipping any bland fluid, swallowing it constantly without intermission until the hiccup ceases; and afterwards he must avoid speaking, for it is exceedingly liable to recur, sneezing and coughing reproducing it.

Adhesion is that termination of inflammation which takes place when the inflammatory action is moderate, and coagulable lymph only is secreted: in common phlegmon, this occurs very soon after the increased action has begun, the lymph being effused into the contiguous cellular tissue, which limits the extension of the inflammation. It takes place also in all acute abscesses, and in all incised wounds, whether accidentally or intentionally inflicted. Adhesive inflammation or union by the first intention, although a termination of inflammatory action, begins a new series of operations, and its doctrine being one of the most interesting and important in surgery, has engaged the pen of our most able pathologists. When a clean incised wound is made, such as that in amputation of a limb, and the sides of such a gap are made to approximate, the first process in nature to effect a reunion, is a moderate degree of inflammation, by which coagulable lymph is effused, which appears to be effected by a modification of the capillary arteries, influenced by the nerves, to secrete this organizable fluid. That coagulable lymph is a secretion, appears evident from the consideration that in slight degrees of inflammation of serous membranes, it is unquestionably secreted, and in abscesses and ulcers it is poured out in profusion; that in fractured bone it is a pure secretion; that in incised wounds, the blood acts as a foreign body, and that every fluid, either healthy or diseased, is secreted, or undergoes modification in vessels; it is also one of the simplest of diseased secretions. The bleeding of a wound must have entirely ceased before coagulating lymph can be effused, hence it appears that some modification of the bleeding or capillary arteries, influenced by the nerves, takes place. This coagulating lymph differs from that obtained when recent blood is allowed to coagulate, by being of a lighter colour, nearly transparent, like animal jelly or made starch, and being more tenacious, also more organizable.

The common doctrine of this lymph either issuing from the half-closed mouths of the vessels, or from the surface of the opened cells of the cellular substance, seems incorrect. After this coagulating lymph is effused, the capillary arteries and veins of each side of the wound shoot into it, soon rendering it a firm bond of union; and an inosculation has been proved to take place in the short space of twenty-four hours. In inflammation of the serous membranes, the pleura, pericardium, peritoneum, internal tunics of arteries, &c. the degree of the inflammatory action is often exceedingly mild, and the duration very short which accomplishes adhesion, apparently almost as soon as inflammation is established, the serous secretion is checked and that of coagulable lymph substituted. On the principle of this adhesive inflammation, are the various incised wounds healed, also as the renovation of a nose, or under lip, or a deficiency of the urethra.

The formation of a new nose or under lip, when either of these has been removed by accident or some previous disease, was first practised in India by Branco, afterwards by Tagliacotius in Italy and Germany, and is now termed the Talicotian or rhino-plastic operation. Tagliacotius used to take a piece of skin off the arm or some other part of the body to make the new feature, upon which Butler has written a humorous stanza, and Addison an amusing paper. It is now performed by taking a piece of the integuments in the vicinity of the feature, from the neck when it is the under lip, and from the forehead when the nose. The latter operation is performed in the following manner:—A piece of leather is cut the shape of the nose, and placed upon it, or where the nose should have been; and, if any skin remains, it is removed, and the margins rendered raw by clean incisions; when all bleeding has ceased, the leather is then laid upon the forehead, and traced round either at once with the scalpel or pen and ink; this portion of the skin is then dissected off from its attachment to the occipito-frontalis muscle, taking along with it as much cellular substance as possible, and leaving a tolerable point of connection at the root of the nose; it is then gently twisted round, and laid upon whatever remains of a root or dorsum, making it correspond with the surface already rendered raw for its reception, only a degree larger; and lastly, stitching it with two silk ligatures on each side of the nose, and one at the columna. If the skin to form the new nose has no support in consequence of the columna and cartilaginous septum being destroyed, it should be gently supported with dossils of lint inserted in each naris; but if there be enough of septum to prevent the skin hanging or dragging, no foreign body should be inserted, as all source of pressure or irritation ought to be carefully avoided. Whenever adhesion has been effected, the nose should be supported by silver tubes. The raw part on the forehead should be approximated with stitches as much as possible, and afterwards healed like any ulcerated surface. Whenever adhesion is perfect, and all irritation and tumefaction have subsided, the little twisted portion of integuments that formed originally the point of connection should be divided, and laid neatly down.

Before performing this operation, the surgeon should be satisfied there is no constitutional affection present, and in those cases where the nose has been destroyed by *noli me tangere*, all tendency to this herpetic ulceration ought to have entirely ceased. If a small portion of the skin of the old nose remains, it had better be removed, as it will disfigure the countenance by a contrast of colours.

Suppuration is another termination of inflammation. Whenever the inflammatory action is more violent than what is necessary for the capillary arteries to secrete coagulable lymph, these capillaries, modified and influenced by the nerves, form small suppurative papillæ that secrete purulent matter, which theory of action constitutes suppuration. When this ensues from acute inflammation, and the matter is circumscribed or confined in a sac, the disease is named acute abscess; for we have purulent matter, or a puriform fluid secreted by mucous membranes, which are the most subject to this termination of inflammation. It is also secreted in incised wounds, and in the skin or cutis vera after a scald with boiling water or the application of a blister. In mucous membranes, such as the urethra, the capillaries are naturally endowed with the power of secreting a mucous fluid; and if these vessels are inflamed, they are easily and quickly modified by the nerves, to secrete a puriform fluid, as for example in Gonorrhœa, occasionally twelve hours after infection. In this case the capillaries do not seem to form suppurative papillæ, as in common suppuration and ulceration. In the cut the capillaries perform the functions of exhalants naturally, so that when stimulated by a blister, they are soon modified by the nerves to perform the function of secreting purulent matter; and if the irritation be kept up by blistering ointment, they soon form suppurative papillæ. In incised wounds, the capillaries perform the same office as in ordinary suppuration; small suppurative papillæ being rapidly formed and then pus secreted. In all cases of suppuration there must be a precedence of inflammation, however slight in degree, even in scrofulous tumours or abscesses. All loose textures, as the cellular, when attacked with inflammation, are more prone to terminate in suppuration than condensed compact structures, because the blood-vessels have greater latitude to form suppurative or ulcerative papillæ.

The symptoms of suppuration are rigors or cold shiverings, which occur at irregular intervals, and are commonly followed by a hot fit and slight increase of the preceding febrile symptoms, if the inflammation has been extensive; a total quiescence of the pain of the inflammation for a time, which is soon resumed if the hot applications are continued, especially if the suppuration be superficial. In a short while the pain returns, but changed to a dull, heavy, and constant feeling; the tumour becomes conical, with a white or yellow tinge at the apex, while the surrounding inflammatory colour is deeper and the skin more glistening; there is occasionally more or less of an œdematous feeling, and matter is then distinguishable to the fingers. One of the best examples of an acute abscess, is the termination of an inflamed inguinal gland in suppuration. Whenever the fluctuation of matter is perceptible in a circumscribed acute abscess, a free incision should be made from the one end of the tumour to the other, with the bistoury; but in an extensive or diffused abscess, the most depending part should be selected to make the aperture. Unless a free incision is made in the circumscribed abscess, the matter is liable to loiter at one of the extremes, and form a sinus or sinuous ulcer or tube, which afterwards requires to be laid open, an event frequently exemplified in the syphilitic abscess. Some authors recommend that abscesses should be allowed to break of themselves, while others recommend caustic instead of the bistoury, but the knife is preferable, as it inflicts less and more transient pain, makes an aperture proportionate to the abscess, and prevents the disease making further progress. After the evacuation of the matter, poultices should be applied for the first twenty-four hours, when the wound ought to be dressed with simple dressings, compress of tow, and a calico roller; and in the case of the groin being the seat of the disease, the bandage should encircle the body and the thigh in the figure of the digit 8. The periods of dressing an abscess must depend on the quantity of matter secreted. In ordinary cases, once or twice in twenty-four hours is sufficient.

In those cases of acute abscess of the palm of the hand, fore-arm, arm, thigh or leg, where the matter is situated beneath or centrad of the fascia, there is generally a dull cutaneous inflammatory discolouration, and an œdematous feeling, which, with the other symptoms already enumerated, indicates the presence of matter. In such cases the fascia must be freely divided with the bistoury. An œdematous boggy sensation is the best index of matter being secreted, yet it is often exceedingly difficult to distinguish its presence; the *tactus eruditus* is a valuable acquisition to a surgeon. When an acute abscess is examined, it is coated with coagulable lymph of a smooth membranous-looking ash colour, which is termed the sac or cyst, and adheres by a vascular cushion to the surrounding cellular substance, the latter of which, in the vicinity of the abscess, is more dense and vascular; and its cells are closed with coagulable lymph. In this vascular cushion and stratum of coagulable lymph, the capillary vessels modified to secrete the purulent matter are situated, together with the nerves, veins, and absorbents. In all abscesses, a secreting and absorbing action is going on. A remarkable circumstance is that an abscess advances almost always to the surface of the body, which has been attempted to be explained on the principle of plants growing towards the light. It appears, however, more probable from the skin offering less resistance, for when matter is deposited beneath a fascia, it burrows in all directions. The matter secreted in an acute abscess, occurring in a healthy constitution, is named pus or purulent matter, and is of a yellow cream colour, and about the consistence of rich cream. For its chemical properties the reader is referred to the article CHEMISTRY. Pus slightly irritates the contiguous skin of an abscess or ulcer, and even the granulations: therefore, from these fretting qualities, it ought to be absorbed by lint and tow as soon as secreted.

An abscess, when freely opened and dressed daily with simple dressings, gradually fills up by the formation of suppurative papillæ or granulations, and when these arrive to be nearly on a level with the skin, it is generally termed an ulcer: an ulcer, therefore, is simply a diseased, or abraded secreting surface, (for there are numerous healthy secreting surfaces,) and has been correctly defined by authors to be a solution of continuity in any of the soft parts of the body, attended with a secretion of pus or some other discharge. Another definition, but not so perspicuous or correct, is, that it is a chasm formed on the surface of the body by the removal of parts back into the system by the action of absorbents; and a third is, a granulating surface secreting matter, the last of which is most satisfactory. The ulcer consequent on an acute abscess occurring in a healthy constitution, is named a healthy ulcer, from its being a process of nature to repair the breach of continuity, but the same is applicable to the syphilitic ulcer. Simple, consequently, is a better appellation than healthy to this kind of ulcer, as no diseased action can be said to be healthy. It is termed the 'simple purulent ulcer;' and 'ulcers in parts which have sufficient strength to carry on the actions necessary for their recovery.' In the *Philosophical Transactions* for 1819, Sir E. Home has detailed some most ingenious microscopical observations on the conversion of pus into granulations, by the extrication of carbonic acid gas from coagulated pus, forming tubes or canals, which are filled with red blood, and thus connected with the circulation: this, however, appears too chemical a process. In this species of ulcer, the granulations are bright red conical points, regularly formed, numerous, firm and distinct; and the matter secreted by them is pus in a moderate quantity. These granulations, when they arrive at the level of the skin, form a thin film or skin, which begins at the edge, if the structure of the skin has been destroyed, and spreads over the sore, and in the middle, or all over the sore, if the cutaneous tissue is preserved, as is beautifully exemplified in the ulceration supervening to a gentle scald. The treatment of this simple ulcer is merely to absorb the pus, and afford support to the edges and the cutaneous circulation; dry lint, therefore, is often preferable to that spread with simple ointment, and should be notched towards the centre in order to give exit to the pus. For the same reason a pledget or compress of tow should be put over it, and a roller gently applied above. The great art in the treatment of this ulcer is not to stimulate it, and to preserve the new skin when formed. On renewing the dressings, the old should be thoroughly softened with warm water before removal. When the ulcer occurs in the leg, which, from its exposed and depending situation, is most subject to ulcers, the roller should be applied from the toes to the groin, as exemplified in fig. 1, of Plate DXVI: and the patient should keep as much as possible in the horizontal position. Various substances are used for bandages, as calico, linen, and flannel.

This simple or healthy ulcer is very easily inflamed or irritated, and then assumes the name of the irritable ulcer, or the 'inflamed ulcer,' or 'ulcers in parts whose actions are too violent to form healthy granulations, whether this arises from the state of the parts or of the constitution,' and is characterized by the sore becoming hot and painful, and the granulations of a dark red colour, approaching to purple, very small, and scarcely distinguishable, the edges of the sore thin, ulcerated, or phagedenic, having a worm-eaten appearance, and the skin around the ulcer inflamed, of a dark purple colour. The secretion is thin, and either bloody, dirty white, or of a green colour; and is so acrid as to excoriate the surrounding skin, and even the granulations themselves. The surface of the sore is occasionally of a brown instead of a purple colour, while at other times white or ash-coloured; and there are frequently irregular elevations and depressions, as if they were excavated by the matter. This species of ulcer is easily produced by the most trifling exciting cause. The treatment of this irritable ulcer is by the application of large anodyne fomentations and poultices, low diet, and absolute rest in the horizontal position, until the inflammatory action is completely subdued, which is indicated by the absence of the pain, and the diminution of the inflamed colour of the surrounding skin; by the edges becoming defined and clean; by the sore becoming more florid in colour, and by the secretion becoming creamy and purulent; or, in other words, by the sore presenting the characters of the simple ulcer. For the first two or three days simple ointment should be used, and a roller applied. The diet and exercise ought to be slowly increased.

Both this irritable and the simple ulcer are very liable to become stationary in the process of healing, and ultimately to be so indolent as to have no disposition to advance; it is then termed an 'indolent or callous ulcer,' which is characterized by the edges being thick, smooth, callous, and of a blue white colour, and by the surface of the sore being below the level of the callous margin, and presenting a smooth, glistening, flabby appearance, there being few or no granulations, and those which do exist, generally pale and languid. The discharge is frequently thin, profuse and viscid, adhering to the ulcer; but sometimes it is scanty, and then the surface of the ulcer is of a brown colour. The skin around is purple and hardened, but not inflamed, particularly if the ulcer has been of any standing; the cautaneous veins are commonly varicose. The bluish white colour of the edges is the most characteristic sign of this species of ulcer. This ulcer occurs, like many others, most frequently on the leg, and generally in advanced life; from the age of maturity, however, all are subject to this disease, which is most prevalent in the labouring classes, and among soldiers and sailors. Its treatment consists in gently and gradually stimulating the parts to action, by the application of a solution of the sulphate of copper, and of a mild ointment of the red oxide of mercury, together with a firm compress and bandage. The judicious arrangement of compresses adopted by Mr. Whately, is particularly applicable to this ulcer. When this solution, and the ointment of the red oxide, lose their stimulating qualities, an event which occurs in all local applications, they must be strengthened gradually and cautiously; and when the ointment has been increased to the strength of ʒij to ʒi of lard; the unguentum resinosum should be substituted for the lard. The patient should be allowed nourishing diet, and even stimulating food, and should keep the leg quiet, in the horizontal attitude. Mercury and cantharides are most powerful auxiliaries, if administered only to excite the system to greater activity. Such a numerous catalogue of remedies are recommended for this ulcer, that John Bell has humorously classified them into innocent drugs, humerous drugs, and devilish drugs. The most common in use are adhesive plaster, ointment of the nitrate of mercury, hot dressings, which consist of resinous ointment and oil of turpentine rendered hot, ardent spirits, solutions of nitrate of silver, nitrate of copper, muriate of mercury, oxide of arsenic, tincture of myrrh, lemon juice, and the gastric juice of ruminating animals. Of these the adhesive plaster is the most valuable, and should be cut into slips of from one to two inches in breadth, and of such a length as to extend some inches on each side of the ulcer, but never so long as to encircle the leg, since it then interrupts the circulation of the skin, unless the roller is applied tight enough to support the cutaneous circulation distad to the adhesive strapping. The slips or straps are applied across the sore, previously heating them gently by drawing the back of the plaster along the surface of a smoothing iron. The lowest or distad one should be first put on, by fixing its one extremity to the sound skin on the one side of the ulcer, where it ought to be retained by the hand of the patient, and pulling it across, while with the fingers of the left hand, the opposite sides of the sore ought to be approximated as much as possible, before applying the other extremity of the strap to the sound skin, because the intention is to bind or approximate the edges by force. As many straps should be used as to extend fully one inch at each extreme of the ulcer, and not overlap each other, but rather to have a small gap between each, to allow the matter to exude. Over the adhesive straps, a compress of tow, and lastly, a bandage are used. The ointment of the red oxide of mercury is preferable to the nitrate. Warm dressings are a powerful remedy, but difficult to manage. Ardent spirits and tincture of myrrh are beneficial. The nitrates of silver, copper, the muriate of mercury, and oxide of arsenic are escharotics, and not stimulants like the sulphate of copper, therefore inadmissible in this species of ulcer. The sulphate of copper never acts as an escharotic, even in its crude state, but always as a stimulant; and it is only when strong compression is combined with its application, that it appears to act as an escharotic, but in reality only as a powerful absorbent. The lemon juice is a good application, and so also is the gastric juice of ruminating animals. The bluish white callous border ought never to be excised with a knife, or destroyed with caustic, as it is the newly formed skin sparingly supplied with blood vessels. This callous margin indicates want of action, and is the most favourable for the application of the adhesive strap.

This indolent ulcer, the most generally met with in practice, is frequently healing in one part, while inflamed and phagedenic in another, apparently from the extent of surface involved; as it sometimes extends from the knee to the ankle joint; and in this case, the inflammatory and phagedenic disposition must be thoroughly subdued by fomentations, poultices, rest, and low diet, before any attempt to heal the callous portion; and even when this irritable disposition has been removed, caution must be observed before we have recourse to exciting treatment, so that simple dressings may be advantageously applied for two or three days. The same inflamed and phagedenic action is also liable to attack this ulcer while under treatment, when the same means must be adopted. The securing of the saphena major vein with a ligature, as practised by Paré, Wiseman, and Sir E. Home, is now abandoned in consequence of the inflammation which is sometimes induced; but this vein, in all cases where it is varicose, should be obliterated with the potassa above the seat of the ulcer.

The fungous ulcer is merely the simple ulcer which has arrived at the level of the skin, and instead of cicatrizing, shoots forth luxuriant granulations, which become pale and flabby, and in common language termed proud flesh, when the sore is of small magnitude. Neither the irritable nor the callous ulcer can produce these exuberant growths, for in the former there is too much action, which checks their production, and in the latter the action is defective. These granulations are found in ulcers occurring in the venereal and scrofulous constitutions, as well as in the cancerous and carious ulcers; and in the latter these fungous excrescences are best exemplified. The treatment consists in reducing the exuberant granulations by the nitrates of silver or copper, to the level of the skin, when they generally cicatrize.

By the Phagedenic ulcer, is generally considered Gangrena Phagedena, or hospital gangrene, but there is a phagedenic ulcer destitute of a sloughing or mortifying disposition, although it eats away to a horrible extent, being derived from φαγω *to eat:* it is termed by Sir A. Cooper, the gangrenous or sloughing ulcer. It occurs commonly after an ulcer has been neglected or suffered to remain too long open, and not unfrequently in the syphilitic constitution. It is characterized by irregular knotted edges, which are smooth and flat on one side, and on the other high and rugged: by its healing in some points, and spreading rapidly in others, but still advancing in extent as a whole; the surface also sometimes looks well, and at others ill-conditioned; the discharge is occasionally purulent, at other times thin and ichorous, and sometimes so profuse as to induce hectic fever; the skin around is purple and violaceous, and more so where it is phagedenic; the pain is very acute, and at times quite insufferable; the inflammatory action is more frequently chronic than acute, becoming acute only occasionally, from some source of irritation. This ulcer attacks the integuments of the legs, the labia of the female; the penis, the scrotum and nates of the male. The treatment consists in subduing all irritation and inflammation by anodyne fomentations and poultices, low diet and absolute rest; then the application of weak escharotic solutions, together with a weak ointment of the red oxide of mercury; these should be changed or increased in strength, whenever they appear to lose their effect. Not unfrequently they produce too much irritation, and require to be given up, and to have substituted the fomentations and poultices. The chief object to be observed in this ulceration, is to endeavour to arrest its progress, and to change it from this inveterate species to the simple ulcer. Nothing is so beneficial in the treatment of this and all inveterate ulcers as change of air. The diet should be mild, consisting of vegetables and fruits, together with poultry, eggs and milk, and the decoction of sarsaparilla with the compound calomel pill may be given. This ulcer may be termed the simple phagedenic ulcer.

There is an ulcer which precisely resembles this phagedenic sore in appearance, for they ought to be considered one, being purely phagedenic, but which only attacks the face, and from its supposed contagious nature is named *Noli me Tangere*; and is classed by authors under the herpetic ulcer. It generally begins at the alæ of the nose, but not unfrequently in the upper and even the lower lip, also in the forehead or angle of the eye, hence no part of the face is exempt from its first attack, and spreads upwards, downwards, and centrad, until it ultimately removes the whole countenance, producing hectic fever, and repeated hemorrhagies, when death closes the scene. Its characters are identically the same as the phagedenic ulcer last described, and need not therefore be repeated. The ulceration however is preceded by a yellow pustular or scabby eruption, surrounded by a violet-coloured circumscribed inflammation. These moist yellow spots either fall off, or are picked off by the patient, and expose this ulceration, discharging at that time a thin serous acrid matter. When the inflammation is moderate, there is commonly little pain, but when severe, there is an acute burning pain, and more or less concomitant fever. It is a most inveterate ulceration, and unless treated in its earlier stages, often foils the labours of the surgeon. The treatment should be the same as that recommended for the simple phagedenic ulcer; but if it does not succeed in curing it, the chloride of lime very much diluted may be tried. The following ointment sometimes produces beneficial effects, ʒss of camphor, ʒiij of the white precipitate of mercury, ℥iss of the prepared carbonate of lime, and ℥ij of lard finely levigated. If after all, the ulceration continues inveterate, the whole base should be excised if practicable, and if not, destroyed or eaten away with the crude nitrate of copper. Some use equal parts of alum and chalk to the edges in order to destroy the diseased structure. A number of authors consider this disease constitutional, and recommend arsenic, antimonials, mercury, purgatives, and sudorifics internally, with vegetable diet and warm baths. There does not appear however the least ground for considering it constitutional, as it begins locally and continues so nearly to the conclusion of the horrid scene. What seems to have deceived us on this subject is, that all ulcers heal from the powers of the constitution, consequently when these are too vigorous or too languid, the healing process does not take place. The constitution, as well as the ulcer, requires to be sound or healthy.

Tinea capitis is also classed under this ulcer, and is a variety of the herpetic or creeping ulceration. Tinea capitis, porrigo, or scald head, consists of six species, according to Bateman, but we shall limit ourselves to two, the porrigo furfurans, and the porrigo scutulata. Porrigo furfurans, or tinea capitis, begins with an eruption of small achores, the excoriation is slight, and the discharge concretes and falls off in innumerable thin laminated scabs. Fresh pustules arise and follow the same course, until the greater part of the scalp of the head is involved. The hair partly falls off, and there is intolerable itching and soreness. This affection commonly begins in early life from inattention to cleanliness, and a peculiar prejudice of the parent against washing the head of the child. The treatment consists in removing the whole hair of the head with a razor, applying a large quantity of resinous ointment at bed time, in order to soften the attachments of the crusts, which, on the following morning, are to be washed off with soft brown soap and warm water. The ulceration is then to be treated with the same escharotic lotions and ointment, as recommended under the simple phagedenic ulcer. Pure nitrate of silver is the most prompt remedy. This ulceration is also considered constitutional, and even infectious by many authors; but it can be no more constitutional than *noli me tangere*, and to consider it infectious appears truly ludicrous; but its contagious character is completely established. In the application of escharotics to the scalp, we must attend to their stimulating effects upon the brain. Porrigo scutulata, or herpes circinatus, or ringworm, attacks the scalp, face, and neck, in the form of separate patches, of an irregular circular shape, resembling the fairy rings made by some of the fungi, from which it derives its name. It begins with clusters of small light yellow pustules, which soon break and form scabs or scales, beneath which a delicate ulceration is perceptible. When neglected, it spreads all over the head in the form of clustered patches. The treatment is precisely the same as that for tinea capitis, and is frequently as obstinate to cure. A variety of remedies are recommended by authors for both of these ulcerations.

Gangrenous phagedenic ulcer, or hospital gangrene, named also malignant ulcer, putrid ulcer, sloughing sore, contagious gangrene, phagedena gangrenosa, gangrene humide des hopitaux, and pourriture d'hopital. It is divided by some authors into two, and by others into four varieties, which is evidently superfluous. This ulceration attacks all kinds of ulcers, wounds, and even blistered surfaces, in hospitals, ships, and in low crowded filthy situations; and the smaller the sore, the more liable is it to be affected. The ulcer or wound becomes covered with a dirty white coloured slough, or a tenacious viscid ash-coloured matter, the secretion being checked; the edges are surrounded with an erysipelatous blush, and more or less œdema. The patient feels little pain in the sore, which has more the sensation of a sting from a gnat; he is attacked with rigors, has a foul tongue, loaded constipated bowels, and excessive thirst, which soon form active fever. On the following day probably, the ulcer has sloughed all round, and may be double, or even quadruple, its original size, and in a few days becomes of such magnitude as to endanger his life. The edges and base of the ulcer slough with alarming rapidity, the former becoming hardened, ragged, and everted, and having a most irregular shape, while the latter or granulations are large, tumid, and distended with gas. Small dark coloured vesicles appear on the sound skin surrounding the ulcer, which burst, and also form sloughing sores ultimately communicating with the original. The discharge is sanious, ichorous, viscid, emitting a peculiarly offensive odour. The patient now suffers continually from burning, lancinating pains. Fresh flabby blackish sloughs are rapidly formed, which overtop the ragged inflamed edges that are immediately involved, until such an extent of ulceration is produced, as either to expose a number of blood-vessels, usually veins, which by repeated bleedings exhaust the patient, or the ulceration carries him off by the debility consequent on so great a source of irritation, or he dies of diarrhœa or hectic fever. Blood-vessels, particularly large arteries, do not generally yield so soon to this frightful ulceration as other textures. This ulcer is described to have occurred spontaneously; but it seems very doubtful if this ever occurs, for it is more probable that some source of irritation existed, as the pulling out of a hair of the skin, or the prick of a pin. Some authors contend that the febrile affection always precedes the ulceration, and if by this is meant, that a patient while affected with a simple ulcer or scratch is attacked with fever, which from the nature of the atmosphere, and the state of his constitution, assumes a very violent type, and readily disposes this trifling ulcer to acquire this gangrenous character, it is no doubt correct, as is satisfactorily proved by the cases of Blackadder. The lymphatic glands of the groin or axilla, whichever extremity is affected, are generally excited early, and sometimes suppurate, and assume this phagedenic ulceration: while at other times they suppurate and heal kindly, while on other occasions again they merely become swollen. During this suppurative and healing process, they suspend the phagedenic disposition of the original ulcer. By some authors it is stated that the syphilitic, cancerous, scrofulous, and variolous ulcers are not liable to be attacked with phagedena, an error very satisfactorily confuted by Drs. Thomson and Hennen. The treatment of this formidable disease, is by the vigorous use of the lancet in the beginning or inflammatory stage, and by repeating it as often as any inflammatory diathesis remains. The inflammatory action does not last long, in consequence of the great debilitating causes present; still, if we do not bleed during the inflammatory stage, the fever will continue to rage, and the ulceration will be the more extensive, and consequently the debility greater, which is clearly and satisfactorily proved by the various cases on record, and is daily evinced in the treatment of continued and typhus fevers. The propriety of blood-letting is supported by Drs. Trotter, Hennen, and Boggie. The application of the actual cautery to the ulcer, followed by hot dressings, and over these dry lint, tow, and the most gentle bandaging. What is termed the eighteen tailed bandage (see Plate DXV. Fig. 4), deserves to be preferred in such cases. The ulcer should be divested as much as possible of sloughs and moisture, previously to the application of the cautery, which should then be applied to every point, particularly the edges, and be repeated whenever there is the least tendency of the ulcer to spread. The actual cautery and compression are the only remedies for ulcerated arteries, as they will not bear the ligature, however remote from the diseased action, and a fresh wound would instantaneously assume the gangrenous action. The hot dressings should be applied as hot as the patient can bear them, and be removed whenever they are moistened with matter, which commonly occurs twice or thrice a day; and the sore at each renewal ought to be washed with a warm solution of the subcarbonate of potash. No sponge should be employed, but lint and tow substituted, which ought to be immediately burned, as cleanliness is of vital importance in the treatment. The bandages after being thoroughly washed, ought to be immersed in lime-water for some hours, a practice of very beneficial consequence in hospitals. In the inflammatory stage the patient should be put into a hot bath once or twice a day, or the vapour-bath can be administered in bed, or he can be sponged with hot water. If possible, his linens and bedclothes ought to be changed daily, and the most free ventilation permitted. His diet during the inflammatory stage should be mild, and consist chiefly of ripe fruits and succulent vegetables, if the season permits. Great debility is necessarily to be anticipated: therefore, whenever all inflammatory diathesis has been subdued, the diet must be rendered nourishing, with a liberal allowance of wine and porter, if the bowels are not relaxed. Large opiates and the sulphate of quinine should be given. Hospital gangrene is peculiarly liable to relapse, on which account the greatest attention should be paid to the patient until the wound or ulcer has completely cicatrized, and he is restored to perfect health. An extraordinary variety of remedies have been used in this ulceration, the most efficacious of which are, the concentrated or diluted mineral acids, the nitrates of copper or silver, or solutions of these, also the solutio arsenicalis. Amputation is inadmissible in this species of gangrene, in consequence of the violent inflammatory fever present, which makes it a case of mortification arising from an internal cause. The daring and convincing experiments of Dr. Blackadder, and the narrative of Dr. Trotter, satisfactorily establish that it is not infectious, but its contagious nature cannot be disputed.

Scorbutic ulcer is now rarely met with; it begins with lassitude, indigestion, bleeding of the gums on the least touch, and roughness of the skin resembling that of the goose. The muscles become rigid, the gums spongy, effusions of blood take place in different parts of the body, frequently under the skin in the form of large livid blotches like ecchymosis, and generally on the lower extremities; and the slightest bruise produces a tumour containing effused blood, which is very liable to ulcerate. The legs become œdematous, the face presents a livid bloated appearance; he is early attacked with diarrhœa, which is often accompanied with blood, hemorrhage being either spontaneous or arising from the most trifling injury. The least degree of exertion produces laborious breathing, and any attempt to raise himself to the erect posture is liable to produce fainting and even death. If the individual has been formerly affected with ulcers, these break out again, and if he has had a fractured bone, the union dissolves and the ends separate. Ulcers also occur spontaneously, and one and all are characterized by livid edges, which are puffed up by luxuriant fleshy excrescences under the skin, by want of granulations, the flesh at the bottom of the ulcer presenting a dark grumous appearance, soft and spongy, and generally covered with cakes of coagulated blood, which adhere so closely as to be with difficulty wiped off. The discharge is thin, fetid, and mingled with blood. As the ulcer advances, a soft bloody fungus shoots forth, which acquires in twelve hours an enormous size, and even when removed with the knife, is as quickly regenerated. This was compared to the liver of the bullock by the sailors of Anson and Cook. Scurvy is produced by living solely on animal diet.

The treatment of this disease consists in the internal use of fresh fruits and vegetables, particularly of such fruits as have the citric acid, and those vegetables which are acid and succulent, as in the class Tetradynamia; also the alliaceous plants in the class Hexandria. Porter and spruce beer are beneficial remedies. The patient should be in a large well-aired apartment, and have plenty of fresh air, remain constantly in the horizontal attitude, taking his food out of a cream-jug or tea-pot, and using a bed-pan and urinal, when the calls of nature occur. The ulcer is to be treated with lime or lemon-juice and gentle bandaging, but the chief object is to change this peculiar diathesis to one of health, and then the ulcer soon heals, and even disunited bones are again consolidated.

When the syphilitic ulcer has been imprudently treated with mercury, without science or system, it inflames, becomes irritable and phagedenic, and is then named the mercurial ulcer; it has irregular hard edges, a deep sloughing base, a dark coloured inflammation around; is apparently healing in one part having a delicate pellicle, while it is increasing rapidity in another. Its treatment consists in applying to the ulcer opiate fomentations and poultices, giving up the mercury; in abstracting blood from the system if it can bear it, giving large doses of the sulphate of magnesia, small doses of sulphur, frequently repeated, the use of the warm bath, and avoiding every exertion.

The other ulcers, the syphilitic, scrofulous, &c. are treated of, under the diseases to which they belong, and for which the reader is referred to the Article Medicine.

Chilblains is that kind of phlegmonous inflammation which attacks the fingers, toes, and heels, and occasionally the nose, lips, and ears in cold weather, particularly of those leading a sedentary life, and women more frequently than men, and children oftener than adults. The parts affected are swollen, of a purple colour, hot and painful, and not unfrequently suppurate, and even mortify. Small serous vesicles often appear, which burst, and become fretful, troublesome ulcers. These occasionally penetrate to the bone, and discharge a thin ichorous or sanious matter, producing caries, which ultimately requires amputation of the limb. These ulcers are sometimes covered with sloughs, or the inflamed part at once ends in gangrene, and then sloughs. Chilblains should be treated, in the inflammatory stage, like phlegmon; during the suppurative, as acute abscess; and while in the ulcerative stage, the same as the irritable, simple, or callous ulcer, according to appearances; and when gangrene occurs, the same treatment as that detailed under mortification should be adopted; and if caries supervenes, the same remedies employed as recommended under that disease of the bones. When chilblains have been cured, the parts should be rubbed with rubefacients, kept warm, and in as frequent motion as possible, as they are very liable to recur. In surgical works, the most heterogeneous medley of remedies is given.

Furunculus or boil, a species of phlegmon, is an exceedingly hot and painful inflammatory tumour, about the size of a pigeon's egg, circumscribed, hard, prominent, of a purple colour, and of a conical shape. A white or occasionally livid pustule soon forms on its apex, but the tumour suppurates slowly, secreting only a small quantity of matter mixed with blood; the greater proportion of it becoming gangrenous, and forming a firm slough or core, as it is named in common language, which is dead cellular substance. If left to itself, this tumour is very slow of bursting and discharging the slough, and there remains a deep cavity, with a circumscribed hard base, which continues to discharge the same bloody matter, and is very long of healing. When there are two or more boils at once, which is no uncommon occurrence, there is more or less symptomatic fever; and they also frequently occur in succession. They generally take place in loose cellular tissue, as that on the nates and back part of the thighs, occurring commonly about puberty, and in the spring, apparently from the excitement given to the constitution at this period of the year, and when the system is undergoing those changes peculiar to that time of life The treatment of this tumour, during its inflammatory stage, is the same as that for phlegmon, and when suppuration has taken place, by a crucial incision. The treatment for the ulcerative stage, is the same as that recommended for ulcers, whether of the irritable, simple, or callous types. The slough is very tardy in being thrown off, and requires hot dressings. To prevent the recurrence of boils, the diet should be mild and nutritive, the bowels attended to, and the patient take plenty of exercise in the open air.

Anthrax or carbuncle, another species of phlegmon, is merely an aggravated or more violent species of furunculus, and is an extensive, flat, hard tumour, of a dark purple colour, darker in the centre than at the circumference, and feeling very deeply seated. It commonly occurs on the back between the shoulders, and begins with great heat and acute pain, a diffused tumefaction, followed early by a small itching pimple, which soon becomes a vesicle or blister, and bursts, discharging a thin brown or bloody sanies, followed by the appearance of a yellow coloured slough. Sometimes several pimples are produced by the patient scratching the surface, which becomes intolerably itchy, while on other occasions several vesicles occur, which spontaneously burst, and discharge the same bloody sanies. When the disease is left to itself, these apertures slowly ulcerate, and run into one another, exposing to view an extensive slough, which, when thrown off, leaves a large ulcerous cavity, discharging bloody sanies. Whenever a carbuncle begins, it should be freely leeched or scarified, large anodyne poultices or fomentations applied, and as soon as suppuration takes place, it ought to be divided by a crucial incision, and the poultices then should have turpentine, resinous ointment, or camphorated oil mixed with them, and continued until the slough is discharged, when it should be treated with charpie, moistened with turpentine or other stimulants, as it is very indolent, and removing portions of it from time to time as they become loose.

Chronic inflammation is that inflammatory action which continues for a long period, so slow, mild and passive, as sometimes to be imperceptible, and considered by some authors as not to exist on many occasions. The most palpable example is that which follows an acute attack of inflammation of the eye, this organ continuing for months and even years, red, fretful, and weak, but not painful, hot, and fiery; all acute inflammatory attacks are liable to become chronic; but there is a chronic state of inflammation which begins *a priori*, as, for example, that which precedes lumbar and other chronic abscesses, and also the formation of tumours. In superficial chronic abscess, there is occasionally tumefaction, which is circumscribed and hard, but attended with as little pain as in the deep seated abscess. In both there is commonly constitutional derangement, and they generally occur in a feeble frame of the scrofulous diathesis. In the progress of this disease the local symptoms of inflammation become more manifest, and still more so in the latter stages. This species of inflammation generally attacks serous and mucous surfaces, although every structure may become the seat of it. Bursæ mucosæ, as that under the deltoid or glutæus maximus muscles are very often attacked, and so also is the synovial membrane of the knee-joint.

The treatment of chronic inflammation, when it attacks an exposed surface as the eye, or accompanies an ulcer, is by stimulant lotions and ointments. The diet should be chiefly farinaceous, bowels attended to, the eyes kept from a bright light, and little or no exercise allowed; when it attacks a mucous canal, as the urethra, by the same stimulant lotions still more cautiously used, and the same diet, with perfect rest in the horizontal posture. When it attacks a deep-seated structure, such as the bursa of the deltoid, the application of leeches or the scarificator is necessary, the latter, however, deserves to be preferred, in consequence of the external irritation excited; these, together with low diet, gentle laxatives and perfect rest, may prevent suppuration; but they generally require to be followed by the moxa. In deep-seated chronic inflammation, the moxa appears to act by inducing counter-irritation or counter-inflammation, which removes the action of the inflamed vessels from the disease to itself, and also excites active absorption. On these grounds, the more quickly the ulceration produced by the moxa heals, so as to enable another to be applied, the better, and hence, small but deep eschars made by moxas are better than large ones. The practice, therefore, of keeping issues open is now nearly obsolete.

Chronic abscess is the cyst or sac of matter resulting from chronic inflammation, and occurs often in the abdominal muscles, particularly in the psoas magnus, and is then termed psoas or lumbar abscess. This species of abscess attacks likewise the ovarium, and indeed every kind of structure. It affects every age and constitution, but more frequently early life, and the scrofulous habit, in consequence of debility. We are seldom aware of the existence of chronic abscess until the matter has been actually secreted, when it ought to be evacuated in the following manner. The skin is to be pulled upwards or aside, that it may act afterwards as a valve, when a small oblique aperture is to be made with the bistoury, and a silver probe inserted in the wound, and the matter evacuated, which is thin, serous, and mixed with curdly flakes, but sometimes purulent. The wound is to be immediately closed with adhesive plaster, and healed by the first intention. During the treatment of chronic abscess, the diet ought to be mild and nourishing, the patient as much as possible in the open air, if dry and temperate, and if the seat of the disease will permit it; and he should take sulphate of quinine, or some of the preparations of iron or diluted sulphuric acid. When the psoas muscle is affected, he will require to be drawn in an easy hung carriage. Tepid and ultimately cold bathing, or sponging, with friction, are powerful auxiliaries. Whenever matter has again collected, however small in quantity, it ought to be discharged. The above treatment must vary considerably according to the seat of the disease.

In lumbar or psoas abscess, the disease begins in the lumbar vertebræ, which ulcerate and become carious, and the matter secreted either gravitates in the course of the muscle, being confined by its fibres or fascia, forming a tube, or proceeds directly dorsad to the integuments of the loins. If it is confined by the fascia of the muscle, the matter sometimes gravitates to the groin, and presents itself either below or above Poupart's ligament, near the anterior superior spinous process of the os ilium, or near the pubes; sometimes it emerges at the crural aperture and descends below or centrad of the fascia lata to the poples, and even retrogrades upwards or proximad to the tuberosity of the os ischium; at other times it gravitates into the pelvic cavity, emerges at the great sacro-ischiatic notch, and makes its appearance near the anus. In rare instances, the matter descends along both psoæ muscles, forming two abscesses or a double abscess. Whenever the matter advances to the integuments or points, the skin at first is not discoloured, but an impulse is given to the fluctuation on coughing, and in a few days the skin becomes discoloured, inflames, ulcerates, and ruptures. The symptoms indicating this affection are remarkably insidious, being seldom apparent until the abscess points. The patient complains of weakness and uneasiness in the region of the loins, which are much aggravated on ascending a stair, and he is easily fatigued with walking. Occasionally there is felt considerable pain in the loins, which seems to follow acute inflammation of the vertebræ; and not unfrequently there is distortion of the spine. As lumbar abscess is liable to be confounded with hernia and fungus hæmatodes, we must be careful in our diagnosis before opening it. The history of the case, together with the fluctuation of the tumour, which is tense in the erect, and nearly disappears in the horizontal posture, becoming softer, flatter, and looser; and when again placed in the erect attitude, by the impossibility of preventing the descent of the matter, lumbar abscess is characterized. The treatment has been already described, with the exception of the injection of lime water. Lumbar abscess attacks youth, and the male more frequently than the female; however, Mr. Abernethy cites more cases of its occurring between twenty and forty years of age, than at an earlier period.

Hectic fever, which particularly accompanies chronic abscess when opened, is characterized by the following symptoms. The patient begins to have a hot skin, especially in the palms of the hands and soles of the feet, a crimson blush on the cheeks, small quick pulse, loss of appetite, thirst, nocturnal perspirations, lateritious sediment in his urine and diarrhœa. There are exacerbations in the evening, there being a chilly, a hot, and a perspirative stage in succession like in intermittent fever. This is supposed by some authors to depend on the absorption of the matter, but no hectic fever takes place until the matter is evacuated; by others to depend on the irritation together with the increased discharge, but in some cases of phthysis pulmonalis, where the individual wastes away without the slightest irritation or pain, hectic fever accompanies the disease almost from the beginning; by others again, to be the consequence of a change in the system, induced by the process of suppuration, or even of the previous inflammatory action that gives rise to this process. It appears rather to be consequent on mere debility of constitution, which whenever it is so far exhausted from a discharge in any disease, that the nervous and circulating systems have not their accustomed supply of nutriment, *i. e.* the blood, then increased absorption goes on with great rapidity, while there is no nutrition, the nutritive lymph being removed by the discharge. The hectic fever which accompanies Nostalgia corroborates this view. Its treatment consists in light nutritive diet, diluted sulphuric acid, and the cretaceous or catechu mixture, when the bowels are affected, attending at the same time to the local affection producing it.

Mortification is one of the common terminations of inflammation, and occurs when the inflammatory action is so extremely violent as to destroy the structure of the nerves, arteries, veins, and contiguous textures, which are overpowered by exhaustion; while the contiguous tissues are destroyed both by inflammatory action and by being gorged with blood, which coagulates in consequence of not being kept in motion. This is usually denominated acute gangrene, also inflammatory or humid gangrene. Gangrene is confined to that degree of mortification where sensibility, motion, and warmth are present: but when these phenomena cease, and the part assumes a livid, brown or black colour, it is then termed sphacelus or complete mortification. Etymologically, these terms do not admit of this explanation, gangrene being derived from γαινα, *to feed upon*, and sphacelus from σφαζω, *to destroy*. Some authors use both terms synonymously, while others consider that sphacelus should be applied only to mortification extending to the bones. Mortification thus dependent on a severe degree of inflammatory action, is originally produced by chemical or mechanical stimuli. When the urethra or urinary bladder is injured, and the urine escapes into the cellular tissue of the perineum or scrotum, gangrene is frequently the result; and this also occurs when any of the abdominal viscera are forced out of their cavity and strangulated. Gangrene likewise takes place from the eating of cock-spur rye, the ossification of arteries, tumours impeding the return of the circulation of the blood, diseased condition of the arteries or veins producing coagulation of the blood in their cavities, and from ligatures applied to the trunks of arteries or veins. Of the two varieties of inflammation, mortification is more liable to supervene to the erysipelatous, and still more so to their combination or erysipelas phlegmonodes, and although all textures when inflamed do sometimes mortify, yet the most compact, such as bone, skin, stomach and intestines, are the most prone to it, because their blood-vessels have not room to form ulcerative papillæ; and the arteries are found to possess the greatest power of resisting mortification.

When a part highly inflamed is on the verge of becoming gangrenous, the pain is violently increased, the colour becomes deeper and extends farther, the tumefaction increases from the effusion of serum, communicating a doughy feeling, the cuticle is raised up into blisters, and the part appears erysipelatous. The pulse at this period is small and rapid, the tongue brown and crusted, and every symptom of typhus fever. This may be considered the gangrenous stage, which if not arrested ends rapidly in sphacelus. The pain and sensibility then cease, the part becomes œdematous, emphysematous, cold, black, and fetid; a profuse watery and dirty-coloured discharge is poured out, the pulse scarcely perceptible, the accompanying fever having as it were ceased, which often takes place suddenly and carries off the patient; but a low typhoid fever more frequently continues for some days, attended with hiccup, subsultus tendinum, low delirium, and diarrhœa. This typhoid fever is supposed by some to arise from the absorption of the fetid matter, but as typhus supervenes to synochus or synocha, if severe and of long duration, we are entitled to ascribe it in this case to the same cause, viz. the violence of the inflammatory fever.

The treatment of the gangrenous or first stage is by applying large anodyne poultices in the hope of subduing the inflammatory action still present, and which is the cause of the gangrene; by keeping the patient quiet, on low diet, and administering purgatives. The constitution is generally too exhausted to bear general blood-letting, but leeches or cupping may be applied to the part. A large opiate should be given at bed-time. Should the part sphacelate, the yest or charcoal poultice should be used, or hot dressings applied, and the strength of the patient supported with beef-tea, animal jellies, and wine, together with the opiate at bed time. If the mortified part is to recover by sphacelation, a red line appears on the sound skin at the point of separation, between the living and the dead portions, which line denotes the adhesive inflammation, soon forming the ulcerative, which producing suppurative papillæ or granulations, secrete purulent matter, so that the whole forms an ulcerated surface. Consequently, in a limb which sphacelates, no hemorrhage takes place; a circumstance also dependent on the arteries being plugged up with coagula of blood.

Whenever the sphacelated parts have been thrown off and ulceration fairly established, the part should be dressed as a simple ulcer. The sphacelated portions may be cut away with scissors or scalped at each dressing.

In cases of mortification occurring from mechanical causes, as severe contusions, or traumatic gangrene, amputation may be with safety performed at any period; but in mortification arising from constitutional causes, as a general diseased condition of the arteries or veins, amputation proves fatal.

Mortification occurs occasionally from excessive cold. Acute pain is experienced in the part affected, with numbness, weight, and a tingling sensation in the legs; the feet of an obscure red colour, and slightly swollen. Sometimes a light red is perceptible at the base of the toes and patellar aspect of the foot; at others, they are deprived of motion, sensibility and heat, and appear black and withered. The treatment is by applying snow or ice cold water to the part in order to thaw it, then camphorated spirit of wine or poultices. When the mortification is superficial, the dead parts commonly separate between the ninth and thirteenth day, and leave an ulcerated surface, which requires the same treatment as ulcers. When a whole limb is affected with mortification, a slow typhoid fever, accompanied with diarrhœa carries off the patient; or the grangrenous portion becomes bounded by the circular line of adhesive inflammation, which suppurates and throws off the mass. Amputation in such cases should be resorted to, for it is mortification from an external cause, the same as that from an external contusion. The operation ought to be deferred until the constitution has rallied from the benumbing effects of the cold, and the reaction of the nervous and circulating systems is fairly established. This mortification from congelation or frost-bite, and also that from ergot, is named by some surgical writers dry gangrene, and by others chronic gangrene.

The eating of ergot, or unsound or diseased rye, or mildewed wheat, has an effect on the constitution not unlike that which the living exclusively on animal food has in producing scurvy. The rye so impairs the nervous and circulating systems, that they become unable to perform their functions, consequently mortification takes place, first, in such parts of the body as are most remote from the centre of the circulation, an event that occurs in all kinds of gangrene. This variety of mortification commonly begins in the toes, which become red, painful, and hot, as if scalded with boiling water; in a few days these symptoms suddenly cease, when the toes feel cold and insensible, become dry, hard, withered, and black as charcoal. The gangrenous action now extends gradually upwards along the foot, leg, and thigh, to the trunk, and is accompanied with fever and delirium. In one instance, the lower extremities were separated at the hip joints from the trunk. This singular species of mortification has occurred chiefly in France, and become occasionally epidemic, sometimes in Switzerland, and once in England. Its treatment naturally consists in at once relinquishing the diseased rye or damaged wheat, and substituting the finest and best wheat, with nourishing diet. The gangrened parts to be treated by hot dressings, and when the sphacelated portions are separated, the ulceration to be dressed with simple ointment, dry lint, or other applications, according to the appearance of the sore. Amputation is inadmissible while the constitution is under the influence of the ergot; but afterwards, it might be necessary to form a better stump.

Mortification frequently occurs in old age, in consequence of calcareous depositions taking place in the arteries, a change of structure observed affecting those of the brain, trunk, arms, and legs, especially the last. The arteries of the lower are more subject to this affection than those of the upper extremities. In general the patient complains of great uneasiness of the foot and ankle-joint, particularly during the night, before any disease manifests itself in the toes, which then appear of a purple colour, have a cold feeling to the surgeon, while hot and painful to the patient; but in some cases only a benumbed sensation is felt for some time. The disease usually begins on the inside or tibial aspect of the little toe, and not unfrequently in both feet; from this it spreads either to the other toes or upper aspect of the foot, ankle, and even the leg; and then produces so much febrile irritation as to carry off the patient. Soon after the purple colour manifests itself, more or less tumefaction ensues, with vesication or phlyctenæ, a dark serous discharge, and a greenish black pulpy appearance of the textures affected. The treatment is by blood-letting, opiate fomentations and poultices, the internal use of opium in small doses, and frequently repeated, but never to produce delirium or impair the appetite, and by the sulphate of quinine. The diet should be light and nutritive, with a moderate allowance of wine. When the fomentations and poultices have subdued the activity of the disease, the toes may be dressed with simple ointment, and kept warm and comfortable with clothing, and on a level with the body. If any of them sphacelate, they ought to be allowed to drop off themselves, as they retain life for a longer period than sphacelated parts arising from active inflammation. This species of mortification, even if cured, is extremely liable to return, to prevent which the diet must be nutritious, with a good allowance of wine, and the feet warmly clothed, in a moderate temperature, and kept as much as possible on a level with the body.

The same peculiar mortification, characterized by simple symptoms, sometimes supervenes to a generally diseased condition of the arteries and veins, in which they become plugged up with coagula of blood interrupting the circulation. This requires the same kind of treatment as the last; and in neither is amputation admissible.

In a few cases, mortification occurs from the arterial circulation being too feeble, in consequence of some disease of the heart; and in others, from both the arterial and venous circulation being impeded by tumours growing around the aorta and vena cava.

Mortification sometimes ensues when the principal artery of a limb is secured by ligature in wounds, or in aneurism, in which case, the heel generally first affected from the pressure becomes black in colour, the cuticle vesicates, and the whole foot cold, lifeless, and of a leaden colour. The gangrene then extends rapidly along the leg, exciting excruciating pain, profuse suppuration, and hectic fever, which soon put an end to the patient's sufferings. The same result occasionally takes place when the blood, in diffused false aneurism, presses on the contiguous nerves, arteries, veins, and lymphatics, or even in circumscribed false or true aneurism from the inosculation of the smaller arteries being unable to carry on the circulation; the two last cases are, however, extremely rare. The treatment of mortification from these causes is to support the circulation by bandage and warmth; and when these fail, amputation is the only alternative. Mortification also occasionally follows gunshot wounds destroying the principal artery or vein, or artery and vein conjointly of a limb, and is evinced by a similar train of symptoms, only they advance with more rapidity, and require earlier amputation.

Mortification also occasionally occurs from long continuance in bed, in protracted fevers, in compound fracture of the bones of the thigh and leg, and from the destruction of the spinal cord in consequence of fracture of the vertebræ; in which cases, those parts of the body which sustain the greatest pressure, are affected, as in the region of the sacrum. To prevent pressure producing mortification in such cases, various contrivances are resorted to; pillows of feathers, down, distended with air, and of various shapes, are employed.

The affections of the heart have been already treated of in the Article Medicine, Vol. XIII. p. 44, and the only one admitting of a surgical operation, is dropsy of the pericardium, which, when the diagnosis is certain, is performed as follows: an incision is made between the fifth and sixth ribs between the integuments, but in such a way that the skin may afterwards act as a valve, and ought therefore to be pulled upwards. The greater pectoral and intercostal muscles are then to be cautiously divided, the operator keeping sufficiently distant from the sternum, so as to avoid the internal mammary artery. In this division of the muscles, the pleura costalis will most probably have been divided, as the pericardium will be generally found adhering to it; the latter is now seen distended with fluid, and is to be opened carefully with a lancet or bistoury, making a small aperture, when the fluid will exude. If the pericardium does not adhere to the pleura costalis, the incision in the pleura must be enlarged so as to admit the finger, which, when introduced, will feel the distended pericardium, that can then be puctured with a bistoury, guided along the finger.

A most interesting case of aneurism of the heart occurred lately, wherein a gentleman cured himself, by injecting his own respired air into the left thoracic cavity, by which he has been perfectly cured, although the symptoms were most unequivocal. He took a common ox's bladder, to the neck or mouth of which he adapted a stop-cock, and very delicate silver tube, and having filled it with his respired air, he punctured his thorax on the left side, with the silver tube, between the fifth and sixth ribs, avoiding the internal mammary and intercostal arteries, and then injected the air into his chest. This he repeated for upwards of seventy times, and several times in our presence. We have ourselves repeated it in other cases with advantage, and consider that it might be employed in other affections of the chest.

The arteries are subject to many diseases, to inflammation and its terminations, adhesion, suppuration, ulceration and gangrene; to aneurism; to the internal or serous coat being found of a deep red colour with a deposition of coagulable lymph; to a deposition of atheromatous matter, a thickened pulpy substance like steatoma, a cartilaginous matter, and a calcareous matter between their coats; they are also involved in inflammation and other diseases of contiguous structures. Of these the calcareous deposit is much the most frequent, and is the most common cause of aneurism.

Aneurism, which is derived from ανευρυνω, *to dilate*, consists of several species, the true, false, internal mixed, varicose, and aneurism by anastomosis. True aneurism, strictly speaking, is a circular or uniform dilatation of the three coats of an artery, and is commonly met with in the aorta, accompanied with thickening of the serous and muscular coats, and depositions of calcareous matter on the exterior surface of the serous, and not unfrequently atheromatous pulp between that and the muscular tunics. Some systematic writers describe two varieties of this, a circumscribed and a diffused true aneurism, which appears superfluous. A partial or lateral dilatation of the three coats of the aorta is also sometimes seen constituting another variety of true aneurism. The true aneurism of the majority of systematic writers on surgery consists in a rupture of the serous and muscular coats, with a distension of the cellular, which effect is produced by the brittleness of the serous tunic being studded with calcareous depositions, by inflammation and ulceration or mortification, by partial dilatation from debility or undue impulsion, by absorption in consequence of some diseased spot of a blackish colour and slightly inflamed, by a deposition of coagulated blood, or by a separation of the serous coat from over exertion plugging up the vessel. The first of these is found to be the most common cause. When the three coats are either at once ruptured in consequence of a wound, or by the cellular tunic in this true aneurism also bursting, and the blood is diffused in the cellular substance in the contiguity condensing it into a cyst, the disease is styled circumscribed false aneurism, to distinguish it from that in which the blood is more extensively diffused in the cellular tissue even of the muscles, and which is named diffused false aneurism. When the muscular coat only is ruptured, and the serous protruded through it, the affection is denominated internal mixed aneurism. Varicose aneurism consists in a communication being established between an artery and a vein from a wound. Aneurism by anastomosis arises from a congeries of arteries and veins forming a vascular tumour.

Aneurisms occur more frequently in men than in women, the former sex being more subject to those occurring in their extremities, the latter to those in the trunk; and in many individuals it is a constitutional disease. Aneurism occurs most commonly between thirty and forty years of age, and is said to attack the irritable, the passionate, the glutton, the drunkard, the debauched, the syphilitic, the mercurial, and the rheumatic. Coachmen, post-boys, postilions, soldiers, particularly dragoons, sailors, porters, labourers, and miners, are said to be most subject to it. These classes of individuals, by indulging in such vices, appear to dispose their arteries either to calcareous depositions or to a brittle condition, so that in the violent exertions which occur in their labours, these vessels rupture and form aneurism, in consequence of the circulation being propelled at such periods with greater force than the artery has powers of resistance; but even in the ordinary circulation of such constitutions, if an artery be weakened, it is unable to resist the momentum of the blood, and therefore, gradually yields and dilates. Violent shocks or contusions, forcible pressure on arteries, the reiterated bruising of parts, the force employed in reducing luxated joints, the violence of falls, fractures and wounds, are also causes of aneurism. The largest artery, the aorta, is most subject to this disease, the next in frequency is the femoral, and its continuation the popliteal, the third is the inguinal, the fourth the subclavian and axillary, and the fifth the carotid. The smaller series of arteries, the radial, ulnar, and tibial, are seldom attacked, with the exception of the temporal, which from being selected in arteriotomy is exceedingly subject to aneurism. The nutritious arteries of the tibia have been found affected with aneurism. The reasons of this order are very palpable, being chiefly consequent on the impetus of the blood, and the deficiency or delicacy of the adventitious tunics, together with the deficiency of support by the contiguous structures.

When true aneurism occurs in the poples, there is at first a small colourless tumour pulsating strongly, and containing only fluid blood; occasioning little or no pain, merely some irregularity of the circulation in the limb, with a spasmodic affection of the muscles, which recurs during the night and prevents sleep. On pressing the artery nearer the heart than the tumour, it is easily emptied and divested of pulsation; and on removing the pressure, the aneurismal sac is immediately filled, and the pulsation returns. Gradually as the artery dilates its powers of resistance are diminished, and the interior of the sac becomes coated with coagulated blood, which is deposited in layers or strata that thicken its walls, and render the pulsation more and more languid, and also prevent the sac from being completely emptied. Acute pain is felt in the limb, particularly below or distad to the tumour, in consequence of the pressure of the coagulated blood on the nerves, and the motion of the fluid in the sac has been compared by the patient to boiling lead. When the cellular tunic of the artery ruptures from over distension, it is converted from the true to the circumscribed false aneurism. The tumour feels now nearly solid, there being a faint pulsation opposite the aperture of the vessel, which however may point centrad, and then none is felt. When the cellular cyst forming the limits of this tumour of almost coagulated blood also ruptures, the blood escapes into the surrounding cellular tissue, diffusing itself in all directions, and forms an irregular shaped tumour, without the least pulsation, and sometimes nodulated. The pressure of the blood benumbs the nerves, impedes both the arterial and venous circulation, particularly the latter, together with that of the lymphatics, the limb consequently feels benumbed and cold, becomes œdematous, swollen, and of a leaden colour, and the joint is impeded in its motions. One or more projecting points of the tumour progressively become thinner from absorption by the pressure of the blood, or the integuments slough and ulcerate, until at last the blood hisses out, and the patient becomes exhausted from repeated hemorrhages, but never dies instantaneously. The same process takes place when aneurism occurs in the contiguity of the trachea, œsophagus, stomach, and other mucous structures: but when a serous membrane, as the pleura, forms the wall of an aneurism, it is lacerated. When a bone is pressed upon, it becomes carious. It occasionally happens that the sac increases in the direction of the artery, and presses on it beyond or distad to the tumour, and obliterates its cavity; the sac at the same time becoming entirely filled with depositions of fibrin, which extend into the artery at both ends to the nearest large branches. At other times, the tumour compresses the artery above or proximad to itself, producing adhesion of its coats with obliteration of its cavity; in other instances, this proximal portion of the vessel is plugged up with a dense compact bloody coagulum. In these cases, according to the blood effused, does absorption take place, or inflammation, suppuration and ulceration, or inflammation and gangrene; and if the patient has strength to support these events, he is cured of the aneurism, the cure being termed spontaneous.

In this gradual development of an aneurism, the trunk of the artery becomes diminished in calibre, and the flow of the blood is also rendered tardy by passing out of its course, by which means the blood is forced into the neighbouring small anastomosing branches that become enlarged. This results particularly if the artery is plugged up. In some cases, the lateral and central walls of the sac are strong enough to resist the pressure of the blood, while the integuments are too feeble, the latter therefore undergo the changes just described in the circumscribed false aneurism. Some cases of aneurism are exceedingly difficult in their diagnosis, particularly the subclavian and carotid.

The treatment of aneurism consists in general and local remedies, the former being chiefly applicable to internal aneurisms, or those situated within the cavities, the latter to external ones, or those of the extremities, neck, and external aspect of the head. The general remedies are, abstracting blood in small quantities, confining the patient to bed, and keeping him on low diet, the application of a firm compress to the tumour, with a bandage rolled from the toes equally upwards to the groin. This is also named the palliative, or Valsalva's treatment, from his being the inventor, in whose hands, as also those of others, it has succeeded. Cold astringent applications, especially ice, have been also recommended. But in aneurism of the extremities there are many cogent objections to this. In the first place, the patient may be so reduced by the confinement, as to be unable to withstand the subsequent confinement after the operation, since, in many cases, it is necessary to remain quiescent in bed for three or four months, for fear of secondary hemorrhage. In the next place, if much blood be effused, the absorbents are incapable of removing it, and inflammation, suppuration, and ulceration, or gangrene takes place, producing great reduction of strength. Thirdly, occasionally great pain is produced by the pressure. This plan therefore can only be judiciously pursued at the very commencement of external aneurism. The reader is referred to the essays and works of Senfio, Freer, Dubois, Sir William Blizard, Deschamps, Scarpa, Seiler, Percy, Duret, Assilini, and Crampton, for various modes of compression.

Formerly when this plan of Valsalva failed, amputation was performed, which however is now limited to those cases of diffused aneurism where it appears the absorbents cannot possibly remove the effused blood, and where extensive suppuration and ulceration of gangrene must be the result. About fifty or sixty years ago, the surgeons of Italy, emboldened by Haller's doctrine, drew a ligature around the popliteal artery both above and below the sac, which they laid open and removed the coagula. This extensive wound healed by granulations, or produced sinuses and caries of the bones, with contraction of the joint. Secondary hemorrhage from securing a diseased artery was also a frequent occurrence; and yet this practice is still followed by Boyer and many of the French surgeons. The celebrated John Hunter, perceiving such unhappy results, performed several experiments on the lower animals, and proved that an artery close to an aneurismal sac is so diseased that it must ulcerate; whereas, if secured between the tumour and the nearest large branch, so as to have the vessel healthy on the one side, and remote enough on the other from the branch, so that the latter would carry the blood along it on the principle of hydraulics, and leave the tied portion at rest, that a coagulum of blood might take place, and the adhesive inflammation not be disturbed, the operation would succeed in the majority of instances. He also saw, that if this operation was performed early enough, the flow of blood into the aneurismal sac would be so far checked as to allow further coagulation of it, and that ultimately both the blood and cyst would be absorbed. Accordingly, in 1785 he secured the superficial femoral artery for popliteal aneurism, shortly after its giving origin to the profunda, but he improperly employed four ligatures, whereas one is now found sufficient, for which important improvement we are indebted to Freer. This operation has undergone many important improvements by Birch, Foster, Freer, Abernethy, Dionis, Richter, Jones, A. Cooper, Travers, Hutchinson, Roberts, Lawrence, Hodgson, and Dalrymple.

The most improved method of securing the superficial femoral artery for popliteal aneurism, is that recommended by Walker, which appears preferable to that of Abernethy, Sir A. Cooper, Hodgson, C. Bell, Shaw, C. Hutchinson, Harrison, or Averil. To prove the necessity of measurement in this and all other operations for aneurism, the reader is referred to an unusual distribution of the superficial femoral artery operated on by C. Bell, and described in *Journal of Medical Science*, vol. iv.; also to Tiedemann, Barclay, Turner, Harrison, and Lizars's anatomical works.

The patient should be placed on a firm table, with the feet at right angles to each other, but the affected separated from the sound limb. The space between the anterior superior spinous process of the os ilium and the spine of the os pubis is to be divided into ten proportional parts, when five and a half measured from the pubes are made the base of an equilateral triangle, which is to be constructed downwards on the thigh, the apex being therefore distad, the base proximad; and the outer or iliac side of this triangle should be extended downwards from the apex twice its length, when the artery will be found to run beneath this line throughout. An incision should then commence at the apex of the triangle, and be continued down the thigh proportionally to the depth of skin and cellular substance of the patient, the latter of which is often infiltrated with serum; a second incision, equal in length to the first, should cut through the fascia lata, and this cautiously, when the pulsation of the artery will be felt; the artery is then to be denuded to the smallest possible extent of its cellular sheath, the latter of which is to be held up with the dissecting forceps in the left hand, and the scalpel in the right held parallel to the vessel, with its cutting edge pointing outwards or fibulad. The operator seeing satisfactorily the artery, vein, and nerve or nerves lying together, inserts the aneurismal needle, delineated in Fig. 5, Plate DXV. armed with a ligature, on the inner or tibial aspect, between the artery and the vein, and carries it round to the fibular aspect, as depicted in Fig. 2 of Plate DXVII. securing the artery with a single ligature of common unbleached linen thread, waxed and tied in the manner of the reef-knot of the sailor; and both ends of the ligature ought to be cut off close to the knot, and the lips of the wound approximated with adhesive plaster; the limb rolled with an eighteen-tailed flannel bandage (see Fig. 4, Plate DXVIII), from the toes to the groin, and applying an ordinary sized compress in the course of the artery from a little above its point of securement downwards, for five or six inches, and a larger one over the sac in the poples. The chief points to be attended to in operations for aneurism are, making clean free incisions, disturbing or insulating the artery as little as possible, and seeing distinctly the contiguous veins and nerves before throwing the ligature around; and if any nervous threads, as the nervus saphenus, so interfere as to impede the application of the ligature, they should be divided without hesitation. The surgeon judges of the artery being secured by the tumour becoming flaccid, and being divested of pulsation, with a diminution of the pain; and soon afterwards by a strong pulsation of the articular arteries. In the majority of cases, the temperature of the limb is rather higher after than before the operation. When an artery is thus secured, the ligature divides its muscular and serous tunics, the vessel shrinks, coagulable lymph is effused, and the adhesive inflammation excited, by which its sides and the wound throughout unite. Some days, or even weeks afterwards, we have known it six weeks, the noose or knot thus left behind, excites the most trifling degree of suppuration, the matter of which is chiefly absorbed, and advances slowly, and unfelt by the patient to the skin, like a plant growing to the light, and appearing like the smallest possible pimple, is ultimately discharged, the patient frequently not observing it.

Various kinds of ligatures have been invented and used, such as fine silk, inkle, dentist silk, twine, tailor's twist, catgut, and other animal matters, but one and all are ejected, consequently that which is smallest in diameter, and of sufficient strength is the best, and therefore we prefer unbleached linen thread, waxed. Mr. Fielding of Hull, has lately employed silk-worm-gut, and found it to be absorbed, but Dr. Crampton lost a patient in consequence of using it. If the operator should insulate the artery too great an extent, and thus cut off its connection with the contiguous structures, and destroy many of its *vasa vasorum*, he ought to throw two ligatures around it, at sufficient distance from each other, and divide the artery between them. If he wounds an arterial branch during the operation, it should be secured with a ligature as in ordinary operations. The wound is to be dressed on the third day, and every day afterwards until healed; the patient to remain quiescent in bed on low or farinaceous diet, until the wound is quite consolidated, avoiding every exertion, even in the change of his linens, which ought to be made to slip on and off so as to occasion the least possible disturbance, and using a urinal and bed-pan when required; three weeks at the very least should be allowed to transpire, before allowing him to sit up in bed, and to have more nourishing food, but even this only provided the wound be healed. The patients of Mott and Graefe, wherein the arteria innominata was secured, evidently fell victims to their being allowed to walk about too early. In such large arteries, and so near the source of the circulation, the patient should be kept in the horizontal attitude, on farinaceous diet, between three and four months.

Not unfrequently a slight pulsation returns in the tumour, which daily increases and constitutes a secondary aneurism, which may arise either from the inosculating branches between the ligature and the sac, or from others communicating directly with the sac, or thirdly, the blood may retrograde from the inferior or distal aperture of the artery into the sac. In such an event, we should first try the general or debilitating plan, and if it fails, secure the artery close above and below the tumour. and even if this last fail, perform amputation, but not amputate at once as recommended by some authors. There is another mode of operating for aneurism, invented either by Brasdor or Desault, and lately practised with success by Messrs. Wardrop, Lambert, Bush, and Evans, and advocated by Bichat, Scarpa, Hodgson, and Breschet. When the tumour is situated in an artery so near the source of the circulation, that a ligature cannot be thrown around the vessel between the heart and the sac; and this consists in securing the artery beyond or distad to the tumour. This method will evidently succeed, provided there is no arterial branch immediately contiguous to the sac, either on its proximal or distal extremity, and none originating from the tumour itself to induce the blood to enter the sac; for on applying the ligature, the blood will flow by the anastomosing branches proximad of the tumour, leave that in the sac quiescent, which will therefore coagulate and lay the foundation of a cure. This we consider an ingenious and very valuable operation.

Our limits will not permit us to enter into a detail of the various aneurisms which affect the different arteries with their operations; suffice it to say, that the arteria innominata, with its divisions, and the abdominal aorta, distad to the inferior mesenteric, with its divisions and subdivisions, have been secured. For an account of these aneurisms, the reader is referred to Hodgson on the *Diseases of the Arteries and Veins*, and for the steps requisite to be pursued in these operations, to Lizars's *Anatomical Plates*. The carotid artery was first secured by Mr. John Bell or Hebenstreit, a German surgeon; the subclavian by Mr. Ramsden: the brachial by Anel; the arteria innominata by Dr. Mott; the abdominal aorta by Sir A. Cooper; the internal iliac by Mr. Stevens; the gluteal by Mr. John Bell; the external iliac by Mr. Abernethy; and the common iliac by Dr. Mott.

Varicose aneurism, named also venous aneurism and aneurismal varix, occurs commonly at the bend of the arm from venesection, but has occurred to the subclavian artery and vein, the popliteal artery and vein, the common femoral artery and vein, and the posterior tibial artery and vein, from punctured wounds of these vessels. In this disease the artery and vein are simultaneously wounded, and a communication is established between them, by which the arterial blood flows directly into the cavity of the vein. When it takes place at the bend of the arm, inflammation is excited at the wounded points of the vein, the fascia of the biceps and the artery, forming a bond of adhesion between them, and a passage for the blood. A tumour is soon formed of a bluish colour, which pulsates like an artery, and communicates a tremulous motion to the touch, and rustling noise to the ear, somewhat resembling the hissing noise of air ejected from a syringe, and occasionally so loud during the night as to prevent the patient sleeping. The pulsation is only distinct in the centre of the tumour, and the contiguous veins are more or less varicose. The artery above, or proximad to the tumour, becomes larger, and vibrates strongly, while below, it is smaller. If the tumour be emptied, and sufficient pressure be applied, either above or below, to check the cutaneous venous circulation, it immediately fills; but if the pressure above be enough to compress the brachial artery, the tumour diminishes. This species of aneurism appears sometimes within three or four hours after venesection, while at others not for several weeks; it has a circumscribed appearance, is about the size of a large walnut, with the cicatrix made by the lancet in the centre. It increases very slowly, excites little pain, producing more a sense of weight, numbness and feebleness of the arm, and is the least dangerous of aneurisms, never rupturing spontaneously, but being liable to be converted into the false, with which it is sometimes complicated. The treatment consists in the application of compression and bandage, wearing the arm in a sling, or keeping it in the horizontal position; or, lastly, in securing the artery, which probably from its being the shorter means of cure, and perfectly safe, is the best remedy.

Aneurism by anastomosis, named also nævus maternus, tumeurs variqueses, or fongueses sanguines, tumeurs erectiles, hæmatoncus, blood-sponge, and in common language, strawberry or raspberry tumour, begins usually at birth, having the appearance of a red, purple, or livid stain, but occasionally there is at once a distinct prominent vascular tumour; in some cases the disease remains long dormant, while in others, this vascular plexus of vessels increases in number and size distending the skin, which ruptures in sultry weather, or in intense cold, producing hemorrhage, which becomes each time more momentous, until at last it proves fatal. This is particularly the case when it attacks a surface delicately covered with integuments, as the lips. It is more frequently situated about the head than elsewhere, sometimes involving a great extent of surface, lips, mouth, fauces, pharynx, neck, and chest; and the same vascular plexus has been discovered within as well as without the cranium, the capillaries of the dura mater being equally affected. This disease has occurred occasionally in the adult, from accidental violence, beginning in the form of a mere pimple or speck, and soon becoming a throbbing incontrollable vascular tumour, bleeding on the slightest exertion, drinking, mental emotion, exposure to the sun or cold. In infancy this disease must be distinguished from the congenitæ notæ, or growths of hair, &c. John Bell, who first correctly described this vascular tumour, conceived there were cells intermediate to the capillary arteries and veins, in which opinion he is joined by Dupuytren and Wardrop, but from what we have witnessed in careful injection and dissection of such tumours, and what is developed in the spleen, placenta, corpus cavernosum et spongiosum penis, especially the latter in the elephant, no cells exist in these tumours, but that the delicate veins form large and frequent anastomoses, which, from communicating freely with each other, and adhering together, resemble cellular tissue.

In young children, before they have been inoculated, it has been cured by inducing adhesive inflammation with vaccine lymph, and obliterating the blood-vessels; but this fails in the adult. If this application fails, or the child has been already vaccinated, in which case it seldom succeeds, compression should be tried, together with astringents, and if both of these fail by the time the child is four months old, it should be treated by ligature, as recommended by John Bell, White and Lawrence. The securing the arteries leading to the tumour has been occasionally successful, but has as often failed, even in the most scientific hands. The extirpation of the tumour is objectionable in early life, as we require to cut at some distance from the tumour, in order to avoid the blood-vessels, thus leaving a great extent of surface to granulate and cicatrize, and causing considerable deformity, if situated about the head and neck. Potassa, or kali purum, applied so as to produce gentle ulceration and sloughing, has also succeeded, but it is only advisable in very small nævi materni, as it has proved fatal even in Boyer's hands. For an elaborate detail of the diseases of the arteries, the reader is referred to Hodgson *on Dis. of Art. and Veins*—Breschet's *Translation of same. Ed. Med. and Surg. Journal*, vol. xxii. p. 4, and vol. xix. p. 45, and *Ed. Med. Chir. Trans.* vol. iii., also to mortification, already mentioned in this article

Under bloodletting we have shown the proneness of the veins to inflammation, and its fatal tendency; and also under ulcers with varicose veins, adverted to the impropriety of securing them with a ligature. The uterine, the crural, the external, the internal, the common iliac, and spermatic veins, even onwards to the renal and vena cava inferior veins, have been found inflamed, thickened, and filled with purulent matter and coagulated lymph, after abortion, ordinary accouchment, and in puerperal fever. Similar appearances have been seen in phthysis pulmonalis and in carcinomatous affections of several organs. A greyish coloured fluid has been found in the splenic and hepatic veins. Inflammation in veins, although rarely, sometimes terminates in ulceration, producing hemorrhage, and commonly begins in the serous tunic; the adhesive inflammation, however, more frequently obliterates their cavities and prevents hemorrhage: and when sphacelation occurs in the contiguity of veins, they become plugged with coagula of blood, as already mentioned under mortification. In violent exertions, cramps, cold stage of ague, and blows, the veins are sometimes lacerated. The veins, from gravity or pressure, frequently become varicose, or present a serpentine swollen knotted appearance, on the lower extremities, the spermatic cords and scrotum, the spermatic plexus of the ovaria, the rectum, especially at its termination or around the anus, and on the integuments in the hypogastric and inguinal regions. In many of these, especially the cutaneous of the leg and the hemorrhoidal veins, coagula of blood are found, which, obliterating the cavity, have produced a spontaneous cure. The veins are also subject to circumscribed distension or dilatation, varying in size from a small nut to that of a pigeon's egg, and sometimes to such an extent as to rupture and prove serious and even fatal. These distensions are occasionally accompanied with pain, and, when situated superficially, sometimes with inflammation and suppuration of the skin and cellular substance in their vicinity, forming ulcers.

The treatment of varicose veins consists in affording them support, or obliterating them with potassa. The saphena major and minor of the leg, when affected, require the roller to extend from the toes to the groins, and are much benefitted by being bathed with a decoction of oak bark, and attention paid to the bowels. When potassa is used, it is applied above or proximad to the varicose portion of the vein, so as to produce an eschar on the skin, by which the vein inflames, the blood coagulates, effusion of lymph follows with an adhesion of the sides of the vein and consequent obliteration of its canal. The veins, like the arteries, have been found cartilaginous and studded with calcareous depositions, and loose calculi in their cavities. In some cases the same diseased structure as that in the vicinity, as, for example, schirrus, has been found growing from the serous tunic of veins. The largest veins of the system, even the vena cava inferior, have been found obliterated, and the circulation carried on by the superficial ones, and the vena azygos.

Hemorrhage from αιμα *blood*, and ῥηγνυμι *to break out*, the dread of both the ancients and moderns, has greatly retarded operative surgery, and precisely in proportion to our ignorance of anatomy. When an artery is wounded, the blood of a bright vermilion colour flows in distinct jets, while when a vein is cut, it flows of a dark purple colour, in a more equable or smooth stream. In the smaller veins contiguous to the capillary arteries, the stream is interrupted, or flows *per saltum*, as if an artery was wounded. When an artery is merely punctured, the hemorrhage generally soon produces fainting, and the blood injects its cellular sheath, which forms a coagulum that becomes a temporary barrier to its flow; but if this process be disturbed, or if inflammation and ulceration follow, the hemorrhage recurs from time to time, until at last it proves fatal. In such cases, therefore, if the vessel be large, as that of the thigh, it should be instantly secured by throwing a ligature around, above and below the seat of the wound, as the retrograde flow from the free inoculation is liable to reproduce the bleeding. But if no disturbance accrue to this process of nature, the wounded edges of the artery inflame, effuse coagulable lymph, and are united by the adhesive inflammation; and if the wound be trifling, the continuity of the vessel is preserved. A long continuance of quiescence is requisite, however, to ensure safety from aneurism. It will be at once seen, that the same causes preventing the success of securing the principal artery of a limb for aneurism, will operate here, and that mortification will be even more liable to follow in this case. When an artery is divided transversely, an impetuous flow of blood takes place, producing fainting, its ends are constricted and retract into the contiguous cellular tissue, which is injected with blood, that soon coagulates, while the blood flows by the proximal branches, allowing a coagulum of blood to take place in the trunk, which thus gradually becomes obliterated, as if secured in aneurism, and thus the hemorrhage is for a time arrested. If this natural process be undisturbed, slight inflammation follows with the effusion of coagulable lymph in the artery, between its coats, and in the cellular substance in the vicinity, which becomes gradually consolidated, and proves a perfect barrier to after bleeding. This, however, is not always the case, particularly if a branch be near the wound, the blood flows impetuously by the trunk, produces fainting, which recurs at each successive rallying of the system, or at once proves fatal. The artery consequently ought to be secured, as in the first instance. If the axillary in its mesh of nerves, veins, and branches, be wounded with a sharp pointed instrument, the subclavian as it runs over the first rib should be tied, and compression applied to the wound, as was lately practised by Langenbeck with success.

Hemorrhage from an artery has been divided into primary and secondary; the former when it occurs within thirty hours after the receipt of the wound, or rather when reaction of the system has taken place; secondary, when it takes place after this period, for the time is so very uncertain, that no definite time can be specified. When the smaller arteries are wounded, as those in the palm of the hand or the sole of the foot, compression with dry sponge, sponge tent, agaric or lint, and a bandage should be employed; and if this fails, the trunk of the bleeding artery secured proximad to the hand or foot, continuing however the pressure. Sponge tent consists of sponge dipped in melted wax, and forcibly pressed into the smallest possible size. The same kind of compression is applied to the internal pudic artery when wounded in lithotomy, to the intercostal arteries, the temporal, and the extreme branches of the internal maxillary after the extraction of a tooth. When a vascular surface, as the mucous membrane of the nares is bleeding, escharotics, styptics, and compression by dry lint are used. If the bleeding proceeds from the stomach, styptics are administered, and venesection to produce fainting, which highly favours the natural process of arresting hemorrhagy; with these are combined cathartic enemata, low diet, and perfect rest. If from the lungs, the same remedies, combined with narcotics and gentle laxatives. When from the corpus spongiosum or cavernosum penis, compression and bandage. The styptics in use are cold water, vinegar and cold water, solutions of the sulphates of zinc, alum, iron, or copper, of the nitrates of silver or copper, the mineral acids, diluted alcohol, alcohol, and sulphuric acid combined. If the bleeding is from the gums, or antrum maxillare, or orbit, after a surgical operation, compression or the actual cautery is requisite.

Fracture, from *frango, to break*, is applied to the bones, and is divided into simple and compound; simple, when the bone only is injured; compound, when the soft coverings are so injured that either one of the fractured ends protrudes through the skin, or the skin and muscles are so lacerated as to expose the bone, the long cylindrical bones of the limbs are most frequently fractured; next the flat, particularly of the cranium, for those of the pelvis and scapula must be excluded; and lastly, the round irregularly shaped bones of the tarsus, carpus, and vertebræ. The bones are fractured by external violence, disease, and the action of the muscles. The long cylindrical bones are not unfrequently broken in more than one point; they are generally fractured at the centre of their shafts, in which case the fracture is more or less oblique; whereas, when it occurs near the extremes, it becomes more and more transverse; hence, fractures have been divided into oblique and transverse. The spongy bones are also fractured transversely. The flat bones in various directions, occasionally stellated. A comminuted fracture occurs when a bone is broken in different places at once, and divided into several fragments or splinters. Longitudinal fractures also occur to the long cylindrical bones. Complicated fractures are those accompanied with luxation, severe contusions, wounded blood-vessels, pregnancy, gout, scurvy, rickets, fragilitas, ossium, and syphilis, which diseases prevent the union of the bones, and also cause them to be very easily broken. Cold renders the bones more fragile, and they are also more brittle in old age. The superficial are more exposed to fracture than the deep seated bones; thus the clavicle is more so than the os innominatum. Others, from their functions, are more exposed; as, for example, the radius from its affording support to the carpus.

When a fracture takes place, there is an effusion of blood from the vessels of the bone, periosteum, and contiguous soft parts, the muscles are violently excited, the periosteum and truncated ends of the bone inflame; and after the inflammation subsides, the vessels of the periosteum and ends of the bone are formed to secrete callus, which is an effusion of gelatin that is gradually converted into cartilage, and lastly into bone by the secretion of phosphate of lime, precisely in the same manner as the formation and conversion of bone in the fetus. During the inflammatory action, no diseased secretion whatever takes place; nay, even the healthy natural ones are more or less suspended, so that no advantage is gained by setting a fracture immediately after the injury; on the contrary, this primary setting, as it is termed, re-excites the already spasmodic action of the muscles, and in nine cases out of ten disappoints the hopes of the surgeon. Callus does not harden for many days; in the adult, it begins generally about the tenth or twelfth day; Boyer, however, says that it is not formed until between the twentieth and seventieth day. The treatment of a simple fractured bone is to lay the limb in the easiest position for the patient, which is probably in M'Intyre's fracture splint, delineated in Fig. 6, of Plate DXV. to apply leeches and anodyne fomentations or poultices, to put him on low diet, enjoin perfect rest, and administer gentle laxatives, until all inflammatory action is subdued; then to extend the limb to its natural length, or apply pasteboard splints dipt in warm water, with wooden ones exterior to them, and fastened with tapes. This latter is termed secondary setting, and is applicable to all the bones of the extremities, and is best exemplified in the os femoris.

The thigh bone is fractured at every point, but more frequently in its centre, in which case the fracture is oblique and splintery, accompanied with crepitus and great retraction of the muscles, rendering the limb shorter and thicker, and the distal portion extremely moveable and overlapping the proximal, while the patient is unable to move the limb. If much spasmodic action of the muscles has taken place, no power we possess can lengthen and retain the limb in its situation. The limb should be retained in the fracture-splint, for fully three weeks after inflammation has been subdued, but may be examined every third or fourth day. More or less œdema supervenes, which is easily discussed by friction and bandage. This mode of treatment is applicable to the tibia, fibula, os brachii, ulna, and radius, when affected with simple fracture.

When there is a compound fracture of the os femoris, and if the bone protrudes such a length that it cannot be with facility reduced within the skin and muscles, it should be sawn off, for it would produce too much injury of the soft parts, to make an incision calculated to replace the protruded portion; but in the tibia, and other thinly covered bones, the integuments may be incised to permit the bone to be replaced. After the os femoris has been replaced, the wound, if simple, ought to be approximated with adhesive plaster, but if contuse, leeches and poultices, or fomentations are requisite. No callus is secreted during suppuration; and as this wound will suppurate, the limb should be placed in an easy attitude on M'Intyre's fracture-splint, an eighteen-tailed bandage applied to prevent the pus burrowing, and to keep on the dressings, which should be simple; and as suppuration ceases callus is secreted, and then the attitude of the limb must be attended to. When suppuration is established, the diet should be nutritious. If the fracture be comminuted, we extract the loose fragments of bone, and treat it afterwards in the same way as has been described; but from the depth of muscular substance, which prevents extraction of these fragments, and the escape of pus when formed, amputation often becomes a matter of consideration for the surgeon; or if in this fracture the femoral artery is wounded, or the knee joint involved, amputation should be performed. This mode of treating compound and comminuted fractures of the os femoris is also applicable to those of the tibia, fibula, os brachii, ulna and radius.

In fractures of the bones of the upper extremity, we have to consider that the arm has no weight to support, is nearer the source of the circulation, and its arteries inosculate more freely with each other, and its returning or venous circulation is more easily performed, consequently in compound fractures, an attempt to preserve the limb may be made with more propriety.

The os brachii when fractured is probably more disposed to form a false joint than any other bone, although in several cases the thigh bone has been affected with this disposition. In this process each fractured extremity secretes callus, which becomes cartilaginous, but never ossifies; and around these ends a synovial pouch is formed by the cellular or muscular tissue, which secretes synovia, and thus forms a rude joint, but so moveable as to render the arm useless. This flexible condition is to be treated with a simple apparatus of leather and iron, to prevent this false joint from moving; and if this fails, the ends of the bone may be rubbed on each other with the view of inflaming and exciting them to more action, the limb afterwards being firmly bound up for a time, or an incision may be made down to the disunited ends of the bone, and rasped or sawn off, and then the bleeding ends put in apposition, and treated as if recently fractured. A third method is the employment of a seton, all of which have occasionally succeeded, and as often failed.

The ribs are generally fractured near their centres, and commonly more than one at a time, and the middle ones more frequently than the extremes; from the lungs being close to them, and their fracture oblique and splintery, such accidents are extremely dangerous. When a simple fracture occurs, it is treated as directed in luxation of their sternal ends, together with local and general blood-letting. If the pleura costalis be injured in this accident, inflammation and suppuration of this membrane may follow, and lay the foundation for empyema (from εν *within*, and πυον *pus*), or a collection of matter in the pleuritic bag; but empyema may be produced by various other causes besides a fractured rib. The greatest difficulty in this, and in all diseases, is a correct diagnosis, which if clear in this case, the matter must be evacuated by an operation termed paracentesis thoracis (from παρακεντεω *to perforate*), which consists in holding up the integuments over the sixth and seventh ribs in their centres, in order that they may act afterwards as a valve, and making an incision through them to the extent of two or three inches, parallel and close to the upper edge of the seventh rib, then dividing to a more limited extent the serratus magnus and intercostal muscles carefully until the pleura costalis appears, which should be punctured with a lancet, and a canula afterwards inserted to remove the matter. When all the fluid has been removed, the wound should be closed and treated on the principle of chronic abscess, which it more frequently resembles, than the acute. This operation is also performed for collections of serum or water, for extravasated blood, and for diffusion of air in the pleuritic bag. A fractured rib occasionally wounds one of the intercostal arteries, which pours out its blood into the pleuritic bag, oppresses the lungs, and afterwards produces empyema; and various instruments have been contrived to suppress this hemorrhage, but the finger of an assistant is undoubtedly to be preferred, and if there was only one rib injured and hemorrhage continuing, the surgeon would be justified in making an incision and thus compressing the artery, or first dividing it so as to allow its ends to retract, and then applying compression; on the contrary, however, in consequence of there being more than one rib fractured, he is only authorized in using the lancet freely and administering digitalis and hyosciamus. One of these arteries may be wounded by a small sword or bayonet, in which case the above treatment by compression is to be adopted. The lungs themselves are sometimes wounded by a fractured rib, producing either hemorrhage or emphysema (from φυσαω *to inflate*.) When hemorrhage is the result, it is commonly alarming and requires active antiphlogistic treatment.

Emphysema consists in the air of the lungs issuing into the bag of the pleura, and generally from thence into the cellular tissue in the vicinity of the fracture, and ultimately over the whole integuments of the thorax, and even the whole body. If the air which is inspired by the lungs, and from them issues into the pleuritic bag, does not escape at the wound of the pleura into the subcutaneous cellular tissue, it makes the lungs of the affected side collapse, and by accumulating in the one bag of the pleura, presses on the mediastinum and diaphragm; and this so impairs the functions of the other half of the lungs and the smaller circulation, as soon to prove fatal. The escape of the air, therefore, from the pleuritic pouch into the cutaneous cellular tissue is favourable. Blood is often extravasated, as well as air, in the pleuritic bag, and the lungs become inflamed. The treatment consists in making punctures with a lancet in the region of the fracture, or wherever the air is diffused, and if oppression of breathing continues, paracentesis thoracis should be performed, and a cupping glass with its syringe applied to the wound. Emphysema results also from the wound of a sword, or any other sharp pointed instrument, from the bursting of a vomica, from violent respiration during parturition, from foreign bodies in the larynx and trachea, from blows on these organs, and even on the back of the neck; from violence in the reduction of a dislocated shoulder joint: from a suppurated lymphatic gland in the region of the neck, and as a sequela of pneumonia and typhus fever. The ribs sometimes become carious after fracture, and require to be removed.

Luxation or *Dislocation* (from *luxo* or *disloc*, *to put out of place*,) is the displacement of those bones which form a joint, and may occur either spontaneously or in consequence of external violence. When dislocation occurs spontaneously, it arises from relaxation of the ligaments and muscles; from palsy; from matter accumulated in the joints affected with white swelling or morbus coxarius. The other species of luxation, and much the more common, results either from violent motions or external injury, and is divided into simple, compound, primary, consecutive, complete, incomplete, and subluxation.

The shoulder joint is dislocated in four directions; the head of the os brachii may be forced either directly downwards into the axilla, inwards on the venter of the scapula, backwards on the dorsum of the scapula, or upwards on the coracoid process of the bone. The first of these is much the most frequent, and is probably the most common luxation that occurs; it is characterized by a conspicuous depression beneath the acromion, in place of the round swell of the shoulder, by the patient inclining his body to the arm, in order to relax the muscles, nerves, and blood-vessels, and relieve the pain, by his supporting the arm with his other hand or on his knee, and not being able to bring it close to his side, or lift it to his head. The capsular ligament and short muscles around the joint are more or less lacerated, while the pectoralis major, the deltoid, latissimus dorsi, teres major, and biceps are thrown into violent action, and contribute to produce the displacement by their sudden contractile efforts, which are performed to prevent the displacement of the bones. The head of the os brachii is forced out of the glenoid cavity between the long head of the triceps and the subscapularis, and rests on the inferior costa of the scapula. This is an example of simple, primary, as well as complete luxation. The arm is a little longer, but the difference is scarcely perceptible; the head of the os brachii is sometimes felt in the axilla, when the arm is removed from the side; paralysis occasionally occurs from pressure on the nerves, and crepitus from gurgling of the synovial fluid, which latter phenomenon is exceedingly liable to deceive the surgeon. Various modes of reduction have been recommended both by the ancients and the moderns; but the most simple and sure method is to fix the patient firmly and properly, as represented in Fig. 10, of Plate DXVII. so that the scapula is made the resisting point, which may be accomplished with a sheet or an apparatus having a hole to admit the arm to pass through, to which is to be affixed a rope extending to a beam of wood or kitchen poker laid across the outside of the door or window of the room, a wet towel is then to be applied to the affected arm above the elbow-joint, and over this, a hank of worsted in the form of the double clove-hitch, to the nooses of which the one end of the pulley apparatus is to be affixed, while the other end is fastened to a piece of wood placed across a door or window opposite the other. When every thing is thus properly adjusted, the patient is to be bled to fainting, and supported in a chair by an assistant, while another instantly begins extension, and continues it gradually and slowly until the surgeon, by poising the head of the os brachii with a towel folded like a bandage or compress, raises it opposite the glenoid cavity of the scapula into which it starts with a peculiar sound; the assistant then suddenly loosens the pulley apparatus and removes it. The operator next puts a cushion in the axilla, bends the forearm across the chest, binds it there to the side, and gives support to the elbow with a long roller, as illustrated in Fig. 9 of Plate DXVII. In general, tartrate of antimony in small doses should be given before using the lancet, as a great quantity of blood is often required to be taken in order to produce fainting.

More or less inflammation occasionally supervenes to luxation, and its necessary reduction, and may require local and general blood-letting, fomentations, local irritants, low diet, cathartics and confinement to bed. The arm should be kept quiet for at least three weeks, to permit the lacerated capsular ligament and muscles to heal, and afterwards passive motion allowed; but the patient ought to be cautioned against lifting his arm with too much freedom, as this luxation is extremely liable to be reproduced. Emphysema, ecchymosis, rupture of the axillary artery, and large abscesses have occurred from reduction. Reduction of this luxation may be attempted during any period within three months; but some have succeeded at the distance of ten months; much, however, must depend on the constitution and violence of the injury, for inflammation, mortification and death have followed attempts at reduction beyond three months. In old luxations, a warm bath should be used immediately before reduction is attempted.

If the head of the os brachii is not reduced, but pulled up by the muscles towards the clavicle, it is then termed a consecutive luxation, a form of the disease said by Sir A. Cooper to be primary. Larrey relates a luxation, where the head of the os brachii was wedged between the second and third ribs. The head of the os brachii now forms a new joint, the inflammation induced consolidates the muscles and cellular substance, which form a cartilaginous bed and a rude capsule, the loose muscles around contract and become rigid, and accommodate themselves to their new functions; the old capsular ligament heals up and the glenoid cavity is filled up with a soft gelatinous adhesive substance. Compound luxation of this joint seldom or never occurs; dislocation, however, with fracture of the neck of the os brachii, fracture of the acromion scapulæ, or fracture of the cervix scapulæ sometimes takes place; and each of these fractures occasionally present themselves without the luxation, so that we ought to be careful in distinguishing between them.

Compound luxation occurs probably more frequently at the ankle joint than at any of the others:

this consists in a protrusion of either the tibia singly, or tibia and fibula combined, through the skin, and the foot hangs loosely on either side of the leg. Compound luxation also comprehends the injury of the integuments and soft coverings, and the exposing of the bones of the joint to the external air. In such cases, if the bone cannot be reduced within the soft parts, it ought to be sawn off; or the practitioner must take into consideration amputation of the limb; for our own parts, we are disposed to prefer amputation, to the tedium of suppuration, exfoliation, and partial anchylosis, at the imminent hazard of the patient's life, consequent on the violent constitutional and hectic fever, gangrene, or tetanus during the cure. If an attempt be made to save the limb, the wounded arteries are to be secured, as many pieces of bone should be gently removed as can be done with facility and promptitude, the protruded bone washed, and either reduced or sawn off, the wound approximated by adhesive straps and suture, and covered with dry lint, and laid on a soft pillow or placed in M'Intyre's fracture-splint. Considerable inflammation, together with suppuration, generally follows, and requires most active antiphlogistic treatment. Simple luxation of the ankle joint may be mistaken for fracture of the tibia into the joint, and for a sprain of the tendons in this region.

Sprains consist in the laceration of the vaginal ligaments or sheaths of the tendons of muscles producing an effusion of lymph in the contiguous cellular tissue, and occur most frequently on the back of the hand; they also affect the muscles themselves by overstretching and slightly lacerating their fibres. In sprains, there is almost immediate discolouration, but no tumefaction until some time after the accident, which is generally only on one side of the joint, but occasionally on both. Sprains are treated first with leeches and warm anodyne applications, and secondly with stimulating liniments, friction and bandage. Ganglions or ganglia are either the result of sprains or bruises, and consist of an effusion of lymph, or the mucous secretion of the sheaths of the tendons; they appear in the form of a circumscribed, moveable, elastic tumour, free of pain, but frequently incommoding the individual in the motions of the parts, particularly if situated on the foot. They should be treated with pressure and bandage, and if these fail, with extirpation of the entire cyst. Sir A. Cooper recommends striking them a smart blow with a book, in order to rupture the cyst, and diffuse the glairy fluid into the cellular tissue that it may be absorbed.

Besides luxation, the joints are subject to many diseases, to inflammation, synovial and serous effusion, suppuration, ulceration, anchylosis, and loose cartilages floating in them. Inflammation has been already noticed under luxation, and which may be produced by the same causes as those that excite it on ordinary occasions, and the treatment requires to be extremely active, both locally and constitutionally, according to the magnitude of the joint and the severity of the injury. When the knee joint is very slightly inflamed from an exposure to cold, the synovial membrane secretes more synovial fluid than in health; and if the inflammation be a little more severe, this fluid becomes more watery, occasionally pure serum or dropsy, which constitutes *hydrops articuli.* From this view, it will be seen, that dropsy is an overabundant effusion of the serous portion of the blood, dependent either upon increased secretion of the exhalants, or on diminished absorption, or on a combination of both. This termination is still better illustrated in the serous cavities of the brain, thorax, or abdomen. If all inflammatory action has abated, the effused fluid into a joint may be discussed with a succession of blisters, compress and bandage, and if these fail, it should be evacuated by a valvular opening made with a bistoury on the outside of the joint between the patella and external condyle of the os femoris. This dropsical effusion is occasionally confined to the bursa under the patellar ligament, and then presents a globular swelling; but when it attacks the bursa under the cruræus muscle it invariably communicates with the joint.

When inflammation is more severe than to terminate in synovial or serous effusion, it ends in the secretion of coagulable lymph, that produces more or less perfect anchylosis; which is the union of the cartilaginous surfaces entering into the formation of a joint, or the osseous texture itself, rendering the articulation stiff and immoveable. In such cases, the treatment requires to be still more active; four or five dozen of leeches should be applied, followed by anodyne fomentations, alternate blisters and moxas, perfect rest, with the limb placed in M'Intyre's fracture-splint, gentle laxatives and low diet; and the puncturing of the joint to give exit to any effused lymph if necessary. The leeches may require to be repeated. A patient should be kept confined to bed until every vestige of inflammation has either been subdued, or the joint quite locked by anchylosis, when a splint of some apparatus ought to be worn to prevent the joint shaking; and even then the slightest motion of it ought to be carefully avoided.

When the inflammation is so severe as to terminate in suppuration, with thickening of the cartilages and ligaments; an effusion of viscid lymph into the cellular substance around the joint, rendering it thick and soft; a peculiar alteration of the adipose and tendinous substances constituting the chief part of the swelling; and the skin assuming a pale tense glistening colour with large veins;—the disease has been termed white swelling. The purulent matter is commonly of a shining coagulated nature. This disease, which occurs chiefly in early life, is almost exclusively confined to the scrofulous diathesis, which in so moist a climate pervades almost every constitution. The inflammation is sometimes slight, and recurs for several successive periods before advancing to suppuration, and occasionally appears alternately acute and chronic. The matter either remains within the articulation, or ulceration of the capsular ligament ensues, when it burrows in various directions, occasionally advancing to the skin in long fistulous tubes. Ulceration of the cartilages and caries of the bones, accompanied with hectic fever, takes place, and carries off the patient. The treatment is the same as that recommended in the last, only it ought to be more rigidly enforced. A peculiar treatment has been lately recommended by Mr. Scott of Bromley, which can only be applied to the early and mild stages of this disease; and a similar treatment is extolled by Richerand. When ulceration of the cartilages and bones have taken place, amputation is too often the only remedy. The rheumatic species of white swelling appears to be nothing more than the inflamed rheumatic joint terminating in suppuration. White swelling attacks the elbow, wrist, and ankle joints, as well as the knee, but the last most frequently.

In wounds of the joints, particularly so large a one as the knee, violent inflammatory action should be apprehended and treated accordingly. No probing whatever should be employed, synovia being easily distinguished from pus. The stomach is peculiarly affected by wounds of this joint, and a blow on the knee produces fainting and vomiting, and also affects the brain.

The articular surfaces forming the joints, especially those of the elbow and the knee, have been excised in an ulcerated state; the operation of the latter consists in making a crucial incision of the integuments on the patellar aspect, so that the transverse one may extend between the os femoris and the tibia; and dissecting aside each angle of the flap extensively from the patella and capsular ligament. The patella is then removed, the lateral and crucial ligaments divided, by which the condyles of the os femoris can be made to project on bending the leg on the thigh, and then can be carefully and slightly cleaned and sawn off from above downwards, a piece of firm leather being interposed between the bone and the popliteal vessels. The head of the tibia is next to be divested of its soft coverings, and projected so as to be sawn off from within outwards. One or more of the articular arteries may require to be secured, the flaps approximated, and then the cut ends of the tibia and os femoris are to be retained in apposition by an ingenious apparatus. There are many cogent objections to excision of the joints, few recovering the least use of them.

The disease which attacks the hip-joint, and which is termed the hip-joint disease, morbus coxarius, scrofulous-hip, or scrofulous caries of hip, is evidently a species of white-swelling, consisting first of inflammation, and suppuration of the synovial membrane and ligaments, and afterwards of ulceration of these and the cartilages and bones. This joint has been affected with fungus hæmatodes, deceiving the surgeon for morbus coxarius. When anchylosis has supervened after this affection, a joint may be formed at the cervix of the thigh bone, which consists in making the crucial incision over the trochanter major, and sawing the cervix close to this process of the thigh bone, and preventing union by ossific matter during the cure. In old age, the interstitial absorption of the cervix of the os femoris takes place, which alters the angle formed by it and the shaft, and so shortens the limb that it may be mistaken either for luxation or fracture. An affection, precisely resembling morbus coxarius, sometimes affects the sacroiliac synchondrosis.

Loose cartilaginous bodies are found in the joints, particularly the knee, and if they cannot be confined with a laced knee cap, so as not to impede the motions of the joint, they should be extirpated. The patient ought to be previously confined to bed for a day or two, and have a cathartic administered; the cartilaginous substance should then be pressed towards one side of the patella, and there held firmly by an assistant, while the operator drawing the skin downwards, or upwards, or to one side, makes a longitudinal incision over the substance, and extracts it either with the fingers, forceps, or a hook. The skin is instantly to be allowed to retract, the lips of the wound approximated with adhesive plaster, and the eighteen-tailed bandage applied, the limb gently extended, and perfect rest, with low diet, enjoined. Inflammation is to be apprehended after this operation, and treated accordingly.

The bones are subject to the same diseases as the soft parts of the body, the phenomena merely differing in consequence of the hardness of their structure; thus they are attacked with inflammation, suppuration, abscess, ulceration, mortification and carcinoma. Inflammation is termed ostitis, and is characterized by the same symptoms and appearances, as described under inflammation, the pain being more or less severe, according to the hardness or compactness of the bone, which, in consequence of its unyielding nature; prevents the expansion of the nerves and blood-vessels; the redness, tumefaction, and increased heat being more or less developed, according to the exposed nature of the bone. The same mode of treatment is also to be followed, with this difference, that as the bones are deeply seated, incisions, the moxa, and other counter irritants are more necessary. The soft spongy bones of the carpus and tarsus, the epiphyses of the long ones, and vertebræ when inflamed, are, in consequence of the blood-vessels having sufficient latitude, capable of forming suppurative papillæ, and thus abscesses are formed, which are treated in the same way as formerly directed. Abscesses in the bones frequently accompany necrosis.

These bones, upon the same principle when inflamed become carious, or, in other words, the abscess bursts, or the supurative papillæ are exposed, and the bone is found ulcerated for caries, (from κειρω *to abrade*,) is considered by modern surgeons, ulceration of the bones, and, consequently, is subject to the same varieties as ulcers of the soft parts; and caries not unfrequently follows ulceration of the contiguous soft parts. When caries attacks one of the carpal bones, a deposition of callus is occasionally generated, which forms a barrier to the progress of the disease; at other times a carious bone becomes soft and diseased throughout, having a fleshy or fatty appearance; on other occasions it becomes dry and friable, crumbling down under the probe; in some instances a separation takes place between the carious and healthy portions, the former being thrown off like a slough. Caries generally attacks the surface of a bone, and extends deeper and deeper, but occasionally it begins in the centre; when the bones of the carpus, tarsus, or vertebræ are attacked, it very frequently spreads from one to another; the cartilaginous surfaces of these bones resist the disease longer than the osseous shells. When this disease attacks the sternum, or any other superficially seated bone, the malady is more easily cured, than when a deep seated one, such as the acetabulum of the os innominatum. Caries attacks the young constitution much oftener than the adult, and spreads with greater rapidity, but heals more quickly, and occurs chiefly in the scrofulous and syphilitic constitutions. From the preceding facts and observations, it appears that caries may be divided into as many species or varieties as ulcers; therefore there are, the simple, the inflamed, the indolent, the phagedenic, the gangrenous, the scrofulous, the syphilitic, and the scorbutic caries; and consequently on this account the carious ulcer, described by authors, evidently involves two or three species of caries or carious ulcers. Some authors make other divisions of this disease, which are equally objectionable. The simple caries is clearly seen in the end of a bone which protrudes after amputation, in compound fracture when the bone is freely exposed, and in caries which commonly attacks the sternum. In these there is no difference from that which occurs in the simple ulcer of the soft parts, and none in the treatment. If the carious portion is not freely exposed, the integuments and all sinuses of the bone should be freely laid open, there being as much or more necessity for bringing it into view than even the ulceration of the soft parts. The irritable or inflamed caries presents the same granulations and discharge as the inflamed ulcer does; it is this species only which tinges the silver probe yellow or black, and when it attacks one of the bones of the carpus, or tarsus, spreads and involves so many, that not unfrequently amputation of the hand or foot is necessary. The antiphlogistic treatment requires to be vigorous in such cases, and all abscesses or sinuses must be freely laid open. If the caries becomes phagedenic, the portion must be removed with the trephine or knife, or destroyed with the actual cautery, nitrates of silver or copper, and if these fail, amputation ought to be performed. The cautery requires to be applied with great caution. But if the caries assumes a simple or healthy aspect, it is to be treated accordingly; or if it becomes indolent, to be stimulated with solutions of the nitrates of silver and copper, sulphate of copper, muriate of mercury, and oxide of arsenic. Moxas applied in the neighbourhood of caries are powerful auxiliaries; thus when the astragalus, tibia and fibula have been carious, moxas around the ankle joint have cured them. The phagedenic caries is best exemplified in severe cases of noli me tangere. The fungous caries is best illustrated in caries of the sternum, where the granulations are occasionally very large and flabby. The scrofulous caries, or caries occurring in the scrofulous constitution, affects either the vertebræ or the joints, the latter of which have already been considered; and when the former are the seat of this disease, either distortion with or without paralysis of the lower extremities, or lumbar abscess, is the result. From the great weight which the spinal column has to support, and the delicate spongy nature of its structure, it is very readily distorted even from continued awkward or awry attitude in the young and delicate scrofulous female. Whenever the muscles on the one side of the spine gain the least ascendency over their antagonists, they instantly lay the foundation for distortion, and in many cases, sooner or later, caries is the consequence. If early attended to, the common steel stays, as represented in Fig. 22, Plate DXVI. should be worn when the patient is erect, but the greater portion of the twenty-four hours should be passed in the recumbent or horizontal position. Open-air, sea-bathing, flesh-brush, attention to the diet and bowels are powerful auxiliaries. If the affection has been neglected, repeated cupping, and moxas, with acupuncturing, should be applied in succession from the occiput to the coccyx, together with the means just mentioned. The patient should remain in bed on a firm hair mattress, until all pain has been subdued, and even all tendency to a relapse has disappeared. In severe spinal affections, as they are termed, the spinal marrow is found sometimes quite disorganized, a complete mollescence, with more or less purulent matter exterior.

There is a peculiar affection of the cervical vertebræ confined at first to the articulations of the occiput and atlas, and atlas and dentata, which consists in ulceration of the cartilages, ligaments, and bones, ultimately involving the periosteum, the theca vertebralis, the dura mater, the medulla oblongata and brain, and also the pharynx. There is a peculiar expression of pain in the countenance, with dread at moving the head, which inclines generally to one side, and that most frequently the left, and when moved a most acute pain darts to the larynx and scapula of the affected side. The patient experiences most insufferable pain when swallowing a large mouthful, or taking a deep inspiration. These symptoms increase, and excite others fully as distressing, under which the patient lingers for months, when death puts a period to his sufferings. The treatment consists in repeated cuppings and moxas to the nape of the neck, confinement to bed, with the head and neck fixed with the chin-stay, see Fig. 22, Plate DXVI; low diet, and attention to the bowels.

When the long cylindrical bones are attacked with inflammation, their vessels having no latitude to expand and form ulcerative papillæ, become gangrenous, so that the bones are deprived of vitality, and either exfoliate or undergo necrosis. Exfoliation or necrosis seems to take place, according to the exposure or non-exposure of the bones; thus the bones of the cranium exfoliate, while the os femoris becomes necrosed: the tibia, however, either exfoliates or necroses. If the tibia be inflamed, and an abscess occurs superficially to it, the bone generally exfoliates; the inflammation being too violent for necrosis, according to the interpretation of the term by surgical writers, who consider it the death of the old bone, with the formation of a new one exterior to it, whereas, etymologically, it means merely the destruction of the old bone, being derived from νεκρόω, *to destroy*. In such a case, the abscess is to be freely laid open, and the condition of the bone examined; and if it appear divested of vitality, either the nitrate of silver or copper applied to accelerate the exfoliation of the sequestrum, or removed with cutting instruments, the latter of which is preferable. The tibia is sometimes deprived of vitality in extensive ulcers of the leg, in consequence of the periosteum being removed by the ulcerative absorption; in which case granulations are occasionally formed beneath the outer layer of bone, which thus becomes a sequestrum, so that both caries and necrosis exist at the same time. Caries and necrosis also sometimes exist together in ulceration of the spongy bones. When the cranial bones are exfoliating, they are to be gently shaken from time to time, and not rudely removed. When the shaft of one of the long bones dies, a separation takes place between it and the epiphyses; the periosteum inflames, with an accumulation of blood vessels, and thickening of this membrane; and if the inflammation be moderate, these vessels, together with those of the epiphyses, begin to secrete callus, in order to replace the decayed portion; and after the secretion of the new bone has extended from the one epiphysis to the other, the periosteum loses its injected appearance, and returns to its natural colour and density. The new shell now separates from the old bone, and the latter is either forced through the former, or is absorbed. A profusion of callus is at first poured into this new shell, rendering it solid for a time, but afterwards the absorbents make it nearly as hollow as the original. The new bone is at first merely a reddish fluid, next gelatinous, then cartilaginous, fourthly ossific or the phosphate of lime is deposited.

Necrosis occurs chiefly in early life, except when the inferior maxillary bone is affected, which is generally after thirty years of age: it attacks the tibia, os femoris, clavicle, os brachii, fibula, radius, and ulna; and there is a case detailed by M'Donald, wherein nearly all the bones of the body were affected. This peculiar disease of the bones is characterized by inflammation, either acute or chronic, tumefaction of the limb, diffused pain along the bone, ulcerous openings or abscesses, discharging purulent matter, which ultimately become fistulous. There is more or less fever throughout, which at first is inflammatory, and afterwards hectic. As long as the fever is inflammatory, and the limb acutely inflamed, the treatment should be antiphlogistic, with fomentations and poultices; and when these conditions have been subdued, if no ulcers have formed, moxas should be repeatedly applied; but if there are ulcerous or fistulous openings, simple dressings and gentle bandaging; the constitutional remedies being mild nutritious diet, exposure to the open air, and sea-bathing if practicable. The dead bone ought to be left alone as long as the health will permit, unless it has begun to force its way outwards, when it should be removed; but whenever the health begins to sink, the bone must be removed, otherwise amputation will be the only alternative, which otherwise need not be considered, until hectic fever threatens to destroy the life of the patient. During the cure, the patient must be guarded against using the limb before the bone has become properly consolidated, as it is very liable to be fractured. Various absurd remedies are recommended for this disease, as madder, assafœtida, hemlock, &c. Its causes are very obscure; the exanthematous fevers, syphilis, mercury, scrofula, and scurvy, also cold and blows, are considered predisposing; while inflammation is the proximate cause in early life, and obliteration of the blood-vessels in advanced age.

Portions of the cranial bones occasionally die, apparently in consequence of too great a deposition of phosphate of lime obliterating their blood-vessels, the dead part becomes a neutral object, excites irritation, and causes a separation between it and the living portion. When the piece exfoliated is small, it is regenerated by the vessels of the pericranium, dura mater, and diploe; but when very large, is never regenerated.

If we are permitted to continue the analogy, with which we set out, between the bones and the soft parts, they should be subject to the same varieties of tumours, of the truth of which we have not the least shadow of doubt, particularly when affected symptomatically. At present they are confined to Exostosis (from ἐξ, *out*, and ὀστεον, *a bone*), which is divided into various species by different authors, as true, false, periosteal, medullary, cartilaginous, and fungous exostoses, and sometimes acquire considerable magnitude. Exostosis chiefly attacks the dense bones, which are thinly covered, such as those of the cranium, inferior maxilla, sternum, clavicle, ulna, and tibia; although all the bones are occasionally affected. The periosteal exostosis is simply a diseased thickening of the periosteum, forming a tumour chiefly attacking the bones of the cranium and tibia, and occurring generally in the syphilitic constitution; but if not attended to, it commonly involves the bone. Sir A. Cooper considers this affection an osseous deposition between the bone and the periosteum, which adheres firmly to both. In its early stage, it may be removed by the application of the moxa, and the internal administration of the muriate of mercury. Medullary exostosis is when the medulla is primarily affected, and the cancellated structure secondarily; this may be treated in the same manner, but generally requires the knife. The cartilaginous exostosis is when cartilage forms the nidus for ossific deposition, which sometimes grows to an enormous size, and frequently attacks the inferior maxillary bone, requiring the removal of more or less of the sound bone on each side. It also takes place on the sternum and ribs, from whence it may be removed. The fungous exostosis is still softer, containing spiculæ of bone, and being of a malignant nature, acquires occasionally a prodigious magnitude. This is evidently the cellular or laminated osteo-sarcoma of some authors, or osteo-sarcosis, or osteo-malakia, or spina ventosa. It attacks the diploe of the cranial bones, the inferior maxillary bone, and the long cylindrical bones. This exostosis can be only cured by the knife, or amputation. Besides these, there is the exostosis eburnea of some authors, a small hard tumour generally situated on the os frontis, the exostosis petrosa, and the stalactitical exostosis. Hydatids are occasionally found in exostosis. From the magnitude which some of these species of exostosis acquire, they impede the functions of the contiguous soft organs; thus when situated in the antrum, the eye; on the cranium, the brain; on the cervical vertebræ, the spinal cord, and in some cases the subclavian artery; on the inferior maxillary bone, the pharynx and larynx; and on the symphysis pubis, the urethra. Various ridiculous remedies have been recommended for these tumours, and different instruments invented; for example, Jeffray's flexible saw, Machell's chain saw, Graefe's orbicular saw, and Thal's rotation saw.

Mollities ossium, named also malacosteon, is that disease wherein the bones become so soft that they may be twisted or bent in any direction, and in which, being deprived of their earthy property, as if they had been macerated in diluted muriatic acid, their animal constituent only remains. When analysed, the quantity of phosphate of lime amounts only to about an eighth. This disease occurs more frequently in women than in men, and generally about the middle period of life. It is preceded by fever and acute pains in the bones, and the urine contains a quantity of phosphate of lime; it is of long duration, Madame Supiot having lived five years. Its treatment is by attention to the early febrile affection, and afterwards to diet and regimen, exposure to the open air in the horizontal attitude, cold-bathing, flesh-brush and stays.

Rachitis or rickets, which depends also on a deficiency of the earthy property of bones, is closely allied to mollities ossium, but generally attacks the child, even the fœtus in utero. In rickets, the spine and ribs are commonly first affected, and afterwards the long cylindrical bones; the abdomen is tumefied in consequence of the liver, spleen, and mesenteric glands being enlarged; the intestines are filled with flatus, the digestion impaired, the breath fetid and sour, and the stools fetid, acid, and liquid. The respiration is also more or less affected; the head is peculiarly large, with a precocity of intelligence. The singular peculiarity in this disease is, that those children who recover from it in early life and continue strong until adult age, become again affected with it. The bones, after death, are found lighter, flatter, of a red or brown colour, porous, spongy, soft, compressible, and vascular; the cranial are thicker, the long bones thinner, and the medulla is like reddish serum. For the treatment, and a fuller account of this disease, the reader is referred to the Article Medicine, Vol. XIII. p. 29.

Fragilitas ossium may be considered the opposite of mollities, although, according to Boyer, the two diseases are combined. In this, there is a superabundance of the phosphate of lime in the bones, and hence it occurs in advanced life, and in either the syphilitic, scorbutic, arthritic, cancerous, scrofulous, or rachitic constitutions, and therefore symptomatic of some other disease. It is only in the scorbutic and syphilitic cases that any hopes of cure, always very doubtful, can be held out. Saviard details a very remarkable case of this disease, where all the bones after death crumbled under the fingers. Anchylosis, the last remaining disease of the bones, has been already described under affections of the joints, a result much to be desired on many occasions; but it has occurred without any marked increased action, as in the extraordinary case of Clark, detailed in the forty-first volume of the Phil. Trans. where all the bones, from the crown of the head to the sole of the foot, were completely soldered together, and whose skeleton is still preserved in the Museum of the College of Surgeons of Dublin.

This species or variety of wounds has ever been considered an important branch of surgery, either in military, naval, or private practice. These wounds are considered by systematic writers to be essentially different from all other kinds of wounds, and to require a different kind of treatment, as mentioned by J. Bell and Mr. Guthrie; but we contend, that they in no degree differ from contused wounds, and demand precisely the same kind of treatment. If a round stone or bullet is thrown from a sling, as in the days of Celsus, with the same velocity with which a musket bullet is fired, it will inflict precisely the same kind of wound; besides, we know there is no difference between the wound inflicted with an air gun, and that exploded with powder. It would appear that the whimsical notions of the writers on surgery before Paré, who conceived that musket bullets were poisonous, still haunt us. If the above be correct, it is easy to apply the same reasoning with respect to all the variety of gunshot wounds, and it consequently follows, that these wounds differ in no degree from contused wounds caused by stones and other foreign bodies, but in the contusion which the rapidity of the projectile produces. When a person is wounded with a musket bullet within half or quarter musket shot, the missile will most probably pass through the body, and there are then two wounds with a long sinuous tube between them; the aperture made by the entrance of the bullet is of a livid ecchymosed colour, is depressed inwards or indented, and smaller and rounder than that made by its exit, which is rugged and lacerated, having everted edges. These, however, sometimes vary, the exit appearing a mere slit, and in cases where the musket has been close to the wounded person, the entrance is as rugged and everted as the exit; much, therefore, depends on the velocity of the projectile, and the medium of the resisting body. Bullets run most circuitous routes in the body, if their course is diverted by a bone, and the position of the patient when wounded may throw light on this point. Bullets flying with great velocity and striking a part of the body which is clothed, seldom carry the clothes before them; the reverse, however, occurs if they are nearly spent in their career. If, therefore, this projectile has passed through the calf of the leg, or any other fleshy part, there will be little or no pain in consequence of the parts being chemosed, and little or no bleeding, because the blood-vessels are of small diameter and cauterized; but if the bullet is nearly spent, or has been rendered rugged, which is a very common occurrence, there will be some bleeding both from the arteries and veins. The treatment is to confine the patient to bed, and to apply poultices or fomentations to the leg, from the knee downwards, with the view of moderating or subduing the consequent inflammation, and of restoring the contused part to a healthy condition. The chemosed tube must suppurate and granulate to a certain extent, consequently poultices correspond most with the theories, opinions, principles and practices of all writers, even of Mr. Guthrie, who condemns them. After all inflammation has been subdued and suppuration established, the wound should be syringed with cold water, and simple dressings, and gentle bandaging applied. For the after treatment the reader is referred to ulcers. The diet is to be regulated according to circumstances. Sometimes only the part which is first struck with the bullet suppurates, being the most contused; while the rest of the tube unites by the first intention. If pieces of the clothes are carried into the wound, and far from either aperture, they should be left alone until suppuration is completely est.blished; but if near either of its apertures, they should be extracted. In some cases they are carried before the bullet, so as to resemble a purse, and are then removed with facility along with the bullet. The course of the bullet should, if possible, be ascertained, in order to calculate whether any important artery is wounded, or bone fractured, in which case the patient, by endeavouring to recollect the attitude he was in when wounded, may facilitate our inquiry.

According to the velocity and ruggedness of the missile, will an artery bleed immediately, or at some more remote period; but in the majority of instances, the hemorrhage is primary, and if it be the principal artery of a limb, so much is instantaneously lost as to produce syncope; if the surgeon is on the spot at the time, a tourniquet should be loosely applied, the artery cut down upon, and secured above and below the wound, but at a little distance from it, to avoid its being involved in the inflammatory action of the wound, which must follow. But if the surgeon is not at hand, and inflammation has begun, a tourniquet must be loosely applied, and an assistant appointed to watch until sloughing and suppuration have taken place; and if then secondary hemorrhage ensues, the artery must be secured; but secondary hemorrhage is so rare, that not above four in the 1000 are attacked with it.

In musket-bullet wounds of the hand or foot, the bones of these are generally fractured, and in the treatment, we must always keep in view, that gunshot wounds are more contused than others. The other bones of the extremities when struck with musket-bullets, are also very often fractured, and commonly splintered, and require the same treatment as described under fractures, bearing in mind that immediate amputation is more necessary in compound fractures from gunshot, than from any other causes. When a musket-bullet runs close beneath or centrad of the fascia of the arm or leg, it not unfrequently produces erysipelas phlegmonodes, which, besides the treatment already recommended for such, often requires the orifices of the wound to be enlarged. Wounds of the joints generally demand immediate amputation, for such a degree of inflammation and fever with suppuration follow, that the individual sinks under it, and there is no opportunity for secondary amputation.

When a musket-bullet is arrested in the body, and not situated in the contiguity of a vital or important organ, it ought to be abstracted wherever that is practicable, even if lodged in a bone, and as it generally prevents the wound healing, and produces inflammation, suppuration, and sinuses, and may prove an annoyance to the patient in after life, sometimes causing lameness if situated in the leg. All the bullet forceps and probes invented are of little or no avail, the finger in many cases being only admissible: the limb of the patient should be laid in the attitude in which it was wounded, and the left hand placed opposite the wound, into which the fore-finger of the right hand is to be inserted. If this fails, the patient should be requested to move gently the limb in various ways, and the seat of the bullet may by this means be ascertained, and removed, due attention being paid to important objects, for when situated near a large blood-vessel, it ought to be allowed to remain. If the bullet which continues in the body is lodged in cellular or muscular substance, and produces no immediate irritation, a membranous cyst is gradually formed around it, which adheres so close as to be with difficulty detached in a few months afterwards; and when situated close to a bone, the periosteum forms an osseous pouch. Sometimes they gravitate down a limb before becoming thus imbedded, and occasionally excite the formation of abscesses at a later period; at other times they excite so severe a pain that they compel the patient to have them extracted. From the earliest records of surgery there have existed much diversity of opinion and discussion, upon the propriety and manner of extracting bullets and other foreign bodies on the receipt of a wound. With respect to dilatation, it is now an axiom in British military surgery, never to dilate, unless necessity requires it.

Wounds inflicted by large shot, named large round, double-headed or bar-shot, grape, cannister, langrel, langrage, and shells, only differ from those caused by musket-shot, in the greater destruction of the part, and the more violent constitutional derangement; for in musket-bullet wounds, unless the head, knee-joint or some important organ be injured, there is trifling constitutional derangement on receipt of the wound. In severe wounds from cannon-shot, there is a dreadful concussion of the nervous and circulating systems, the patient has a pallid anxious countenance, a cold clammy skin, a feeble pulse, and most acute pain. In such a condition of the constitution, and supposing the knee-joint the seat of the injury, amputation cannot be performed any more here than in compound fractures of the bones forming this joint; and if the patient has lost much blood, there will be probably convulsive motions of the limb, and even of the whole body, together with irritability of the stomach, hiccup, wavering of the intellect, and extremely feeble voice, and a pulse scarcely perceptible. These constitutional symptoms, however, are said by Dr. Quarrier not to be always present. When the patient rallies, which will be after a longer or shorter time, according to the extent and nature of the injury, and the idiosyncracy of his constitution, for no precise period can be mentioned as described by authors on this subject, amputation should be performed. The rallying of the patient is characterized by pain, and a sensation of heat in the wound, a warmth of the skin, a quickness of the pulse, and thirst. There is another reason against immediate amputation, when the patient has been exposed to external cold after the receipt of the wound, for he then becomes in a measure frost-bitten, and requires to be thawed. On the propriety of immediate amputation, according to the hitherto received idea of this expression, there has existed much diversity of opinion from the early part of the sixteenth century. Dr. Quarrier and the other medical staff who were at the battle of Algiers, consider the expression "immediate" to apply to amputation performed as soon after the receipt of a wound as possible; while it had been formerly applied to the operation, whenever the system had rallied from the shock received by the wound, and contradistinguished from amputation performed when suppuration had taken place. The advocates for primary amputation, or when the constitution has rallied from the shock of the wound, are Du Chesne, Wiseman, Dionis, Le Dran, Ranby, Faure, De la Martiniere, Morand, Van Gescher, Pott, Schmucker, Boy, J. Bell, Dupuytren, Sanson, Begin, Larrey, Graefe, Guthrie, Thomson and Hennen. The advocates for secondary amputation, or when suppuration has taken place, are, Le Conte, Boucher, Bagieu, Bilguer, Percy, Sabatier, Mehee, and J. Hunter. Drs. Dewar and Quarrier, and Mr. C. Hutchison, recommend amputation instantaneously after the receipt of the wound, and contend that constitutional symptoms do not take place immediately; indeed the latter surgeon treats with contempt nervous commotion occurring to British seamen or soldiers: so that the only way of reconciling the opposite sentiments of Drs. Dewar, Quarrier, and C. Hutchison, with those of Drs. Hennen and Guthrie, is, that in the navy a man is brought instantaneously after being wounded to the surgeon, before constitutional symptoms have had time to appear, which, says Dr. Hennen, is a much earlier opportunity than any army surgeon can possibly enjoy; whereas a few minutes at least must elapse before the army surgeon can arrive at the wounded soldier, however fleet or active his ambulance may be. It is to be feared this instantaneous amputation was performed indiscriminately in the reign of Louis the XIV., which from its fatality alarmed him and all France. There appears two conditions of the constitution after gunshot wounds, the one wherein no commotion follows, as in the seamen at the battle of Algiers; and the other wherein nervous agitation exists, as occurred to the duke of Montebello, narrated by Larrey: that in the former, amputation may be instantaneously performed; while in the latter, some time must be allowed to elapse; and even both Mr. Guthrie and Mr. C. Hutchison recommend these methods of practice. In amputation of the upper or proximal third of the thigh, the operation is allowed by all writers on this subject to be seldom or ever successful; and many cases are on record of those wounded in this region dying in a few minutes, before amputation could be performed.

In gunshot wounds, the brain, the lungs, and the liver are often injured when the wound is quite remote. See Larrey's *Account of General Caffarelli, Duke of Montebello, &c.* The wind of a ball, as it is termed, is now completely established to depend on the projectile striking the body, but not producing any apparent injury of the skin; many interesting cases of which are related by Schmucker, Hennen, and Guthrie.

Tetanus, which has been already described in the article MEDICINE, Vol. XIII. p. 16, supervenes more frequently to wounds made by pieces of shell, langrage, and splinters of wood, than any other kind of missiles, and is then termed traumatic. See Larrey's *Military Memoirs*, and Sir J. M'Gregor's *Observations on the Peninsular War*.

Barons Percy and Larrey invented flying *ambulanee*, that of the latter great surgeon being evidently the better; it consisted in an admirable arrangement of surgeons, assistants, soldiers, officers, instruments, and medicines, all at a moment's command, to afford immediate assistance to the wounded, even while under the fire of the enemy. They followed the advanced guard, and the instant a soldier was wounded, he was dressed, or had his limb amputated on the spot, and then put into a light covered wagon, which conducted him to the hospitals in advance. The number of people attached to each division of ambulance amounted to 113, and consisted of one staff surgeon, two staff assistants, twelve assistants, two of the latter of whom did the duty of apothecaries; a lieutenant to command the economy of the division, but under the orders of the staff surgeon; a sub-lieutenant, who was inspector of the police of this division; a serjeant-major; two serjeants; a trumpeter, who also carried the instruments; twelve horse soldiers, among whom was a farrier, a shoemaker, and a coachmaker; an inferior or deputy commissary; two provision searchers; three corporals; a drummer, who also took charge of the surgery; twenty-five soldiers; twelve light cars or covered wagons capable of being driven on all kinds of ground, with the exception of a very steep hill; four heavier carriages. The light cars were mounted, some on two, and others on four wheels.

In the explosion of gunpowder, an individual is commonly scalded as if with boiling water, but occasionally so severely injured as to be instantly deprived of life. Burns differ in the extent of the surface injured, in the depths of the parts destroyed, and in the vitality of those parts; these three being equally destructive. In cases where the injury is confined to the integuments, there is no difference between it and that inflicted with boiling water, oil, or lead, or that caused by sliding down a rope from a height, or being grazed by falling from a height along a stone wall; one and all of these evidently may be referred to contused wounds, and since they have no mysterious character, require the same kind or mode of treatment; for on no subject of surgery does there exist more contrariety in the treatment, from the high authority of Dr. Thomson to the whimsical doctrines of our worthy citizen Mr. Cleghorn the brewer. Burns or scalds should be treated like contused wounds; and when they become ulcers, like these affections, and if they advance to mortification, the same as it; for according to the extent of injury do they inflame, suppurate and mortify, and involve the constitution. The practice long pursued in the Greek islands, in America, and now in this country, of enveloping the scalded or burned surface with raw cotton, or the wadding employed in ladies' dresses, is truly an invaluable and soothing remedy. It seems to act by excluding the external air, in the same way as when vesication takes place and left alone, no pain is felt, but whenever the vesicle is freely laid open, the pain is most severe: in vesication, therefore, a small puncture should be made to evacuate the serous fluid. Powdered chalk, and flour out of the cook's dredge box, so ably advocated at present, act on the same principle as the cotton. In extensive scalds or burns, there is generally great prostration of the vital powers, and if the patient rallies, violent reaction follows; occasionally wild delirium and coma; at other times an oppressive difficulty in breathing; in other instances inflammation of the mucous membrane of the alimentary canal, in others, hydrocephalus supervenes. When the grains of gunpowder are lodged in the skin of the face, they may be removed by a needle. In the healing of extensive burns, great attention should be paid that no unnatural adhesions or contractions of the integuments occur, as the union of the fingers, or of the chin to the neck, or of the latter being twisted to one side. The eye-lids, particularly the lower, is occasionally allowed to adhere to the cheek so as to form ectropium.

Amputation, from *amputo, to cut off*, is one of the most common, simple, and, however paradoxical, one of the most difficult operations in surgery: for, to execute it scientifically and dexterously, requires a most intimate knowledge of the relation of the arteries to the veins, nerves, and muscles. This operation is performed, when a member of the body is so injured or useless, as to be of no service to the individual, and the surgeon is placed in a most critical and perplexing situation, and requires a firm mind to decide, whether or not nature, if assisted by art, might not restore the use of the limb, a consideration of such importance to the individual, that amputation ought never to be performed without the deepest reflection. In private practice, there are all the various comforts of life; but in an hospital, there is extensive suppuration and gangrene staring the conscientious operator in the face; on board of ship, there are the inconvenience of the elements to contend with, and the distance from port; and on the field of battle, there is the exposure of the wounded to the inclemencies of the weather, the transportation to a house or hospital, the breaking up of that hospital on the approach of the enemy, and a thousand incidents at once embarrassing and perplexing; so that, too often, the most fixed axioms in surgery are overturned by these fortuitous events. We have already stated under mortification, that gangrene resulting from mechanical causes, or traumatic gangrene, requires amputation: and it may be set down as a general law, to amputate whenever a joint is exposed together with fracture of one or more bones entering into the formation of that joint, or the main artery of a limb so injured as to cut off its circulation, or the limb extensively contused and lacerated: in short, in such a condition, that it is the surgeon's conscientious belief and conviction, that no other means than this will save the limb, or probably the patient's life. But such a variety of opinions exist on these points, that much must be left to the discretion of the surgeon. Compound and mutilated fractures afford other grounds for amputation, and when these injuries occur from musket-bullets or grape-shot, the bone is generally much shattered, and the fracture very oblique; hence in such cases there can be no precise rule. When a limb is torn off by machinery or cannon-shot, amputation is performed, in order to make a clean and neat stump. White swelling of a joint in the last stage, large exostosis of a bone impairing the health by its bulk and weight; osteo-sarcoma attacking the bones of the extremities; caries and necrosis affecting these bones and injuring the health, or producing luxation of a joint, with anchylosis and deformity, require this operation. Fungus hæmatodes, or medullary sarcoma affecting the extremities, or even other species of sarcoma incapable of extirpation; old ulcers of the leg or arm, affecting the bones or articulations, or producing hectic fever; deformity of a limb itself may require amputation. From these cases it appears, that a limb should be amputated, when there is no prospect of saving it; and when the disease threatens to endanger the patient's life; when the limb is cumbrous and useless, and that its removal would be of essential service to the individual.

In extensively contused and lacerated wounds, in compound fractures, in compound luxations, in cases where the arterial trunk of the limb is destroyed, and where the limb is torn off, amputation should be performed whenever the system has rallied from the shock of the injury. For, at first, the patient is exhausted, cold and lifeless, and requires some minutes or even hours, before the nervous and circulating systems regain that degree of strength to bear such another shock; because in so great a dismemberment of the body as a thigh, the patient must be overcome, even granting that not a drop of blood were spilt. If therefore amputation be performed too early, one shock is added to another, and the individual is destroyed. When the patient has rallied from the shock of the injury, his skin becomes warmer, the pulse beats stronger, and he complains of thirst; and if this critical period be overlooked, or if the surgeon does not arrive until it is passed, inflammatory action has commenced, and then the operation must be deferred until all inflammation is subdued. Afterwards, when suppuration is completely established, and if then there appears no prospect of saving the limb, it should be amputated: and should the inflammatory action run on even to mortification, this operation must also be performed. In cases of caries, necrosis, fungus hæmatodes, and tumours of the bones, if the patient has just arrived from a journey, or has any degree of fever, some days of repose should be allowed him before operating. Prior to the use of the ligature, a limb was either cut off with a red hot knife, or the stump seared with a red hot iron or boiling oil; and before Petit's tourniquet was invented, a general circular compression was employed to compress the arteries. Objections are urged against the tourniquet, but if it is properly applied they are fallacious. This instrument, delineated in Fig. 3 of Plate DXVII, ought to be always used in amputation, when a large artery is to be divided. A bandage of calico four inches in breadth is firmly rolled up until it is about two inches in diameter, which is to be applied in the course of the artery on the proximal portion of the limb, sufficiently distant from the point where it is to be amputated, and the roller fixed to the limb with a bandage sufficient to surround it; the screw of the tourniquet is then placed on the roller, and the buckle on the outside of the limb. The screw is not to be tightened until the operator has the knife in his hand, in order that the artery and other textures may be compressed for as short a period as possible. The deviation of the superficial femoral artery, which occurred lately to Mr. C. Bell, when securing it for aneurism, is a satisfactory evidence of the necessity of a tourniquet, and of not trusting to the compression of the artery by means of the fingers of an assistant, who may become agitated or seized with sickness, fainting, cramp, or epilepsy.

There are various ways of performing amputation. In the days of Celsus it was done by the skin being previously retracted, and a circular incision made at once to the bone, from which the soft parts were detached and drawn upwards, and the bone sawn, which in our opinion is the best mode of performing the circular amputation, and, if applicable any where, to the middle of the arm. Paré and Wiseman operated in the same way, but used stitches to the wound, as practised by some modern surgeons, and Wiseman laid aside the use of retractors, which are formed of linen, leather, or tin, to keep the soft parts out of the way of the saw. The flap operation below the knee-joint was next invented by Lowdham. J. L. Petit made the double circular incision of the soft parts, the first through the integuments, the second through the muscles of the bone, after the integuments had been drawn upwards; and this is the method commonly adopted when the circular operation is preferred. Ravaton made a circular incision to the bone, then one on the fore part and another on the back part of the limb upwards or proximad for four fingers breadths detached these flaps from the bone, which he afterwards sawed. Vermale operated by transfixion, with a long bistoury, which is the mode followed by Desault, Lisfranc, and others. Various instruments and other inventions were contrived by Verduin and others, to supersede the necessity of ligatures to the divided arteries, and, strange to tell, some of these are at the present day used in Germany by Dr. Koch. Marquest de La Mothe seems to have been the first who carefully drew out the arteries from the contiguous veins and nerves with the forceps, before securing them with the ligature, and Alanson with the tenaculum. The forceps are best for large arteries, or arteries surrounded with loose cellular substance; the tenaculum for small arteries imbedded in the muscles, and the curved needle when the latter are indurated or converted into cartilage. Louis invented the division of the loose muscles in the first incision, and in the second those adherent to the bone, a mode much used by those who recommend the circular incision. Allanson, after the circular division of the skin and its retraction, attempted to make a circular oblique incision of the muscles upwards or proximad, so that when the bone was sawn, the stump should present a concave cone, the apex being the truncated bone; but in effecting such a form of stump, he must clearly have deceived himself, for in no other way than by two or three circular sweeps in succession can a concave cone be accomplished, as is clearly proved by Marten, Richter, Hey, Graefe, and Langenbeck. Yet this mode of forming a concave cone is talked of by the majority of systematic writers. Kirland cut off a piece of skin at each angle to prevent puckering.

Having made these observations on the different modes of amputation hitherto in use, we shall describe that practised by ourselves, to illustrate which the thigh is selected, that being the extremity to which the preceding modes chiefly apply. The patient being placed as usual on a low firm table, with the leg held by an assistant, and the tourniquet applied as directed, the operator stands on the left side of the patient, and when all is prepared, the screw of the tourniquet is tightened, and the operator with the knife delineated in Fig. 2 of Plate DXVI. makes a lateral incision nearly transversely to the bone on the outer or fibular aspect of the thigh, its direction pointing a little obliquely upwards or proximad, as represented in Fig. 3 of Plate DXVII. then with the same sweep of the knife he cuts upwards or proximad along the same side of the bone, to an extent equal to the diameter of the limb; then an assistant takes hold of this flap when cut, and a corresponding flap is then made, on the inner or tibial side of the thigh, which is also held by the assistant, who now gently retracts them both, since, if any bleeding occurs, he can thus easily command it. The surgeon then divests the bone of any muscular fibres at the root of these flaps, and saws it. The arte ries are next secured and both ends of the ligatures cut off. Whenever the trunk of the femoral artery is secured, the tourniquet should be suddenly slackened, to enable the operator to find the smaller branches, and may be tightened again or not, as necessity requires. The instant all the arteries are secured, it should be completely loosened. The wound is then cleaned with warm water, and if the weather be sultry, and the patient flabby, it should be afterwards sponged with cold water. In summer, the wound should be stitched, and no bandage applied; while in winter, a roller is brought loosely down along the thigh from the loins until the near end of the bone, when the flaps are approximated by adhesive straps, the wound covered slightly with two pieces of lint placed across, and the roller continued down to the end of the stump, and afterwards a little upwards. With the tourniquet loose around the limb, the patient is carried to bed, the stump placed on a pillow, and left uncovered, and a draught containing 50 drops of laudanum given. A diagram, representative of this mode of operating, is given in Fig. 3, Plate DXVII. This mode of operating seldom requires more than thirty seconds, and is preferable to transfixion, on the following grounds:—The flaps are more easily made, are fuller and thicker, and can be lengthened, if they appear too short, after the same manner of incision, and a third flap can scarcely occur. When sawing a bone, the saw should be swept lightly from heel to point, and no weight or pressure whatever used. In all operations the patient should take a dose of physic the preceding day, and after amputation, he is to be kept quiet, on low diet, with an assistant at his bed side for at least thirty hours, in case of primary hemorrhage. As for secondary hemorrhage, we have seen it vary from two to thirty days. When hemorrhage occurs, the bandage should be examined, and if found in the least degree tight, ought to be instantly loosened, as pressure is very liable to check the cutaneous venous circulation, and thus produce venous hemorrage; and this occasionally arises not from the bandage being applied too tight at first, but from the wound becoming tumefied. If the slackening of the bandage does not stem the bleeding, and the latter appears to be trifling, cold water, with a little vinegar in it, should be used; but if profuse, or not stopt by this means, the wound must be opened, and the bleeding arteries secured with ligatures, or sponge applied in the form of compression. If the bleeding takes place within the first two or three days after the operation, it is then from small arteries, but if afterwards, it is most probably from the trunk, in which latter case, the artery high up in the thigh must be secured, a plan superior to another or secondary amputation, as recommended by some authors. Spasmodic action of the muscles sometimes occurs to such a degree, as to require the stump to be fastened down to the mattress by a broad strap, and large opiates administered internally. Inflammatory fever occasionally supervenes, and requires active treatment, even in the emaciated constitution. As suppuration results in forty-eight hours, the wound should be dressed on the third day after the operation in summer, and fourth in winter, and not deferred until the eighth, as recommended by some. The straps of adhesive plaster should be most carefully removed at both ends, and one substituted before another is detached, and the clean bandage rolled downwards to the end of the bone, before their reapplication. Unctuous dressings are to be applied. Warm water ought to be injected into the wound, if there are any cysts or abscesses, and should be gradually reduced to the ordinary cool temperature, at each daily dressing. The diet should be moderate, as long as there is any increased action, and ought to be carefully augmented, but if the suppuration be profuse, it may then be nourishing. In amputation of so large a member as that of the thigh, the patient should be kept in the horizontal position, for at least a fortnight, and even then be allowed very little exertion. If bleeding has occurred after the operation, and so filled the wound that its lips are opened, and the bone has been deprived of its periosteum during the operation, there will not only be protrusion of it, but death of the bone. If the latter be the case, the protruded portion should at once be sawn off, and if the former, or simple protrusion, this step must be left to the discretion of the surgeon. We would recommend the same little operation to be at once adopted. After amputation, the patient should walk upon crutches for at least six months, before attempting to walk upon a wooden or cork leg, in order that the stump may be thoroughly consolidated and strong. Our limits will not permit us to give a description of the individual amputations; for them the reader is referred to Lizars's *Anatomical Plates.*

Incised wounds are made with a clean sharp instrument, although a very blunt one, by no means clean, when moved with velocity, may inflict a very cleanly incised wound. Whatever be the extent of such wounds, they are to be gently approximated with adhesive straps, compress, and bandage; but so prone is the scalp to inflammation, which generally assumes the erysipelatous type, that even the adhesive strap is occasionally inadmissible. In such cases, either poultices alone or combined with the strap are to be applied. In every case, more or less internal excitement is to be dreaded, so that the patient should remain quiet, on moderate diet, and pay attention to his bowels, and if the leat degree of headach follows, venesection ought to be performed. In injuries of the head, blood-letting should be prescribed with as much freedom as a dose of salts.

In lacerated wounds, whatever may be their extent, and however insulated may be the scalp, the part, if possible, should be preserved. This plan was followed in the time of Celsus, but went into desuetude until Paré revived it, and again was laid aside until the day of La Motte, for in the Hotel Dieu the lacerated scalp was dissected off by Petit and others. Cases of prodigious portions of the scalp, which had been torn off and reunited, are to be found in the works of Paré, La Motte, Hill, Pott, J. Bell, and Abernethy. In all cases of lacerated scalp, the whole hair of the head is to be shaved off, and the portion which is torn to be cleansed of blood and dirt, and carefully replaced, and retained in position by adhesive straps, gentle compression and bandage, or a handkerchief. The latter, when folded triangular, is named *kerchef* or *couvrechef*, when folded square and applied, is termed *grand couvrechef*. Poultices, although condemned by some writers, will be found of much more service than cold lotions in those cases where inflammation of the scalp takes place. In lacerated wounds, there is always such a degree of injury done to the bone or its contents, that we must keep in view the most active antiphlogistic treatment. Wounds of the scalp are fully more dangerous than those of the brain, so that even after the wound is healed, the most rigid attention should be paid to diet and the bowels, and all exciting causes avoided for some time to come. Suppuration is very frequently consequent on this injury, and the matter requires to be most freely evacuated. Occasionally portions of the scalp slough, and require removal, but never until the part has completely sphacelated.

The same treatment is to be adopted in contused wounds, accompanied with laceration of the scalp, or lacerated wounds attended with contusion. In the latter case, we must anticipate suppuration and sphacelation, and poultices are more necessary. Lacerated and contused wounds frequently lay the foundation of suppuration of the membranes of the brain, and even of the brain itself.

Punctured wounds of the integuments of the cranium are subdivided by Pott and the majority of surgical writers, into those of the cutis, of the subcutaneous cellular tissue, the tendon of the occipito-frontalis, and the pericranium, and they have attempted to assign symptoms characteristic of each, with an appropriate treatment, "opinion évidemment née des applications anatomiques," says Desault, "plutôt que de l'observation de la nature." And with equal truth, says J. Bell, "the integuments of the skull are essentially connected as a whole, having one continuous circulation, and having their disease in common." In punctured wounds, therefore, there is commonly erysipelatous inflammation, with more or less affection of the brain and its membranes, accompanied with general fever, in which the hepatic and gastric organs are affected. The treatment consists in general and local blood-letting, leeches being applied to the parts adjoining the wound, and the temporal artery, or external jugular vein should be opened ; fomentations and poultices afterwards to the scalp, brisk cathartics, warmth to the feet, blisters to the nape of the neck, low diet, and confinement to bed in a darkened chamber. If there be much tension around the wound, the expansive tendon of the occipito-frontalis muscle should be divided transversely ; and it may be even advisable to take into consideration the propriety of making several incisions in the erysipelatous scalp, as mentioned under erysipelas phlegmonodes. When suppuration follows punctured wounds of the scalp, free incisions ought to be made to evacuate the matter, which, on some occasions descends to the eye-lids, and even beneath the fascia of the temporal muscle down to the mouth.

The integuments of the cranium are frequently so bruised by a blow, that the blood is injected chiefly into the cellular tissue, between the cutis and occipito-frontalis muscle, communicating to the fingers of the surgeon the feeling as if a portion of the bone was depressed ; whereas it is mere ecchymosis, or, suggillation, according to J. Bell. There is a tumour commonly the size of a crown-piece, hard in its circumference, from the cellular tissue injected with extravasated blood, which gradually declines towards the centre, where the bone is distinctly felt through the blood, which here remains fluid. In such cases, all that should be done, is either to leave this blood to be absorbed by the vessels, or to apply warm discutients. If a considerable quantity of blood is effused, it is liable to destroy the connection of the pericranium with the bone, and even the bone itself; therefore, all such cases should be carefully watched, and if the effused fluid does not diminish in a few days, but continues to increase, or begins to excite headach, &c. a puncture should be made to evacuate it, and the condition of the bone examined. See cases detailed by Hill and J. Bell.

When a blow is inflicted on the head so as to stun the individual for a time, it frequently lays the foundation for irreparable evil. In a short while, he recovers his faculties and pursues his ordinary occupations for a week or two, when he begins to complain of headach, listlessness, thirst, loathing of food and nausea, passes restless nights, feels his face flushed, his eyes tender, swollen and watery, with contracted pupils, and which feel pained on looking at the light of a candle or a fire. He is attacked with rigors, cannot articulate distinctly, his tongue quivers and will not obey the voluntary powers. A small tumour appears where the blow was inflicted, feels tender on pressure, which, if severe, produces a convulsive action. He now becomes despondent, peevish, fretful, oppressed and sick during the day, muttering to himself in a lethargic state, and when roused, appears stupid, immediately relapsing into the same comatose condition. The pulse is quick, feeble and hard, the tongue foul, the skin dry with flushed countenance, and red gummy swollen watery eyes, the urine scanty and high-coloured, the hands and the tongue tremble, the bowels are constipated, and during the night he is delirious. He then becomes comatose, has a dilated pupil, occasionally stertorous breathing, delirium, and sometimes convulsions, when death closes the scene. On dissection, the puffy tumour contains a sanious fluid, the pericranium is separated from the bone, the latter of which is of a white colour, and has a dry appearance, no blood-vessels being present. Underneath the bone, matter is also deposited, and the dura mater separated from the bone is ulcerated, presenting a dirty yellowish green colour, while the brain itself is soft and also ulcerated. These fatal effects are all attributable to the bone in the first instance having been so contused, that its circulation is destroyed, the pericranium and dura mater separated from it, a slow degree of inflammation is excited, which terminates in suppuration. The death of the bone sometimes follows lacerated, contused, and punctured wounds of the scalp, as proved in J. Bell's *Principles of Surgery*. It is only when the bone is contused that such fatal events occur, for otherwise it is very tenacious of life, being highly vascular, and having three sources of nourishment, the vessels of the pericranium, those of the diploe, and those of the dura mater; and when cut and replaced, readily unites. The dura mater is a sero-fibrous membrane possessing little or no sensibility, for acids and cauteries have been applied without producing pain, and like bone enters slowly into inflammatory action, but then that action is with greater difficulty checked. These insidious symptoms are by no means regular in the period of their occurrence after an injury, varying from weeks to months; but whenever any of them do present themselves, we should instantly take alarm and apprehend the most dismal consequences, for too often the patient is beyond the reach of help. The most diagnostic symptom is the rigors, which are occasionally very slight; we are therefore immediately to confine our patient to bed, and pursue the most active antiphlogistic treatment. And if the insidious inflammatory symptoms are not subdued by such means, but on the contrary becomes comatose with rigors, with or without a puffy tumour, the operation of trephining should be performed, in order to give exit to the matter; for a puffy tumour is not always present to guide us. See Abernethy's *Surgical Works*, vol. ii. p. 27.

The patient ought to be laid on a low firm table, with the head on a thin pillow; a tripod or crucial incision is then to be made through the integuments forming this puffy tumour, the contents of which are foul and sanious, and the bone dry and of a yellowish white tinge; the crown of the trephine represented in Fig. 17 of Plate DXV. is then applied to this dead bone, with the central pin elongated, and cautiously and lightly worked with semicircular turns, first standing on the one side of the table and then on the other, until the teeth of the saw have made a distinct circular groove. The central pin is then to be retired and fixed, and the crown of the trephine cautiously turned in the same manner, examining very frequently the depth to which the instrument has sawn, with a quill cut like a pen, and brushing away the dry and bloodless dust from the teeth of the instrument and the groove in the bone. If the groove be attentively examined, the inequality of the bone may be observed, and whenever one point appears sawn through the outer table, diploe, and the least of the inner table, the elevator delineated in Fig. 18 of Plate DXV, should be tried. The operator must then saw those points of bone which remain entire with short turns, and use the elevator from time to time. If the circular disc remains, it is to be removed with the forceps. If any spiculæ of bone remain so as to injure the dura mater, they are to be removed with the elevator, but the surgeon should not be too fastidious about these spiculæ. Some use a perforator before applying the crown of the trephine, but this is seldom necessary. As this operation is generally done on patients in an insensible state, and as it is attended with the greatest danger, there is no cause for expedition. It is one of the operations in surgery whose success depends more on cautious delay than celerity. After the removal of the circular disc, the dura mater will be found coated with matter green and ulcerated, and if the matter does not exude out at the trepan hole, it ought to be gently syringed with warm water; and if no relief whatever has been obtained, but the symptoms still continue, this membrane should be freely incised across with a bistoury; and even then, if the symptoms are not sensibly alleviated, an incision ought to be made into the brain itself. "*Melius esse experir remedium anceps quam nullum;*" or "can the surgeon be said to destroy by his operation, a patient who is declared past all hope?" For confirmation of this practice, the reader is referred to Hill's *Cases in Surgery*, and to the Lancet, No. 117; also to Wiseman's and J. Bell's works.

The repetition of the operation of trephining is now never adopted, as was proposed by Lassus, and performed on the Count of Nassau in King William's wars no less than twenty-seven times; but it may be done on any part of the cranium within reach; the superior longitudinal sinus and other objects forming no interdicted points, as in the days of the ancients, but only points of caution. On some rare occasions, blood and even pus have been found effused in the diploe. See J. Bell's *Principles of Surgery*, vol. ii. p. 431. After the operation of trepaning the patient should be bled and treated antiphlogistically, and for months afterwards he ought to avoid all exciting causes. The flaps of the integuments are to be put down and managed lightly with simple dressings. Suppuration of the dura mater occurs in caries of the frontal and parietal bones in corona veneris, and even sometimes spontaneously, as exemplified in the case detailed in Abernethy's *Surgical Works*, vol. ii. p. 108. Blows or contusions of the cranium produce sometimes only an exfoliation of the bone, which, though slow in its progress, never is free from danger. It has been proposed to replace the circular disc, but this is perfectly inadmissible in disease.

After the operation of trepaning, phrenitis is a common occurrence, and hence the reason of directing bloodletting after this operation on all occasions; for the nature and treatment of this affection, the reader is referred to the article MEDICINE, p. 720; and we have only to observe that we prefer arteriotomy to phlebotomy, apply cold cloths to the head and warmth to the feet, blisters to the nape of the neck, but never to the crown of the head, and that it is very difficult to produce syncope in affections of the brain. Acute inflammation of the brain, if neglected, generally soon terminates fatally, either by general effusion between the arachnoid membrane, and pia mater, and into the ventricles; or by effusion of coagulable lymph, or suppuration of the tunica arachnoides and pia mater. But cases are detailed of its terminating in blood and even gangrene.

After this operation, also, if the dura mater be injured, a fungous growth of the brain sometimes shoots forth, termed hernia, or fungus cerebri, which excrescence depends both upon a healthy and diseased condition of the brain; springing up with surprising rapidity in the latter state of this organ. This fungous growth is also consequent on fracture of the cranium with depression, wounding the dura mater, or on ulceration of the dura mater, or on concussion of the brain. For an example of hernia cerebri arising in a healthy condition of the brain, the reader is referred to Hey's *Pract. Observ. in Surgery*, case of Boy Topham; and for cases depending on a diseased condition of the organ, to Hill's *Cases in Surgery*, J. Bell's *Principles of Surgery*; Abernethy's *Surgical Works*, Hennen's *Military Surgery*, and Thomson's *Report on Belgium*. In the healthy condition, the pia mater is wounded, and the tumour has the natural appearance of the brain, merely more vascular, and is evidently analogous to fungous or exuberant granulations of other parts of the body; while in the diseased, it is generally of a grayish colour with coagulated blood, and a turbid serous fluid around, and strangulated at its root, and resembles fungus hæmatodes of other textures. In the latter, it is preceded and accompanied by more or less stupor, slowness of pulse, dilatation of the pupils, slight strabismus, and paralytic affection of the mouth, the symptoms in many cases precisely resembling those of compressed brain; and in some instances, by symptoms of inflamed membranes of the brain, and particularly delirium. The treatment of this tumour by the authors referred to is very variable, but what we have found most beneficial is the free use of the lancet to remove the cause, and whenever the fungus appears above the level of the surface of the brain, to pare it off with the scalpel, and apply the most light and gentle dressings possible; to evacuate any matter lodged beneath the tumour; to remove all cause of strangulation at its root; to put the patient on low diet, in a darkened chamber, and to keep his bowels very open. If hemorrhage occur, exposure of the surface to the air generally checks it, otherwise the actual cautery should be applied: the bleeding is generally more beneficial than injurious. In the fungus originating from a healthy state of the brain, low diet, open bowels, perfect rest and cutting off the luxuriant growth, almost always succeed; but if it continues to sprout forth, bloodletting should be adopted.

Compression of the brain may be produced by the effusion of matter, blood and water, or serum; by the congestion of blood in the vessels, and by depression of the bone. This state of the brain is indicated by loss of sense and voluntary motion, the individual being unable to move a limb, being blind, deaf, dumb, and without the faculty of smelling or tasting; a slow heavy pulse, stertorous breathing, and dilated pupils, because the fountain or centre of nervous energy is suspended in its function. The depression of the bone is always the result of external injury, and is of a greater or less extent, according to the severity of the blow. Simple fractures of the cranium are in themselves productive of no evil, and occasionally take place on the opposite side of the head to that where the blow was inflicted, and sometimes produce a circular fracture of the entire cranium, and are often the cause of hemorrhage and inflammation. When a fracture occurs in the base of the cranium, some of the blood-vessels are generally wounded, producing extravasation, that leads to fatal events, and not unfrequently blood issues from both the nostrils and ears. When the frontal sinuses are simply fractured, and the nose blown, the air escapes into the cellular substance of the forehead, rendering it emphysematous.

Depression of the bone is more or less serious, according to the depth of depression, and the spiculæ into which the bone has been broken. Our guide in the treatment of depressed bone should be the symptoms of compression of the brain, for there are numerous cases on record in the works of Wiseman, Platner, Turner, Desault, Hill, J. Bell, Abernethy, Hennen, and Thomson, where patients have recovered without the operation of trepan, especially among young people. As long, therefore, as there are no urgent symptoms of compressed brain, so long there can be no necessity for trephining, but merely strict and active antiphlogistic treatment, and by which mode of delay, the aggravation attendant on the operation is avoided.—"Si nulla mala indicia sunt, modioli usus supervacuus est." "It is remarked, that in times of war and trouble, when men are not allowed to take care of their wounds, those who are least cared for are soonest cured; and a man who is forced to wrap a clout about his head and ride for his life, is safer than one who is chambered up, dieted, and dressed, and perhaps trepanned by the surgeon." Cases have occurred where the trephine was about to be applied to a depressed bone, when the patient has awoke from the stun of the blow. The depression frequently extends only to the inner table of the skull. There are some exceptions, however, to this general rule of the non-employment of the trephine; thus, for example, when the bone is injured with a sharp-pointed instrument, as a mason's chisel or a spike of an iron railing, the spiculæ project in such a manner inwards upon the brain, as to require a large crown of a trephine to encircle and remove the whole: this is termed the punctured fracture. Secondly, if the bone be so indented as to afford every reason to believe there are spiculæ projecting inwards, it is also proper. Thirdly, the application of the trephine is also considered by some indispensable in compound fracture, and in the camerated fracture of the ancients, but unless spiculæ are supposed to be formed, there are no just grounds for such an operation; since the antiphlogistic treatment is sufficient. When the trephine is used in depressed bone, the centre pin of the instrument must rest on the sound portion of the cranium, while a little less than the half of the circle includes the depressed portion: previously however to its application, a tripod incision of the scalp is made, and the scalp dissected back from the pericranium, the latter of which being easily cut with the teeth of the saw, forms no impediment to its operation. Having removed a portion of the sound cranium with the trephine, the elevator is inserted beneath the depressed portion, and steadily elevated. From this it will at once appear evident, that the trephine should be applied to that portion of the sound cranium opposite to the most depressed and loose portion. Hey's saw, depicted in Fig. 19 of Plate DXV. is oftener employed to remove a sound part of the bone, so as to allow the elevator to be used, because a smaller portion can be taken away with it, and it can even be applied to the depressed portion; all spiculæ or fragments must be carefully picked away. The remaining steps of this operation have been already detailed. In some instances of depressed bone, even Hey's saw is not necessary, there being sufficient space to use the elevator. A case is related by Sir A. Cooper, of a man who remained comatose for thirteen months, in consequence of depressed bone, and who was then trephined and recovered.

When symptoms of compression of the brain are produced by extravasion of blood, there is generally an interval of sense between the receipt of the injury and the insensibility occasioned by the effusion of the blood, and commonly some degree of swelling of the scalp; but in other cases, the individual lies in a state of stupor from the first, and there is no mark or trace where the effusion has taken place, or whether he be not in a state of concussion; while in others again, only one or more symptoms of compression present themselves. Sometimes the blood-vessels of the dura mater are ruptured, at other times those of the brain; hence, the effusion of the blood may either be between the cranium and dura mater; the dura mater and arachnoid membrane; the arachnoid membrane and pia mater; in the medullary substance of the brain, or in the ventricles. The first of these is more or less circumscribed; and when it occurs at the basis of the cranium is generally fatal. When between the dura mater and arachnoid membrane, the blood is extensively diffused, so that unless the quantity be great, there is no marked degree of pressure. It is also widely extravasated when situated between the arachnoid membrane and pia mater, one of its most common seats, and does not produce much pressure, unless the quantity be considerable. When effused in the medullary substance of the ventricles, it is circumscribed, and resembles that effused in apoplexy. In some rare cases, blood has been extravasated at once in all of these places. In the treatment of this affection, when the blow has been severe, and the patient lies in a state of stupor from the beginning, we can only use the lancet, and watch the progress of the symptoms, and if these continue clearly indicating compression, apply the trephine. If the blow has not stunned the patient, bloodletting nevertheless should be had recourse to, as it may check the further effusion of blood, and prevent inflammation succeeding. If the patient recovers from the insensibility which is occasioned by the blow, and again relapses into stupor, the trephine should be instantly applied. If there be no tumefaction of the scalp to denote the seat of the injury, the instrument must be applied in the region of one of the meningeal arteries, where it imprints the anterior inferior angle of the parietal bone, being there commonly encased in a bony canal, and consequently very liable to be ruptured either from the unyielding nature of the bone, or from fracture of this delicate osseous channel. If no extravasated blood be found on the side we have trephined, there is no other alternative than the applying of the instrument to the opposite side; and even then the blood may be effused in the basis of the cranium. If no blood be found between the bone and dura mater, but the latter appears purplish, it is probable the fluid is effused between the arachnoid membrane and pia mater, and in such an event we appear justified in puncturing these membranes, in order to give exit to the blood, although it is commonly so extensively diffused, that it either proves fatal by compression, or by inducing inflammation. Cases are on record where both sides of the cranium required to be trephined, the first operation removing only one clot of extravasation, and symptoms of compression still continuing until the opposite was removed. No reliance should be placed on the condition of the bone, as inculcated by some writers; it is of no moment whether the bone be dry or bleed, for its circulation may be carried on for a time by the vessels of the diploe.

Concussion is that state of the brain which results from a fall or blow, wherein its particles are so agitated, and its minute vessels so injured, that symptoms of compression are more or less evidenced; for if the violence of the concussion produce lesion of the medullary fibres or globules, and extravasion of blood, as was observed in dissections by Sir A. Cooper, the same train of symptoms must take place in concussion as in compression. Pott, Desault, and Bichat assert, that concussion and compression are frequently evinced by the same symptoms. In the majority of cases, the patient lies comatose, but still feels when his skin is pinched; the pulse is slow and intermitting; the breathing laborious without stertor; the pupils in some degree dilated; and the extremities cold. If not attended to, he remains for some time in this state, and either falls a victim, or becomes paralytic, or is attacked with inflammation of the brain, which may be said in such a case to be beyond the power of art. Inflammation is the most frequent consequence, and there often occurs a longer or shorter interval between the state of oppression, and that of excitement, which have been divided by Mr. Abernethy into three stages, but such a division is seldom verified in nature, and has led to erroneous practice. The treatment of concussion is by active and strict antiphlogistic means from the very beginning; copious bloodletting at this early period is supported by Sir A. Cooper's dissections, and by his own scientific practice, and also by that of Pott, Boyer, J. Bell, Abernethy, and Hennen. Broomfield, B. Bell, and Allan recommend cordials. The most characteristic symptom of concussion, is that degree of sensibility even in a comatose state, and which resembles somnambulism, some extraordinary and diverting cases of which are related by Sir A. Cooper. Concussion occasionally co-exists with extravasion of blood, the former preceding the latter; and so also do compression and concussion. The symptoms set down as indicating either of these conditions of the brain, are far from being conclusive, as is candidly acknowledged by many experienced surgeons. Convulsions and paralysis are frequently consequent on these affections of the brain.

In injuries of the brain, there occasionally exist some remarkable peculiarities in the symptoms, those in the pulse are related in Latta's *Surgery* and Hennen's *Military Surgery;* those of the memory in the latter work, and in Larrey's *Memoirs of Military Surgery* and Sir A. Cooper's *Lectures;* those of the stomach and liver, by Bertrandi, in *Memoirs of the French Academy of Surgery*, vol. iii. in Pouteau's *Works*, Desault's *Works*, J. Bell's *Principles of Surgery*, Richerand's *Nosographic Chirurgicale*, Hennen's *Military Surgery*, and *Rose's Observations upon Depositions of Pus and Lymph;* but it is doubtful if these visceral sequences are not the result of confinement.—See *Edinburgh Annual Register* for 1822.

Acute inflammation of the brain generally soon ends fatally, either by general effusion between the arachnoid membrane and pia mater, and also into the ventricles; or by effusion of coagulable lympth; or by suppuration of the arachnoides and pia mater. Gangrene and blood are said by Bursarius, Riverius, J. Bell and others, to be also terminations. The first of these constitutes acute hydrocephalus, which prevails both in the child and in the adult, and originates from many causes; and when it is evident that effusion has taken place, there is no hopes of relief but by an operation, however faint that hope may be; for no medicine as yet discovered can remove the effused fluid. The operation must be performed early if at all, and ought to be repeated on any appearance of re-accumulation of the fluid. In all cases where the symptoms have crept on gradually and insidiously, the water is found effused solely in the ventricles; while, where the symptoms have been rapid, the effusion has taken place, both within the cavities and on the surface of the brain; because in the latter it produces compression more suddenly, for it is only when the whole brain is acted on by the general pressure of the fluid, that its functions are paralyzed or destroyed. Chronic hydrocephalus, from being generally congenital, and from the cavity in which the fluid is contained being invested with an epithelium, resembling coagulable lymph, there is less chance of success. In infancy the operation is performed with a small trocar and canula, which is carefully plunged into one of the lateral ventricles, at one of the lateral corners of the anterior fontanelle. After the closure of this fontanelle, especially when the bone has become ossified, a small trephine is required to remove a circular portion of the bone, before having recourse to the trocar and canula. In those cases however, where the fluid is effused between the arachnoid membrane and pia mater, and at the same time into the ventricles, the mere puncturing of the arachnoid membrane with a lancet will evacuate the fluid, in consequence of the free communication inferior or basilad to the velum interpositum Halleri. For an account of hydrocephalus, the reader is referred to the article Medicine, to *Edin. Med. and Surg. Journal*, vols. xv. and xvi; and *Medico-Chirur. Review*, vol. vii. No. 21.

Chronic Hydrocephalus occurs also between the dura mater and arachnoid membrane, as lately proved by the dissection of a patient in Guy's Hospital. The fluid sometimes appears through a foramen of the cranium from a deficiency in the bone, and forms a tumour, whose sac consists of the dura mater and integuments. This has been termed spina bifida; although spina bifida or hydro-rachitis literally applies to a disease of the spine, and consists of a malformation of the osseous canal, the spinal cord and its membranes; the bone being deficient in few or more of its spinous processes and arches, the membranes with the integuments forming a pouch, which contains either the cord itself or the nerves, together with serous effusion. The fluid only occasionally communicates with the ventricles of the brain, and is precisely analogous to congenital hydrocephalus. Children seldom live for many years under this affection, but there is on record a person who survived until twenty years of age. This disease generally occurs in the lumbar or sacral region, but has been observed also in the dorsal and cervical, and in one instance the spinous processes were deficient the whole length of the column. Sometimes there is a double cyst. In consequence of the effused fluid pressing upon the nerves, there is involuntary passage of the feces and urine, and this is instantaneously produced, together with occasional convulsions, by external pressure on the tumour; and in the worst cases paralysis of the lower extremities is present. The treatment is by puncturing the tumour with a fine needle, previously drawing upwards the skin that it may act as a valve; and whenever the water collects, removing the fluid, but never the whole quantity at once, as it is liable by producing a collapse to prove fatal. Between the intervals gentle pressure should be applied. Caustic and ligature have proved fatal. Apoplexy has been already treated of under Medicine, Vol. XIII. p. 11. The reader is also referred to Abernethy's *Surgical Works*, to J. Bell's *Principles of Surgery*, and to Dr. Armstrong's *Lectures*, for further information on this interesting disease. Paralysis or palsy has been also described under Medicine.

Besides the diseases of the brain already enumerated, there are several diseased secretions, such as calcareous depositions, scrofulous tumours and abscesses, and globular vascular tumours, some of which are evidently scirrhous, and all of which are described by Platerus, Bonetus, Baader, Anderson, J. Bell, Bateman, Yellowly, and Baillie. These tumours produce acute or obtuse pain of the head, either constant or intermitting; occasionally the pupils appear dilated with more or less strabismus; now and then convulsive or epileptic fits, commonly transitory; and not unfrequently paralysis of one or more extremities: and in the last stage, symptoms of compression. In most cases the side opposite to the tumour is affected with paralysis, according to a principle generally prevalent in effusion of blood or matter in the brain. When these tumours are situated in the region of the optic nerves, vision is impaired; when on the tuber annulare or medulla oblongata, convulsions manifest themselves. Such tumours are beyond the reach of surgery. Fungoid tumours occasionally grow from the dura mater, in consequence of the latter being injured in a general concussion of the brain, and of then healing apart from the cranium, which is absorbed by the pressure, and allows the fungus to protrude. These tumours are also generated when the cranium is rendered carious, and the dura mater separates slowly from the bone. They excite either epilepsy, or palsy, in which the bone remains firm, and forms a resistance to the tumour; and when pressed upon, pain, tremors, and convulsions are excited. Instances are detailed by Baader, Sivert, Le Grand, Chopart, Marignes, Hill, and J. Bell. These tumours when opened, immediately prove fatal, so that the patient's sufferings can only be palliated. In the Edin. Medico-Chir. Trans. vol. iii, an interesting case is described by Dr. Stewart, Physician to the Forces. These tumours seemed to originate in the diploe. The air of particular countries and hospitals has been considered to be more prejudicial to injuries of the head than other wounds, by Lusitani, Phioravanti, Donatus, Saviard, La Motte, Petit and Desault; but this is evidently to be ascribed to the importance of the organ injured. The rapid putrefaction of those who die of such affections is also taken notice of, which is to be accounted for, by the centre of the nervous energy being injured in its organization.

The ear is subject to many diseases which are commonly left to the aurist. The auricle is affected in early life particularly with a herpetic ulceration, which sometimes spreads over the scalp, producing tinea capitis, and is to be treated in the same manner, preceding it, however, with anodyne fomentations and poultices, until all inflammatory action is subdued. The cerumen of the auditory tube is sometimes too copious, and slightly impairs the hearing, and is readily checked with the same astringent lotions and ointments, as mentioned under tinea capitis, together with a blister behind the auricle. When the secretion of the cerumen is scanty, deafness is occasionally the result, and is to be remedied by electricity gently administered, and an ointment of iodine applied at bed time, and washed away in the morning with soap and water. Children often insert pease and other foreign bodies into the auditory tube, the removal of which, although tedious, may be accomplished by a common probe, having the eyed-end bent. When cotton or wool has been inserted in the tube, and allowed to remain surrounded with cerumen sometimes for years, deafness is gradually produced, in which case the cerumen becomes exceedingly hard, and should be softened with oil of olives for six or eight nights, before attempting to remove it by syringing the ear with warm water and soap. Various insects sometimes get into the tube, and produce a terrific noise resembling thunder, and occasionally convulsions. They are easily killed by dropping oil of olives into the ear, or a decoction of tobacco, and afterwards, if small, syringed out, and if large, removed with the forceps or probe. These various objects are easily discovered by means of Buchanan, Le Roy or Segala's speculum, delineated in Fig. 25, Plate DXVI., or simply by placing the ear affected in the rays of the sun, and taking hold of the auricle with the thumb and forefinger, and gently raising or elongating it.

Polypus not unfrequently grows from either the sides of the tube or the membrane of the tympanum, impairing the hearing, and sometimes destroying the membrane, the tympanic cavity, and extending its irritation to the dura mater and proving fatal. It generally produces a copious discharge of fœtid matter from the tube; and is to be treated as Polypus in the nose, with fully more caution, as they are liable to excite inflammation and suppuration of the dura mater and prove fatal. Children are seldom born with a septum shutting up the auditory tube, but when such occurs, it ought first to be punctured with a very small trocar, for it might be the membrana tympani; and if found to be an adventitious septum, it ought to be entirely removed with forceps and knife or scissors. The membrana tympani is sometimes so relaxed that it cannot receive the aerial impulsions, and hence more or less deafness results; and is to be treated with electricity and the iodine ointment. It is sometimes ruptured from blowing the nose too forcibly; and occasionally thickened after measles and other acute diseases, and likewise in syphilis: when it is consequent on measles, &c. electricity and iodine ointment are applied to the tube, with blisters or moxas around the root of the auricle. When it occurs in the syphilitic constitution, these are to be combined with mercury, &c. The threads of the facial nerve supplying the ear and the chorda tympani are subject to neuralgia, which is here termed otalgia, and is to be treated in the same way. If dependent on a carious tooth, this should be extracted, and a decoction of tobacco dropped into the tube. The Eustachian tube becomes obstructed from many causes, some of which are mentioned under diseases of the nose; it is easily distinguished by making the patient shut his mouth and compress his nostrils, while he attempts to breathe through the latter with a gentle force, when, if the tube be pervious, the air will rush along it, and cause a crackling sound of the membrana tympani, whereas, if the tube be shut up, no sound is heard; also, by putting a watch between his teeth, when its sound will be heard if the auditory nerve be healthy. It is extremely difficult to insert bougies along the nares into the tube to dilate it, unless by means of the speculum, Fig. 25, Plate DXVI.; and therefore the membrana tympani should be punctured with the trocar by inserting it sheathed in the canula until the latter meets with resistance from the membrane, which is known by the yielding and springing vibration felt, and then the trocar is to be pushed along the canula, and the membrane punctured. In this little operation, the rays of the sun should be directed along the tube, and the auricle held as in inspecting the ear. When the obstruction is recent, it is most probably from mucus, and may then be removed by injections of warm water. Inflammation of the internal organ named otitis has been already described in MEDICINE. Otorrhœa is a discharge of fetid ichorous matter from the mucous membrane investing the tympanum, and occasionally even from the vestibule, cochlea, and semicircular canals, the bone being occasionally carious. Sometimes it begins in the ear itself, on other occasions within the cranium, and succeeds various acute febrile affections, particularly in scrofulous constitutions. Air rushes out from the pharynx at the ear, and water injected by the tube flows into the pharynx; and the ossicula auditus, especially the malleus and incus, are generally discharged. This affection should be treated as ophthalmia. An abscess sometimes takes place in the mastoid cells in children, the communication with the tympanic cavity being shut up with coagulable lymph, in which case the application of a small trephine is necessary, otherwise the disease proves fatal. The labyrinth is subject to many affections, the greater number of which are beyond our compre hension, partly from our ignorance of the physiology of this most interesting and most important organ, and partly from the difficulties encountered in examining morbid cases, in consequence of the prejudices of the public. There are diseases of the auditory nerve, of the *fenestra ovalis et rotunda*, and of the secretion of the labyrinth. For further information on this interesting branch of pathology, the reader may consult Itard, *Traité des maladies des oreilles.* Saunders *On the Ear.* Buchanan *On the Ear*, and M'Crae's interesting inaugural dissertation *De Morbis Auris*, 1828.

In consequence of the division of Medicine and Surgery into Physicians, Surgeons, Accoucheurs, Oculists, Aurists, Dentists, &c., the diseases of the eye have multiplied to no less a number than one hundred and eighteen; a catalogue at once frivolous and arbitrary.

Ophthalmia, or inflammation of the eye, is most absurdly subdivided according to the part affected, thus there are ophthalmia conjunctiva palpebrarum, ophthalmia conjunctiva oculi, ophthalmia conjunctiva corneæ, and ophthalmia sclerotica. There is also idiopathic, symptomatic, erysipelatous, mucous, purulent, catarrhal, orbital, and chronic ophthalmia.

In acute inflammation of the eye, there are pain, heat, redness, and swelling, with the feeling of sandy particles between the upper eye-lid and the ball of the eye, and an increased secretion of tears and mucus; which symptoms vary according to the severity of the injury, and the extent of the inflammation. As the disease advances, it extends to the brain, and the whole constitution, producing more or less phrenitis and inflammatory fever. The sensation of sand is caused by the blood-vessels of the eye-ball becoming turgid with blood, and being felt as a neutral body between the globe of the eye and the eye-lid. The eye, when thus affected, has its blood-vessels enlarged and increased, those which formerly carried serum, now conducting coloured blood, while the ciliary glands appear turgid and secrete yellow mucus resembling pus. The treatment depends on the violence of the inflammation: if the brain or constitution be not affected, leeches, warm anodyne applications, cathartics, low diet, rest and confinement in a darkened chamber will suffice: but if the brain or constitution be involved, general blood-letting from the temporal artery, external jugular vein, or one of the veins of the arm, will be required. The turgid vessels of the eye-ball and eye-lids ought only to be scarified when the affection is tardy, or these blood-vessels threaten to shoot over the cornea. The rubbing in gently of the extract of belladonna on the outer surface of the eye-lids and contiguity is of benefit. Whenever the sensation of sand leaves the eye, the warm applications are to be laid aside, and pure cold water used in their stead, bathing the eye whenever it feels weak and tender; at the end of twenty-four hours, rose-water is to be substituted, and after a few hours perseverance, as much sulphate of zinc is to be added as to produce the feeling of heat in the eye. This solution is to be progressively and cautiously strengthened, and to be dropped into the eye whenever it feels feeble. Laudanum may be early added to it, and afterwards sulphuric ether. As soon as the sulphate of zinc can be employed, the margins of the eye-lids should be gently anointed at bed time with an ointment of the red oxide of mercury, in the proportion of three grains to the two drachms of lard. After blood-letting has been performed, blisters to the temples and nape of the neck will be found advantageous. There are other local astringents besides those mentioned. If the eye-ball feels very tense, it will be advantageous to evacuate the aqueous humour with a couching needle. See Fig. 22 of Plate DXV. The causes of ophthalmia are exceedingly various; when it arises from sand, lime, pepper, snuff, insects, &c., they should be washed away with warm water and a syringe; when from a piece of a quill, iron, steel, gunpowder, small leaden shot, the couching needle, or cataract knife, depicted in Fig. 20 of Plate DXV., the forceps and camel's hair brush are the best to remove them. When ophthalmia becomes chronic, which is best distinguished by its duration, it ought to be treated with the same astringent applications rendered gradually stronger, together with mercurial ointment and opium to the eye-brow, and blisters, moxas, and setons. For further information on ophthalmia, the reader is referred to the article MEDICINE.

Iritis or acute inflammation chiefly of the iris, although it affects at once the whole choroid coat, and rapidly extends to the other structures of the eye, is consequent either on an injury, or occurs in syphilis, gout or chronic rheumatism, and frequently after operations on the eye. The surface of the eye, or tunica conjunctiva, is slightly inflamed, the iris appears swollen, changes its colour, when naturally black or brown to red, and when grey or blue to green, and the pupillary is darker than the ciliary margin, with some degree of deformity, not being so distinct and sharp, and gradually becoming more and more contracted. The inflammatory action extends most rapidly to the capsule of the lens, to which the iris is liable to adhere, and a deposition of lymph takes place early in the texture of the iris. There is a dull heavy pain of the eye, with intolerance of light, violent headach, and symptomatic fever. This affection requires very active antiphlogistic treatment; and after the first bleeding, mercury ought to be administered so as to prevent the deposition of lymph, or to excite its absorption; and in order to prevent the adhesion between the iris and capsule of the lens, the extract of belladonna ought to be employed, also mercurial ointment, with opium. Coagulable lymph is not unfrequently effused into the posterior chamber of the aqueous humour, especially in the iritis consequent on syphilis, and forms a delicate semitransparent web, which shuts up the pupil. Closure of the pupil also occurs from adhesion of the iris to the cornea, and is that in which an artificial pupil succeeds best. This operation, however, should never be attempted if the patient can see with the other eye, or when there is any complication of disease, and not until all inflammatory tendency has ceased for some time. In the majority of cases, there is more or less opacity of the cornea, so that the best point of the iris for making a pupil depends on the part where the cornea is transparent; it is therefore better to remove the opacity in the first instance. Various modes have been recommended for making an artificial pupil, from Chesselden downwards, and the most simple is that supported by Janin, Maunoir, Guerin, Scarpa, Richter and Beer, which consists either in making a puncture of the cornea with Daviel's scissors, as represented in Fig. 11 of Plate DXVI. at the upper part, and then cutting the iris perpendicularly near the inner or nasal canthus, or in making an incision of the cornea, first with the cataract knife, and next using the scissors.

Hydrophthalmia is dropsy of the eye, consequent on violent acute ophthalmia, and in this disease the eye is swollen, with protusion of the cornea, which is tolerably clear, although the aqueous humour is turbid. The sclerotic coat around the cornea is of a blue colour, the iris dull and dark, the pupil neither contracted nor dilated, and the vitreous humour much increased in quantity. In the beginning of the disease, the patient sees objects at a greater distance than formerly, or is far-sighted, but this soon changes to weakness of vision, the eye becomes horribly disfigured, its textures are disorganized, the bones of the orbit rendered carious, and the patient is soon cut off. By some, it is stated that the tunics burst, while by others this is denied. In the commencement, the cornea should be punctured, or an issue or a seton established, as recommended for staphyloma; and if these fail, the cornea ought to be removed, as described under that disease. Hypopium is an effusion of coagulable lymph and purulent matter in the posterior, and afterwards into the anterior chamber of the aqueous humour, consequent on acute ophthalmia, and is to be treated by active antiphlogistic means, and puncturing the cornea, also using astringent and stimulating ointments, with an alterative course of mercury. If not cured, adhesion of the iris to the capsule of the lens, and an opacity of the lens, together with ulcer of the cornea, are liable to follow.

Opacity of the cornea, named also albugo, leucoma, nebula, and speck, is one of the consequences of ophthalmia, whether acute or chronic. Nebula is said to be the result of chronic ophthalmy, and to consist of an effusion of milky serum in the tunica conjunctiva corneæ, with thickening of this coat and varicose veins; albugo, to be an effusion of coagulable lymph between the laminæ of the cornea, consequent on acute ophthalmy, and to have first a milky and then a pearly appearance; and leucoma to be also an effusion of lymph, but to occupy the whole extent of the cornea, and to arise either from violent acute ophthalmy, or ulceration of the cornea, or a wound of this tunic; but these opacities indiscriminately arise from chronic as well as acute ophthalmia, and being evidently the same disease, require therefore the same line of treatment, which consists in applying daily, or every second day, the dry nitrate of silver for an instant to the opacity, and bathing the eye for a few minutes afterwards with warm water or oil. In children it may be removed by blowing into the eye a finely levigated powder of equal parts of calomel and white sugar. In acute inflammation of the eye, a pustule occasionally appears on the cornea which requires to be freely opened; otherwise the depression or pouch is filled with lymph, and forms an opacity or leucoma. This pustule sometimes appears larger and more formidable, and is then termed an abscess, which should be treated in the same way. When the abscess bursts, it becomes an ulcer which is characterized by high ragged edges, by the base being of an ash-colour, and the discharge acrid serum. An ulcer is also consequent on wounds from sharp-pointed instruments, glass and lime. The symptoms are the same, as in acute or chronic ophthalmy according to its duration; and the best diagnostic of an ulcer is the pain produced on looking at the light, for on general examination it very much resembles an opacity of the cornea. A chronic interstitial ulcer is described by some oculists. If an ulcer of the cornea be neglected, it either spreads superficially and destroys the transparency of this tunic, or penetrates deeply to the anterior chamber of the aqueous humour, producing a fistulous aperture, where prolapsus of the iris may take place, and even protrusion of the crystaline and vitreous humours. A fungous excrescence sometimes protrudes, resembling a pterygium. As long as the pain is severe, and there is acute inflammation, it should be treated as the irritable ulcer of other parts; and whenever these are subdued, by the application of the nitrate of silver every two or three days; and when granulations are visible, by astringent collyria. Puncturing the cornea to evacuate the aqueous humour and thus relieve the tension and pain will be found beneficial, and prevent prolapsus iridis taking place. If a fungus shoots forth, it ought to be excised with the knife or scissors, and the nitrate of copper or silver afterwards applied.

When the cornea ulcerates, and the aqueous humour escapes, the support of the iris is removed, and the latter protrudes, forming prolapsus iridis, named also staphyloma and procidentia iridis. This also ensues occasionally after the operation of extraction of the lens, likewise when the cornea is ruptured by a contusion, especially from glass, and in evacuating the matter in hypopium, and even sometimes from violent vomiting. The iris appears like a small dark brown or grey tumour, surrounded by an opaque circle of the cornea, with an oval-shaped pupil, and more or less inflammation of the conjunctiva. On some occasions, there is more than one protrusion, simply because there is more than one aperture. The symptoms are pain like a pin pricking the eye, an oppressive sensation of tightness over the eye-ball consequent on the strangulation of the iris, a burning effusion of tears and intolerance of light. If the prolapsus be recent, an attempt should be made to reduce it with a probe, but if that fails, as it is very difficult, it may be removed with the knife, scissors, or nitrate of copper or silver, taking care not to continue the application of the escharotic too long. Whenever the wound heals, the pupil tends to reoccupy its former situation, although the adhesion remains. The wound is recommended by some oculists to be enlarged, which is improper; by others, the iris to be stimulated to retire into the eye by exposing the eye to a vivid light, a practice still more improper. Besides the iris being protruded, the investing layer of the cornea is occasionally forced out filled with the aqueous humour in the form of a transparent vesicle, and termed by Janin prolapsus of this tunic, in which formation of this disease he is joined by Pellier, Guerin, Descemet, Demours and Veitch; this is considered by Scarpa to be the hyloid membrane of the vitreous humour; while Bëer and Travers conceive it to be the innermost lamella of the cornea, the former naming it ceratocele. We are disposed to consider Janin in the right. The symptoms and treatment of this protrusion are the same as in prolapsus iridis. The choroid coat has also been protruded through the sclerotic near its junction with the cornea, in consequence of violent ophthalmia producing an abscess at that point. This is to be treated in the same manner as the last.

Staphyloma (from σταφυλη, *a grape*) consists of an opacity with distention of the cornea, according to Scarpa; while according to Richter, there must be also an adhesion of the iris to the cornea, but it may certainly be both. The eye has a disgusting appearance, from the variegated or mottled look of the cornea, which is alternately of a white, bottle-blue, or purple colour. Sometimes only the one half of the cornea is affected, which is commonly the lower; sometimes the cornea forms one uniform convex projection, while at others there are two or more, giving it a nodulated appearance. The distended condition follows a superabundant secretion of the aqueous humour, for in many cases the individual has indistinct vision with remarkable projection. Staphyloma is the result of acute, especially the purulent form of ophthalmia, and occurs frequently in children after small-pox From the projection of the eye-ball, it is exposed to the sun, air, and to particles of dust producing friction between it and the eye-lids, and rendering it a most distressing complaint; and it not unfrequently ends in ulceration of the cornea. This affection, if vision be totally gone, is to be treated by piercing the projected part of the cornea with a tenaculum, pulling the eye-ball gently forwards from the eye-lids, which ought to be kept out of the way by an assistant, and then cutting away the whole projection with a scalpel at once. The eye-lids are then to be gently closed, and the eye bathed with hot water for the remainder of the day, and afterwards to be treated with mild collyria. On the second or third day, the wound is filled with coagulable lymph, which gradually cicatrizes with an opaque horny texture, not unlike the cornea. Some recommend the establishment of an ulcer at the lower margin of the cornea; while others the inserting of a seton of fine thread, but unless the adhesive inflammation accompanies the ulcerative, it fails.

Cataract, (from καταρασσω, *to confound*, is either an opacity of the crystaline lens, its capsule, or the fluid between these, or a combination of them all. The varieties of this disease, according to ophthalmologists, are truly ludicrous, and would form a rhyme for Caleb Quotam. They may, with every propriety, be reduced from upwards of fifty to four. The capsular, the lenticular, and the milky. with a combination of these, and it is even very difficult to discriminate between these four in the living body When examining the diseased eye, the sound one should be closed or shut up, in order to prevent the motions of the one influencing the other. The capsular cataract presents a general white surface behind the pupil, producing nearly total blindness, with dilated pupil, which is not affected by any light; and when belladonna is rubbed on the eye lids, no ring is seen around this white spot. This species is generally consequent on local causes. The lenticular begins in the centre of the lens, producing opacity behind the pupil, with dilatation, so that although vision is no doubt impaired, yet the patient can see in an obscure light, as the twilight, in consequence of the rays being admitted around the lens; and there is almost always a clear deep ring around, particularly if the pupil be dilated with belladonna. This species commonly arises from constitutional causes, rendering the disease idiopathic. The milky variety, termed also cataracta morgagniana, begins in the liquor morgagni, and involves the lens, which degenerates into a thin milky fluid; it also generally affects the capsule, so as to form a combination of these three textures. Cataract is sometimes complicated with adhesion of the iris, obliteration of the posterior chamber of the aqueous humour, the latter of which is termed false or spurious. This disease is either idiopathic or local, is very often hereditary, and also congenital; the hereditary disposition being very extensive, frequently affecting a whole family. In the constitutional species, the individual begins to complain of weakness of sight, that he cannot see distant objects, has a mistiness or cloudiness over his eyes, and that when he turns his back to the light, or when the sun begins to set, he sees more distinctly; and he also occasionally sees more distinctly on the one side of the axis of vision than on the other. A candle appears to him to have a halo around it, and as he recedes from it, the halo becomes broader and the flame more indistinct. These defects gradually increase until he can only distinguish between light and darkness, and then the opacity may be perceived behind the pupil, having either a gray, silvery, dead white, yellow, brown, or dirty black appearance. In some rare cases, the opacity begins with two or three white spots. Local or accidental cataract is consequent on inflammation from wounds, and is sometimes so gentle and insidious, that the patient has not been conscious of its formation. With the exception of the congenital, we never succeed in curing cataract but by an operation, and before it is performed, several circumstances are to be attended to. We must distinguish between this disease and amaurosis, and be careful that the two affections are not co-existent; also between cataract and glaucoma, and there must be no inflammatory tendency, the eye ought to be free from all other disease, and the patient to be in a healthy state. A number of other points are mentioned by ophthalmologists, which do not merit attention. The inflammatory tendency is characterized by flashes of light, fiery sparks, pain in the eye, orbit, or forehead. When both eyes are effected, the one should be operated on before the other.

There are various operations for this disease, as couching, depression, displacement, and extraction. Under the three first, there are operations posterior and anterior to the iris; under operations posterior to the iris, there are simple depression, the depression of Scarpa, and the reclination of Willberg and Beer. Under operations anterior to the iris, there are the reclination of Langenbeck and keratonyxis. Before any of these operations is performed, the patient should take a brisk cathartic the preceding day, and any other course of preparation, as recommended by some, is unnecessary. An hour or so before operating, the extract of belladonna should be rubbed on the eye-lids to dilate the pupil, when the operation of couching is performed. The patient should sit on a low chair before a clear light, with an assistant behind, who is to raise with his fingers the upper eye-lid, while the operator depresses the lower; the surgeon then inserts Scarpa's needle, previously moistened with the tears of the patient, about a line and a half from the cornea, and half a line below its horizontal diameter, at the outer canthus of the eye, directing the needle towards its centre; the hand of the operator resting on the patient's cheek. The needle is to be seen anterior to the capsule of the lens, with the one flat surface upwards, and the other downwards, and the lens is then to be depressed to the bottom of the vitreous humour, keeping the instrument above the lens for a few seconds. The motions which are described by opthalmologists, to be performed in this simple process of depression, resemble the broad sword exercise. If the lens does not rise again, the needle is to be cautiously withdrawn; but if it ascends, the depression is to be repeated. The operation of reclination of Wilberg is almost the same. Langenbeck performs reclination through the cornea anterior to the iris, with a curved needle, the convexity of the instrument being towards the lens. Keratonyxis consists in entering a spear-pointed needle through the cornea, at its inferior margin, lacerating the capsule of the lens laterally, and either merely making a small aperture in the texture of the lens, or by breaking it up, and endeavouring to bring it into the anterior chamber of the aqueous humour, where it is ultimately dissolved and absorbed by its agency. Care must be taken to prevent the escape of the aqueous humour. This operation is the simplest and safest which can be performed for cataract, whether capsular, milky, or lenticular. It is advocated by Conradi, Bëer, Saunders, Buckthorn, Langenbeck, and Walther, with a slight variation in some trifling points.

Extraction, the most radical cure for hard or lenticular cataract, is probably the most difficult to perform. The patient should lie on a firm table, and an assistant hold up the upper eye-lid, when the operator, with a cataract-knife, (Fig. 20, Plate DXV.) makes an incision of the lower half of the cornea, entering the instrument at the outer canthus, about a line from the sclerotic coat, and nearly the same distance above the horizontal plane, pushing the knife at once across the cornea, and transfixing the other side, as delineated in Fig. 5 of Plate DXVII., and then cutting downwards and outwards, care being taken not to wound the iris. If the operator cannot force the point of the knife through the opposite aspect of the cornea at once, before the aqueous humour escapes, he should gently press the cornea in front of the knife, which causes the iris to retract, and then proceed with the knife; or he may withdraw the knife, and complete the incision with Daviel's scissors, which are to be used to enlarge the incision if too limited. After the incision of the cornea, great care is required to employ no degree of pressure, otherwise the vitreous humour will protrude; the capsule needle or cataract lance is then cautiously inserted onwards to the cataract, and the capsule lacerated by crucial incisions, the operator previously seeing the pupil distinctly, which if not fully dilated, a curtain should be interposed between the patient and the light. The lens generally follows this capsule needle, but if not, the most gentle motion of the eye upwards, together with very delicate pressure on the lower eye-lid, discharges it; but if this does not take place, Daviel's scoop should be inserted between the cornea and the iris, and the lens assisted by its pressure. The operator should carefully investigate if the section of the cornea be large enough, and the capsule of the lens sufficiently lacerated. All fragments of lens should be carefully removed with the scoop, the patient put to bed, the eyes covered with a handkerchief, and warm applications, and otherwise treated antiphlogistically, according to the state of the inflammation. When the right eye is the seat of the cataract, the section of the cornea should be upwards. Extraction is recommended in hard cataract, keratonyxis for soft and capsular cataract. Capsular cataract frequently follows extraction, and then keratonyxis is requisite. There are a number of circumstances mentioned by authors, interdicting extraction, which appear frivolous. Congenital cataract is almost always the capsular, and should be removed by keratonyxis, when the child is six months old.

Glaucoma, (from γλαυκος, *bluish green*), consists, first, in an alteration of the texture of the vitreous humour and its membrane, ultimately involving the retina, choroid coat, and lens; the vessels of the choroid being varicose. The eye has an unhealthy appearance, and feels firm and hard, the cornea is turbid, the sclerotic of a bluish or yellow tinge, with tortuous varicose vessels piercing this tunic at a distance from the cornea, leaving the latter surrounded with a white circle; the iris, if naturally blue, becomes gray, and if black, a dirty brown; the pupil is dilated, irregularly angular or oval, and immoveably fixed as it were to one canthus. The individual cannot distinguish light from darkness. As the disease advances, the green colour increases; the lens swells and presses the iris forwards into the anterior chamber of the aqueous humour, when it is termed glaucomatous cataract. The treatment consists in local blood-letting, blisters applied to the temples, moxas, issues and setons to the nape of the neck, laxatives, mild diet, and the avoiding of all exciting causes.

Amaurosis, or gutta serena (from αμαυροω, *to obscure*), is generally consequent on a diseased affection of the retina and optic nerve, since the function or structure is deranged. The patient sees in the light gnats, or flies, or threads or spots flying before his eyes; while in the dark he perceives fiery sparks, or balls, and flashes of blue, yellow, or red; and often sees double and squints. The flame of a candle appears to change from white to yellow, red or green; the halo also appears of these colours; at last total blindness ensues. When the eye is examined, it is either clear or cloudy, the cloudiness being deep in the eye, the bottom of which is of a pale greenish colour resembling horn. The pupil is very variable, commonly irregular, angular and fixed. This disease is sometimes slow, at other times rapid, and is even congenital, being more hereditary than cataract; and its causes are exceedingly various, from which it is either temporary or permanent, depending either on a deranged function of the eye itself or the brain, or some more distant organ, or even on an organic affection of them all. When it originates from diseased function it is sometimes capable of being cured, but when from diseased structure incurable; and none of the diseases of the eye so completely baffles the skill of the surgeon. When diseased function is the cause, it is generally from pressure of the blood on the internal carotid or its branches, particularly the opthalmic artery on the optic nerve; also from the arteries distributed on the choroid coat when varicose pressing on the retina. In these cases, blood-letting, blisters, moxas and issues to the nape of the neck, pediluvium, shower-bath, powerful cathartics, and low diet occasionally cure it. When suppressed discharges are the cause, they require to be restored, or others to be substituted; when it arises from over-excitement, it is generally easily cured, and it is a peculiar circumstance in this case that the patient can see while under the influence of a glass of wine. When narcotics, it is curable; emetics are recommended, but they should never be administered, as vomiting is a common cause of the disease, and as calomel with other cathartics removes the diseased secretion of the stomach, and more effectually prevent regurgitation of the bile. When hydrocephalus, tumours in the course of the optic nerve, exostosis at the basis of the cranium, thickening of the retina, shrinking or atrophy of the optic nerve cause the disease, the case is hopeless. It is often very difficult to ascertain from what this disease originates. In northern and tropical climates, from the glare of the sun or snow, a variety of amaurosis occurs, which, if it produces blindness during the day, is named Nyctalopia; if during the night, Hemeralopia. A third variety exists, in which the individual is blind all day until a certain hour, when he sees distinctly, or he sees and is blind every alternate day, or is only blind one day in the week, fortnight, or month. These varieties are treated by purgatives, by removal from the effulgence of light, blisters to the temples, moxas to the nape of the neck, electricity, and nourishing diet with tonics.

Cancer of the eye begins either in the lacrymal gland, the conjunctiva, or the eye-ball itself, attacks the constitution after the meridian of life, and is characterized by acute stinging pains like the pricking of needles or lancets, the eye presenting an irregular nodulated tumefied appearance, the cornea becoming opaque, varicose blood-vessels forming on the conjunctiva, which become ultimately like flesh, and even the whole eye resembles firm flesh. When the conjunctiva is first affected, it is a common ulcerated fungus, hard and cartilaginous, attended with darting lancinating pains, exquisite sensibility, icorous discharge, and varicose enlargement of the blood-vessels, and ultimately involves the eye. If confined to the conjunctiva, we may then consider whether it ought to be removed together with the eye-ball, but if the eye-ball itself is affected, the whole ought to be extirpated. The eye-ball is to be transfixed with a curved needle, armed with a broad ligature, and if the eye-lids can be preserved, an incision is to be made between them at the outer canthus, to enable the operator to use more freedom; the conjunctiva at its angle of reflection between the eye-lids and eye-ball is then to be divided completely round: next the insertions of the superior and inferior oblique muscles; the knife is then carried close around the bone, and deep into the orbit, pulling gently at the same time the ligature, and lastly dividing the origins of the recti muscles, and the optic and other nerves. Great care should be taken to remove every portion of the disease, and if there be much bleeding, a piece of dry sponge should be inserted, or the actual cautery applied; but if not, the orbit ought to be gently filled with lint, with a small compress over the eye-lids, and a bandage around all; the patient put to bed, and an opiate administered. Inflammation may be apprehended, and the patient ought to be treated accordingly.

Fungous hæmatodes also attacks the eye, commencing in the retina and optic nerve, the vessels of which secrete the peculiar medullary matter that fills up the whole cavity of the eye-ball, presenting an irregular nodulated appearance, with a muddy cornea, and a dark livid coloured conjunctiva. At first, the cornea is so transparent as to resemble a piece of polished steel, or a concave silver plate, and the bottom of the eye is greenish, or of a dark amber colour, the pupil being dilated and immoveable. As the tumour advances to the iris, it can be seen to be a solid body of a yellow or brown colour and an irregular shape, with arteries ramified upon it. The aqueous, crystalline and vitreous humours are absorbed, together with the retina and choroid coats; the optic nerve becomes thickened, of a brownish colour, and divided by the tumour into threads. The nerve is sometimes involved even backwards to the thalamus and anterior lobe of the brain. The cornea or sclerotic coat ulcerates, and a fungus protrudes of an irregular, red colour, covered with coagulated blood, bleeding on the slightest touch, and discharging a fetid matter. The lymphatic glands in the region of the parotid and submaxillary glands become affected. On rare occasions, the disease begins in the cellular tissue, connecting the conjunctiva to the cornea. This affection also requires extirpation of the eye, but unless the operation be early performed, it rarely succeeds. It attacks chiefly children under twelve years of age.

Cancer of the lacrymal gland is a very rare disease, and is characterized by lancinating pains in the region of the organ, which from its irregular hardness and enlargement, presses the eye-ball downwards and outwards, which cannot be turned towards the external canthus without producing violent pain. This also requires removal by the knife, although it is objected to by Beer and others. An incision should be made over the tumour parallel with the superciliary ridge through the integuments, orbicularis palpebrarum, and ligament, which descends from the frontal bone until the tumour is exposed, which is then to be insulated from the bone and muscles of the eye, and removed. If hemorrhage follows, it must be stemmed with dry sponge and pressure. The lacrymal gland is occasionally subject to inflammation and suppuration, and an encysted watery vesicle, for the encysted lacrymal swelling, and the watery vesicle of the lacrymal gland are the same disease. During inflammation, there is a suspension of the secretion of the tears. The encysted swelling arises from the obstruction of the ducts of the gland, for the tears collect and form a pouch, which should be punctured, and a seton inserted from the conjunctiva to the skin at the external canthus, or a portion of the pouch removed with scissors, in order to obliterate the sac.

Tumours of the eye-lids are very common, from a simple stye to a cancerous watery excrescence. Hordeolum or stye is a small phlegmon generally on the margin of the lower eye-lid, and is commonly one of the ciliary glands, which advances slowly to suppuration and bursts; and it occurs most frequently in the scrofulous constitution, and may be treated as a common phlegmon.

If hordeolum does not suppurate, it is liable to degenerate into a hard tumour, named chalazion, grando, lythiasis, tophus, porosis, &c. which are sometimes small fleshy tumours containing calcareous matter. These require to be extirpated, for if allowed to remain, they often produce a malignant ulceration. Other small tumours of a fatty or chalky nature, or hydated vesicles, termed phlyctenulæ, occur on the eye lids, which require to be lanced, and their contents squeezed out. Warty excrescences should be excised. Encysted tumours are very prevalent on the eye-lids, occurring sometimes between the tarsus and skin, on other occasions between the tarsus and conjunctiva, in which latter situation they ought to be extirpated, if possible, from the inside of the eye-lid, by making an incision parallel with its margin; and after its removal, the wound should be anointed with oil of olives to prevent adhesion. As inflammation is liable to follow this operation, the patient must remain in a darkened room on low diet.

Encanthis, (from εν, κανθος, *the angle of the eye*,) is an enlargement of the caruncula lacrymalis, which ultimately involves the plica seminularis, and when inveterate extends along the eye-lids and surface of the eye-ball to the cornea, and even the whole eye, it being then purely cancerous. It ought therefore to be excised as early as possible; for, in its advanced stage, the whole eye may require to be extirpated.

Pterygium (from πτερυξ, *a wing*) is a triangular object or tumour situated on the conjunctiva, generally at the inner canthus of the eye, with its base towards the caruncula and apex towards the cornea.

There are two species of this, the membranous and the fleshy pterygium, both of which require to be removed with the forceps and knife or scissors, since they are liable to degenerate into a malignant or cancerous nature, although they often remain dormant for years. When they become cancerous, the whole eye should be extirpated. A small deposition of matter sometimes takes place near the edge of the cornea, which should be removed. Small oval substances, of a dirty yellow colour, also form in advanced life, in this place, which may be left alone so long as they remain inert. Fleshy and cartilaginous tumours are not unfrequently formed beneath the conjunctiva, and require extirpation. A small pale red, hard and itching tumour of the size of a pin's head is found on the lower eye-lid, near the plica semilunaris, occurring in chlorotic young women, and likewise requires removal with the knife.

Lippitudo, or blear-eyedness, is a diseased secretion of the ciliary glands and conjunctiva palpeblarum, the eye-lids are red and excoriated, are glued firmly during sleep, and vision is in some degree weakened or impaired. The treatment consists of warm anodyne applications in the first instance, and afterwards of cold astringents and stimulant ointments as mentioned under ophthalmia. The preceding affection often gives rise to diseases of the lacrymal passages; and on everting the eyelids, they present a villous granulated appearance, with swollen ulcerated ciliary glands; and in scrofulous patients the lacrymal sac is frequently inflamed from this source. In which case, there is a circumscribed hard tumour of the shape of a bean, in the situation of the sac, attended with lancinating pains when touched, and soon having a red external appearance, which is more or less erysipelatous. The lacrymal puncta or papillæ are shrunk and invisible; the tears flow over the cheeks, and the affected nostril is at first moist, but soon becomes dry. There is more or less headach and even symptomatic fever. The inflammation ultimately extends to the conjunctiva of the eye-lids, the caruncula lacrymalis and plina semilunaris, producing a copious secretion of tears, mucus, and purulent matter; coagulable lymph is effused into the nasal duct, the sac enlarges, the skin becomes of a deep red with a white point in the centre, and ultimately bursts, forming a fistulous opening. The moment that the sac tumefies, and the tears are shed over the cheek, that instant it should be freely lanced, and afterwards treated on the common principles laid down under inflammation and suppuration; attention being paid at the same time to the ciliary glands and conjunctiva, as recommended under ophthalmia; and likewise, to the nasal duct, which is more or less obstructed. At first a simple gum bougie should be inserted into the duct, and worn as long as it produces no painful feeling or inflammation. This should be repeated either daily or every second day, first washing out the sac and duct with warm water, and afterwards with a solution of the sulphate of zinc in rose water, gradually increasing its strength. The bougie is to be progressively enlarged, to the size of a large crow quill, and anointed with a weak ointment of the red oxide of mercury, which ought also to be gradually augmented. If the lacrymal sac does not advance to ulceration and rupture, a discharge of puriform mucus takes place, named blenorrhœa, in which affection the tears flow over the cheek. This requires to be treated as the preceding, otherwise it gives rise to repeated attacks of erysipelatous inflammation of the integuments over the sac, which ultimately induces closure of the nasal duct, or a communication with the sac named spurious fistula of the sac; or ulceration of the sac and integuments forming true fistula lacrymalis, in which latter case obstinate blenorrhœa occurs with stillicidium lacrymarum. Dropsy of the sac or mucocele also occasionally results, and must be also treated in the same way. Sometimes the puncta lacrymalia, and canaliculi are obliterated, causing stillicidium lacrymarum for life, in which event the lacrymal bone should be pierced from the inner canthus immediately inferior to the caruncula, and a bougie inserted daily until it forms a mucous tube. When the nasal or lacrymal duct becomes obstructed from such diseases, or if it is congenital, the same treatment ought to be adopted as mentioned under inflammation with suppuration of the sac; and if this is found impracticable, a small trocar and canula, as that used for piercing the membrana tympani, is to be inserted along the duct to the naris, and followed by a bougie; and if even this is impracticable from the obliteration of the duct, the anterior fossa of the lacrymal bone must be pierced with a small style, and then a bougie inserted. The after treatment is the same as that mentioned above. Some recommend the dilatation of the nasal duct in these obstructions, by a probe inserted from the lower extremity in the naris, but this is with difficulty effected. Various other modes of treatment have been recommended from the time of Fabricius to the interesting work of M'Kenzie on *Lacrymal Diseases*.

Entropeon, (from εν, and τρεπω, *to turn*,) named also entropium, ptosis, phalangosis, trichiasis, trichosis, distichiasis and tristichiasis, is an inversion or irregular direction of one or more of the eyelashes, either alone or accompanied with an alteration of the curvature of the eye lid, which produces great irritation, and even inflammation ending in opacity of the cornea, which sometimes resembles a macerated ligament. Occasionally the other eye also becomes affected. When the eye-lashes merely are attacked, it has been proposed to pull them out, and also to burn their roots; but these seldom succeed, and therefore in such mild cases, a longitudinal portion of the integuments of the eye-lid should be removed with scissors, and the wound approximated with fine ligatures and adhesive plaster. In severe cases, besides the removal of this longitudinal portion of the integuments, it is necessary to make a transverse one on each side of the inverted hairs, through the tarsus, guarding against wounding the punctum lacrymale, and healing these lateral incisions slowly by granulations. When the lower eye-lid is the seat of the disease, a transverse incision at the outer canthus is generally all that is necessary.

Ectropium or Ectropeon is an eversion of the eye-lids, commonly the lower; occasionally however both, and then the eye has an annular shape; and when confined to the upper eye lid, it is termed lagophthalmos. In mild cases, the nitrate of silver shaped like a pencil and passed along the conjunctiva longitudinally, the eye being bathed immediately after with warm water or oil, will effect a cure; but in severe cases, if the preceding treatment fails, a longitudinal portion of the conjunctiva should be removed with the knife or scissors, and a corresponding incision in the integuments made, the eye-lid brought down, and fixed with adhesive plaster, compress and bandage; care being taken that no adhesion occurs between the conjunctiva palpebræ and the eye-ball. The nitrates of silver or copper may be still necessary to establish a cure. When the lower eye-lid is everted from a scald or any cicatrix, the adhesion of the cicatrix is to be detached from the bone, and then a triangular portion of the eye-lid is to be removed, the margin of the eye-lid forming a base; and the limbs of the triangle are next approximated by suture. The edges of the eye-lids are sometimes united at birth, which is termed ancyloblepharon, and is cured by a simple division. The eye-lid occasionally adheres to the ball of the eye, and is named symblepharon, which is cured by division and preventing re-union by anointing from time to time the surfaces with olive oil.

The cornea has been found ossified, and also so convex, that the individual has not been able to see at the distance of two inches, which condition, when originating from disease, is termed myopia, and is to be remedied by concave glasses; likewise in some instances both convex and irregular on its surface, and requiring the same remedy. At other times, the cornea is flat and relaxed, which can only be remedied by convex glasses. See a most philosophical explanation of these by Dr. Brewster, in Wardrop on the Eye, Vol. I. p. 132. The eye has been transformed into a calcareous mass; the cornea, the capsule of the lens, the lens itself, the iris, the hyaloid membrane, and choroid coat have been ossified.

Under adhesion the Tagliacotian operation has been considered, and under fractures, injuries of this organ. In the article Medicine, Vol. XII. p. 815, inflammation with increased secretion of the mucous membrane is described, and we shall merely add, that venesection should be more frequently had recourse to, so as to prevent the baneful consequences of this disease. Inflammation of this membrane occasionally produces abscess of the frontal and superior maxillary sinuses. That of the frontal is characterized by violent pain in the region of the sinuses, darting along the forehead, and sometimes down the neck, with a profuse discharge of most offensive matter, intolerable both to the patient and the bystander, and convulsions or epilepsy on some occasions occur. The best treatment is the inhaling the vapour of water, the remaining in a moderately dry warm room, farinaceous diet, and preserving the bowels open. When the disease becomes chronic, the smoking of tobacco is beneficial; but if it continues severe, the sinus should be trephined, and afterwards mild warm diluents, and ultimately cold astringents injected. Abscess of the antrum maxillare also originates from carious teeth, and from injury occasioned by their extraction. It begins with acute pain in the fangs of the teeth, darting upwards to the nostril and cheek, and ultimately producing tumefaction of the latter, which then moderates the pain, while the cheek itself feels hard and painful when pressed upon, the pain often darts along the pharynx, and the patient imagines the secretion comes from them. When the patient inclines the head to the opposite side, a most offensive discharge flows out at the nostril. The external wall of the antrum becomes extremely thin, ulcerates, and then involves the muscles and integuments of the cheek, forming fistulous apertures; at other times, the matter excites absorption and caries of the alveolar sockets by which the matter is discharged; while at others the palate ulcerates and the discharge flows into the mouth. Whenever, therefore, the diagnosis clearly shows that matter has been deposited in the antrum, the second anterior molar tooth or bicuspis ought to be extracted, and the antrum perforated with a small style, but occasionally this tooth communicates with the cavity, and no perforation is required. This disease ought to be afterwards treated as recommended for abscess of the frontal sinus. If the osseous structure be carious, it becomes sometimes necessary to open the cavity freely by dissecting the lining membrane of the mouth upwards, and removing gently and carefully the diseased bone, taking care not to induce inflammation. Tincture of bark and myrrh form a good injection in such cases.

Inflammation of the mucous membrane of the nares sometimes ends in a malignant ulceration, which is characterized by pain, redness, and tumefaction, extending to the cartilages, bones, and integuments of the nose, the ulceration being first confined to the inside of the ala, and afterwards spreading both inwards and outwards, and then resembling *noli me tangere*. There is also an increased discharge of mucus, which soon becomes ichorous and fetid; the breathing is obstructed; the pain is increased by pressure, and on inserting the finger, which also produces slight bleeding. The cartilaginous septum is first destroyed, next the ethmoid bone and vomer, and ultimately all the bones entering into the formation of the nares, rendering the nose flat and disfigured. This affection, named ozæna, generally follows some syphilitic or scrofulous taint in the constitution, and prevails in the highlands, where yaws and sibbens are common. During the inflammation, it ought to be treated with the inhalation of steam, and warm anodyne injections into the nares, with fomentations and poultices externally, and with the insertion of small pieces of lint dipt in olive oil; and when the pain has been subdued, cold astringent injections and ointments should be applied, and the muriate of mercury and compound decoction of sarsaparilla administered internally. The patient should be instructed to snuff up into the nares the different injections used, and bring them round the velum, into and out at the mouth; and he should remain in a warm dry atmosphere.

Epistaxis or hemorrhage from the nares is a more serious disease than is generally supposed, proving fatal even in early life; therefore, in all cases where the bleeding is not arrested by styptics, the naris should be plugged up first at its posterior aperture into the pharynx, which is accomplished by introducing a long double canula, with a loop of silver wire along the floor of the naris, keeping close to the mesial septum, backwards to the pharynx, and downwards behind the velum palati, until the loop is felt or seen in the throat, when it is to be brought forwards by the forceps into the mouth, and then have attached to it a dossil of lint or piece of sponge, with a ligature, which is to be pulled upwards into the posterior aperture of the naris, so as to shut it up. The canula should then be removed, but the ligature left hanging out at the anterior aperture, which must be also stuffed with lint.

Polypus is a delicate fleshy tumour, of the shape of a pear, which frequently grows in the nose, either from the mucous membrane investing the bones of the nares being generally attached to the ethmoid bone, or in the antrum maxillare or in the frontal sinus. The mucous membrane appears to take on a diseased action for secreting these bodies, since they grow like fungi, or the shoots from creeping plants. In some individuals, the mucous membrane throughout is flocculent and spongy. They are variously arranged and divided by Pott, J. Bell, Ritcher and others. The delicate pale gelatinous polypus and the fleshy one adhere commonly by a small pedicle; they appear visible in the anterior nares, and can sometimes be felt, and even seen, hanging down behind the velum; and they are not attended with pain, until they press on the contiguous parts, when they produce sneezing, watery eyes, headach, stupor, and difficulty of breathing, and deafness; they destroy the ethmoid bone, the vomer, the walls of the antrum, raise the nasal bones, project the eyes out of their sockets, cause amaurosis, and ultimately prove fatal. The fleshy polypus is the most numerous. The firm, hard, dark red polypus, with a broad base, is commonly solitary, and is usually, though not always, attended with pain from the beginning, and is more frequently reproduced, than the others. Polypi are removed by excision, extraction, ligature, and caustic. The first is to be preferred whenever it can be accomplished, and should be done by seizing hold of the tumour with the forceps delineated, Fig. 9 of Plate DXVI. and gliding along them, the open limbs of curved blunt-pointed scissors, Fig. 11 of Plate DXVI. until they reach the pedicle of the polypus, which is then to be cut. If any hemorrhage occur, it is easily stemmed with the nitrate of silver, but if not, the actual cautery can be used, or the nostril plugged up. The caustic should be applied on the day following, and every succeeding day, until the pedicle is completely stunted. But if the polypus has a broad base, or plugs up the anterior naris, the knife Fig. 8, or 12 of Plate DXVI. should be employed. When the polypus hangs back into the pharynx and cannot be pulled forwards, it should be noosed by silver wire and a double canula, which are passed as recommended for epistaxis, and the noose carried around the polypus, and elevated as near its root as possible, when the wire is to be tightened. Silver wire must not be twisted, as it readily breaks, but turned round one of the rings of the canula daily. If neither scissors, knife, nor ligature can be employed for this polypus, it must be bruised with forceps, Fig. 10 of Plate DXVI; but it ought never to be extracted with the polypus forceps or any other instrument. No pulvis sabinæ or any other errhines should be used.

Polypi or sarcomatous tumours in the antrum maxillare burst open the parietes of this cell, and either force their way into the nostril, or forwards towards the cheek, or upwards into the orbit, and even into the cranium, or downwards into the mouth, by exciting absorption of the bone, or rendering it carious; and sometimes they force their way in all these directions at once, giving to the countenance a horribly distorted appearance. The alveolar processes become fungous, the teeth drop out, a fetid discharge flows, the eyes weep, are amaurotic, and even burst, and the patient is rendered wretched to himself, and loathsome to his friends. By the present mode of proceeding to remove this disease, with the exception of one or two cases, all have either died in a few weeks after this operation, or the disease has returned, so that we have proposed the entire removal of the superior maxillary bone. See Lizars's *Anatomical Plates*, Part IX. Occasionally a fungus excrescence grows from the gums, which is liable to deceive us for that originating within the antrum; but it can be easily removed and prevented from regenerating by the nitrate of copper or the actual cautery. Other tumours of a firmer consistency originate from the gums, and commonly on the lower maxilla, and ultimately involve the bone. When early perceived, the teeth should be extracted in their vicinity, and the tumour, with every portion of the diseased gum or bone, removed. The teeth being like the nails inert, inanimate objects, and in this resembling minerals, are subject only to denudation or desquamation, decay or rottenness, and lastly fractures. The other diseases usually described as belonging to them properly attack the contiguous textures.

The inferior maxillary bone is affected with encysted tumour and osteo-sarcoma; the former being distinguished by crepitation and the absence of pain, and treated like encysted tumour of the soft parts: the latter or osteo-sarcoma by the following operation: An incision ought to be made along the base of the bone, in order not to disfigure the face, when the facial artery will spring and require to be secured; the tumour and bone are then to be divested of their soft coverings, and the latter at its symphysis first sawn in a slight degree, and next broken across with Liston's forceps; having previously extracted any tooth which may interfere with the saw. The operator can then move this half of the bone outwards, divide the insertion of the pterygoideus internus from above downwards, cut across the coronoid process with the forceps, leaving the division of the insertion of the temporal muscle until the operation is nearly finished. The insertion of the external pterygoid muscle is next to be divided, keeping the back of the knife towards the internal maxillary artery, and by now depressing the symphysis, the capsular ligament may be easily but carefully cut round, and the one half of the bone removed. The coronoid process may then be detached. It is seldom necessary to remove either the condyloid or coronoid processes, but merely to saw and cut with the forceps the ramus immediately behind the dens sapientiæ. If the whole bone be diseased, the same steps are to be pursued on the opposite side, if the tumour will admit of being divided in its middle at the symphysis menti. After the removal of the bone, all arteries are to be carefully secured, the wound approximated with stitches, adhesive plaster, compress and bandage. The patient should be fed on liquids for some time, and nature left undisturbed, will repair the deficiency of bone by an exudation of callus, which will nearly remove all deformity.

Calcareous depositions are found in the submaxillary duct, which are easily extracted by an incision through the mucous membrane of the mouth and the duct; and when either these or any other causes prevent the escape of the saliva from this duct, the latter enlarges, forms a large pouch which occasionally becomes thickened in its coats, and constitutes the disease named ranula. This is to be treated by removing a portion of the sac and applying the potassa so as to obliterate it, or following the plan of Dupuytren, which is by making a puncture into the tumour, and inserting a small hollow cylinder of the shape of the eye stilette, with a small ellipical plate convex externally attached to each extremity of the tube, in order to prevent it from slipping either into the dilated duct, or out of it into the mouth.

The tongue is subject to tumours, to enlargement from mercury and small pox, to abscess, and to cancerous ulceration. Tumours are removed either with the knife or ligature, and if the former be preferred and the tumour very large, the lingual arteries ought to be first secured, or the actual cautery applied. In enlargement of the tongue, we make free longitudinal incisions, and if they do not bleed sufficiently, perform venesection at the bend of the arm, administer saline cathartics and glysters, expose the patient to a cool atmosphere, and discontinue the mercury if it be the cause. In abscess a free opening should be made. In cancerous ulceration, either the ulcerated surface or the whole tongue must be removed, with the ligature or knife; if the latter is used, the lingual arteries ought to be first secured. The ligature produces less irritation in this case than almost in any other disease. When the ulceration is trifling, a mixture of honey and water, or a weak solution of arsenic often succeeds; and if these fail, the nitrate of copper or silver, and even the actual cautery may be tried. If any of the teeth irritate the tongue, they should be extracted. Children are occasionally born with the frenum linguæ so short that they cannot suck, in which case it is to be divided with a pair of blunt pointed scissors, directing their points towards the symphysis of the inferior maxillary bone. Tumours occasionally grow from the mucous membrane of the mouth, investing the cheeks, lips, and palate, and require to be removed by the knife. The amygdalæ or tonsils frequently suppurate when attacked with inflammation. See Article Medicine, Vol. XII. p. 807, and should be freely opened with a bistoury cutting towards the mesial line, to avoid any risk of wounding the important blood-vessels in the vicinity. They are also subject to such a degree of enlargement as to require extirpation, as they impair the voice, the breathing, and deglutition. This operation is effected either by the knife, the cautery, or the ligature. When the knife is adopted, the operator seizes hold of the tonsil with the forceps, Fig. 9. Plate DXVI. and pulls it gently forwards and mesiad, while he carries the scalpel from above downwards, or from below upwards, by which the greater portion of the mass may be extirpated. Any bleeding is easily suppressed by styptic solutions, but if not, by the actual cautery or sponge held on the part. When the uvula is so elongated as to irritate the tongue and epiglottis, exciting coughing and a disposition to swallow, and even to interrupt respiration, it must be trimmed with forceps and scalpel or scissors.

Children are not unfrequently born with a cleft velum palati, which can only be remedied when they arrive at an age capable of appreciating the beneficial effects of the operation. The operation is termed velu-synthesis or staphyloraphy, and consists in rendering the edges raw, and approximating them by means of the interrupted suture. See Dr. Stephenson's *Inaugural Dissertation*, and Lizars' *Anatomical Plates*, Part IX. The partition occasionally extends between the two superior maxillary bones, and even the upper lip, exposing at once to view the nares and basis of the cranium. Children when thus malformed cannot suck, and are even with difficulty nourished on spoon meat. The cleft lip is named hare-lip, and should be operated on when the child is three or four months old, by rendering the edges raw, and approximating them with delicate sewing needles, and entwining a large flat ligature in the figure of 8 around each needle, being careful not to do it too tightly, as some degree of tumefaction must occur; a piece of lint is then to be put between the ends of the needles and the lip, and the whole gently covered with a compress and a roller. In transfixing the lip, the needle should pass as near as possible to the mucous membrane investing it, and the one near the villous part of the lip should be inserted first; the needles should be removed on the third day. When there is a double cleft, the middle portion is to be left or removed according to its magnitude; and if of such a size as is to be left, one of the fissures is to be operated on before the other, allowing two or three months to intervene. We thus perceive that in such cases of extensive malformation, all that can be done in very early life, is to cure the cleft lip; and the two sides of the face, or the superior maxillary bones might be slowly and gently approximated by an apparatus resembling the chin stay: and about maturity the cleft soft palate can be united, so that if any fissure remained in the hard, its edges might be rendered raw and approximated, or if impracticable, a piece of sponge and silver plate, or simply a silver plate with a groove round its margin might be inserted.

The lips, particularly the lower, are very subject to cancerous excrescence and ulceration, which if not early removed, soon contaminate the contiguous lymphatic glands, rendering an operation hopeless. When the lower lip is the seat of disease, the cancerous portion, with some of the healthy structure on each side, requires removal, and is done by making two incisions of the figure of the letter V, the apex pointing towards the chin, and approximating the raw surfaces as described above.

The nerves of the face, viz. the supra-orbitary, infraorbitary, mental and facial, are all liable to be affected with neuralgia, or tic douloureux, which is a peculiar excited state of the nerves, being either an inflamed condition of the neurilema, or a spasmodic condition of the medullary structure, and often results from a deranged state of the stomach, or rest of the alimentary canal or liver. The treatment therefore depends on the cause; if not constitutional, the best local application is the moxa, the next the knife. For an account of the various operations, see Lizars' *Anat. Plates*, Part. II.

The face, from its glandular structure, is very subject to tumours, warty excrescences, and cancerous ulceration, all of which should be early excised; and in performing operations in this region, we must be careful to avoid the parotid duct, and disfiguring the face. When the parotid duct is wounded, the saliva discharges itself over the cheek, constituting salivary fistula, and is to be treated by establishing a fistulous aperture into the mouth by means of a seton, then closing the external wound towards the cheek by caustic, actual cautery, compress and bandage. The parotid gland, and particularly the lymphatic ones superficial to it, are frequently scirrhous, and require extirpation. Some we have known remain dormant for thirty years, while others have advanced to ulceration, and produced a most painful and loathsome existence. In removing the parotid gland with the knife, the common carotid of the affected side ought to be first compressed or secured, then an incision over the gland, from the zygoma downwards to the sternomastoid muscle, or two semi-elliptical ones, according to the magnitude of the tumour. The skin dissected, first forwards towards the face, and next backwards towards the ear; and the gland carefully insulated by lateralizing the knife with its cutting edge towards the chin, and preserving the nervus vagus and internal jugular vein, both of which may be so embedded in the tumour, as to require a portion of the disease to be left. It has been removed repeatedly with success.

The submaxillary gland, or its contiguous lymphatic glands, are subject to the same diseased condition as the parotid, and also require removal with the knife; but as there is only the facial embedded in the tumour, there is no necessity for securing the carotid. The lingual, however, may be wounded in the operation. The knife should be lateralized in the same manner as recommended for the parotid. The different lymphatic glands in the region of the carotid artery, are very subject to the various sarcomatous enlargements, particularly the carcinomatous, and require extirpation. Those at the angle of the inferior maxilla, are frequently so braced down by the sterno-mastoid, and the platysma myoides muscles, together with the cellular fasciæ, that they are in close contact with all the important blood-vessels and nerves in this region, while they appear to be immediately under the skin. In removing them, the knife is to be lateralized as mentioned above. In the lower region of the neck, and near the axillary plexus, tumours are generally softer, occasionally encysted and cartilaginous.

The enlargement of the thyroid gland, which depends on the water drunk by the individual, is now found curable by iodine, and a removal to a distance from the water which produced it, avoiding, however, every danger of falling into Charybdis. Wry-neck is a contraction of the sterno-mastoid muscle, which then requires to be divided. Sometimes only the clavicular attachment need be separated; but if the whole muscle, either its origin or insertion should be selected, and the latter is less dangerous; and if the operator proceed cautiously, he will injure no important objects. After the operation, the chin-stay, Fig. 22 of Plate DXVI. should be worn.

While in the act of eating various substances, especially fruits, the stones are liable to be swallowed and enter the larynx, and unless removed, immediately produce suffocation, by entering the glottis, or sacculus laryngis; or they descend into the trachea, and produce difficult respiration, inflammation, effusion, and occasionally emphysema. They even sometimes descend into the minute divisions of the bronchii, and produce abscess of the lungs, or phthysis pulmonalis. As suffocation may be produced by bodies arrested in the pharynx, a probang should be first inserted into it, but if the suffocating symptoms continue, laryngotomy ought immediately to be performed, which consists in making a longitudinal incision over the thyro-cricoid membrane, and securing any small arteries, if necessary; then making an incision in this ligamentous membrane, and searching for the foreign body. If it be below the incision in the trachea, the efforts of coughing will bring it up; and if in the ventricles of the glottis, a probe scoop, or forceps will dislodge it. Any incision of the thyroid, or even cricoid cartilage, is to be as much as possible avoided, especially the former. Laryngotomy is also performed when foreign bodies have been arrested in the œsophagus, threatening instant suffocation, and the operator unable to dislodge them by the probang; it is also adopted to inflate the lungs in suspended animation, likewise in laryngitis. See Article MEDICINE, vol. XII. p. 807. And when the glottis is ulcerated in syphilis, or too much mercury has been taken, and when tumours in the vicinity oppress the breathing. With the exception of the first of these cases, laryngotomy appears unnecessary; and when performed, a trocar and canula, as delineated in Fig. 18, Plate DXVI., should be plunged obliquely downwards into the trachea, after the oblong square space is brought into view, the canula left and the trocar withdrawn.

Tracheotomy is performed for supended animation, foreign bodies in the trachea, and œsophagus, chronic laryngitis, and trachitis; but, with the exception of the three last of these affections, laryngotomy is to be preferred. This operation is done by making a longitudinal incision in the mesial line of the trachea, through the integuments, when the operator should feel that there be no artery pulsating, as the innominata and right carotid may come in the way of the knife. He must then proceed cautiously, avoiding the isthmus of the thyroid gland, and plunge the trocar and canula through the rings of the trachea obliquely downwards, withdrawing immediately the trocar.

During mastication and deglutition, fish and other bones, pieces of flesh, &c. are sometimes arrested in their progress to the stomach, either in the pharynx or œsophagus. Fish bones are generally found sticking in the fauces or pharynx, so also are needles, pins, and fish-hooks; while bread, bone, flesh, gristle, cheese, coins, and other large bodies, are arrested where the pharynx becomes œsophagus; and when these objects are very large, they often produce instant suffocation; if not, they excite inflammation and suppuration, or gangrene, which ultimately prove fatal. But sometimes an abscess forms in the neck that bursts externally, from which they are discharged; at other times they are spit up, or fall into the stomach, and if insoluble, they are generally arrested in their course along the alimentary canal, and excite inflammation, ulceration, gangrene, and death; pins and needles, however, occasionally travel with impunity over the whole body, when some are expelled per anum, others per urethram, others again through the skin, and some have been known to produce fistula in ano. When they are soluble in the gastric juice, and not sharp-pointed, they should be pushed down by the probang into the stomach; but if otherwise, they ought to be pulled up into the mouth, either with the common polypus forceps, or with a hank of thread doubled; so as to form a number of loops, and fastened to the probang, or with the hook end of that instrument. If the object arrested in the pharynx cannot be dislodged, and if it threatens suffocation, the operation of pharyngotomy ought to be performed, which is done by making an incision through the integuments and platysma myoides, on that side of the neck where the body projects most, parallel with the tracheal margin of the sterno-mastoid muscle, avoiding the external and internal jugular veins, the common carotid artery, and the nervus vagus, which ought to be held aside towards the dorsal aspect by an assistant, when the prominent object will appear, which should then be liberated by an incision through the muscular and mucous tunics of the pharynx. The knife should be lateralized with its edge towards the trachea. The external wound is afterwards approximated by adhesive plaster, the patient kept extremely quiet, nothing allowed but milk or water for some days, which must be introduced into the stomach by an elastic tube, or the patient supported by injections of nourishing soups, per rectum.

The mammary gland is generally the seat of disease in the female, but rarely in the male. It is subject to phlegmonous and erysipelatous inflammation, to mammary abscess and sinuses, to excoriation and ulceration, to lacteal swelling, to the various species of sarcoma, to hydatid or encysted swelling, to cartilaginous and ossific tumour, to hypertrophy, and to simple chronic tumour of the mamma. Inflammation of this gland is to be treated in the same manner as formerly recommended under inflammation; and the reader is also referred to the Article Midwifery. The treatment ought to be active and prompt, as all glands are easily and rapidly ruined in their functions by an injury done their structure. Under inflammation it is stated that coagulable lymph was effused, which in glandular texture unites its conglomerate portions in such a manner as to suspend the functions in the first place, and in the second to obstruct too often the secretion ever afterwards. The coagulable lymph lays the foundation for future diseased organization, and forms the substratum of the diversified variety of tumours, and in those tumours where no acute inflammatory action is present, a chronic state exists, which converts the secretion of the capillary vessels of the affected part from their natural to the diseased condition which they respectively assume, in precisely the same way as acute inflammation disposes these capillaries to secrete lymph or pus. This appears a simpler explanation, than Adams's multiplication of hydatids, or Dr. Baron's conversion of encysted hydatids into tubercles. For the phenomena and treatment of mammary abscesses and sinuses, see acute abscess, for in no respect do they differ from those occurring in any other part of the body, with this exception, that sinuses of the mamma should first be tried to be cured by injections of diluted acids. Exfoliation of a rib has supervened to deep abscess of this gland. Mammary inflammation and abscess occur most frequently within the first three months after parturition. A deep-seated abscess is described by Hey, but this is simply a chronic species of it. The excoriation and ulceration which attack the nipple are to be treated like ring-worm, tinea capitis, or noli me tangere, according to their severity. Lacteal swelling of one or more of the lactiferous ducts requires to be punctured.

The mamma is peculiarly subject to the sarcomatous tumour, which is divided by Mr. Abernethy into the common vascular or organized, the adipose, the pancreatic, the mastoid or mammary, the tuberculated, the pulpy or medullary, and the carcinomatous. Of these various sarcomatous tumours, the pancreatic, the medullary, and the carcinomatous chiefly affect this gland. The pancreatic attacks the portion situated between the nipple and the axilla, and ultimately involves the axillary glands. It is either quite indolent or very active; and when the latter is the case, there are severe lancinating pains with an inflamed state of the skin, which produce fever and undermine the health. The treatment is to reduce the cutaneous inflammation and constitutional febrile excitement, and then to extirpate the whole mammary gland, together with the axillary. The medullary sarcoma or fungus hæmatodes is characterized by its elastic feeling, nodulated appearance, some portions being inflamed, others indolent, and some again natural. The elasticity of this tumour often deceives the practitioner for matter, but it consists of a brain-like substance, cartilage, bone, flesh and blood. This species also involves the axillary glands; occasionally it is as encysted as the common wen, and may then be removed by the scalpel with every chance of success.

The carcinomatous sarcoma, or scirrhus, or occult cancer, attacks this more frequently than any other gland, and is characterized by an unequal knotted hardness, diminished bulk, and a puckering or depressed appearance of the nipple, while the skin remains in a natural state. These phenomena constitute the indolent state of the scirrhous mamma, but when it assumes the malignant disposition, there are most acute lancinating pains, the skin acquires a purple hue in some spots, and the veins of the skin become enlarged and more or less varicose, and is then termed occult cancer. Whenever ulceration takes place, it is denominated open cancer, which generally occurs before the mass has acquired any great magnitude, when it now forms irregular sloughs, or ulcerates and sloughs in different places; has everted irregular hard edges, with a violaceous coloured inflammation around; and the discharge is thin, dirty green, and ichorous. The axillary glands are commonly affected immediately after the disease becomes occult cancer, and they soon afterwards contaminate those under the claviele and in the neck; and even all the subcutaneous, for it is a mistaken idea to suppose that ulceration must precede the contamination of the axillary glands. The affection now becomes constitutional, extending to the glandular system of the thorax and abdomen, and even to the pleura costalis and ribs; but by some authors these constitutional symptoms are supposed to take place at an earlier period. When the constitution is affected, the patient feels pains darting along the spine, and has cough with difficulty of breathing. This species commonly begins in a small spot at the nipple, and extends around in all directions like the radii of a circle, ultimately involving the whole mammary gland, the skin, the cellular substance, the muscles, the lymphatic glands, &c., for there seems no disposition to this horrible disease in the surrounding parts prior to the actual carcinomatous action. In some rare instanees this disease is sacculated. When the tumour after removal is bisected, it presents a hardened glistening appearance, with firm white bands intersecting it in all directions, either like radii or irregular bands, or in an arborescent manner; the whole very much resembles cartilage. This species generally attacks the female when the catamenia cease, between forty and fifty years of age, but occurs occasionally at its first appearance, when the pains are aggravated at every period of menstruation. It may be produced at any period of life by a blow, or succeed mammary inflammation and abscess. This species of tumour may be attempted to be discussed by the repeated application of leeches, especially when the catamenia are expected to take place, and by anodyne fomentations, poultices, low diet, and gentle exercise; and when pain has been subdued, by local pressure. But the tediousness and anxiety are such, that most patients demand an operation, which, without doubt, is the safest.

The patient should be laid on a table, and the arm of the affected side elevated towards the head with the hand supinated; two semi-elliptical incisions are to be made from the axilla to the sternum, so as to include all diseased skin, and to leave if possible enough to cover the wound, and the lower or sacral made first. These incisions should extend through the skin and cellular substance to the fascia of the muscle, dissecting the lower from the gland first, and defining clearly both angles. A few sweeps of the scalpel from above downwards will remove the whole gland, all of which ought to be invariably extirpated. Sometimes the muscle itself is affected to a considerable extent and requires removal. During the removal of the tumour, an assistant should put his fingers on the bleeding arteries, which ought now to be secured. The edges of the wound are then approximated either with ligatures or adhesive straps, according to the deficiency of the integuments; compresses of lint, together with a roller around the trunk, supported by two shoulder straps or braces are lastly applied. If there have been many small arteries wounded, and not all secured, a second roller should be applied, and tighter than the first, and which must be removed in a few hours, for whenever re-action takes place, respiration becomes affected. The wound to be dressed on the third or fourth day. When the axillary glands are diseased, one of the external incisions should extend over them at the outset of the operation; but they ought not to be cut out till the removal of the mammary gland, and the knife should run parallel with the axillary vein, with its back to the vessel. Whenever an artery springs in this region it ought to be secured; and even if a vein bleed freely, a ligature must be thrown around its mouth. There is a cutaneous variety of cancer which attacks both the male and female promiscuously.

Ascites has been already treated of in the Article Medicine; and when diuretics and cathartics fail to remove the effused fluid, paracentesis abdominis should be performed, and these remedies afterwards still persevered in. This operation consists in surrounding the abdomen with a belt of strong calico, which is to keep up an equable pressure during the flow of the fluid. The patient is to sit on the edge of a chair, when the operator pierces the abdomen with a trocar and canula, in the direct line of the linea alba, midway between the umbilicus and pubes, and removes the trocar. If the patient becomes faint during the flowing of the fluid, the bandage should be tightened, and the finger applied to the mouth of the canula for a few seconds. When all the fluid has been evacuated, the canula is withdrawn, a compress of lint applied to the wound, with a larger one of calico, and the ends of the bandage brought firmly round and pinned. The greatest care must be taken that the compression prevents any further flow of the fluid, for it collects with rapidity, and would soon exhaust life if the discharge continued. The best canula is that made of steel, the size of a hen's quill in diameter, and the round is superior to the flat. After paracentesis abdominis, if any inflammation follows, leeches, with warm fomentations to the abdomen, and, if necessary, the lancet, castor oil, low diet, and the warm bath. Many of the acute diseases affecting the abdominal cavity are detailed under MEDICINE. When knives or such foreign bodies are swallowed and lodged in the stomach, and appear to involve the life of the individual, they should be extirpated by cautiously making an incision in the line of the linea alba from the ensiform cartilage to the umbilicus, through the integuments and tendons of the muscles to the peritoneum, which is then to be carefully punctured, and one or two fingers inserted into the abdominal cavity, and this membrane divided to the same extent as the integuments. The stomach is next to be gently raised with the left hand, and opened with a transverse incision, and the foreign body taken out. The external wound is then to be stitched with broad ligatures, at the distance of an inch from each other, and the needle, Fig. 17 of Plate DXVI. passed immediately superficial or peripheral to the peritoneum, compresses of lint applied, and a large handkerchief rolled round like the binder after parturition. The patient should be nourished for three or four weeks, or even longer if his constitution can bear it, with animal jellies, soups and milk injected per anum. This operation is termed gastrotomy.

When laudanum or other narcotic poisons are swallowed, they should be discharged from the stomach by the stomach-pump delineated in Fig. 12 of Plate DXV. The surgeon puts the fore and middle fingers of his left hand into the mouth of the patient and presses gently on the tongue, while with his right hand, he glides the tube marked *a* over the tongue into the pharynx, œsophagus and stomach, and then proceeds to pump out of the latter viscus its contents with the syringe *b*. The gag of wood *c*, ought to be in the mouth to prevent it from injuring the tube. If the contents of the stomach are scanty, or of a thick consistence, warm water should be first injected into it, by putting the end of the syringe into a basin full of warm water, and joining the two tubes *a*, *d*, together. By alternately filling and emptying the stomach in this manner, it may be fully divested of every drop of the narcotic fluid; and when this has been accomplished, a tea-cupful of strong coffee ought to be injected, and allowed to remain; the patient kept walking about his room between two attendants; and his bowels afterwards freely opened. In some cases, it is necessary to apply a blister to the region of the stomach.

Ileus, volvulus, or intussusceptio, is already described under MEDICINE, and if the remedies mentioned there fail to effect a cure, we should first try large enemata of a weak infusion of tobacco, pressing the caput cœcum coli at right angles in order to overcome the valve: and if these enemata likewise fail, we seem justified in opening the abdomen and disentangling the viscus. This operation ought only to be performed in the adult, as children in the last stage of tabes mesenterica have occasionally from one to seven intussusceptions.

Calcareous concretions are occasionally deposited in the colon, and if our diagnosis is clear, they ought to be removed by gastrotomy. The spleen is subject to prodigious enlargement, which sooner or later destroys the individual; and if iodine, mercury and other medicines fail to reduce it, gastrotomy may be considered. In this case, whenever the enlarged spleen is brought into view, its plexus of vessels should be secured by a ligature, both ends of which are to be cut off. Abscess of the liver is a frequent termination of hepatitis (see MEDICINE), and when clearly indicated, should be freely opened with a bistoury; and the nitro-muriatic acid pediluvium, or the alterative course of mercury continued. Biliary calculi have been proposed to be extracted by an operation.

Nephrotomy, or the removal of calculi from the kidney was proposed in 1696, but has never been performed until the calculus has produced inflammation and suppuration with a prominent tumour. Many die before such a result takes place, from the urine diffusing itself between the peritoneum and the parietes of the abdomen. Sometimes a communication is established between the pelvis of the kidney and the colon. When a calculus is arrested in its progress along the ureter, it generally soon proves fatal, by exciting inflammation, suppuration and ulceration; but occasionally it advances to the external parietes of the abdomen, and is discharged near the umbilicus, or pubes, or crista of os ilium. Various kinds of tumours grow in the abdominal cavity, as the fatty pendulous, and the medullary sarcoma; the latter of which affects the kidneys, and the mesenteric glands.

Hernia or rupture is commonly applied to a protrusion of one or more of the abdominal viscera, either at one of the natural apertures of the abdomen, or at some preternatural one; and in the majority of cases, there is a sac formed by the peritoneum. Hernia is applied also to a protusion of the thoracic viscera. It is estimated that one-eighth or one-sixteenth of mankind are affected with rupture, young and old, male and female indiscriminately, and in every condition and mode of life. It is not immediately dangerous, but the least exertion is liable to render it fatal, and it too often keeps up such a determination to the intestines, that they either become strictured, tuberculated or ulcerated, and then cause death. Hernia is divided first into the reducible and the irreducible; the former signifying the possibility of reducing the protruded viscera into the abdominal cavity; and the latter or the irreducible, the reverse. The irreducible is subdivided into the simple irreducible, the irreducible with obstruction, and the irreducible with strangulation or incarceration. The viscera, which are protruded, are the omentum, then named omental hernia or epiplocele; the intestine, named intestinal hernia or enterocele, and these two viscera conjointly entero-epiplocele. When the stomach is the protruded viscus, gastrocele; the liver, hepatocele; the spleen, splenocele; the urinary bladder, cystocele or hernia vesicæ; and besides these, the uterus or ovarium, or both, in conjunction. The omentum and the intestines are those most commonly protruded; the omentum the most frequent, next the ilium, then the jejunum, and lastly the colon. The apertures of protrusion are, the inguinal canal, the crural or femoral aperture, the umbilicus, the great sacro-ischiadic notch, and the foramen ovale. Sometimes one of the apertures of the diaphragm, and occasionally a gap in the muscular parietes of the abdominal cavity. When the viscera are forced out at the inguinal canal, either in the male or female, it is named bubonocele, or incomplete hernia, and when into the labium pudendi or into the scrotum, complete hernia; that into the scrotum is termed also scrotal hernia or oscheocele. When the viscera do not descend along the inguinal canal, but protrude opposite the external aperture, it is named ventro-inguinal or direct or internal hernia; and when they merely enter the inguinal canal, but do not appear externally, it is denominated internal hernia. Male children are occasionally born with inguinal hernia, which is then named hernia congenita, or hernia congenita infantilis; and this as they advance in life, is liable to be complicated with common inguinal hernia. When the viscera protrude at the crural foramen, it is termed crural or femoral hernia, or merocele; the protrusion at the umbilicus, umbilical hernia, exomphalos or omphalocele; and when the viscera are forced out at any muscular gap, ventral hernia, which protrusion generally occurs at the linea alba. Hernia may be said also to exist within the abdominal cavity, when a portion of the intestine is entangled by the omentum, the latter of which in such a case commonly adheres to the muscular parietes in the region of the inguinal or femoral aperture. Two or more hernia not unfrequently exist at the same time, generally double inguinal, *i. e.* an inguinal rupture on each side; and there are instances where three protrusions have existed in one inguinal region. The assigned causes of hernia are exceedingly numerous, but they may be reduced to violent muscular exertion, and a more than natural size of aperture, in consequence of a relaxation of the muscular fibre; and hence hernia is as hereditary as scrofula or phthysis pulmonalis. In scrotal hernia, the peritoneal sac has descended to the knee, in which case it becomes so remarkably thin, that the vermicular motion of the intestines has been seen through the integuments, and a blow inflicted on the tumour has ruptured it; the omentum, jejunum, ilium, colon, and even the pyloric orifice of the stomach, have been found in it; and if the sac adhere intimately to the ring, the fundus is occasionally lacerated, forming as it were small cysts or secondary cavities, and if the neck of the sac yields and descends, a new neck is formed, and thus two or more constrictions are produced. The sac very early forms adhesions to the contiguous cellular substance, and through this means to the neighbouring organs, uniting in a mass the integuments, cremaster muscle, sac, and even the intestines in the inguinal hernia. By some the sac is said to become thickened, but this only occurs in small old hernia; in large hernia, the cellular substance is generally thickened, but not the sac. When the caput cœcum coli, the sigmoid flexure of the colon, or the urinary bladder is protruded, there is commonly no peritoneal sac.

The symptoms which distinguish reducible hernia from the numerous affections with which it is liable to be confounded, are a colourless tumour in the region of one of the abdominal apertures, or even at any part of the abdominal cavity capable of being returned with the fingers, varying in size before and after meals, and in the mornings and evenings, influenced by coughing, and disappearing in the horizontal position; and the patient is frequently troubled with colic. Its treatment consists in reducing the protruded viscera into the abdomen, which is termed the taxis, and is performed by placing the patient on his back, in the horizontal position, with his head and shoulders and knees so elevated, as to relax the abdominal muscles and the fascia lata femoris; and by pressing with the fingers upwards and outwards in inguinal hernia, and centrad upwards and inwards in crural hernia. Pressure first near the neck of the sac, and then on the body of the tumour, sometimes succeeds, but various other ways are recommended, which in our estimation appear fanciful and absurd. Then applying a rupture bandage, Fig. 24 of Plate DXVI. which ought to be worn day and night for life, together with the application of oak bark decoction for three or four months, (See *Edin. Med. and Surg. Journal*, vol. xviii.) These will in nine out of ten cases effect a radical cure.

By irreducible hernia is understood the impossibility of returning the protruded viscera into the abdominal cavity, in consequence of their having either remained so long down in the sac as to have become swollen, and hence too large, or contracted adhesions with the contiguous structures and the different viscera; the omentum is the most frequently so situated, next the caput cœcum, then the sigmoid flexure of the colon, and lastly, the urinary bladder. In this species of hernia, as the patient's life is constantly endangered, every attempt should be made to reduce it, and the bowels ought to be first unloaded by means of a cathartic; but we often fail, and if the mass protruded be very large, the patient cannot suffer it to be returned, in consequence of the abdominal cavity having become habituated to a smaller quantity of intestine, and to persist may prove fatal. The patient must be exceedingly circumspect in his diet, his regimen, exercise, and all his conduct; and should support the mass with a T bandage or suspensary truss. Long confinement to bed, light spare diet, occasional bleeding, purgatives and glysters, have succeeded in returning the protruded viscera; so also has the employment of trusses with hollow pads gradually reduced in size, together with confinement to bed; likewise rest in the horizontal position, combined with suspensary bandages progressively diminished in size. The application of ice has also succeeded. An operation has been likewise performed, but from the peritoneal inflammation which followed, it ought not to be done unless absolutely necessary. The great Zimmerman nearly fell a victim to this operation, and the illustrious Gibbon preferred carrying his load along with him to the grave. In some of these large irreducible hernia, so great a quantity of serous effusion takes place at the fundus of the sac as to require to be drawn off with a trocar and canula.

In this irreducible hernia, if the protruded intestine becomes overloaded with feces, and an impediment be produced, or a fresh portion of this viscus or omentum be forced out, strangulation may occur; again, in the reducible hernia, if a greater portion of viscus be protruded, and the bowels be loaded with feces, which may be only a portion of the diameter of the intestine; while again, in a recent hernia, if the aperture be too small to permit the return of the viscus, the same event may take place, strangulation may also ensue. Inflammation is soon excited, which causes thickening of the coats of the protruded intestine, and interruption to the circulation of the protruded omentum, an effusion of bloody serum in the herniary sac, coagulable lymph on the intestine, with adhesion of the parts to each other, and ultimately mortification; while within the abdominal cavity, the inflammation extends to the intestines above the seat of the stricture, and to the peritoneum, both of which generally become coated with coagulable lymph, and more or less serous effusion is deposited. The strictured portion of intestine almost immediately assumes a dark purple colour, in consequence of its venous circulation being arrested, and soon becomes black and brown, and then ruptures; the portion of intestine above the seat of the stricture within the abdomen becomes also purple and black, approaching nearly to gangrene, while that below the seat of the protrusion retains its natural colour. When the omentum is the protruded viscus, its circulation becomes also strangulated, and produces inflammation, mortification, and death. If the patient has not previously fallen a victim to the derangement thus produced in his system, the strangulated portion of the intestine mortifies and ruptures, the feces are diffused in the neighbouring cellular tissue, which produce sloughing of the integuments, and are thus discharged, forming an artificial anus; or the integuments over the intestine inflame, mortify and ulcerate. In some cases the feces are so extensively diffused in the cellular tissue of the thigh, as to produce erysipelas phlegmonodes, and death. In those instances where a portion of the diameter of the intestine is merely strangulated, the feces not only escape by the mortified aperture, but also descend naturally along the intestine to the anus.

The symptoms of strangulated intestine are obstinate constipation, pain in the tumour extending from thence over the whole abdomen, aggravated on coughing, sneezing, pressure, or any movement, nausea, vomiting, small, quick, and hard pulse, anxiety, restlessness, thirst, and general inflammatory fever. These are soon followed by hiccup, cold extremities, cessation of the pain, cadaverous countenance, imperceptible pulse, feeble respiration, cold clammy perspiration and death. Strangulated hernia is as liable to be confounded and complicated with other diseases as reducible hernia, so that we require to be very circumspect in our diagnosis; and probably, of all such affections, a swollen inguinal gland, accompanied with obtinate constipation, is the most frequent, and at the same time the least dangerous, for even, provided an operation is performed in such a case, no evil would be produced.

Let us suppose it to be purely strangulated inguinal hernia, the taxis is to be first employed, and if there be not much pain, it may be persevered in for some minutes; but if the reverse occurs, venesection even to fainting should precede the taxis, and if a warm bath can be procured, it ought to precede blood-letting. He ought to be bled while immersed in the water, and the taxis tried while in it. If he does not faint when the ordinary quantity for producing this effect has been abstracted, he ought to be raised to the erect attitude, and the instant syncope takes place, to be seated in the bath and the taxis employed. The tobacco enema may be combined with blood-letting to produce fainting in this disease, but is objectionable as it retards an operation. Purgative enemata should be employed. The time which is to be allowed in the employment of the preceding measures must be regulated by circumstances; more patients, however, fall victims to delay, than to an operation. We should operate immediately if the pain increases after giving a fair trial to the taxis combined with blood-letting, for perseverance in the taxis may produce suppuration, gangrene, and rupture of the intestine, and we allow the opportunity to pass of saving our patient by an operation. Small herniæ are more difficult of reduction than large, in consequence of the smallness of the aperture. We must be careful not to be deceived in reduction, for sometimes, only the contents of the intestine are returned; in other instances, only one of the viscera; at others, the intestine is still in the inguinal canal strangulated; in others, although the sac and intestine are returned, still the neck of the sac continues to incarcerate the intestine; in others the omentum bridles down the intestine and strangulates it; in some ileus may be combined; while sometimes there exist two distinct herniæ, and the contents only of the one are reduced. The symptoms consequently ought to be our guide, but here also we may be deceived, for after reduction, although the patient is relieved from his immediate sufferings, inflammation may continue from the effect of the stricture. If therefore pain with vomiting still continues after reduction, strangulation must exist, and an operation is required, and if after that operation these symptoms are not abated, either the omentum must be bridling down the intestine or ileus exist, and then the propriety of gastrotomy must be considered. When the mesentery within the abdominal cavity is the cause of strangulation, the case is named mesenteric hernia, and when the mesocolon, mesocolic, and that formed by the omentum may be termed internal omental hernia.

The operation to relieve strangulated inguinal hernia is performed by making an incision from a little above the tumour down to its lowest point, carefully through the skin and cellular substance; then pincing up with the fingers at the lowest portion any cellular tissue, and cutting it horizontally with the scalpel, until the sac or intestine appears, for in some cases we have said there is no herniary sac, but when present, it is of a whitish colour, while the intestine is purple. We must likewise be on our guard in case of the spermatic cord running superficially to the peritoneal sac. The sac is next to be divided in the same cautious manner, when a bloody serous fluid generally escapes, and afterwards cut up to the seat of the stricture, with a probe-pointed bistoury represented in Fig. 8 of Plate DXVI. The portion of the muscle forming the seat of the stricture, which in a recent small hernia is commonly the transversalis, while in an old large hernia the external oblique, is now to be divided directly upwards with the same bistoury, but in some cases only the sharp-pointed bistoury can be admitted. The viscera are now to be returned, reducing that first which protruded last; thus if both intestine and omentum are present, the former should be first replaced, and in doing so, considerable difficulty is generally experienced, in consequence of the action of the diaphragm and abdominal muscles forcing it out as soon as replaced. The edges of the wound are to be approximated with sutures passing the needle through the muscles, then applying adhesive plaster, lint, and bandage. The nates are to be elevated above the level of the body when the patient is put to bed, and as mild diarrhœa commonly follows, a gentle laxative, as castor oil, should be given; and since inflammation frequently supervenes, if the patient has not lost much blood, venesection ought to be performed. The other remedies adopted in this affection are to be kept in view, and the diet should be low for many days. When the individual has recovered the operation, he must wear a rupture truss for life.

There are many points to be attended to in this operation; thus the spermatic cord sometimes descends in front of the tumour running on the sac, but generally it separates into its constituent parts, the plexus of nerves and blood-vessels lying on the inner and anterior aspect, and the vas deferens on the posterior and outer aspect; while in other cases, this order has been reversed. In the ventro-inguinal hernia, the epigastric artery runs on the outer or iliac aspect of the neck of the sac. At the period of reducing the protruded viscera, we should examine carefully that two herniæ do not exist, or that there is not a second protrusion near the same aperture. We must be also guarded against pushing the viscera between the abdominal muscles, or between the muscles and peritoneum, instead of into the abdomen, which is termed by the French *reduction en bloc*. We must be satisfied that the viscera are returned into the abdominal cavity; adhesions are occasionally formed between the portions of intestine, or the intestine and omentum, or between these and the herniary sac, and if recent or of trifling extent, they should be carefully separated by the scalpel, but if the intestine adheres intimately and extensively to the sac, the stricture is to be freely relieved, and the intestine covered with the integuments, when nature will afterwards reduce it. On the contrary, sometimes an artificial anus is the result. The colour of the protruded intestine ought to be no criterion with regard to reduction; unless it breaks down or ruptures under the fingers, it should be reduced: the colour of a gangrened intestine is commonly brown. The omentum sometimes surrounds the intestine in such a manner as to require to be disentangled. The omentum is also occasionally so consolidated, as to be incapable of being returned without making a prodigious aperture, and even when returned, it has excited inflammation, suppuration, and mortification. It should therefore be excised, and if the vessels bleed, which are here chiefly veins, they must be secured. A serous fluid is not invariably present in a herniary sac, neither is the herniary sac itself, and in those latter cases, when the colon has been the viscus, it has been proposed not to return it, which, in our opinion, appears injudicious. In a large hernia, the sac should not be opened, as the neck is large enough to allow the reduction of the viscera, and would expose too large a surface; all that is requisite, therefore, is to divide the stricture formed by the muscle on the outer side of the neck of the sac. Congenital inguinal hernia is of most importance when it occurs in the male, and consists in a protrusion of the viscera, within the tunica vaginalis testis, either with or without a peritoneal sac, and, consequently, in some instances, in contact with the latter body. In children, as the testis cannot be felt before the viscera are reduced, we require to be careful in the application of the truss; and as children are subject to hydrocele, and these diseases frequently co-exist, equal caution is requisite. When this variety becomes strangulated, the sac should not be laid open from the bottom, but at the upper margin of the testis, in order that enough may be left to cover the gland: but if any adhesion exists, the sac must be cut open to the bottom. Sometimes a common inguinal and a congenital hernia exist together.

Crural hernia is said to be peculiar to the female, and inguinal to the male, although our own observations do not corroborate this. The viscera are protruded either at the crural aperture, or in the sheath of the femoral vessels, but much more frequently at the former than the latter place. The stricture in this hernia is generally caused by Gimbernat's ligament, and requires to be divided horizontally towards the pubes, inserting Weiss's probe-pointed bistoury, Fig. 12 of Plate DXVI. as short a distance as possible within the abdomen. There is seldom any serous fluid effused in the sac of femoral hernia, and intestine more frequently than omentum is protruded. The constriction produced on the intestine by the crural aperture, has sometimes caused either permanent contraction of the part, or ulceration of the mucous and muscular tunics, followed by fatal extravasion.

Umbilical is fully more frequently congenital than inguinal, and great circumspection, therefore, is required in securing the umbilical cord at birth. The peritoneal sac in this species becomes exceedingly thin, and is often ruptured, forming cysts, and the viscera, not unfrequently, adhere to the integuments, and have been strangulated at these foramina of the sac. It is not very liable to be strangulated, but when this event does occur, the symptoms are more violent, and gangrene takes place more rapidly than in the preceding species, and hence an earlier operation must be had recourse to. The stricture is to be divided either directly upwards or downwards in the linea alba, but the latter should be preferred. Ventral hernia commonly occurs in the linea alba near the umbilicus and between it and the ensiform cartilage. Perineal hernia is when the viscera protrude between the urinary bladder and the rectum in man, and between the rectum and vagina in woman, rupturing the fibres of the levator ani muscle. Vaginal hernia is when the viscera descend either between the urinary bladder and uterus, or between the uterus and rectum. Pudendal hernia is when the viscera protrude between the ramus of the ischium and vagina through the fibres of the levator ani muscle, the tumour appearing a little below the middle of the labium externum. Sacro-rectal hernia is a peculiar species arising from an incomplete ossification of the sacrum.

If the intestine which is protruded becomes gangrenous and ruptures, an artificial anus is formed, and if this portion be even so near the anus as the ileum, close to the caput cæcum, the patient dies from inanition. If the intestine at either end admits the little finger, there is no necessity for dividing the stricture, if otherwise, there is. The palliative treatment consists in cleanliness, in stopping up the external aperture by sponge or linen plugs, and ultimately, when the aperture of the intestine is reduced to a small foramen, by applying the actual cautery, and nourishing the individual with nutritive soups and enemata; the radical cure, in destroying the septem with Dupuytren's forceps, delineated in Fig. 16 of Plate DXVI.; but this instrument ought not to be used too soon after the formation of an artificial anus, and if inflammation is induced, it must be subdued by local blood-letting, fomentations, &c. The external wound is to be afterwards healed by pressure, caustic, and the actual cautery, or paring the edges and employing a suture. Dupuytren uses an instrument consisting of two pads and a screw, to approximate the sides of this fistulous aperture.

Retention of urine, or ischuria vesicalis is, when the urine is collected in the bladder and cannot be expelled; and is either partial or total, or complete and incomplete. Partial or incomplete retention is when the patient voids a little urine from time to time, but still his bladder is becoming more and more distended with water, a condition very deceitful and equally dangerous as the complete, and hence very improperly named. The complete or total state is, when no urine whatever is voided. The causes of this malady are, inflammation of the neck of the bladder or urethra, stricture of the urethra, diseased prostate gland, fistula in perineo, blood, worms, calculi or other foreign substances in the neck of the bladder or urethra, pressure of the uterus in the advanced stage of gestation, and displacement of the viscera of the pelvis in the female, pressure of the rectum, tumours, and abscesses in the vicinity of the neck of the bladder, paralysis of the bladder, and, in some instances, from a false passage made by the surgeon. In all of these, there is acute pain in the hypogastric region, particularly when pressed upon, with a constant desire to make water, and accompanied with some degree of a fever. On examining the hypogastric region, the urinary bladder is found distended, and more or less of a pyramidal figure; and on inserting the finger in the rectum in the male, or vagina in the female, a bulbous projection is felt. If the urine is allowed to accumulate, the bladder loses its contractile power, inflames, sloughs, and ultimately ruptures, when the urine escapes into the pelvis, and is extravasated into the contiguous cellular tissue, occasionally upwards to the loins, and downwards to the perineum, scrotum, penis, and upper region of the thighs, either exciting inflammation of the peritoneum and viscera, with a typhoid fever ending fatally, or at once producing coma and death. The kidneys, in the advanced stages of retention are mechanically impeded in the further secretion of urine, by this fluid accumulating in the ureters and pelvis of these organs.

In retention of urine, there is commonly no time to investigate the cause, since the urine must be immediately removed by inserting into the bladder a silver catheter delineated in Fig. 8 of Plate DXV, which is done, either while the patient stands, or lies on his back, by the surgeon grasping the penis with his left hand, while with his right he enters the point of the instrument into the urethra, the handle being over the left groin of the patient; the catheter is then slowly and cautiously conducted along the urethra, bringing its handle to the mesial line, while the penis is at the same time pulled upon it, until the operator considers the point of it in the membranous portion of the canal, when he is to relax the member, and bring forward the handle to a right angle with the body, and ultimately depress it, pressing upwards the point of the catheter with the fore-finger of his left hand in the perineum. If he is foiled in its introduction, he should partially withdraw it, and insert the fore-finger of his left hand in the rectum and press upwards its point as he glides the instrument onwards: this latter attention is especially requisite when diseased prostate gland is the cause, or he may try a smaller-sized instrument. If he is still foiled, he ought to try a flexible gum catheter after the manner of inserting a bougie, which is, to withdraw the stilet, make the patient stand before him, grasp the penis with the left hand, and gently elongate it, so as to make the urethra a straight canal; then insert this catheter cautiously. If these trials fail, and the patient is not suffering severely, he should be bled to fainting, and the introduction of the catheter again attempted; or he may be put first into a warm bath before being bled; and if the catheter does not pass along, a tobacco glyster as directed in hernia may be used: but no violence whatever should be employed in the attempts to insert the catheter, for the surgeon may rest assured that whenever blood flows at the meatus urinarius, he has ruptured the mucous coat of the urethra, is in the corpus spongiosum, or cellular tissue in the vicinity of the membranous portion, and has begun to make a false passage, so that he ought to desist, and puncture the bladder. Male catheters are of different shapes, varying chiefly in their curves. Lieutaud employed a straight catheter, which is now used by Mr. Amussat and others in Paris; a surgeon should have them of different curves, and longer and shorter in the beak, and of smaller and larger diameters. The French, when foiled in the introduction of the common catheter, occasionally use a conically pointed one, which is termed a *sonde conique*, and which they force onwards from the point of resistance in the urethra into the bladder. If the operator succeeds in its introduction, the instrument should be kept in the bladder until all irritation is subdued by antiphlogistic means, when the cause ought to be investigated, and if possible removed. Mr. Amussat, in the Bulletin des Sciences Medicales for October 1825, describes a most ingenious apparatus for relieving retention of urine, by forcing an injection of warm water along the urethra.

The female catheter is delineated in Fig. 10 of Plate DXV. although a male one is equally serviceable, and is inserted while the patient is in bed with her limbs in a bent position, by the right hand of the surgeon holding the instrument, being conducted under the right thigh, when the clitoris is to be felt by the middle finger, and the point of the catheter glided downwards about an inch into the meatus urinarius, and then its handle gently depressed and pushed upwards and backwards around the symphysis pubis. The operator is nearly equally liable to injure the mucous coat of the female urethra, and hence ought to proceed with the same precaution as in the male.

The urinary bladder is punctured at the perineum and per rectum in the male, per vaginam in the female, and above the pubes in both. The operation per rectum is much the simplest and safest, and can be done even in cases of enlarged prostate gland. The patient's nates are brought to the edge of the bed, and his feet placed on chairs widely separated, so that the position nearly resembles that adopted for the lateral operation of lithotomy; the operator then inserts the fore and middle fingers of his left hand oiled into the rectum until he feels the prostate gland, when he conducts along them the trocar and canula delineated in Fig. 11 of plate DXV, sheathed to the space formed by this gland and the fold of the peritoneum named the *cul de sac*, and the vesiculœ seminales, and then plunges the trocar with the canula into the bladder, depressing at the same time its handle, so that the instrument may run parallel with the patient's body; the trocar is next removed, and when the urine has been evacuated, the canula is fixed by tapes run through the hole at its exterior aperture and around the loins and thighs of the patient, this aperture being plugged up with a piece of wood, and the patient afterwards laid in bed, with directions to remove this plug when the bladder feels distended.

After this operation, there may continue such a degree of inflammation or inflammatory fever, as to require active antiphlogistic treatment, and in such an event the canula ought not to be plugged up. The surgeon ought next to investigate the cause, which he is to endeavour to remove; but whatever that may be, he should at the end of 48 hours, by which time suppuration will have ensued, substitute a flexible gum catheter for the silver one, as the latter will excite ulceration of the bladder; a small papilla will direct him, and as the urinary bladder and rectum are intimately united in the healthy state in this space, he can scarcely introduce the instrument between them. When performing this operation on a stout fat man, the operator must expect to experience difficulty in feeling the prostate gland, and reaching the space beyond it. In the female, the bladder is easily punctured from the vagina, the operator calculating the length of the urethra, and if the canula requires to be left, it should be fixed with a T bandage, and care taken that it does not slip into the bladder. The after treatment is the same as that directed in the male.

Stricture of the urethra frequently ensues from gonorrhœa, (described in the article MEDICINE under *Syphilis*, Vol. XIII. p. 30.) and every patient who has been once affected with this complaint, has more or less contraction of the urethra, in consequence of the injury done to the canal, but if left alone to nature the apparent stricture will be removed, while if bougies be used, it will be aggravated. Stricture also arises from stimulating medicines taken internally, from stimulating injections, ulcers in the urinary canal, injury of the urethra, calculus in the bladder, and excess of venery. It has likewise occurred in those who have resided in a warm climate, and in people of a naturally irritable urethra, and so early in life as eleven years of age. It is divided into the spasmodic and permanent, and a combination which is termed the mixed stricture; it occurs in every part of the urinary canal, but most frequently just behind the bulb, which is between six and seven inches from the meatus urinarius; next, anterior to the bulb, or about four and a half inches; thirdly, three and a half inches; fourthly, close to the meatus; occasionally in the prostatic portion; and on some rare occasions, at all these places in one individual. Spasmodic stricture consists in a temporary contraction of the longitudinal fibres of the urethra; permanent stricture, in a greater or smaller contraction of the passage from thickening, which is consequent on an effusion of coagulable lymph, that becomes more and more organized, and ultimately hard and of a white colour. Sometimes this permanent stricture is so narrow or short, as to resemble the constriction made by tying a thread round the urethra, and is named the corded or ring stricture; at other times, only one side of the canal is contracted; while occasionally, cases occur where the whole diameter is contracted for a considerable extent, and this has been termed by some the ribbon stricture. There is always an enlargement of the urethra immediately behind the stricture, considerable thickening of the coats of the urinary bladder, enlargement of the ureters, with affection of the kidneys.

The symptoms of this disease are, inability to expel all the urine at once, there being always a few drops remaining between the stricture and the bladder, so that when the patient imagines he has finished, he finds his clothes wet, and on pressing the penis more urine is expelled; the stream soon becomes wiry, spiral, forked, or scattered, and there is straining with an uneasy feeling in the perineum and anus after voiding the urine; there is a greater desire to make water in the evening and during the night, being seldom able to lie longer than four hours, and occasionally making it involuntarily, with now and then a nocturnal emission. A gleety and even a purulent discharge is present from the beginning, so that it is liable to be mistaken for gonorrhœa. As the disease advances, the urine is voided in drops, great pain is experienced extending to the loins, the urinary bladder is thrown into violent action, and discharges mucus and pus, and the patient elongates the penis. These symptoms, with retention of urine from time to time, either gradually exhaust the patient, or the urethra behind the stricture bursts, and the urine is effused into the cellular substance in the vicinity, as described under retention, or the bladder ruptures, and the same event occurs, or lastly, the urine escapes, and forms fistula in perineo, and the patient survives. The slightest excess in drinking aggravates the symptoms, and often produces the spasmodic stricture, as well as retention of urine; and so also does the change from a warm to a cold atmosphere. These causes, together with the insertion of the bougie, often produce a febrile paroxysm resembling ague. The simple spasmodic stricture is rarely met with in consequence of the patient disregarding it until a permanent state has been induced by the inflammation excited from repeated attacks. When the violence of the spasm is present, the treatment is by bloodletting, a dose of nitrous ether and laudanum, the warm bath, an enema of warm water, or one combined with laudanum, and warm opiate fomentations.

The treatment of the permanent, is by catheters or bougies, the latter of which are made of wax, cat-gut, horse-skin, elastic gum, silver and steel; but the wax, elastic gum, and steel, are those chiefly employed. One of elastic gum or steel, as large as the meatus will admit of, is to be conducted along the urethra down to the seat of the stricture, and the point marked with the nail of the finger, when various ones of smaller dimensions are to be inserted, until one enters the stricture, which if of short extent, or the ring stricture, may be treated with the caustic bougie, which is merely one of wax, having a small portion of the nitrate of silver inserted in the point, and which is to be conducted to the stricture, and kept there with a slight degree of pressure for a few seconds at first, but at each application longer and longer, previously however inserting a common bougie of the ordinary size of the canal for a few seconds, to remove any mucous or spasmodic irritability of the urethra. If the caustic produces so large an eschar as to plug up the urethra, a small common bougie will remove it; and the application of the caustic ought only to be repeated every second day. When there is so great a degree of irritability of the urethra and bladder that the caustic produces a febrile paroxysm, the pure potassa should be used instead of the nitrate of silver, and the warm bath combined, together with the internal exhibition of the muriate of mercury and nitrous ether. The caustic occasionally produces hemorrhage, which may be easily suppressed by compression. The caustic is very liable to make a false passage, especially if the stricture be beyond the bulb of the urethra, and consequently ought never to be employed excepting in this ring stricture. A false passage is to be apprehended if the bougie makes progress towards the bladder, while the difficulty of voiding the urine continues as at first.

In the lengthened stricture, the common or metallic bougie is to be preferred, beginning with one the size of the stricture, and gradually increasing them in size, and retaining them each time for a longer period: indeed, even when a cure is established, the patient should be taught the insertion of an ordinary sized catheter, which he ought to use at least once a week. If irritability follows the employment of this bougie, the same mode of relief is to be adopted as recommended when using the caustic one. The metallic bougie acts by distention, absorption, ulceration, and again absorption. A more expeditious and safe way of curing either the short or long stricture, if the patient will confine himself to bed, is by the insertion into the bladder of a series of elastic gum or silver catheters, beginning with one the size of the stricture, and progressively increasing them. They can generally be enlarged every second day. This is also preferable to Mr. Arnot's method or Mr. Stafford's lancetted stilettes.

The stricture, if of some length, and so small that the bougie cannot overcome it, ought to be cut down upon, and a larger urethra made by the introduction of the flexible gum catheter. A sound is inserted in the urethra down the length of the stricture, and an incision made with a scalpel to its point, when the strictured portion is to be discovered with a probe and laid open, the sound withdrawn and a catheter inserted in the bladder. When the stricture is situated opposite the scrotum, a free incision should be made in the cellular tissue of the latter to prevent the urine from diffusing itself in it. The French use a *sonde conique* and force the obstruction. Mr. Amussat, however, employs the injection of warm water as described under retention of urine. In many instances of strictured urethra, it is advisable to puncture the bladder, and afterwards restore the continuity of the canal.

When the canal ruptures behind the stricture, a free incision should be made to allow the urine to flow by the wound, and the contiguous infiltrated cellular tissue ought to be freely punctured. When the surgeon makes a false passage by the bougie, which is known by the rough feeling communicated to the fingers, by a tearing sensation, and by the instrument being in a degree grasped, he should immediately withdraw it, and desire the patient to retain his urine if possible, that it may not irritate the wound, and diffuse itself in the contiguous cellular tissue, but allow a clot of blood to form, and a slight degree of inflammation to heal the wound. If he persists, either with the bougie or the catheter, he will only aggravate the evil, for the false passage being distended with blood, presses on the urethra, and prevents him from conducting it onwards to the bladder, the urine flows into this passage, is extravasated in the contiguous parts, and forms an abscess which commonly ends in fistula in perineo, or urinary fistula. This disease also ensues from ulceration of the urethra behind a stricture, which is sometimes involved in the ulceration. If there be only an abscess, it ought to be most freely cut open. In this affection, a sound should first be passed into the bladder, and then a flexible gum catheter, which must be worn and progressively enlarged until the fistula is healed. When a stricture has been the cause, either this should be destroyed with caustic or cut down upon, and the latter ought to be preferred. In some rare instances no trace of the original canal can be discovered, in consequence of the urine rendering the substance in the contiguity of the fistulæ (for there is often more than one aperture) purely cartilaginous; and then the operator must make a urethra according to his anatomical knowledge. In the healing of such a wound considerable difficulty is experienced, and may be best accomplished by treating it, as recommended in hare-lip, or by the actual cautery. Stricture of the urethra rarely occurs in the female, and only in consequence of maltreatment in parturition, or in the insertion of the catheter; and when it is present, its treatment is the same as recommended in man.

The prostate gland is very liable to be affected with inflammation in gonorrhœa, and in stricture, and to lay the foundation for more serious disease. In these affections, the symptoms indicative of the prostate gland being inflamed, are an irritable state of the urinary bladder, pain and straining at stool, with tenesmus. An examination per rectum confirms it. Sometimes retention of urine ensues with a throbbing pain in the region of the neck of the bladder, and when the catheter is inserted, great pain is experienced when the instrument arrives at the gland, and is with difficulty passed beyond it into the bladder. The treatment consists in the application of leeches to the perineum or in the anus, enemata of warm water followed by one of laudanum, warm fomentations externally, gentle laxatives, low diet, and rest. General bloodletting is sometimes requisite, and even puncturing the bladder. Abscesses occasionally succeed this inflammatory attack, and the matter is sometimes situated on the exterior aspect of the gland: in general their formation is indicated by rigors, which, however, are not always present, particularly when it takes place in advanced life, from irritability of the bladder. Sometimes the matter is discharged into the urinary bladder, sometimes into the urethra, rectum, and occasionally at the perinæum. Whenever it is ascertained that matter is formed, it should be freely evacuated by an incision; and in those cases where there is not too much irritation it is advisible to insert an elastic gum catheter and retain it in the bladder. Calculi are sometimes secreted in its substance, and require to be removed by an operation similar to the lateral one of lithotomy. Varicose enlargement of its blood-vessels occasionally take place, and are relieved by leeches applied through the medium of the rectum. Medullary sarcoma, fleshy excrescences and scrofulous enlargement, with suppuration, occur; but the chronic scirrhous state is the most common affection of this gland, attacking the male about forty years of age, like that disease in the female mamma about the same period of life. It has been seen in a few rare cases of early life.

The symptoms are, a frequent inclination to make water, which is voided very slowly, in small quantities and with difficulty, and has a strong flavour of ammonia; a dull heavy pain in the region of the gland, which, however, is occasionally sharp and lancinating along the urethra even to the glans, the latter of which, as well as the prepuce, sometimes feels benumbed. He has a difficulty in expelling his feces, which become small, wiry, or flattened; is affected with hemorrhoids and prolapsus ani. When riding in a carriage or on horseback, he passes blood per urethram, and as the disease advances, the urinary bladder becomes affected, and also the urethra and kidneys. On dissection, the gland is indurated, and resembles that described under scirrhus of the mamma; and when much enlarged there projects towards the bladder a portion which resembles a third lobe; sometimes, however, this projection takes place laterally; and in rare instances fungous polypi are attached to its base. The mucous tunic of the urinary bladder, immediately behind the prostate gland, is occasionally forced through the muscular, forming herniary sacs, an event that sometimes occurs in stricture of the urethra, in consequence of the violent straining efforts in expelling the urine. The treatment hitherto has been only considered palliative, which consists in local bloodletting, semicupium, domestic and opiate enemata, and teaching the patient to draw off the urine with the catheter whenever he has a desire to void it, or by his wearing a flexible gum or pewter catheter, which must be changed every ten or fourteen days. The radical treatment consists in removing the gland by an operation, for which the reader is referred to the late Dr. Bruce's Thesis *De Morbis Glandulæ Prostatæ* 1827. In the fungoid condition of the gland, the blood flows into the urinary bladder, and requires to be removed by a silver catheter having a brass syringe adapted to it.

Calculus in the urinary bladder has been already described under *lithiasis* in the article Medicine, so that it remains only for us to detail the resources of surgery, which are the extraction of the stone along the urethra by means of a pair of forceps, with or without dilatation of the urethra; secondly, the breaking down of the calculus in the bladder by means of a lithontripter; and thirdly, by an operation to cut into the bladder and remove the stone. When the calculus is small, it may be extracted by the forceps represented in Fig. 14 or 15 of Plate DXV., or by dilating the urethra by means of flexible gum catheters or metallic bougies, for small calculi are often voided with the urine; but if large, attempts may be made to seize and break it down with the lithontripter represented in Fig. 16 of Plate DXV. which was invented either by Meirieu, Leroy, or Civiale; but the pain attendant on this method is so harassing, and occasionally so severe, that a patient affected with calculus vesicæ will rather submit to the lateral operation. Besides the lateral, there are several other operations of lithotomy; the apparatus minor or cutting on the gripe; the apparatus major; the high or hypogastric; the recto-vesical; the bilateral or Celsian; and lastly, the quadrilateral method. The apparatus major, and the recto-vesical operations may be said to be now abandoned; and the high operation only performed when the calculus is so large that the outlet of the pelvis will not permit its exit. The bilateral is a revival of Celsus or rather Ammonius of Alexandria's method by Beclard and Dupuytren, and differs from the lateral in this, that a lunated incision is made from the tuberosity of the one os ischii to that of the other; and Beclard's differs from Celsus's that he keeps the sound in the urethra until the bladder is freely incised. This is evidently an advisable operation when the calculus is large, and is decidedly to be preferred to the hypogastric. We are confident that this mode, together with Le Cat's teeth forceps or Mr. Earle's stone breaking or screw forceps, will extract the largest calculus that was ever removed in life. This bilateral appears to answer every purpose that the quadrilateral operation, invented the other day by Vidal, can possibly do, and is unquestionably safer and simpler.

The lateral operation is found to succeed best between sixty and sixty-five years of age, next from four to twenty, and most seldom between twenty and sixty. A patient who is to undergo this operation should be free from any flakes of purulent matter in his urine, from diseased prostate gland, from spasmodic action of the abdominal muscles, or any affection of the thorax; he should take a cathartic the day before, have a laxative glyster on the morning of the operation, and the hair of the perineum shaved off. He is then to be secured with tapes on a firm table, with the nates projecting over the margin, and again sounded with a staff delineated in Fig. 3 of Plate DXVI. In ordinary cases of sounding, the patient is not tied up, but is laid horizontally, and if no calculus be found, he should be sounded with a catheter while standing, and when the bladder is full of urine, by which means the stone will strike the point of the instrument; and to facilitate this, the flow of urine may be stopped from time to time. When using the sound, the fore and middle fingers of the left hand of the operator should be inserted in the rectum. A calculus being ascertained to be in the bladder, the staff is to be held firm by an assistant at right angles to the pelvis close under the symphysis pubis, who at the same time supports the scrotum, while two assistants hold the feet and knees of the patient. The operator then makes nearly a perpendicular incision with a scalpel two or three inches longer in its handle (see Fig. 14 of Plate DXVI.) on the left side of the raphe of the perineum, from the root of the scrotum to the fibres of the gluteus maximus muscle which cross the bottom of this wound, and some of which ought to be divided if the operator calculates the stone to be large; this incision is to run midway between the anus and tuber ischii, and should divide the integuments and cellular substance. The operator next deepens this incision opposite the membranous portion of the urethra, carefully avoiding the bulb and the accelerator urinæ and erector penis muscles, but cutting freely the transversus perinæi and levator ani muscles. Having reached the staff, by dividing the membranous portion, he enters the point of the scalpel into its groove, and with his fore and middle fingers depressing the rectum, he runs the scalpel along the groove of the staff through the prostate gland into the bladder (when the urine flows, satisfying him that he has entered the viscus) and cuts obliquely downwards and outwards between the termination of the ulcer and vesicula seminalis, proportioning the incision in the bladder and that of the levator ani muscle to the size of the calculus. The moment he has finished the wound of the bladder and the levator ani muscle, he should insert the fore and middle fingers of his left hand into the bladder over the stone, to prevent its being grasped by the muscular contractility of the viscus; and then pass below his fingers a scoop represented in Fig. 4 of Plate DXVI., and if he cannot easily remove it with this instrument, he should seize it with a pair of forceps, Fig. 5 of Plate DXVI., below the scoop which is to remain in order to prevent the calculus from being removed from its situation, and extract it. If either the bladder, the levator ani muscle, or the external wound is the barrier to its extraction, it should be more freely incised.

Whenever a calculus is extracted, its surface should be examined, and if any part be depressed, it is to be presumed that another calculus is present, which is to be extracted in the same way, but if grasped by the muscular contractility of the bladder, and it cannot be with facility removed, the patient should be unbound and put to bed, for, when suppuration is fully established, which is commonly the third day, it may be done without giving the patient the least pain, by simply inserting the fore and middle fingers of the left hand into the wound. But if not, the scoop may be again used, or the forceps, if the operator prefer them, and even a sound may be inserted along the urethra without exciting pain. This mode is termed *operation en deux tems*, and may even be employed with advantage, if any difficulty exists in extracting the first, or even when only one calculus is present. If a calculus is soft, and breaks in extraction, the bladder should be carefully washed out with warm water injected by means of a syringe.

When the operation is finished, the patient should be unbound, and put to bed, with a piece of oiled lint applied to the wound, and a bottle of hot water to his feet; and, whenever reaction has taken place, he ought to be bled, if he has not lost much blood during the operation, and in both cases, if there be the slightest appearance of peritoneal inflammation, which, if it follows, must be most promptly treated with antiphlogistic remedies. If hemorrhage supervenes, it is to be checked with a piece of dry sponge inserted in the wound, having a female catheter pushed through its centre to allow the urine to flow. If the blood flows into the bladder, it excites spasms, and must be washed out with tepid water. Low diet, with gentle laxatives for eight or ten days, ought to be prescribed. In general the urine begins to flow along the urethra about the twentieth day, and the patient is well in four or five weeks.

When calculi are encysted in the bladder, unless at its neck, they produce no irritation; and when situated there, they require to be removed by the same operation. Occasionally, calculi have been found in the bladder at death, in those who have never complained of them during life; and individuals have passed the greater portion of their lives with a calculus in their bladder, until a certain exertion has called into action all the horrible sufferings attendant on this complaint. In this lateral operation, there have been a great many deviations, and a great number of instruments invented, from the time of Ammonius of Alexandria to the present day; indeed, it may be said, "that every surgeon performs this operation after his own fashion, the same manner as he signs his name."

Cutting on the gripe, invented by Fabricius Hildanus, and practised in the present day on boys, consists in inserting a staff or sound into the bladder, then the fore and middle fingers of the left hand in the rectum, and bringing forwards the calculus to the perineum, when an incision is made on the left side of the raphe in the perineum as in the lateral operation, at once upon the stone, which is extracted with the fingers of the right hand or a hook.

When calculus occurs in the female, it may be removed by dilating the urethra with Weiss's forceps; but unless the stone is small, this is a cruel method, and often causes the patient to be tormented with incontinence of urine for life. An operation is, therefore, to be preferred, and that per vaginum, as done by Fabricius Hildanus, Ruysch, Tolet, Klein, and Vacca, appears superior to those of Messrs. Louis, Dubois, and Lisfranc.

When small calculi are arrested in the male urethra, they are stopt either at the perineum, opposite the scrotum, or opposite the frenum. When at the perineum, a large sound is cautiously inserted into the urethra, until it touches the calculus, the penis and sound are then tied with a piece of tape, and the patient desired to drink freely of diluents; and when the urine has accumulated in the bladder, the tape and sound should be removed, that he may make water forcibly. If this does not succeed, an incision should be made over the stone and extracted. When opposite the scrotum it is highly dangerous, and an attempt must be made to push the calculus gently backwards to the perineum, and treated as just recommended; but if this is impossible, a free incision must be made through the scrotum over the calculus and extracted. When opposite the frenum, it may be removed by inserting a common silver probe, with its eyed-end bent for a short distance; but if this does not succeed, it must be extracted by an incision.

There are a few surgical operations appertaining to gonorrhœa and syphilis, which require to be adverted to. In both of these diseases, phymosis, which is a swollen condition of the prepuce, with inability to denude the glans penis, frequently occurs, and when it takes place in syphilis, and the surgeon suspects chancres beneath it, it ought to be cut up, by inserting the curved sharp-pointed bistoury, with a button of wax, between the prepuce and glans, until its point reach the angle of reflection between them, when the operator, retracting the skin, pushes the point of the bistoury through the prepuce in the mesial line, and opposite the frenum, or by the side of the frenum, and cuts at once outwards. The two sides should be stitched individually, to accelerate their healing. A contracted state of the free margin of the prepuce is a frequent congenital affection, and should always be divided, so that the individual may be able to denude the glans; for, as Mr. Roux observes, such a condition predisposes to cancer of the penis.

Paraphymosis is a contracted condition of the prepuce behind the glans, preventing the latter from being covered, and frequently happens to boys in their innocent gambols. In this affection, the glans becomes tumefied, and both it and the prepuce are infiltrated with serum, sometimes giving a peculiar twisted shape and appearance to the organ. If recent, it may be reduced; and, in general, a few punctures of the lancet, followed by fomentations or poultices, subdue the swelling, and allow the prepuce to be brought forward; but in some cases it is requisite to divide the strictured integuments and mucous membrane of the prepuce with a bistoury. Abscesses sometimes occur in the lacunæ of the urethra, which require to be freely opened from without, otherwise they are liable to produce retention of urine, fistula in perineo et ano, and if into the scrotum, they prove fatal. When a chancre affects the frenum præputii, the latter should be divided with a bistoury.

The prepuce, glans, and even the body of the penis sometimes become indurated, and the glans ultimately cancerous or fungous, either spontaneously or in consequence of repeated attacks of syphilis, and sometimes from neglected warty excrescences. The discharge in such cases is extremely fetid and sanious. If the remedies recommended under syphilis fail to cure it, the diseased portion ought to be removed by laying hold of the penis, and cutting it off at once, at a healthy portion of the member; then instantly inserting a flexible catheter in the urethra, securing the arteries, approximating the edges of the wound, from above downwards with suture and adhesive plaster, but leaving the catheter free. The wound to be dressed on the third or fourth day.

The testis is extremely liable to be affected in gonorrhœa, and when inflamed, swollen, and painful, it is termed hernia humoralis: and is treated by antiphlogistic remedies, with the injection of warm water into the urethra, to reproduce the discharge which is ordinarily checked, or to mitigate the irritation of the canal, the source of the disease of the testis. If the patient cannot procure leeches, he should immerse the scrotum in warm water, or stand before a fire until the veins become turgid, when they should be lanced in several points, and the scrotum again immersed in warm water; the patient standing all the time, for whenever he sits the bleeding ceases. After the activity of the inflammation has been subdued, and if the swelling remains, the scrotum should be fumigated with mercury, or anointed with mercurial ointment, having ultimately camphor mixed with it. In some cases an alterative course of mercury, with sarsaparilla, is requisite, with a succession of blisters, and the insertion of the bougie into the urethra, and the patient ought to be confined to the horizontal position for a considerable period. The testis sometimes suppurates, and should then be freely opened, as recommended under acute and mammary abscesses. Occasionally a fungus shoots forth, which requires to be removed either with the knife or the caustic. At other times wasting, or a total disappearance of one or even both testes occasionally takes place, and generally occurs between 14 and 20 years of age; and sometimes from the most simple accidental causes.

The different species of sarcomy, and the theory of their formation, have been described under diseases of the mamma; and the medullary, and carcinomatous of the testis, in no respect differ from these affections of the mamma, either in character or treatment. The medullary very soon contaminates the spermatic cord and lymphatic glands in the region of the kidney, the latter appearing in the form of a tumour in the short space of a few weeks, so that unless castration be performed very early in this species of sarcoma, it soon becomes incurable. It attacks the constitution so early as four years of age, but more commonly between fifteen and thirty-five.

If the antiphlogistic treatment, and other means mentioned under hernia humoralis fail in curing the carcinomatous, and the spermatic cord is free from pain, castration should be performed in the following manner:—An incision is made from the external aperture of the inguinal canal along the cord to the inferior point of the scrotum, through the skin and cellular substance; the cord is then insulated, and grasped by the fingers of an assistant, and divided between the fingers and the testis, the latter of which is to be dissected out, cutting first on the mesial aspect, to preserve the mediastinum scroti. The arteries of the scrotum are next to be instantly secured, and then those of the spermatic cord; the sides of the wound approximated with sutures and adhesive plaster, and a piece of charpie and two silk handkerchiefs, or a T bandage applied. If there is any diseased skin, two semi-elliptical incisions are to be made on each side of it, that it may be removed along with the testis; and since hemorrhage from the arteries of the scrotum is exceedingly liable to follow, an assistant ought to be appointed to observe their situation during the operation.

If hemorrhage ensues and fills the scrotum, the affection is termed hæmatocele, and is to be treated by styptics; and if these fail, the wound must be exposed, and the arteries secured, but they are commonly so small as to be scarcely visible, the wound therefore must be stuffed with dry lint or sponge, and afterwards stitched. The common vascular or organized sarcoma, or sarcocele also requires castration, and in this species the cord is commonly thicker, which however is no obstacle to the operation. In the advanced stage of sarcocele, cancer, and fungus hæmatodes, a fungus excrescence sometimes originates from the body of the gland; and a similar growth, in some instances, arises from the tunica albuginea, or even the body of the testis, in consequence of hernia humoralis, or an enlargement from a bruise. A small abscess occasionally appears, which bursts, and a fungus is protruded, that is named lipoma. In all of these the excrescence should be removed with the knife, and nitrate of copper or potassa afterwards applied. A chronic enlargement of the testis sometimes occurs in gonorrhœa, stricture, and syphilis, which is to be treated as recommended under hernia humoralis. At other times, this chronic enlargement is not dependent on these affections, but upon scrofula, and acquires, on some occasions, a prodigious magnitude, ultimately involving the other testis and the scrotum, and cured by no other remedy but castration.

A peculiar irritable condition of the gland not unfrequently presents itself, resembling neuralgia; which is to be treated with rest, warm bath, and the mecurial pill, combined with hyosciamus; and if these fail, by castration. A neuralgic affection of the external spermatic nerve occasionally occurs, which is to be treated as recommended under that disease of the face. Sarcocele is frequently accompanied with hydrocele, and then termed hydrosarcocele, in which case it will become a matter of consideration, whether the hydrocele ought not first to be cured, and then an attempt made to cure the affection of the testis, by the means recommended for hernia humoralis. This will chiefly depend on the magnitude of the gland; and hence, in all complicated cases, a trocar and canula should be plunged into the tumour, to ascertain whether fluid does not chiefly constitute the bulk of it.

Hydrocele is also occasionally complicated with hernia and circolele. In simple hydrocele, the serous fluid is effused between the tunica vaginalis, and tunica albuginea, and gradually as it collects, the testis ascends, and occupies the middle and back part of the tumour, while the fluid rises by the side of the gland and cord, upwards to the inguinal region, and hence is liable to be mistaken for hernia, diseased testis, circocele, and anasarca of this part. Hydrocele is distinguished from these affections by its pyramidal figure, elasticity, transparency when examined by a candle, by the deficiency of swollen cutaneous veins, and the history of the case. The fluid is generally serous, of a pale straw colour, but sometimes greenish, at other times dark, turbid and bloody, while occasionally it is of a violet colour. When the disease has existed long, cartilaginous bodies are found in it, and the tunica vaginalis becomes thickened. In some instances, adhesions exists either between the middle, the sides, or the bottom of the testis and the tunica vaginalis.

The treatment of hydrocele is palliative and radical; the former consists in simply drawing off the fluid with a trocar and canula of steel, as represented in Fig. 9 of Plate DXV, which are to be plunged into the tumour, a little below its middle, and where no veins are present, first at right angles until the operator feels he has entered the tunica vaginalis, and them sloped obliquely upwards nearly parallel with the integuments; the operator during this grasping gently the tumour and the testis with his left hand, in order to remove the latter from the trocar, which is then to be withdrawn; and after the removal of the fluid, the canula also. A piece of adhesive plaster, a compress of lint, and a T bandage are to be applied. This palliative operation is performed to remove the fluid when the testis is diseased, in order that all pressure may be removed; and afterwards, an alterative course of mercury with sarsaparilla, a succession of blisters or mustard cataplasms, or friction with the ointment of iodine, and the insertion of the bougie if necessary. It is also performed to ascertain the condition of the gland.

The radical treatment consists in incision, excision, caustic, tent, seton, and injection, the last of which is now only employed. A kind of tent, however, made of a piece of elastic gum catheter is employed by Baron Larrey; the seton by Sir A. Cooper in children; and excision in a modified way by Mr. K. Wood. Injection is merely re-distending the vaginal sac, after the evacuation of the serous fluid, with cold water, port wine, a solution of the muriate of mercury in lime water, spirit of wine, a solution of the sulphate of zinc in water, in order to excite such a degree of inflammation, as to cause adhesion between the tunica vaginalis and albuginea, which is accomplished with the greatest safety and equal certainty by the cold water; for if injected at the temperature of 32° of Fahrenheit, it will produce, instead of the adhesive inflammation, mortification; and if diffused in the contiguous cellular tissue at a more moderate temperature, it will prove less stimulating than any of the other fluids. In this operation, therefore, whenever the serous fluid has been evacuated, the canula is to be allowed to remain, and into it is to be inserted the pipe of a common brass stopcock having affixed to it an ox's bladder, filled with cold spring water, see Fig. 23 of Plate DXV. The cold water ought to excite pain in the testis, spermatic cord, and loins, which it commonly does in ten or fifteen minutes; but if not, a fresh quantity should be injected, or some at a lower degree of temperature. If the water by accident is diffused in the cellular tissue of the scrotum, it should be evacuated by punctures with the lancet.

If hemorrhage takes place in the tunica vaginalis producing hæmatocele, this tunic is to be laid open, according to circumstances, the blood removed, and its further effusion checked by the application of cold water, or some other styptic, or lint. After this operation, the patient is to be treated antiphlogistically, or allowed to walk about, according to the inflammation induced; and when this action subsides, the scrotum should be annointed or fumigated. If this operation fails, it ought to be repeated in the course of two or three months. Encysted dropsy of the spermatic cord occasionally occurs, particularly in children, and is to be treated like hydrocele.

Circocele, or varicocele of the spermatic cord, is a varicose enlargement of the veins of the cord, occasionally extending to those of the testis and scrotum, and sometimes present on both sides, which either presses on the gland, and removes it by absorption, or produces ulceration. It has a knotted or vermiform appearance, and is easily distinguished from the preceding diseases. The mode of treatment is confining the patient as much as possible to the horizontal position, suspension of the parts with a suspensory truss, the application of cold water, or oak bark decoction twice or thrice a day, and keeping the bowels gently open.

Chimney sweeper's cancer, or soot-wart, is a peculiar cancerous ulceration of the scrotum, which spreads to the clefts between the latter and the thighs, and ultimately involves the testis, the lymphatic glands in the groins, the spermatic cords, and the viscera of the abdomen, and proves fatal. The ulceration is divided into rugæ, is of a red colour, and the discharge extremely nauseous and fetid, even the perspiration of the whole body has a rank ammoniacal smell. This ulceration generally occurs between twenty and forty years of age, although it has appeared so early in life as eight, and attacks chimney sweepers, shoemakers, and smelters of ores which contain arsenic, and all classes of workmen who are uncleanly in their persons. The treatment is the same as that recommended for *noli me tangere*, and the other herpetic ulcers; and if this fails, by the knife.

Some of the diseases of the female organs have been already described in the present article, and others under Medicine and Midwifery. One or both of the external labia are sometimes so injured in parturition by a blow, that ecchymosis takes place to such an extent as to produce retention of urine by closing the meatus urinarius. This is to be treated by leeches, warm fomentations or poultices, and drawing off the urine by the catheter. Sometimes they suppurate and even mortify, the treatment of which is described under acute abscess and mortification. Laceration of the labium or perineum is sometimes to such an extent, and produces so much hemorrhage as to require compression with lint, or dry sponge and a bandage. The labia, particularly in children, are often attacked with inflammation that runs on to phagedena gangrenosa; and in milder attacks, or even in excoriation, they sometimes adhere, and shut up the passage, which requires to be opened with the scalpel, that the urine may be voided.

Children from one year old to puberty are frequently the subject of a purulent discharge from the pudendum, that originates chiefly beneath the præputium clitoridis, the nymphæ, the orifice of the vagina, and the meatus urinarius, all of which are inflamed: and this disease has been mistaken for the injury done to these parts in a rape, and men, says Sir A. Cooper, have been executed on the evidence of an ignorant surgeon. The treatment is the same as that recommended for acute inflammation of a mucous membrane.

Imperforated congenital vagina is far from being uncommon, and there is generally a mark or raphe indicative of its situation; sometimes it is deficient, at others the whole of the middle portion of the canal is filled up with solid matter; and in other instances again a firm septum is stretched across behind or deeper than the hymen. An incision should be made from above downwards, carefully guarding against wounding the meatus urinarius, and preserving enough to correspond with the perineum; and preventing a reunion by oiled lint. In some instances there is a small aperture superiorly into which a probe or bistoury can be inserted, and the part divided.

Imperforated hymen is fully more common than that of the vagina, but is seldom discovered until the catamenia have been secreted, when great pain is produced by the distention of the uterus and vagina; and a tumour becomes perceptible above the pubes. A transverse division of it with the bistoury gives free exit to the catamenia and relieves the patient, but attention must be paid to the effects of their retention, for frequently considerable inflammation is excited, which requires active antiphlogistic treatment, with injections of warm water per vaginam. To prevent the membrane from reuniting, a rectum bougie should be inserted, either daily or every second day. In the division of the hymen the operator must guard against wounding the meatus urinarius. This membrane has been also found so rigid, as to require a similar incision. In some cases, there is great confusion of the genital parts, the vagina communicating with the urethra, the rectum terminating in the vagina, a double vagina, and even two uteri. There are also cases of the uterus being deficient.

Various species of tumours grow from the labia, nymphæ and orifice of the uretha, requiring to be removed by the knife. The nymphæ become sometimes so pendulous as to require partial removal; and the clitoris so large, that when a congenital protrusion of the ovaria at the inguinal canals is combined, the sex is mistaken, or the individual is pronounced a hermaphrodite; it is also occasionally affected with cancer, and, in either case, requires amputation. In these little operations, there is commonly so considerable a degree of hemorrhage as to require the ligature or actual cautery. The clitoris, likewise, requires to be removed in nymphomania. In ascites and dropsy of the ovarium, the fluid occasionally gravitates between the vagina and rectum.

The uterus is subject to acute inflammation from cold, which often becomes chronic, although this latter stage sometimes begins *à priori*, and leads to dropsy, ulceration, scirrhus, cancer, ossification, atheroma, steatoma, medullary sarcoma, tubercles, polypus, moles, and hydatids: calculi, vermes, and air have been generated in the uterus. The acute is easily distinguished, and is to be treated antiphlogistically; the chronic is peculiar in this, that the patient often feels pain near the liver, and after it has continued for any time, a discharge of mucus which becomes occasionally purulent and mixed with blood, takes place: there is sometimes uterine hemorrhage, and the patient has an exsanguineous countenance. On examination, the os tincæ is larger than natural, soft, and tender; and, in the hypogastric region the uterus feels swollen, and is painful to the touch. The palliative treatment in this and the other diseases is by cupping or leeches, to the pubes and groins, anodyne enemata, and injections, per vaginam, extract of hemlock inserted in the vagina, gentle laxatives, low diet, and confinement to the horizontal position, and the administration of ergot internally. The radical, by extirpation of the organ, as lately done with success by that profound scientific accoucheur, Dr. Blundel of Guy's Hospital. The uterus has been extirpated by Carpus, Laumonier, Osiander, Langenbeck, Sauter, Siebold, Holscher, Wolff, Recamier, and Lizars.

There is a peculiar ulcer described by Dr. Clark, termed the corroding ulcer of the womb, and by Mr. Burns, phagedenic ulcer, which should also be treated by excision, as practiced by Lisfranc, or extirpation, by Dr. Blundel. There is another species of ulceration attacking the os and cervix uteri, described by systematic writers, which, however, is merely a modification of the preceding, and should be treated in the same manner. Firm and cauliflower excrescences frequently grow from the os uteri, which should be excised. Polypous excrescences from this region may be removed either with the ligature and double canula, or the knife.

The ovarium is subject to acute and chronic inflammation, to dropsy where the fluid is contained in one or more cysts, to dropsy combined with various degenerations of texture, and morbid productions, viz. collections of hydatids, scirrhus, ossification, calculi, steatoma, sarcoma, atheroma, melliceris, hair, bones, and teeth. The ovaries, as also the fallopian tubes, are subject to congenital malformation. These tumours grow sometimes to an enormous size, and are then frequently complicated with ascites, or adhesions to the abdominal parietes and viscera, when hydatids also originate from the latter. In the first stage, their pedicles are very small, and they can be removed from the one side of the abdomen to the other, and are then favorable for an operation, which is performed as recommended for ileus. When the abdomen is freely laid open (the temperature of the room being at 80° Fah.) the viscera are to be encircled in a towel that had been previously immersed in warm water at 98°, the tumour held by an assistant, its pedicle secured with a ligature, both ends of which, as also the tumour, are to be cut off. If the disease be complicated with ascites, the case is still more favourable. If extensive adhesions are present, an incision through the abdominal parietes should be made, and if these are found to exist between the tumour and the anterior parietes of the abdomen, a seton ought to be inserted across the abdomen and tumour, care being taken not to wound the epigastric arteries. For further information on this subject the reader is referred to Lizars *on Extraction of the Ovarium.*

It is chiefly in the female constitution that violent or excessive hemorrhages occur exhausting life, which is reanimated by the process termed transfusion, for the revival of which the public is indebted to Dr. Blundell, who has now performed it repeatedly with success. The best apparatus is that invented by Reid, which is delineated in Fig. 13 of Plate DXV. A vein of the arm of a healthy person should be opened, as in phlebotomy, and the blood received into the cup *a*, from which the tube *b* conducts it to the bottom of the syringe *c*, whence it is propelled along the tube *d*, into the small pipe *e*, inserted in the vein of the expiring patient.

The diseases of the rectum are piles, tubercles, sarcomatous tumours, and ulceration; stricture of the rectum, abscess near the anus, fistula in ano, prolapsus ani, and imperforate anus. Piles, or hemorrhoids, arise from constipated bowels, pressing and impeding the circulation of the hemorrhoidal veins, or from relaxation of the bowels, produced by diarrhœa while these veins are not sufficiently supported, or from one or other of these causes, especially the first occurring in pregnancy; and hence pregnant women are most subject to them, for the pressure of the uterus becomes also a cause. They are small purple coloured tumours situated around the anus, consisting either in a distended thickened varicose state, or rupture of these veins, the blood, in the latter case, being most frequently diffused in the cellular tissue around them. Piles are divided into external, internal, blind, and open. The external are situated outside of the anus, the internal within the rectum; the blind are such as do not bleed, while the open bleed.

Piles are a most troublesome complaint, preventing the patient from either walking or even sitting with comfort, since he is only easy in a horizontal attitude; and not unfrequently the pain is most excruciating, particularly on going to stool, when they sometimes bleed to such an extent as to debilitate the individual, and give to his countenance the peculiar exsanguineous aspect. The great Copernicus bled to death from this disease. The treatment consists in removing the cause, which, when constipation, by mild laxatives, and in laying them open with a lancet or bistoury, or applying leeches to them, and afterwards by fomentations or poultices. After the inflammation has been subdued, by the application of the ointment of gall nuts, or a decoction of oak bark. When piles are lanced, care should be taken that hemorrhage does not flow internally in the rectum, for patients have thus bled to death. Sponge is the best suppressor of bleeding in this part. When neither pregnancy nor diarrhœa is the exciting cause, an alterative course of mercury is beneficial; but the last mentioned disease must be checked by astringents. A rectum bougie or tallow candle is an excellent discutient, which should be inserted at bed time, and allowed to remain during the night, care being taken that it is properly fastened to a belt round the loins, and that the hemorrhoids are reduced within the anus. All kinds of constipating stimulant food ought to be abstained from, and the patient should avoid exercise, and sit on a hard chair. When piles are large and pendulous, they ought to be removed with the knife; ligatures should never be applied, as they have produced symptoms of strangulated hernia and tetanus.

Tubercles of the rectum frequently follow hemorrhoids or constipation, and consist of an indurated state of the solitary glands of this intestine; the mucous tunic being arranged into irregular hard folds, and the muscular subdivided by membranous septa, the whole wall of the gut being much thickened and hardened, and this condition of the rectum is seldom discovered before it has assumed the carcinomatous action. The patient is troubled with irregularity of his stomach and bowels, with vomiting, cholic, diarrhœa, and dysentery. The disease next forms a stricture, and often extends to the colon, when more than one of these constrictions is present; in this case, there is greater irregularity of the bowels, for the patient occasionally has no motion for days, which either passes in the form of an earth worm, or is liquid from medicine, and he experiences considerable pain and straining at stool. The tubercles next become malignant and ulcerate, when his sufferings are generally truly deplorable. There is a voracious appetite, a constant vomiting, and a burning pain in the stomach and over the whole abdomen, with lancinating burning pains of the rectum and anus; together with hectic fever, and an inclination to go to stool every moment. This ulceration of the rectum occasionally extends to the urinary bladder, forming a communication between them, when sometimes the fœces flow into the bladder, and at other periods the urine into the rectum, and on some occasions they flow promiscuously into each other; and towards the end of the flow of the urine, air gurgles along the urethra, producing a loud and unpleasant sound: on rare occasions there is little or no pain. In some cases, a total obstruction to the passage of the feces along the colon takes place, when this intestine acquires so prodigious a magnitude as to deceive us for ascites. In other cases, the ulceration is fungoid, bleeding and discharging a great quantity of pus at every evacuation of the feces, with little or no pain.

In the first stage of the disease, the patient should be confined to bed, take gentle laxatives, apply leeches within the anus, have laxative and opiate enemata administered with the warm hip bath once or twice a-day; and his diet should be purely farinaceous. And if by this treatment no amelioration is produced, and the diseased part can be reached by the knife, it should be extirpated, as lately done by Lisfranc. If the pain can be subdued, the rectum bougie ought to be used, and may be anointed with an ointment of opium, hyoscíamus, or hemlock: and where a short stricture exists, it ought to be divided in the four diagonal directions with the bistoury. Generally all kinds of external applications produce pain, even warm oil. If the patient can be removed to a warm climate, he ought instantly to go, and if not, the same soothing means must be continued until the disease either subsides or proves fatal. The compound powder of ipecacuan in small doses is an excellent anodyne in this disease.

Abscesses very often occur near the anus, in consequence of the loose delicate cellular and adipose tissues in this region, and when permitted to burst of their own accord, generally rupture with a small aperture, become fistulous, and occasionally burrow towards the rectum, and even form a communication with it. They arise from constipation and hemorrhoids; also from fish bones, &c. which have been swallowed and arrested in the rectum; from bougies breaking, pieces of wood, and other foreign bodies slipping up the rectum. For the treatment of this, the reader is referred to acute abscess. When this becomes fistulous, the disease is termed a blind external fistula in ano, and should be freely laid open with the curved sharp-pointed bistoury, having a button of wax upon it, and afterwards treated as directed under acute abscess. All fistulous tubes are more or less callous. Sometimes this fistula burrows along the rectum for a considerable extent, having many digressions in its course in the natis, so that considerable difficulty is occasionally experienced in arriving at its source; and when the surgeon has inserted the bistoury into what he conceives the root of the fistula, and pushed the instrument through the walls of the rectum, and cut outwards so as to make them one tube, he has probably by no means reached the termination of the fistula. In such cases, the daily insertion of sponge tent, making it larger at each introduction, will so expand the sinus or fistula, as to enable the operator to explore all its circuitous routes. If the matter runs into the rectum, and there is no external aperture, the affection is named a blind internal fistula, a variety which seldom or ever exists, but when it does, ought to be laid freely open.

When the fistulous tube opens both externally and into the rectum, which is the most common variety, it is styled complete fistula in ano, and is ascertained by inserting a probe into the fistula while the fore-finger of the left hand is in the rectum. It is treated by inserting a probe-pointed bistoury into the fistula onwards into the rectum, and cutting freely downwards and outwards, so as to convert the fistula and rectum into one tube. The after treatment ought to be the same as described under acute abscess. The patient, after having motion in his bowels, should be careful to wash the surface clean with tepid water or a syringe. When fistula in ano occurs in a phthysical constitution, it is a question whether or not it should be cured, because it acts as a counter-irritant, or on the principle of counter revulsion, according to the doctrine of the ancients. Ligatures are used in France, but never in this country.

Prolapsus ani consists in an eversion of the rectum, consequent either on relaxation or irritation, and occurs in children affected with ascarides or calculus in the urinary bladder, in adults from gestation, hemorrhoids, constipation, dysentery, diarrhœa, and drastic purges; and in old people more frequently than in those of the meridian of life. On some rare occasions, the prolapsed gut has become gangrenous and sloughed off. The prolapsus is to be returned by making the patient stand on his feet, with his head dependant or resting on a chair, and then taking a piece of fine soft linen, and pushing gently and gradually. When reduced, a recurrence is to be prevented by remaining in bed for some time, or wearing a steel spring, delineated in Fig. 7 of plate DXV. by removing the cause if possible, and by injecting a strong decoction of oak bark. Sometimes it is necessary to foment the gut with warm water, or even to scarify or leech it before attempting reduction. Sponge has been inserted in the anus to prevent a recurrence, and pessaries have been worn; and the late Mr. Hey, Langenbeck, and Dupuytren, treat it by raising with the forceps or a ligature the skin around the anus, and removing this with curved scissors. A circular portion of the mucous tunic of the intestine has been also removed.

Imperforate anus is a congenital malformation, and hence all children should be carefully examined when born. Sometimes the rectum is perfect onwards to the integuments which are entire, and have a raphe and every indication of a perfect anus; at other times, there is a distinct external aperture or anus, but the rectum is closed by a *cul-de-sac* a little within or centrad; at others again there is no external aperture, but a communication with the vagina in the female, and with the urethra or urinary bladder in the male. In the female, the aperture of communication is occasionally exceedingly small, while in others it is tolerably large; in the male, the rectum commonly ceases at the promontory of the sacrum, where it forms a puckered purse-like pouch, which either communicates with the bladder by a valvular opening, or descends in a small tubular form, adhering to the bladder, and enters the membranous portion of the urethra in the same valvular manner. The last variety occurs where there is no communication with the bladder or urethra in the male, or with the uterus or vagina in the female, and no external aperture.

In the first of these cases, where the rectum is close to the integuments, a simple incision with a scalpel, will allow the meconium to be evacuated; but care should be taken that the bougie or wax candle is inserted daily until all tendency to contract is removed. Some authors recommend that this operation should be done between twenty-four and sixty hours after birth, but in our opinion the sooner nature is relieved the better, as respiration is much impeded until the evacuation of the meconium takes place, and inflammation not unfrequently ensues from delay, which is to be subdued by a leech or two applied to the hypogastric region and the warm bath, together with castor oil. Before making an incision in such cases, the skin should be titillated, which causes the child to make efforts to evacuate the feces, and produces a protrusion where the anus is to be made. A trocar and canula is recommended to be used for perforating the integuments and even the rectum in the other cases, but it is a dangerous instrument. Instead of the bougie or candle, sponge and sponge tent are used by some, but these, since they excite ulceration, ought not to be employed.

In the second variety, or where there is an anus, but the rectum has formed a *cul-de-sac*, the latter is to be opened with a narrow shaped scalpel. In that variety occurring in the female, where there is a communication with the vagina, characterized by the meconium discharged by this passage and in that of the male where it takes place with the urinary bladder or urethra, the meconium is discharged mixed with the urine; and in the last variety where none of these characters exist, the operator must divide the integuments with a narrow-shaped scalpel perpendicularly to the extent of an inch or so, sufficient to admit his forefinger where an anus should be, and which is generally distinguished by some puckering or indentation of the skin. He must next dissect carefully along the concave aspect of the os sacrum, leaving it sufficiently clothed with cellular substance, until he feels a small distended pouch, which he may rest assured is the rectum filled with feces, and forced down by the action of the diaphragm and abdominal muscles; this he is to puncture with the same scalpel, and not with a trocar and canula, when the meconium will flow by the side of his finger. After this operation, a tea spoonful of castor oil should be given, and the child immersed in a warm bath, and if there appear the slightest enteritic or peritoneal inflammation, one or more leeches must be applied to the hypogastric region. The after treatment is the same in this as in the first variety. Mr. Burns directs us, if no rectum can be found, to open the sigmoid flexure of the colon, and Mr. C. Hutchinson the caput cæcum coli; but neither we apprehend will ever be required, and of the two we should prefer the former, which we may observe has been done. Callissen recommends the colon to be opened in the dorsal region near the left quadratus lumborum muscle, while Mr. Burns more judiciously between the anterior and posterior superior spinous processes of the left os ilium; the gut to be opened where it is uncovered by the peritoneum, a direction difficult to be fulfilled, as it is loosely bound down by the mesocolon. In the Revue Medicale for December 1823, there is an extraordinary case detailed of a man who arrived at the age of seventy years and who was born with an imperforate anus and urethra, and who vomited his excrements during all that time. He was alive five years ago.

ERRATA.

Page 536, first column, for Plate CXVI read Plate CXVII.
" 547, first column, for Plate CXVIII, read Plate CXV.
" 555, second column, for Fig. 22 read Fig. 21, in two places.
" 568, second column, for Fig. 25 read Fig. 24, in two places.
" 579, second column, for Fig. 22 read Fig. 21.
" 583, second column, for Fig. 24 read Fig. 23.

DESCRIPTION OF THE PLATES.

PLATE DXV.

Fig. 1. Scarificator, consisting of a brass box of twelve lancets, six of which move on two rollers in opposite directions through the medium of a lever *b*. When the lancets are moved round and hid, they are said to be set; and when applied to the skin, they are fired off by compressing the spring *c*. See page 527.

Fig. 2. A common bistoury five inches long in the blade, the point of which is double edged for a short distance. See page 535.

Fig. 3. A moxa-holder or *port-feu*. See page 531.

Fig. 4. An eighteen-tailed bandage, which may consist either of calico or flannel; *a*, is a longitudinal piece to which the other cross ones *b*, are stitched. See page 530.

Fig. 5. An aneurismal needle. See page 546.

Fig. 6. M'Intyre's fracture-splint improved by Mr. James Fortune. *a*, a joint between the thigh board *b*, and the leg board *c*, moved by a screw, so as to alter the angle at pleasure. *d*, a screw attached to the board *e*, in order to lengthen it. *f*, a foot-board moved by the screw *g*. See page 550.

Fig. 7. Bandage for prolapsus ani. &c. *a*, the belt which surrounds the loins; *b*, the pad which supports the protrusion. See page 596.

Fig. 8. A male catheter, to draw off the urine. See page 586.

Fig. 9. A trocar and canula employed in dropsy. *a*, the trocar, *b*, the canula. See page 581.

Fig. 10. A female catheter. See page 587.

Fig. 11. A trocar and canula for puncturing the urinary bladder. *a*, the trocar, *b*, the canula. See page 587.

Fig. 12. The stomach-pump. *a*, the tube inserted in the stomach; *b*, the syringe; *c*, the gag; *d*, a tube to carry the fluid into a basin. See page 582.

Fig. 13. Transfusion apparatus. *a*, a cup to receive the blood from a person in health; *b*, a tube which conducts it to the syringe *c*; *d*, a tube which conducts the blood from syringe *c*, to silver pipe *e*, that is inserted in vein of expiring patient. See page 595.

Fig. 14. Forceps to extract calculi from the urinary bladder. *a*, a silver canula; *b b b*, three prongs capable of being opened or shut by the spring *c*, together with the handle of the instrument. See page 590.

Fig. 15. A two-pronged forceps for the same purpose as Fig. 14. See page 590.

Fig. 16. Civiale's lithontripter, that consists of a canula *a*, in which is concealed a three-pronged forceps *b b b*, together with a drill *c*. The drill and forceps are represented in Fig. 24, concealed as they are introduced along the urethra; while in Fig. 16, they are expanded as if in the urinary bladder. The instrument is held firm by an assistant, and the operator, by means of the handle *d*, while the latter works the drill *c*, by a common drill-bow having the catgut string round the wheel *e*. See page 590.

Fig. 17. A trephine. *a*, the crown or saw. *b*, the centre-pin which is extended or retracted by means of the button *c*. See page 564.

Fig. 18. An elevator used when trepanning the skull. See page 564.

Fig. 19. Hey's saw, employed in depressed cranium. See page 566.

Fig. 20. Cataract knife. See page 572.

Fig. 21. Dissecting forceps. See page 546.

Fig. 22. Cataract needle. See page 569.

Fig. 23. Bladder, with stop-cock for hydrocele. See page 593.

Fig. 24. See Fig. 16. and page 590.

PLATE DXVI.

Fig. 1. Liston's forceps.

Fig. 2. Amputating knife. See page 561.

PLATE DXVII.

INDEX.

SURINAM, one of the provinces of Dutch Guiana, which derives its name from a river of the same name in which the capital Paramaribo stands, at the distance of 18 miles from its mouth. It is bounded on the north by the Atlantic, on the east by the Marawina or Maroni, on the south by an Indian territory, and part of French Guiana, and on the west by the river Corentyn. Its extent is about 150 miles from west to east, and 60 from north to south. The chief rivers are the Surinam, the Corentyn, the Copename, the Seramica and the Marawina. These rivers are generally from two to four miles broad, and are very shallow and rocky, with numerous waterfalls. The water rises and falls about 60 miles from the mouth of the river.

The climate of Surinam is now greatly improved in consequence of the clearing of the ground and the diminution of the swamp. The thermometer ranges between 70° and 84°, and the year is divided into two dry and two wet seasons. The first wet season is from the middle of April to August, the long dry season continues from August to November. The second wet season occurs in December and January, and the second dry season in February and March. The great rains fall in the middle of June.

The banks of the creeks or rivulets, which are both large and numerous, are cultivated by Europeans, with coffee, sugar, cocoa, and indigo plantations, which present a delightful picture to those travelling by water. In the time of Capt. Stedman there were about 700 plantations producing annually more than a million sterling. He computed the number of slaves at 75,000, and the annual supply at 2500. Paramaribo, the capital, contains about 5000 souls, of whom about 1800 were whites. A full account of the Natural History of Surinam will be found in our article GUIANA, Vol. X. p. 144.

SURREY, one of the inland counties of England, is bounded on the south by Sussex, on the east by Kent, on the west by Berkshire and Hampshire, and on the north by Middlesex and part of Buckinghamshire, from which it is separated by the Thames. It is about 37 miles long from east to west, and its breadth from north to south is 25 miles. It is divided into 13 hundreds (with the boroughs of Southwark and Guildford) which contain 14 market towns and 146 parishes, in the diocese of Winchester. It contains 758 square statute miles, or about 485,120 statute acres. The annual rental is L.369,901, and the amount of tithe L.47,320. In 1806 it paid L.3,646,783 of property tax, and in 1803, L.179,005 of poors rate, at the average of 5s. 8d. in the pound. The county pays 18 parts of the land tax, and returns 14 members to Parliament, viz., 2 from Southwark, 2 from Bletchingley, 2 from Gatton, 2 from Reygate, 2 from Guildford, 2 from Haslemere, and 2 from the county. The elections are held at Guildford and the assizes once a year. The other assizes are at

Kingston and Croydon alternately. The gaol is in Southwark.

The principal river in Surrey is the Thames. The Wey is the only other navigable river, barges going above Guildford into the Basingstoke Canal, which was finished in 1796. The Mole disappears in dry weather by absorption at Boxhill, and rises again in a strong spring at the bridge of Thorncroft, where the current continues constant. Its banks are beautiful all the way to Esher. It flows into the Thames opposite to Hampton Court. The Wandle, which runs into the Thames a little below Wandsworth, though it has only a course of 10 miles, yet it turns nearly 40 mills, and employs about 40,000 people. The Medway only has its origin in Surrey. The Loddon supplies the Basingstoke Canal, and there is a nameless stream rising in the town of Ewell, which supplies several gunpowder mills at Ewell and Maldon, and a large cornmill at Kingston, where it joins the Thames. The canals are the Basingstoke, the Croydon, and the Surrey Canal, already fully described in our article NAVIGATION INLAND, Vol. XIV. p. 280.

The surface of this county is generally undulating, and presents a great diversity of scenery. The northern part of the county is most beautiful, and covered with villas. The central part is a range of chalk hills, interspersed with dry arable fields. The southern part is a flat clayey country, containing the finest oaks in Britain. The north-west district is covered with black and barren heath, and on the south-west near Farnham, we meet with the most productive land in England.

The soils of Surrey may be divided into clay, loam and chalk. The Weold of Surrey in the south, about 30 miles by 4, is a pale, cold, retentive clay. Farther north it is chiefly loam across the whole county, and near Godalming, it has great depth reposing on an iron-veined sandstone. The chalky downs now begin, and have a breadth of about seven miles. Besides the crops common to other counties, there is a great deal of clover and sainfoin cultivated on the hills, and wood is also raised in the same districts to a great extent. Plants for druggists and perfumers are extensively cultivated near London on about 350 acres, and superior hops are raised near Farnham. The waste lands occupy 73,000 acres.

The principal useful minerals are fullers' earth, which has been dug for 60 or 70 years; there are two kinds, the blue and the yellow, the last of which is the finest. Excellent freestone is extensively wrought near Godstone. When first taken from the quarry it can scarcely bear damp, but when kept for a few months under cover, it resists the heat of a common fire, and is in great demand in London and elsewhere for fire-places. Limestone is abundant, especially near Dorking, and it and chalk are made into lime on a great scale for the metropolis. The sand of Dorking and Ryegate is in great request for hour-glasses and for the manufacture of glass. Iron ore was formerly wrought at Haslemere, Dunsfold and Cranley, in the south-west of the county, and about Lingfield and Horne in the south-east; but from the high price of fuel the works have been abandoned as unprofitable.

Surrey has no particular breed of cattle. It supports about 600 cows for the supply of London with milk, which are chiefly of the short-horned or Holderness breed. Cows of the Staffordshire breed are common and highly esteemed. The cattle on the heights are poor looking, but have a fine bone. They resemble the ordinary long-horned. The horses generally employed are usually large, heavy, and black. Great numbers of sheep are bred in the central and western districts. The most common are the South Downs, Wiltshire and Dorsetshire. Great numbers of hogs are fattened at the distilleries and starch manufactories. House lamb-suckling is a great object with the farmers. In the Weold, geese are reared in great numbers on the commons. The Dorking fowls, which are large, handsome, and perfectly white, with five claws on each foot, are well known. There is a rabbit warren of about 30 acres near Banstead Downs, where 200 pair are kept. It is surrounded with a brick wall ten feet high, with openings at regular distances, within which are wire gratings or hinges. These give way to the hares when they enter, but prevent their egress. In summer they are fed on clover, rye, &c. and in winter on hay.

The manufactures of Surrey are numerous and extensive, but the most important belong to London. (See our article LONDON, Vol. XII. p. 208.) On the banks of the Wandle are large establishments for bleaching and calico printing. At Beddington there are large flour mills, skinning mills, calico-printing works and bleaching greens. At Carshalton the same business is carried on, with the addition of a large cotton factory, paper mills, and several snuff and oil mills; and Mitcham and Morton are celebrated for their extensive calico and bleaching establishments. The principal objects of manufacture are starch, tobacco, snuff, gunpowder, paper, vinegar, leather, earthenware, wax, and hats.

Among the antiquities in this county are the Ermine Street, a Roman road passing through Clapham, Epsom, Dorking, and Farnham. Stane Street Causeway, a branch of Ermine Street, begins at Dorking, and may be traced through Ockley to Sussex. Another military way has been traced through Stretham, Croydon, and Godstone, to Sussex. Vestiges of Roman camps occur at Bottlehill and Waltonhill, on the Thames. The remains of a Roman temple, surrounded with embankments, occur on Blackheath, in the parish of Oldbury. There appear to have been Roman stations at Kingston and at Woodcote, near Croydon, the last of which, Camden and Horsley consider to be the *Noviomagus* of Ptolemy.

The following was the population of the county in 1821.

Number of houses, .	64,790
Number of families, .	83,806
Number in trade,	46,811
Total population,	398,658

The population of the principal towns is as follows:

Southwark, six parishes,	85,905
Croydon town and parish,	9,254
Richmond town and parish,	5,994
Kingston town and part of parish,	4,900
Chertsey town and parish,	4,279
Godalming town and parish,	4,098
Dorking town and parish,	3,812
Guildford, borough of,	3,161
Farnham town and parish,	3,132
Ryegate borough,	1,328
Bletchingley, borough of,	1,287

See the *Beauties of England and Wales*, vol. xiv. Stevenson's *View of the Agriculture of Surrey*, Manning and Bray's *History of Surrey*, and Salmon's *Antiquities of Surrey*. See article LONDON, Vol. XII. p. 208.

SURRY, county of, Virginia, bounded E. and SE. by Isle of Wight county; by Southampton S.; Blackwater river separating it from Sussex SW.; Prince George's county W.; and James river separating it from Charles City county NW.; and James City county NE. and E. Surry county of Virginia is nearly a square of 18 miles each way, with an area of 324 square miles. Extending in lat. from 36° 50′ to 37° 11′, and in long. from 0° 19′ E. to 0° 08′ W. from the meridian of Washington City.

The height of ground between the Chowan and James river basins, passes through and divides this county into two not very unequal portions. The northern declivity falls towards and is drained into James river, whilst the southern gives source to many creeks of Blackwater branch of Nottaway river, which water is finally discharged into Chowan river.

There are no villages or towns of consequence in this county; the court-house is situated rather to the eastward of the centre; and beside one there, in 1831 post-offices existed at Bacon Castle, Baileysburg and Cabin Point.

Surry Court-house and Post-office, Surry county, Virginia, is situated by post-road 60 miles SE. by E. from Richmond, and 183 miles a very little E. of S. from Washington City. Lat. 37° 09′ N., and long. 0° 10′ E. from the meridian of Washington City.

SURRY, county of, North Carolina, bounded by the northern part of Stokes county of the same state NE.; by Yadkin river separating it from the southern part of Stokes SE.; by Rowan S.; Pedell SW.; Wilkes W.; the Blue Ridge separating it from Ashe NW., and by Grayson and Patrick counties of Virginia N. Greatest length from S. to N. 33, mean width 22, and area 726 square miles. Extending from 36° 04′ to 36° 33′ N.: and in long. from 3° 26′ to 3° 58′ W. from the meridian of Washington City. By a local curve in its general direction, the Blue Ridge forms a boundary for Surry county, North Carolina, on the northwestern and northern borders, giving source to Toms, Ararat, and Fisher's creeks, which pour their fine mountain currents southwardly into Yadkin river. The latter, a navigable stream when issuing from the valley of Wilkes into Surry, crosses the latter in a direction a little north of east, dividing the county into two not very unequal portions, and again by a rapid bend turns to a little W. of S., and forming the southeastern limit, leaves Surry, and continues its southern course between Stokes and Rowan.

From the remarkable curve of Yadkin the southern section of Surry is enclosed on two sides by that stream, and the creeks flow like radii from a common centre, though all have the Yadkin as a recipient. Taken as a whole, the general declivity of Surry is eastward.

Beside at Rock Ford, the county seat, by the post office list of 1831, there were post offices at Hamptonville, Huntsville, Jonesville, Judsville, Kincannon Ironworks, Mount Airy, Panther Creek, and Scull Camp.

Rock Ford, the seat of justice, is situated near the centre of the county, on the left bank of Yadkin river, by the post road 151 miles NW. by W. from Raleigh, and 379 W. from Washington City.

The northern and northwestern sections of Surry are mountainous, but the features soften advancing to the southeastward down the beautiful valley of Yadkin. The soil is generally productive, and comprising air, water, and variety of surface, few if any other counties of the United States exceed Surry as affording a delightful residence to human society. The population of this county was 12,320 in 1820. DARBY.

SURVEYING is the art of measuring land, or of laying down or delineating the surface of a kingdom or any portion of the globe. In our article MENSURATION, Vol. XIII. p. 57. Sect. 1, the principles of land-surveying are laid down with sufficient clearness to enable any person to apply them in practice. The more important subject of measuring a base, and of carrying on large trigonometrical surveys, and of measuring a degree of the meridian, has been treated pretty fully in our article on PHYSICAL GEOGRAPHY. Vol. XV. p. 556. Our limits will not permit us to enter more fully upon any of these subjects.

SUSA and SUSIANA. See KUSISTAN, Vol. XI. p. 637.

SUSQUEHANNA, river of New York, Pennsylvania, and Maryland, having the basin of the Delaware E.; the valley of Potomac SW.; the valley of Ohio W.; the valley of Lake Ontario NW. and N.; and that of the Mohawk branch of Hudson NE.

If the correct principles of physical geography had been pursued in the nomenclature of the rivers of the United States, the name of Susquehanna would have been continued to the Atlantic Ocean, but custom has restricted the name to that part of the river above tide water, and confirmed the name of Chesapeake Bay to the common recipient of Patapsco, Patuxant, Potomac, Rappahannoc, York, and James rivers on the west; and Pocomoke, Nantikoke, Choptank, Chester, and other smaller streams on the east.

The great physical section, however, comprised in the real valley of Susquehanna, as the name is restricted, extends in lat. from 39° 33′ to 42° 55′ N.; and in long. from 2° 25′ E. to 1° 50′ W. from W. C., and embraces an area of 28,600 square miles. A small fraction of the extreme lower part of the valley, 350 square miles, is in Maryland; above N. lat. 42° the state of New York comprises of this valley 7600 square miles, drained by the two northern branches and their numerous confluents. But the main part of the valley, 20,650 square miles, lies within, and forms the central and upwards of four-tenths of the whole state of Pennsylvania.

The Susquehanna is formed by two main branches, called with some inconsistency the northern and western branches. The northern and principal branch rises in Otsego county of New York, by two confluents, the Unadilla and Chenango. As delineated on Tanner's United States, the creek which falls into the head of Otsego Lake has its remote source within five direct miles from the Mohawk, at the Little Falls, and is the highest northern fountain of Susquehanna. Other sources pour their tribute into the Unadilla or Susquehanna from the Catsbergs. Westward from the sources of Unadilla rise those of Chenango in Madison county. Both streams assume a southwestern course, and flow nearly parallel about 50 miles, where the Unadilla, now known as the Susquehanna, sweeps an extensive curve to the southward into and again out of Schuylkill county, Pennsylvania. Returned into Broome county, New York, this already navigable river is augmented by the reception of the Chenango at Binghampton. Thence first pursuing a western course of 20 miles to Oswego, inflects to SW. separating Broome from Tioga, re-enters Pennsylvania, and at the town of Athens on Tioga Point, receives another considerable branch of the Chemung or Tioga from the NW.

Before receiving the Tioga, the eastern branch of Susquehanna has drained an elliptic valley of 110 miles in its greatest length; 65 miles where widest, but having a mean width of 45 miles, or, area 4950 square miles, embracing in New York all the counties of Otsego and Chenango, with a large part of Delaware, Broome, Tioga, Courtlandt, and Madison; and in Pennsylvania the northern part of Schuylkill, and the northeastern of Bradford counties.

The Tioga or Chemung, the northwestern confluent of the north branch of Susquehanna, is composed of three minor branches, Tioga proper, Canisteo, and Conhocton.

The Tioga rises by numerous creeks in Tioga county, Pennsylvania, draining the northeastern half of that county, and after a general course northeastward unite on the boundary between Pennsylvania and New York. Entering Steuben county New York, and flowing N. about 10 miles. The Tioga joins the Canisteo from the west.

The Canisteo has its remote sources in Alleghany, but assumes the magnitude of a river in Steuben, near the village of Canisteo. Flowing over Steuben 35 miles to the SE. and uniting with Tioga as already stated, the united water turns to a little N. of E. and receives the Conhocton at Painted Post.

The Conhocton rises in the northeastern part of Livingston county, and affords the extreme northwestern fountains of Susquehanna. Similar to most other branches of that great river, the Conhocton becomes navigable within a few miles from its source, and at Arkport in Steuben turns to SE., and continuing in that direction 35 miles unites with Tioga, and known by the latter name continues on nearly the course of Conhocton 35 miles, to its final exit into the Susquehanna at Tioga Point.

The Tioga drains a valley of about 90 miles by 30 mean width, or 2700 square miles; comprising in New York all Steuben, and a part of Alleghany, Livingston, Yates, and Tioga counties; and in Pennsylvania a part of Potter, Tioga, and Bradford counties.

Combining the two sections of this northern section of the valley of Susquehanna, we have a physical section extending from the eastern sources of Unadilla to the western of Tioga, 180 miles, with a mean width of about 48, and area 8640 square miles, of which 1040 are in Pennsylvania.

The features of this region, and its lines of connection with the adjacent vallies, present some very interesting phenomena to the geographer and statesman. On the sides towards the Schoharie and Mohawk, where the Catsbergs and other elongations of the Apalachian chains form the dividing ground between the Susquehanna and Hudson vallies, there exists no intermediate gaps except at great comparative elevation. On the contrary, between the sources of Chenango and those which flow nothwards into the Ontario basin, deep vales extend from the respective sources through the intervening ridges. It is very difficult in many places to determine the point where the waters separate. The face of the country is hilly to an extent which gives a mountainous appearance, and yet the intermediate valleys are many of them broad and marshy. Very striking examples exist in Courtlandt and Madison counties. These deep traverse vallies are not, however, peculiar to the head sources of Chenango; one of the most remarkable amongst them extends from the Tioga at Elmira, to the head of Seneca Lake.

The mean water level at Tioga Point is 723 feet above the Atlantic Ocean; and from the Point to Newtown or Elmira on Tioga river the rise is 103 feet, giving to the water level at Newtown a comparative water level of 826 feet elevation. Though the hills are very high in the vicinity of Newtown, the natural valley stretching from the Tioga river northwards to the head of Seneca Lake, has a rise of only 59 feet above the former, though the declivity on the northern side towards the Seneca has a descent of 445 feet in 10 or 11 miles. The intermediate summit level is 885 feet above the surface of the ocean, and is the lowest gap through which a canal could be formed to connect the Atlantic and interior waters of the United States, from the valley of the Mohawk to Lower Georgia. A single glance on a map of this physical region, will serve to exhibit the singular natural facilities afforded to navigation, or to the creation of artificial water channels of intercommunication, by the depression of the vallies between them, and the approximation of the St. Lawrence lakes to the northern streams of the Susquehanna.

Though so far advanced towards as to be at the extreme eastern sources within 40 miles from tide water in Hudson river, the entire northern section of the Susquehanna valley is on the interior floetz or secondary formation, and has a discharge from this formation not from but directly into the Appalachian system.

A very erroneous opinion may be here noticed and corrected. The Appalachian system of mountains is commonly regarded as a dividing barrier between river source. This is so far from being the real state of nature, that the mountain chains have in no one place in the United States distinctly influenced the general course and recipient of any river: the bends, or the inflections of the streams if viewed on a large scale, appear to be either at right angles or parallel to the chains, and give to river physiognomy a family similarity which must greatly interest the attentive observer; but the system of mountains traverses the Atlantic and Mississippi plains obliquely. It is from such a physical structure of the continent that the Susquehanna is seen pouring down from an elevation above that of the base of the mountains, against which its various branches impinge; and that these branches have in the course of time torn passages through the river rocks, and their waters gradually uniting, at length reach the level of the Atlantic tides, and gradually mingle with the waters of the Atlantic Ocean. This contest between the apparently stable mountains, and the equally apparently fleeting rivers, which began, it is most probable, with the creation, is far from being terminated. It is a feature in physical geography in a high degree, not simply favorable to their actual construction, but to excite original conceptions of canals. The rivers have, during accumulated centuries, done that which man would without their aid never dared even the conception. The rivers rising beyond have fallen with steady and irresistible weight on the mountain sides, and torn them to their bases, and given to human beings, and the fruits of their labour, a free passage:—but we must return to our subject.

Below their junction at Tioga Point, the united water of Susquehanna and Tioga, flow a little S. of E. 15 miles, to the northwestern base of the Appalachian system below Towanda, the seat of justice for Bradford county Pennsylvania. The now large stream quits the secondary and enters on the transition or inclined rocks, and to an eye above the mountains seems to sink into their recesses; but without even a cataract the volume turns to southeast, and following that general course fifty miles, breaks through several chains, and finally at the mouth of Lackawannock river, nine miles above Wilkesbarre, enters the beautiful valley of Wyoming. Inflecting at right angles it now turns to the southwest and passing the villages or towns of Pittstown, Wyoming, Wilkesbarre, Berwick, Mifflinsburg, Cattawissa, and Danville, continues the latter course by comparative distance about seventy miles down the mountain vallies to the borough of Northumberland, and to the influx of the West Branch.

The West Branch is entirely a river of Pennsylvania, having its most remote southwestern fountains, and indeed the most western fountains of the whole valley of Susquehanna proper, in Cambria and Indiana counties. These fountains rise within thirty-five miles from the Alleghany river, at Kittanning, and produce streams which unite in Clearfield, and after a comparative course of seventy-five miles to the northeastward, enter Lycoming, and receiving a large accession by the influx of the Sinnamahoning, from the northwestward, and from Clearfield, McKean, and Potter counties. Now a navigable river, the West Branch continues N. E. 20, and thence turns to S. E. 25 miles, to the influx of Bald Eagle river from the southwestward and from Centre county. Below the mouth of Bald Eagle, the course is a little north of east thirty-five miles to Pennsborough, having passed Dunnstown and Williamsport, and having received in the intermediate distance, and from the northward, Pine, Lycoming, Loyalsock and Muncy creeks. Below Pennsborough, with partial winding and an elliptic course to the westward, the general course is nearly due S. twenty-five miles to the junction of the two main branches at Northumberland, passing the villages of Watsonburg, Milton and Lewisburg.

The valley of the West Branch lies between lat. 40° 30′ and 41° 45′ N. and between longitudes 0° 33′ and 1° 50′ W. from Washington City; and if the extent is taken from the eastern source of Loyalsock, to the extreme west fountains in Indiana, the length is 140 miles. The mean width at least 50 miles, and area 7000 square miles, comprising all the counties of Lycoming, Clearfield and Centre, with very little exception on the borders of the two latter; and part of Tioga, Potter, McKean, Indiana and Cambria.

The now large and wide volume of the Susquehanna assumes a course of a little W. of S. forty miles to the great bend at the northwestern base of Kittatinny, having passed the towns of Sunbury, Selinsgrove, Georgetown, Millerstown, Halifax, and Petersburg; and received from the eastward, Shamokin, Mahanoy, Mahantango, Wicomisco, and other small rivers or creeks; and from the westward, Penn's creek, Middle creek, Shareman's creek, and the Juniata river.

Juniata, which deserves the title of the Southwest Branch of Susquehanna, rises by its most remote southwestern source on the border of Somerset, but entering and traversing Bedford county in an easterly direction, passing the borough of Bedford and the village of Bloodyrun, and rapidly augmented by numerous mountain streams, it thence abruptly bends to the northward inclining a little eastward, forty miles to the influx of Frankstown branch, a small distance below the borough of Huntingdon, in Huntingdon county. The general course of Frankstown branch is from the northwest to southeast; and below their junction the united stream follows that course fifteen miles, breaking through Jack's mountain. Again inflected to the northeast, the Juniata leaves Huntingdon and enters Mifflin county, and pursuing that direction near thirty miles, passes the borough of Lewistown, and again winding to southeast, breaks through Shade mountain into Tuscarora valley; crossing that valley in a course of ten miles reaches the northwest base of Tuscarora mountain, down which it flows northeast ten miles, where, near Millerstown, it passes the latter mountain, and once more turning to the southeast, enters on Perry county, over which it flows fifteen, to its final influx into the Susquehanna above the village of Petersburg.

In all its parts, Juniata is a real mountain stream. The current rapid, though the channels have no direct falls of any great consequence; the beds are deep, embosomed in the mountain vales, and rocky. The whole valley comprises an area of about 2750 square miles. The sources of both branches are in the slopes of the Alleghany mountain, at an elevation of upwards of two thousand feet above the ocean tides. The descent near the sources is very rapid. The general level of the farms of Bedford and Huntingdon may vary from nine to twelve hundred feet above the ocean; and that of Frankstown branch at Frankstown 910 feet. In lat. this minor valley extends from 39° 50′ to 40° 50′, and the channel of the main stream has gained great importance amongst the commercial channels of the United States, by affording a passage for the Pennsylvania canal through five considerable chains of mountains.

Augmented by the last of its large tributaries, the Susquehanna pierces Kittatinny mountain, inflects to the southeastward, and maintains that course eighty miles, receiving from the right Conedogwinet, Yellow Breeches, Conewago, Codorus, and Deer creeks; and from the left Swatara, Conestoga, Pequea, and Octoraro, with numerous smaller streams, is finally itself mingled with the water of Chesapeake bay, after falling over the lower primitive ledge of the Apalachian system; having in the latter courses passed Harrisburg, Middletown, Columbia, and Havre de Grace.

Including all its higher branches the Susquehanna is peculiar in the structure of its vallies. Wide and often highly productive bottoms of two, and sometimes three stages of relative elevation, spread along the convex side of its bends, whilst hills, or more frequently mountains, of more or less elevation, rise along both sides of these spreading vales. Exuberant fertility is, at a single step, followed by rocky and sterile steeps. The natural timber of the bottoms in most species different from that of the hills and mountains. On the former, sugar maple, black walnut, elm, beech, *leucodendron tulipifera*, white walnut, and other trees indicative of a fertile soil abound; on the slopes of the mountains pine, oak, and chesnut, and above Wyoming valley inclusive, hemlock, are the prevalent trees. As a navigable stream, or streams, if all the confluents are taken into view, independent of artificial improvement, the Susquehanna is much less interrupted by rapids, or dangerous shoals, than could be expected from the tortuous channels through an extensive mountain system. It is also perhaps peculiarly remarkable, that in the reaches where the various branches of this river traverse the respective chains, rapids but seldom, and direct falls no where exist.

Until recently the advantages of Susquehanna valley, as affording canal improvements, was theory, but the people of Pennsylvania, on their own resources, and by the authority of the legislature of the state, have commenced and considerably advanced in the execution of a system of canal, lock, and rail-road improvement. The Pennsylvania Canal has three divisions in whole or in part within the valley of Susquehanna.

Transverse division of the Pennsylvania canal has its commencement at Columbia, on the east bank of the Susquehanna and in Lancaster county. It thence ascends that great river along the east bank, intersects the Union Canal at Middletown, near the mouth of Swatara, and continuing along the same side to Duncan's Island, at the mouth of Juniata river. There crossing the Susquehanna, and following the valley of Juniata to the junction of the two main branches below the borough of Huntingdon, and thence along Frankstown branch to its termination at Frankstown.

Besides many places of lesser note, this canal passes through Middletown, Harrisburg, Lewistown, and Huntingdon.

Another section of the same system of canals is to ascend the Susquehanna, from Duncan's Island, opposite the mouth of Juniata, to the New-York line above Tioga Point; length, 204 miles; rising, 423 feet.

The West Branch section commences at the borough of Northumberland, and following the left or northern side of the West Branch river, 70 miles by a rise of 109 feet, to Dunnstown, passing by, or through Milton, Pennsborough, Williamsport and Jersey Shore.

It may be doubted whether the execution of any other line of canal of equal extent in the United States, would produce so great and permanent revolution on inland trade as would a line of navigable canals from the mineral districts on Susquehanna, into the western part of the state of New-York.

If the valley of the Susquehanna offered no other resource but the vast strata of anthracite coal in the valley of Wyoming, a line of canals in both directions would be fully sustained; but it may be questioned, whether the value of the strata of iron ore, on the waters of Juniata, do not exceed that of mineral coal, and both combined present a fund to reward enterprize, which seems to have surface without a discoverable base. In brief, whether we regard it as a physical section of the earth, or as a political and commercial link in the chain of connexion between different portions of the United States, the valley of Susquehanna deserves profound attention from the philosopher, geographer, and statesman. Darby.

SUSQUEHANNA, county of Pennsylvania, bounded on the E. by Wayne county, of the same state, S. by Luzerne, W. by Bradford, and N. by Broome county of the state of New York. Greatest length from east to west, 35, width, 26, and area, 875 square miles. This county extends in lat. from 41° 40′ to 42′ N. and in long. from 0° 50′ to 1° 32′ E. from the meridian of Washington City.

This county occupies a curious physical section. The main volume of the Unadilla, or eastern constituent of Susquehanna, curving with the Coquaso branch of Delaware, sweeps to the east of south from Broome county, of New-York, into Susquehanna county, of Pennsylvania. In the latter, the stream is turned by one of the low ridges of the Appalachian system, and bending at more than a right angle, follows northward by comparative courses about ten miles, and again enters Broome county, but gradually winding in an elliptic curve, the Susquehanna, after a comparative course of upwards of eighty miles in Broome and Otsego counties, of New York, and Bradford of Pennsylvania, approaches the SW. angle of the Schuylkill to within one mile.

It is evident from such relative position that Schuylkill county occupies a plateau, or table land. The surface is very broken by hills, and towards the eastern and southeastern sides by mountains. The central part is elevated, and the watercourses having their sources on these high vallies, flow rapidly in deep channels, and diverge like radii from a common centre.

The southeastern angle is in the valley between the Lackawannoc and Tunkhannoc mountains, and gives source to the Lackawaxen branch of Delaware, and the Lackawannoc of Luzerne county, entering the Susquehanna in the valley of Wyoming. The sources of the two latter streams are separated from those of the Tunkhannoc by Tunkhannoc mountain.

Tunkhannoc rises in Schuylkill, and within four miles from the Susquehanna at the Great Bend in the northern part of the county, but flows SW. over Schuylkill county, and entering Luzerne falls into the main volume of the Susquehanna, if the general curve is only regarded, about one hundred miles below the Great Bend. Westward again from the Tunkhannoc, rise and flow southwestwardly into Susquehanna, the Misshopper and some smaller creeks. The western part of the county is chiefly drained by the higher creeks of the Wyabyssing. The latter rises near Montrose, and near the centre of the county, and flowing to the westward enters Bradford and there bends to the south of SW. and falls into the Susquehanna nearly opposite the Wyabissing hills.

To the water courses already noticed as having their origin in Schuylkill county and flowing to the south and west, are opposed another series of creeks flowing northward also into Susquehanna, but into the eastern branch. Advancing from east to west, the latter creeks are in order, Starucoa, Conewanta, Salt Lick, Snake, Choconut, and Apollocan.

Taken as a whole this really fine county and physical section is divided by nature into two unequal declivities, the larger falling southward towards the main colume of Susquehanna, and the other in an opposite direction towards the eastern branch.

The soil of this county is generally good. Sugar maple abounds in the vallies and on the slopes of the hills. If any particular species of timber prevails in quantity, it is the hemlock, which here grows in abundance and to an enormous size. Oak, hickory, beach, ash, &c. are plentiful.

The rapid increase of population shows the value of the soil of Schuylkill county. In 1820 the inhabitants amounted to 9960, and in 1830, to 16,677, or at a rate exceeding 67 per cent increase.

By the post list of 1831, beside at Montrose, the seat of justice, there were in this county twenty-two post offices, namely at Birchardsville, Brooklyn, Choconut, Dimocksville, Dundoff, Ellerslice, Fairdale, Friendsville, Gibson, Great Bend, Harewood, Harford, Jackson, Lanesborough, Lawsville, Lawsville Centre, Lenox, New Milford, Rushville, Silver Lake, Springville and Springville Four Corners.

Montrose, the county town, is situated near the centre of the county, and on one of the higher sources of Wyabussing creek, by post road, 49 miles N. from Wilkesbarré; 163 NNE. from Harrisburg, and by the route of Wilkesbarré, 150 miles NNW. from Philadelphia. It is a very neat village, situated on an elevated and pleasant site, and, with several handsome private buildings, contains the usual edifices belonging to a county seat. DARBY.

SUSSEX, a southern and maritime county of England, bounded on the north by Kent and Surrey, on the east by Kent, on the south by the British Channel, and on the west by Hampshire. Its figure is that of an oblong, about 70 miles in length from east to west, and its utmost breadth from north to south 26 miles. It contains 1463 square miles. Its rental is L.549,950, and the amount of tithe L.100,498, the annual value of a square mile being L.445. In 1806 it paid L.1, 436,563 of property tax, and in 1803, L.206,591 poor's rates, at the average of 8s. 7½d. in the pound. It pays sixteen parts of the land-tax. It is divided into six portions or rapes, in nearly equal parts from north to south, which are subdivided into 65 hundreds, and contain 313 parishes. The county is within the diocese of Chichester, and the province of Canterbury. It is now included in the Home Circuit.

The general appearance of the country is rich and fertile. It is thickly clothed with the finest wood, which is computed to occupy an extent of not less than 170,000 acres. Formerly the whole northern part of the county was one continued forest, and it still contains some of the finest oaks in the kingdom, which are in great demand for the use of the navy. The soil in most places consists of a stiff deep clay, with the usual variations of sand, loam, gravel, and chalk; of the latter substance, there is a whole range of hills called the South Downs, which run in a direction parallel to the coast, and on which immense flocks of sheep are pastured. In the small vallies that intersect these hills, large crops of grain are raised. Near the coast there is some very fine pasture land, on which a considerable number of the valuable oxen of the county are fed, to supply the London market.

Sussex is by no means deficient in mineral productions, the principal of which is limestone, which is found in the eastern part of the district called the Weolds, in the greatest abundance and variety. It has been found to excel both that of Maidstone and Plymouth. There is also a very beautiful marble dug up in this country, called the Sussex and Petworth marble, which is capable of receiving a high polish, and is in great request for ornamental chimney-pieces. The stratum of this marble lies from ten to twenty feet beneath the surface, and is about nine or ten inches thick. The other minerals are ironstone, fuller's earth, red ochre, chalk, and marl.

The agriculture of the county, and the rotation of the crops varies with the difference of the soil. Fallowing is much resorted to in the stiff clay of the Weold, but is rarely to be met with in the district south of the Downs. The crops usually raised in Sussex, are wheat, oats, barley, clover, pease, and tares, turnips, potatoes and beans; and hops are also grown in considerable quantities. The cultivation of the hop is chiefly confined to the eastern part of the county, where it is practised on such an extensive scale as to require almost all the manure of the farm, the necessary consequence of which is, that the crops of wheat and other grain are comparatively small. In the western part of Sussex, there are some large and valuable orchards, which, when the soil is adapted to the fruit, yield a considerable produce. The best cider in the county is made near Petworth.

Sussex has been long celebrated for the excellence of its breed of cattle, which is universally acknowledged to be inferior to none in the kingdom. The distinguishing marks of a thoroughbred Sussex cow, are a deep red colour, fine hair, a small head, and clear and transparent horns, running out horizontally, and turning up at the point. However superior the quality of their flesh may be, the quantity of milk yielded by the cows, is by no means equal to that of many other breeds; in consequence of which there are few dairies to be met with, and the cattle are reared chiefly for the sake of the meat, which is of the very best quality. The oxen are much used in ploughing, in which employment they generally continue for three or four years before they are fed for the butcher. They are, however, worked very moderately, in order that their growth may not be affected, the usual number attached to a plough on ordinary soils being eight, but on a stiff soil ten and sometimes twelve. The sheep are of the well known South-Down breed, (so called from the hills of that name on which they are pastured,) which, as well as the cattle, peculiarly belongs to Sussex. They have now, however, in a greater or less degree extended themselves over most parts of the kingdom. They have black faces and legs, and no horns. Their flesh is excellent; and their wool is in every respect equal to that of Hereford. They are likewise a hardy breed, able to bear the severest storms, and requiring but a small quantity of food for their sustenance.

At present there is nothing in Sussex that deserves the name of a manufacture. There were formerly several establishments in the Weold for making iron into bars, which gave employment to a considerable number of persons. But they have been long disused, and removed to those districts where pit coal abounds, such as Scotland and Wales, where it is made at a much cheaper rate. The only other employment in which the population are engaged, besides agriculture, is that of fishing, which, in the summer season, and especially when the mackerel appear, is very productive.

The rivers of Sussex are few, and of no great importance when compared with those of most other districts in the kingdom. But their origin and courses are confined within the limits of the county. The principal are the Arun, Adur, Ouse, Lavant, and Rother, the two first of which are navigable a few miles from their mouth. The Rother forms Rye harbour, and separates the county from Kent. There is only one canal in Sussex, which joins the towns of Petworth and Midhurst with the Arun.

Sussex contains many Roman and Saxon antiquities. There are still some remains of the Stane Street road, which ran from east to west of the county, and there are several ancient camps to be seen in the vicinity of the Downs. The most remarkable of the Saxon remains are Pevensey Castle, Arundel Castle, and Battle Abbey. The others of less note are Eridge Castle, Bodeham Castle, and Bayham Abbey. In 1717 a tesselated pavement and bath were discovered near Eastbourne.

Sussex sends twenty members to parliament, two for the county, and two for each of the under-mentioned places, Chichester, Arundel, Horsham, Bramber, East Grinstead, Lewes, Shoreham, Midhurst, aud Steyning.

The following was the population of the county in 1821.

Number of Houses . .	36,283
Families	43,568
Ditto in trade	15,463
Total Population	233,019

The population of the principal towns in 1821, was as follows:

Brighton . . .	24,429
Chichester, city of . . .	7,362
Lewes, borough . . .	7,003
*Hastings, cinque port, and parishes	6,085
Horsham, borough and parish	4,575
Rye, cinque port, and parish	3,599
East Grinstead, borough and parish	3,153
Battle, town and parish	2,851
Arundel	2,511
Steyning, borough and parish	4,324
Seaford, cinque port, and parish	1,047

See the *Beauties of England and Wales*, vol. xiv. Young's *Agricultural Survey of Sussex*, and Russel's *Description of Kent and Sussex*.

* The town and port contains only 5,085 inhabitants.

SUSSEX, extreme northern county of New Jersey, bounded by Orange county of New York NE; Bergen of New Jersey E. SE. and S; Warren SW; and Delaware river separating it from Pike county, Pennsylvania, W. and NW. Length 25, mean width 18, and area, 450 square miles. Extending in lat. from 40° 54′ to 41° 22′, and in long. from 2° 3′ to 2° 40′ E. from the meridian of Washington City.

The features of Sussex county of New Jersey are in some respects not only curious, but peculiar. The county embraces a part of the valley between the Kittatinny and Blue Ridge chains, and in no part falls below an elevation of 800 feet above the surface of the Atlantic tides. On the side towards the Delaware river it is traversed by the continuation of the Kittatinny, and on the opposite side, is separated from Bergen and Morris counties by the Blue Ridge. The intermediate valley about 15 miles wide is a real table land, discharging southwestwardly towards the Delaware, Pequest and Pawlings creeks, and to the northwestward the sources of the Wallkill.

On the heads of the Wallkill, though elevated above eight hundred feet above tide water, spread marshy plains, having the aspect of the alluvial flats along the border of the Atlantic Ocean. The southeastern section on the heads of Pequest and Pawlings creeks, the country rises into hill and dale; and the transition from a comparative monotonous to a broken and diversified surface, is in no other part of the Appalachian system so rapid and striking.

The western borders between the Kittatinny and Delaware river, is a narrow slope or valley, from two to four miles wide, and extending the entire length of the county. Along this confined declivity flows the Flatkill, 17 or 18 miles between the mountains on the SE. and Delaware river NW. and seldom two miles from either.

The Morris canal touches, but only merely touches, the southeastern angle of Sussex. The summit level of this canal is at the place where it passes the Blue Ridge, 915 feet above the surface of the Atlantic Ocean.

The author of this article traversed Sussex in the latter part of September, and proceeded from Newburg on Hudson river, by Goshen, Newton, and by Somerville to the Delaware at New Hope, and had a fair opportunity of seeing the difference in the advance of the season at the different points. In Sussex early frost had destroyed tender vegetables on the high plains and vallies of Sussex, whilst no similar effect was perceptible on the Hudson, nor had frost yet occurred on the Delaware.

By the Post-Office list of 1831, there were post-offices in Sussex, at Andover, Augusta, Benville, Bevins, Branchville, Coursenville, Deckertown, Flat Brookville, Fredon, Gratitude, Greenville, Hamburgh, Lafayette, Lockwood, Monroe, Montague, *Newton*, Sandyston, Sparta, Stanhope, Stillwater, Vernon, Walpack, and Wartage.

Newton, the seat of justice, is situated on an elevated site and on the waters of Pawlings Kill or creek, 40 miles NE. from Easton, 60 miles NW. by W. from the city of New York, about a similar distance SW. from Newburg, and by post road, 70 miles very nearly due N. from Trenton, and 228 miles NE. from W. C. N. lat. 41° 3′, long. 2° 9′ E. from the meridian of Washington City.

The village is small, with the ordinary buildings for public use at a county seat. The adjacent country is diversified and pleasant to the eye.

When the census of 1820 was taken, Sussex county embraced the area now included in Warren, and of course, the aggregate population 32,752, was that of the superficies now constituting both counties. DARBY.

SUSSEX, the most southern county of the state of Delaware, in the United States, bounded on the N. by Kent county, Delaware; NE. by Delaware Bay; E. by the Atlantic Ocean; S. by Worcester county, Maryland; SW. by Somerset county, Maryland; W. by Dorchester county, Maryland, and NW. by Carolina county, Maryland. Greatest length from the Maryland line to the northern bend of Mispillion creek, 36 miles. The utmost breadth from west to east very nearly equals the length, but the area being about 910 square miles, the mean breadth will be 26 miles. This county lies between lat. 38° 27′, and 38° 58′ N.; and between long. 1° 14′ and 1° 58′ E. from W.C.

Though the surface of this county is level, and in part marshy, it is nevertheless a table land, from which flow southwardly the extreme sources of Pocomoke river; southwestwardly, those of Nantikoke river; eastwardly, Indian river, and other confluents of Rehoboth bay; and Broad Hill, Cedar, Mispillion, and some other creeks flowing northeastwardly into Delaware bay.

The surface being so nearly a plain admits of little variety. The soil, if taken generally, is of middling quality. Population in 1820, 24,057.

By the post office list of 1831, beside Georgetown, the county seat, there were post offices at Bridgeville, Cannon's Ferry, Concord, Dagsborough, Laurel, Lewis, Millsborough, Milton, and Seaford.

Georgetown, the seat of justice, is situated near the centre of the county, 40 miles a little E. of S. from Dover, the seat of government of the state of Delaware, and by post road, 122 miles a little S. of E. from Washington City. N. lat. 38° 40′, long. E. from W. C. 1° 39′.

Dagsborough is on Pepper Creek branch of Rehoboth bay, 14 miles SE. from Georgetown. Bridgetown is situated on a small branch of Nantikoke river, and in the northwestern part of the county.

Lewistown, or Lewis, is situated on the extreme southern arch of Delaware bay, W. from Cape Henlopen. The Delaware break-water has given additional importance to Sussex county as a part of the maritime coast of the United States.

SUSSEX, county of Virginia, bounded by Southampton, SE.; Greensville, SW.; Dinwiddie, W.; Prince George, NW.; Black Water river separating it from a part of Surry, N.; and by the southernmost angle of Surry, NE. The greatest length is a diagonal extending from west to east 37 miles;

mean breadth 16, and area 592 square miles. Lying between lat. 36° 42′, and 37° 7′ N., and in long. from 0° 2′ E. to 0° 46′ W. from the meridian of W. C.

This county has a southeastern declivity, down or rather over which the Nottaway river winds by a wide sweeping curve, first east, thence northeast, east, and finally southeast, into Southampton county. The eastern part is drained by Black Water river, but here again the descent of the plain is to the southeastward. Sussex is an undulating surface, within the climate in the United States where cotton can be cultivated as a staple commodity.

Besides at Hunting Quarter or Sussex Court House, there are by the post list of 1831, post-offices at Conan's Well, Littleton, Parham's Store, and Rowanty.

Hunting Quarter, the seat of justice, is situated near the centre of the county, and though not actually on the Nottaway river, that stream semicircles it by a bend from the west, thence round by north to southeastward, as noticed in the description of the county. This place by post road is 172 miles a little west of south from Washington City, and 50 miles SSE. from Richmond. N. lat. 36° 50′, long. 0° 22′ W. from the meridian of Washington City.

Sussex county of Virginia contained, in 1820, a population of 11,884.

Darby.

SUTHERLAND, one of the most northerly counties of Scotland, extending across the island from the Atlantic to the German Ocean. It is bounded on all sides by the sea, except on the north-east by Caithness, and on the south by Ross-shire. The length, from east to west, varies between 45 and 50 miles, and its breadth, from north to south, between 35 and 50. It contains 1865 square miles of land, and 38 square miles of salt water lakes, or 1,193,940 English acres* of land, and 24,230 of lakes. It is divided into 13 parishes, which belong to the synod of Sutherland and Caithness.

The western coast of Sutherland is a succession of inlets of the sea, variegated with bold promontoties, and numerous rocks and islets. The interior, which is almost universally wild, rocky and mountainous, may be divided into three districts. The eastern is a level piece of land on the east coast, about a quarter of a mile broad, and is sheltered from the north by a ridge of mountains, from 300 to 800 feet high. The middle district is occupied by the four straths of the rivers of Helmsdale, Brora, Fleet, and Oickel. Black cattle and sheep form here the wealth of the farmer. The western district, which borders on the Atlantic, is wild and mountainous. The mountains of Ben-mor, Assyant, Glass-bhein, Ben-canap, Benchoinag, or the sugar loaf mountains, Ben-evie, Craig-rou, Benmore, and Stackben are of great altitudes, and though entirely barren, yet at their base they display many extensive and well managed farms.

There is little more than one acre in a hundred cultivated in this county; the whole extent of cultivated land, grass pastures, and woods not exceeding 60,000 acres. Wheat grows well in the eastern district, and sometimes ripens as early as in England. Since 1818, extensive fields of wheat, drilled on the Norfolk system, have been sown; several hundred acres of turnip have been sown upon the ridge, and excellent crops of barley and clover have been raised. Oats, bear, and potatoes are raised by the small tenants in the inland straths. The number of sheep is calculated at about 140,000, yielding about 18,000 stone of wool, 24 lbs. per stone. The small tenants, on the south-east coast, pay a rent according to the quantity of grain that may be sown, which is from 15s. to 20s. per boll, which is paid partly in money and partly in oatmeal and bear. In other parts the tenants pay in proportion to the number of black cattle they can support.

The county of Sutherland has derived immense advantages from the admirable establishments of the Marquis of Stafford. Formerly the only manufacture was that of kelp, to the extent of 250 tons annually. Very important fisheries are carried on in the west, north and east coasts. At Helmsdale, on the east coast, the Marquis of Stafford has expended large sums in erecting buildings necessary for this purpose, and the tenants who had been removed from their farms have embarked with much success in this new profession. A considerable number of boats are occupied in the cod, ling, haddock, and herring fisheries, on the north and west coasts, where lobsters and mussels are also obtained in abundance. In 1814, there were caught at the village of Helmsdale 2400 barrels of herrings. This quantity increased annually, and in 1827 it amounted to 20,600 barrels. In 1814 not a single boat entered this creek, whereas in 1819 no less than 5246 ton of shipping entered there. A regular trade has been established with Leith, and other branches of industry have begun to flourish.

In this county both coal and limestone have been recently discovered. The coal is now wrought to a considerable extent on the little rivulet of Brora, and it is conveyed by a railway to the harbour at its mouth. The small coal is consumed at the salt-works there. It is employed also in burning lime and making bricks; it is not so good for domestic purposes. A general account of this coal field is given in our Article Scotland, Vol. XVI. p. 694. and in Mine, Vol. XIII. p. 340. The west coast is in a great measure formed of this mineral; but as it is in many cases combined with magnesia, its utility as a manure is diminished. It is also found in some parts of the interior. The marble quarries of Lechmore and Leadbeg, yielding a pure white marble, like alabastar, were for some years wrought by Mr. Jopling from Newcastle, but we understand they were abandoned on account of the magnesia. A fine black marble, streaked with yellow veins, is found at Edderachillis. Near the coast the limestone is sometimes found in the state of marble. Traces of ancient iron mines are said

* Some other statements make it 1,840,000, deducting 32,000 of salt water lakes.

to have been found on the west coast. Gold is found near Helmsdale, garnets on the coast, in the parish of Tongue, and it is said that lead ore rich in silver, and a vein of black manganese, have been found near the Dornoch Frith. Purple fluor spar is found in the gneiss and granite. White actynolite, approaching to tremolite, is found near Standa, and schistose actynolite is also found in the county.

In the limestone rock, on the north coast, there are some remarkable caves, one of these at Smoro, to the east of Balnaheel and Durness, is 96 feet wide and 60 feet high; another at Fraisgill is 50 feet high and twenty feet wide at its mouth, gradually contracting till it terminates at the end of half a mile.

The principal streams are the Oickel or Firth of Dornoch, Fleet or Strathfleet, Broro, and Helmsdale. The Oickel is navigable for 12 miles for ships of 50 tons, and about eight miles farther for boats. These streams rising in the interior fall into the Dornoch Firth; but others, such as the Strathy, the Naver, and the Dinart, the Hallidale, the Kenloch, the Hope, and the Eribol, flow towards the northern and western shores.

The principal lake in this county is Loch Shin, extending 20 miles from NW. to SE. and about a mile broad. It abounds with salmon and trout. Loch Assynt is six miles long and one and a half broad. The others are Loch Naver, Loch Hope, Loch Lyal, Loch More, Loch Brora, and Baden Loch, all abounding with trout.

The valued rental of the county is L.26,193 9s. 7d. which is divided among seventeen proprietors, the Marquis of Stafford having L.16,951, Lord Reay L.3720, Skibo L.1975, Bighouse L.900, and the rest between L.200 and L.500. The real rent has been estimated at L.40,000 sterling. A superiority of L.200 Scots gives a vote for the member of Parliament, when L.400 is necessary in the other Scotch counties. The number of freeholders was 22 in 1828. Dornoch, the country town, is a royal burgh, which, along with Dingwall, Tain, Wick, and Kirkwall, sends a member to Parliament. The town is small. A part of the old cathedral, said to have been built in the 11th century, is kept in repair as the parish church. The ruins of the bishop's castle, which seems to have been a stately building, still remains. Dornoch contains only 132 houses, 140 families, 58 of whom are in trade, and 9630 inhabitants.

Among the antiquities of Sutherlandshire are two circular buildings, Dun-Dornadil and Castle Coll. Dun-Dornadil, in the parish of Durness, is in a ruinous state. Only a portion of the wall is standing, which does not exceed 18 feet in height. The area seems to have been enclosed by two concentric walls, and a large triangular stone serves as a lintel to the doorway. Castle Coll, on the east side of the county, has a circuit of 162 feet, with walls 13½ feet thick at the base, inclining inwards nine inches for every three feet of altitude. On each side of the doorway are two small apartments. Both of these buildings consist of large stone nicely joined together without cement. Cairns and tumuli are very numerous. In the isle of Oldney is a considerable cairn with a hollowed stone, having a cover likewise of stone. The first of these stones is said to have contained a rounded one of various colours. On the east coast is a rocky precipice called Craigbar, fortified with a ditch of circumvallation.

The population of Sutherland in 1821, was as follows:—

Parishes.	Inhabited Houses.	Families.	Population.
Assynt, . .	547	547	2803
Clyne, . .	399	432	1874
Creech, . .	389	389	2364
Dornoch, . .	651	660	3100
Durness, . .	178	178	1004
Edderachillis, .	239	239	1229
Farr, . .	374	376	1994
Golspie, . .	230	292	1036
Kildonan, . .	97	97	565
Lairg, . .	219	227	1094
Loth, (with Helmsdale,)	400	417	2008
Reay, part of, .	192	198	1057
Rogart, . .	420	420	1986
Tongue, . .	318	350	1736
Total	4654	4822	23,840

See Forsyth's *Beauties of Scotland.* Henderson's *General View of the County of Sutherland*, and *An Account of the Improvements of the Marquis of Stafford in Sunderland*, by James Loch, Esq. M.P. See also our Article Scotland, *passim.*

SUTTON, Coldfield, a market town of England, in Warwickshire, which is on the high road from Birmingham to Litchfield. It is a small town, consisting of a spacious street, with several smaller ones. The church is a large handsome structure, with a new channel and two side aisles. There is a grammar school founded by Bishop Vesey. A few manufactures connected with Birmingham have been advantageously introduced. The bleak district called the *Coldfield*, to the west of the town, contains 13,000 acres. To the north-west of the town is Sutton Park, containing 300 acres, belonging to the poor of the town. They receive from it peat, and obtain pasturage for their cows. The Roman street of Icknield passes through it.

Population of the parish in 1821. Number of houses 677, families 706, ditto in trade, 227. Total population, 3466. See *Beauties of England*, vol. xv. p. 295.

SUWAROF, Rymnikski Alexander Count, a celebrated Russian general, descended of a Swedish family, was born in 1730, and died on the 18th May 1800, at the age of 70. An account of his military career will be found in our articles Britain, Franoe and Russia.

SWABIA, one of the ten circles into which Germany was divided by Maximilian I. It now forms part of Baden, Bavaria, and Wirtemberg, and is consequently described under these articles. See our article Germany, Vol. IX. p. 704—709.

SWAFFHAM, a market town of England, in the county of Norfolk. It is situated on high ground, and consists of a principal street, on the high road from Lynn Regis to Norwich, with several smaller ones branching off to the north and south. Most of the houses, particularly those in the market place, are handsome. In the centre is a large open area, with a pool of water. The principal public building is the church, which is a handsome edifice with a nave, two aisles, two transepts, and a well proportioned and lofty tower, surmounted with enriched embrasures and purfled pinnacles. The nave is lofty, and has twenty-six cleristory windows, with a highly ornamental inner roof. The other public edifices are a Quakers' meeting house, and a new assembly room on the west side of the market house. Races are held annually about the end of September, on an extensive heath near the town. A great cattle market is held here. Population in 1821:—The town and parish contained 553 houses, 587 families, 263 families in trade, and 2836 inhabitants. See the *Beauties of England*, vol. xi. p. 272.

SWANSEA, a town of South Wales, in the county of Glamorgan, "which, from its population and commercial importance, is entitled to be ranked as the metropolis of the county, if not of the principality of Wales." It is situated on the west bank of the Taw, on a point of land near the junction of that river with the sea. It is nearly two miles long, including the suburb of Greenhill, and half a mile broad. There are many streets, with a great proportion of well built houses. The church is a handsome building, with a suitable aisle, two side aisles and a large quadrangular tower at one end. It is 72 feet long, and 54 wide. The town hall, erected on a part of the castle inclosure, in the middle of the town, is a spacious and elegant modern building. A commodious theatre, and some public rooms have been lately erected. The latter form a mis-shapen pile of buildings. The castle is situated on an elevated spot in the middle of the town, and would have a grand appearance, were it not buried among houses. A lofty circular tower is the principal portion that remains. On the eastern side of the tower a large part of the original building is standing, surmounted by an elegant parapet with arched openings. The habitable apartments form a poors' house and a debtors' goal.

Swansea is the resort of numerous bathers, and warm and cold salt water baths have been made in the burrows, and near the pottery by the river side. Handsome lodging houses, the chief of which are at Mount Pleasant, and the Burrows, have been erected for the same purpose. There are at Swansea, places of worship for various dissenters, and the Presbyterian meeting house is one of the oldest in South Wales. There is here a public library, a free school, and several Lancasterian and other schools for the poor. A weekly newspaper has been long established here.

There are in Swansea various important manufactures, arising from the abundance of coal and iron in the neighbourhood. There are two pottery establishments, on a large scale, furnishing almost every article of the Staffordshire ware, of the first quality. There are also two large copper houses, to which ships of 200 tons can sail, an iron foundry, two roperies, several tan yards, a soap manufactory, an extensive brewery, and a dry dock. Swansea carries on an extensive commerce, which is greatly aided by the Swansea canal, and the Oystermouth railway, both of which we have already described in our article NAVIGATION, *Inland*.

The number of vessels which cleared out in the following years, are as below:—

	Vessels.	Tons.
1788	694	30,631
1790	1697	74,926
1800	2590	154,264
1810	2717	171,672

Swansea is a corporate town, and shares the privileges of Cardiff as a contributory burgh, in returning the member for that place. It is governed by a portrieve, twelve aldermen, two common attornies, a town-clerk, and two sergeants at mace. The population, in 1821, of the town and franchise, with the hamlet of St. Thomas, which has only 248 inhabitants, was as follows:—

No. of Houses,	2,049
Families,	2,124
Families in Trade,	739
Total population,	10,355

The increase of population since 1811, in the town and franchise of Swansea, which is 2082, is attributed to the improved state of trade and commerce in that town and port, and to the public spirit of the inhabitants of its vicinity. See the *Beauties of England and Wales*, vol. xviii. p. 720; NAVIGATION, *Inland*, Vol. XIV. p. 285; and GLAMORGANSHIRE, Vol. IX. p. 741.

SWARTZ OLOF, See BOTANY, Vol. IV. p. 26.

SWATARA, river of Pennsylvania, rises by numerous branches in the deep mountain vallies in the southern part of Schuylkill county. It thence flows in a south-western direction over the western part of Lebanon and the southern part of Dauphin county, falling into Susquehanna river immediately below Middletown, after a comparative course of 40 miles.

The valley of this fine small river, for nearly one half of its course, is now made a navigable route by means of the Union Canal. By its numerous branches, it drains a section of Schuylkill county, the extreme western angle of Berks, all Lebanon, except a very confined angle in the extreme south. and the southern and finest part of Dauphin county. The valley of Swatara is about 40 miles long, with a mean width of 15, and embraces an area of about 600 square miles.

The western side of this valley is mountainous and all parts are hilly. With the exception of the higher north western sources, the Swatara valley is in the mountain valley between the Blue Ridge and Kittatinny mountains. Along the former ridge and spreading from 5 to 8 miles wide, extends a zone of limestone, on which the soil is in a high degree productive. The limestone tract is followed by slate land towards the Kittatinny range. On the latter zone the surface becomes more broken and soil less fertile; but even in the mountain vales above the Kittatinny, some belts of fine meadow and arable lands skirt the streams. DARBY.

SWEDEN.

SWEDEN. Respecting the origin of this word, there have been several conjectures. The inhabitants of the country which it denotes are supposed to have been the *Sitones* mentioned by Tacitus, an appellation probably derived from the chief town *Sietuna*. (*De Mor. German.* cap. 44-5.) This hypothesis is not fanciful; but the more probable opinion is, that the term in question is derived from Suitheod or Sweireke according to the more modern orthography, a Scandinavian word signifying a country whose woods have been burned or destroyed. From this term, softened by its conversion into the Latin speech, the *Sitones* of Tacitus may without any impropriety be supposed to have been derived.

The country of Sweden has at various times been of very different extent. And even within the present century, it has undergone great changes in this respect. In 1809, it lost Finland, a province which has since belonged to Russia, and which in superficial extent is equal to England, and contains a population of upwards of a million; and in 1814 it added Norway to its territories in return for ceding to Prussia the island of Rugen, and the province of Swedish Pomerania. This exchange, so favourable to the country under review, was guaranteed and confirmed by the Congress of Vienna in 1815. Sweden, exclusive of Norway and Finland, but including Swedish Lapland, extends from south to north 1150 miles, namely, from 55° 20′ to 71° 10′ north latitude; and from east to west, it averages nearly 300 miles. From its sloping situation, its breadth cannot be known from the degrees of longitude within which it lies; at its extreme diagonal points it measures from 11° 10′ to 23° 30′ east longitude. The area which it embraces has been calculated at 168,802 square miles. It is bounded on the east by the Baltic, gulf of Finland, and Russia; on the north by Norwegian Lapland; west by Norway; south by the Sound and the Baltic.

This country has been divided into three provinces, namely, Gothland on the south, Sweden Proper in the middle, and on the north Norrland, including Swedish Lapland.* These provinces have been recently subdivided into districts called *Laens* or Stadholderships, of which the following is a list, together with the ancient division:—

Gothland.

Divisions, called Laens *or Stadholderships.*

New Division.	Old Division.	Sq. miles.	Capitals.
Gottenburg.	West Gothland.	1835	Gottenburg.
Halmstadt.	Halland.	1963	Halmstadt.
Christianstadt, and	Schonen, or Scania.	2174	Christianstadt.
Malmoe.	———	1750	Malmoe.
Carlskrona.	Blekingon.	1088	Carlskrona.
Calmar.	Smaland, and Island of Oeland.	4181	Calmar.
Kronsberg, or Wexio.	Smaland	3495	Merioe.
Jonkoping.	Smaland.	4267	Jonkoping.
Linkoping.	East Gothland.	4305	Linkoping.
Skaraburg.	West Gothland.	3207	Mariestadt.
Elfsburg.	West Gothland, and Dallen.	3008	Wenersburg.
Wiseby.	Island of Gothland.	1045	Wiseby.
Sweden Proper.			
City and district of Stockholm, Drottingsholm.	City of Stockholm Upland, and Sudermanland.	2624	Stockholm.
Upsal.	Upsal.	2261	Upsal.
Westeras.	Westmanland.	2793	Westeras.
Nykoping.	Sudermanland.	2880	Nykoping.
Orebro.	Westmanland, & Nericke,	3670	Orebro.
Carlstadt.	Wermeland.	6550	Carlstadt.
Norrland, including Swedish Lapland.			
Falun, or Storakopperberg.	Dalecarlia.	12,587	Falun.
Geffeberg.	Herjedalen, Helsingland and Gertricia.	7765	Gefleberg.
Hernosand.	Medelpad, Jamtland, and Angermandland	18,261	Hernosand, and Oestersund.
Umea.	West Bothnia, & Swedish Lapland	75,093	Umea.
		Total square miles, 168,802.	

The climate of this extensive country varies much in different places. The southern provinces may be compared to Scotland, which lies under the same parallel. In the middle and northern districts it becomes proportionally rigid and severe; so that in Swedish Lapland, which extends beyond the 71° of latitude, the cold is as intense as in the northern parts of Russia. The Gulf of Bothnia is frozen during several months in winter, and affords a communication by ice between the people on the opposite shores. In the southern latitudes, flowers and fruits are produced in great variety and abundance; but these productions become extremely rare beyond Gefle, a town a hundred miles beyond Stockholm. Oats are not to be found beyond that town; but forests of pine and fir extend to the 66th degree. In more distant latitudes the beech disappears: in Swedish Lapland, the oak draws out a dwarfish and sickly existence, and is at length succeeded by the birch; a tree which seems the most capable of enduring cold, and which, even under the Polar circle, is known to grow at an elevation of 1483 feet. Barley and oats are cultivated in Sweden at the 70th degree, while in North America they are not yet known beyond the 52d. Some plants, indeed, the lichen for example, though not unknown in central Europe, are regarded as indigenous in Lapland. Other particulars connected

* In this sketch we shall confine ourselves solely to Sweden, as it now stands, referring our readers to NORWAY for an account of that country; to RUSSIA, for an account of Finland; to PRUSSIA, for a description of Pomerania.

with the climate of this country, cannot be better given than in the words of Voltaire. "Winter reigns here nine months in the year. There is neither spring nor autumn: the heats of summer succeed all at once to an excessive cold; and it freezes from the month of October, without any of those insensible gradations which elsewhere bring on the seasons, and which render the change more agreeable. Nature, in recompence, has given to this rude climate a serene sky, and a pure air. A very short interval elapses between the disappearance of the snow and frost of winter, and the rich verdure and luxuriant vegetation of summer: a circumstance owing to the rapidly increasing length of the day, and the strength of the heat of summer. In the extreme north, indeed, the sun is visible for several weeks in succession. The long nights of winter, in like manner, are rendered comparatively mild, by the *aurora borealis*, by the extreme length of twilight, and by the light of the moon, which is there obscured by no cloud, augmented still by the reflection of the snow which covers the earth; insomuch that travelling in winter takes place in Sweden by night as well as by day. (*Histoire de Charles XII. liv. I.*)

Of this great extent of country the population is not great. The number of inhabitants, in November 1828, was ascertained to be 2,860,000, or so small as only to average about 17 to a square mile. There is, as may be conjectured, great difference in this respect, in different provinces. Gothland contains about 42 to a square mile; Sweden Proper about 24; while Norrland, including Swedish Lapland, not much above 2. The relative density, when compared to other countries, may be understood, when it is mentioned, that the average population of the Netherlands is 212 to a square mile; of England and Wales 207; of the Lowlands of Scotland 127. But the population of Sweden is advancing at a considerably rapid ratio; the best mark of the prosperity and increase of the capital of the country. Between the year 1820 and 1825, it advanced at the rate of $7\frac{3}{10}$ per cent.; an increase greater than at any former period; though it must, at the same time, be confessed, that between 1825 and 1828, the progress has been comparatively small, being only 37,000 per annum, or about 4 per cent.* Longevity, however, is extending: a fact that is found always to result from the improved condition of the people with regard to food, clothing, and cleanliness. During the five years previously to 1821, the annual average of mortality was 62,329; while, during the succeeding five years, it was only 58,919, making an annual reduction of 3410. Previous to the age of ten, the mortality of boys was ascertained to be greater than that of girls; between that age and that of twenty, it was nearly equal between the sexes; from that till sixty, it was greater among the males; beyond sixty, it became more prevalent among the females: and with regard to both sexes, it was found to be greatest between the ages of sixty and seventy-five. During the five years last specified, 26 individuals, namely, nine males, and fifteen females, exceeded a hundred years of age: of whom six men and eleven women reached 101; two men 102 years; two women 103; one woman 104; one man and two women 105; while one woman attained the age of nearly 107; a proof that the female life, in this instance, considerably exceeds that of the opposite sex. During the same *lustrum*, the annual number of marriages was 23,772,—of which, 18,764 were of persons before in a state of celibacy; 2,628 were of widowers who united themselves to maiden females; 1611 of widows who married bachelors; while 768 widowers married widows. In the same five years, there were 101,941 marriages for the first time; 16,092 for the second; 774 for the third; 48 for the fourth; 5 for the fifth; and only a single instance of one that married for the sixth time. During the same time also, there were 7148 instances of twins: 100 instances of three at a birth; 3 instances of four. The average number of births was 95,706, while that of deaths, as before stated, was 58,919. The greatest number of births was found to be in the month of September; the smallest in that of June. The proportion of illegitimate children was as 1 to $13\frac{3}{10}$.†

The condition of the people may be thus classified. The number of the clergymen is 3476; that of public teachers, paid by government, is 968. The army extends to 31,000, exclusive of the national militia; marines, of every kind, amount to 10,000. Manufacturers and miners exceed 28,000. None of these calculations include children or servants. The number of poor, including mendicants, is 21,216; that of prisoners, 1833. The peasantry, including their children, amount to no fewer than 1,594,703, more than the half of the whole population.

As the population and the climate of Sweden are so various, its physical appearance must evidently partake of a similar character. Rivers, lakes, mountains, forests, vales, so abound and so succeed each other, as to impart a character equally picturesque, magnificent, and interesting to this northern region. Rich pastures, or cultivated fields, barren rocks, rugged mountains, or foaming cataracts, and scenery of the most opposite description, are so peculiarly blended, that there is, probably, no country in Europe where such contrasts, and such a variety of surface may be seen. Sweden has, of late years, been much denuded of its forests, though these still extend over immense tracts, being calculated to cover about a third of the whole country. Towards the north and west, it exhibits chains of lofty and almost inaccessible mountains, an account of which may be found under the article NORWAY. Sweden, however, is not remarkable for any thing so much as for the number and extent of its lakes and rivers. The former have been computed to

* Conjectures to account for this decrease may be found under the head *Commerce*.

† The government of Sweden, so far back as 1749, appointed a commission, to give quintennial reports on the population of the kingdom: a measure which did great honour to that government, and which has not even yet been adequately imitated in other countries. This commission has been ever since kept up: and to the returns made by it, we are indebted for the above important and curious abstract, which, had our limits admitted, we would have gladly extended. (*Revue Encyclopedique*, for February 1829, Coxe's *Travels*, iv. 134.)

occupy 9200 square miles, or about an eighteenth part of the whole surface; while the number of the latter, none of which are very large, though many of them are navigable, is greater than that of any other country in Europe.

No country in the old world can rival Sweden in the extent and number of its lakes. Wener, lying between Skaraberg and Carlstadt, is the largest, being about 100 British miles in length, and 60 in breadth. It is remarkable, however, for little except its great extent. "Its shores," says Mr. Coxe, "are low and level, so that the view over the surface of the water appears boundless like a sea." "The shores of the lakes," says Mr. Derwent Conway, "are not particularly interesting; nor was there any thing to see but a vast expanse of water, enlivened by so few sails, that a feeling of sadness, rather than any other emotion, was produced in viewing so vast an arena of water contributing so little to the utility of life." (*Personal Narrative of a Journey through Norway, Part of Sweden, &c.* Part III. Chap. I. Coxe's *Travels through Sweden, &c.* vol. i. p. 302). Wener receives the water of 24 rivers, while it is connected with the Cattegat by one only, the Gotha. It is studded with many romantic islands. The Weter is next in importance after the one now described, and lies about 40 miles to the south-east of it. It is of equal length, namely 100 miles, but its breadth, which is irregular, no where exceeds 20. It is of a different character from the Wener, being surrounded by mountains, so that it is peculiarly liable to storms and hurricanes. Its surface is also variegated by numerous islands: and though its communication with the Cattegat is by a single river, the Motala, it forms the reservoir of no fewer than 40 streams. The Maeler, the only other lake that requires to be minutely described, is like Weter, of irregular form, its greatest length being about 80 miles, its mean breadth about 18. Its islands are numerous and picturesque; on seven of which, on its east coast, is situated Stockholm, the capital of the kingdom. The waters of the Maeler discharge themselves at this place into an inlet of the Baltic. The only other lake in Gothland or Sweden Proper, is Hiemar, south-west from that of Maeler, a sheet of water chiefly remarkable for its utility in the line of canals which connects the Cattegat with the capital. Many other lakes in the northern portion of the kingdom, some of them of considerable extent, might be mentioned; but as none of them is very large, or of much practical use, such an enumeration is unnecessary. The largest is Enara in Swedish Lapland, 70 British miles in length, and 30 in breadth. All the lakes which we have described, or to which we have referred, abound with fish of almost every variety; and their banks are skirted with woods or forests, even to the margin of the water.

Sweden is as remarkable for the number of its rivers as of its lakes; though of the former, none deserve notice on account of its size or extent of course. They are indeed in this respect comparatively uninteresting. Not a few of them exhibit the form of creeks, or, like the Motala already mentioned, form outlets to the lakes. The most important is the Gotha, which, as already stated, serves as the outlet of Lake Wener, and which falls into the Cattegat by two branches, the one passing through the town of Gottenburg, the other a few miles north. This river, soon after leaving its parent lake, being impeded by rocks, forms at Trolhetta one of the finest cataracts in Europe. The width of the river between the falls and the lake varies between 300 yards and a mile; but at Trolhetta, two opposite ridges of mountains approach its banks so closely that the stream is confined within a channel of 400 feet. There are four successive falls, the perpendicular height of the whole, considered as one, is about 100 feet. The falls are separated by whirlpools and eddies, "forming," as Coxe remarks, "during the whole way, the most awful scenery, ever varying, and too sublime to be accurately described." "The roar of waters," says Mr. Conway, "was greater than that of any fall I had ever before visited; and now that several years have elapsed during which I have travelled in other countries, I may say greater than that of any water-fall I have ever since seen." The river Dahl, next in importance to the Gotha, is also celebrated for a cataract, described as scarcely inferior to that of the Rhine at Schaffhausen. This river, which rises in the Norwegian alps, and which, after a course of 260 British miles, falls into the Gulf of Bothnia, presents the cataract in question, not far from its mouth. The breadth of the stream is about 400 feet, and the perpendicular height of the fall is between 30 and 40. A ridge of rocks and a high islet about a quarter of a mile in circumference, divides the stream into three parts, making as many falls. The basin below is scarcely 100 feet wide, so that the white spray rising in dense clouds, and the struggling of the waters for vent, constitute one of the most striking features of the scene. (*Wraxall's Northern Tour*, p. 158). The Tornea forms the boundary between Sweden and Russia on the north, and after flowing about 300 miles, enters the northern extremity of the Gulf of Bothnia. In addition to the rivers previously given, we may mention the Angermann, the Umea, the Skelleftea, the Pitea, the Lulea, the Calix, all flowing into the Gulf of Bothnia. Their course varies respectively from 200 to 300 miles; and though in winter their channels are comparatively empty, owing to the frost-bound mountains from which they flow, in summer, when the snow melts, they not unfrequently overflow their banks, and inundate large tracts of the adjacent districts.

As connected with the rivers and lakes of Sweden, reflections on its internal communication immediately obtrude themselves on our attention. There is no country either in the old or new world on the same parallel of latitude, in which such communication is under more favourable circumstances. Where the river Gotha is rendered innavigable by the intervention of the cataracts of Trolhetta, a canal has been cut through a solid rock of granite of two miles in length, and 150 feet in height. This stupendous work had been long contemplated; and during the last century many plans were successively adopted, all of which proved abortive; and it was not till the year 1800 that it was completed. The execution of it was reserved for a private company; and it gives us pleasure to state that during the year after it was opened, there passed through it no fewer than 1380 ships of various sizes, laden with iron, steel, timber, herrings, grain, and flour; and that it pays 12 per cent. on the capital invested on it. A canal uniting the lakes in the province of Darlecarlia with the Maeler has been completed. Other similar works are contemplated, or have been begun, or are finished. The canal of Gothland, extending from Gottenberg to Norkioping on the Baltic, thus connecting the two opposite seas, is either finished or nearly so. It passes through the most fertile portion of Sweden, and promises to be of incalculable advantage. Its length is 240 miles, including the lakes through which it flows. Lake Hielmar communicates with the capital by means of a canal; and two others of smaller extent are forming. The government is very liberal in spending money on such works; indeed, considering the scanty means of the nation, the present sovereign is entitled to the greatest praise for what in this department he has achieved. Several of the largest of the rivers are navigable, as well as many estuaries and inlets of the sea.*

Sweden is not more celebrated for any thing than for the state of its roads. "The high roads," says Mr. Coxe, (*Travels*, vol. iv. p. 35), "wind agreeably through the country, are made with stone or gravel, and are as good as our turnpikes in England; and yet not a single toll is exacted from the traveller. Each landlord is obliged to keep in repair a certain part of the road in proportion to his property; and for the purpose of ascertaining their respective portions, small pieces of wood or stone marked with numbers and capital letters are placed at different distances on each side of the way." "Such indeed are their goodness throughout the whole country, that during several thousand miles which I travelled in this and my former tour in 1779, I scarcely met with fifty miles that deserved the appellation of indifferent. They are also as pleasant as they are good, and in many places look like gravel walks carried through gentlemen's grounds and plantations, as they wind through the fields and extensive forests, the lofty trees casting a gloomy shade with their overhanging foliage." (Coxe, vol. v. p. 65). These observations have been confirmed by more recent travellers. Sweden, in truth, has been gradually making improvements in the departments in question, especially in the eastern and southern divisions of the kingdom, and she already is incomparably superior to Norway, Denmark, and Russia, and is not much inferior to the most civilized countries of Europe.

When treating of internal communication, and of the state of roads, the transition is easy to the consideration of the modes of travelling that obtain. Nor is less praise due here than on the former head. There is no regular supply of post horses kept, except in those places where the thoroughfare is very great: but they may at once be had by a traveller sending forward a peasant to bespeak them. The usual mode of supplying such horses may be explained in a few words. Horses are supplied by the country people in proportion to the quantity of land they rent; most persons generally send one or more horses to the nearest post-house, where they remain twenty-four hours; during which time, if employed, compensation is of course obtained, but, if otherwise, no remuneration is received. Travelling is unusually cheap, because one-half only of the charge is paid by the hirer, the other being defrayed in the shape of a tax, by the landholders. "I found," says Coxe, "travelling so exceedingly cheap in Sweden, that during a course of 500 miles, my whole expenses, including the prime cost of my cart, the hire of post-horses, the gratuities to the drivers, and the accommodations on the road, did not amount to 20*l.*, the drivers being the peasants themselves, who usually attend with their own horses, and are contented with a small acknowledgment of about 2*d.* or 3*d.* for each post. The horses are small, but lively and active, and they generally went at the rate of six or seven miles in an hour." (vol. iv. p. 349-50). "To Sweden," says Mr. Conway, "I give the travelling premium over every other country. I may still farther state that the traveller is in no danger of being imposed upon; and he will everywhere find clean inns, passably good fare, cheap bills, and civil people." (p. 286).

A country that can boast of such advantages in regard to internal communication possesses great facilities for general amelioration. At least without such advantages few steps can be taken in the career of improvement. Nor can it be denied that Sweden has availed herself in an eminent degree of the facilities she enjoys. The soil, in general, is not propitious; not more than a 20th part is arable, and not more than the half of that portion has actually been cultivated. But agriculture has done what could be effected under such circumstances. Husbandry in Sweden has been pronounced superior to what prevails in Denmark and even in Germany, and it is daily making rapid progress. as the quantity of corn raised is still not equal to the demand. A considerable quantity of corn, however, is made use of in the distillation of malt spirits: Hence they not only import from other countries, but it is not unusual with the poorer classes, in order to supply the deficiency, to mix with their flour or meal the inner rhind of the fir tree or the roots of certain bog plants. But the alternative will not long be necessary; for the southern and middle provinces, where agriculture has been very assiduously attended to, and where it has been brought to great perfection, produce wheat, rye, oats, hops, beans and pease, hemp, flax, in considerable luxuriance. The cultivation of potatoes having of late been introduced, that root is rapidly supplying the deficiency

* A full account of the inland navigation of Sweden is given in our article NAVIGATION INLAND.

occasioned by the limited quantity of corn. It has been stated that during the space of ten successive years, one harvest fails, two are scanty, five are moderate, and two are abundant; a proportion not much inferior to that of more southern countries, and of milder climates. The wheat and rye are sown in the middle of August, and are reaped in the same month of the following year. Barley and oats are consigned to the ground in spring, immediately on the melting of the snow: the former is cut down towards the end of August; the latter about the middle of September.

Among the various vegetable productions of Sweden, those of its forest are by far the most prominent and important. No less than one-third of the superficial extent of the whole country is covered with wood. These forests contain birch, poplar, mountain-ash, alder, pine, and fir. Dalecarlia, now called Falun, abounds more with such forests than any other province; and the numerous lakes are skirted with wood even to the margin of the water. Timber, as may be inferred, is one of the chief exports of Sweden; though by far the greater part of the houses, of the middle and lower classes, are composed wholly or chiefly of wood, and the same article is almost used throughout the whole kingdom for fuel. The wood and plants of Sweden differ in truth very little from those used in Britain, except some trees, as mentioned under the head *climate*, do not succeed in the former country beyond a certain degree of latitude; a remark which is applicable also to some plants, such as broom, firs, the walnut-tree, &c. Some indeed of the plants found in Sweden are not unknown in central Europe: the lichen of Lapland is frequently found on the plains at the 54th degree. The lichen rangiferinus, or rein-deer lichen or white moss abounds throughout the whole extent of Lapland, the chief support of the animal whose name it bears. The sagacious animal discovers it when covered with snow by the peculiar acuteness of its smell.

A remark, similar to that just made respecting the vegetable productions of Sweden, is applicable to the animals of that country; namely, that they differ extremely little from those of Britain. Horses, oxen, cows, sheep, differ only in this, that in Sweden they are of considerably inferior size; the consequence, it is likely, of poorer pastures, and of the comparative want of skill, and deficiency of capital on the part of the agriculturists. Goats and pigs are not very abundant. Hares and foxes seem equally common in the two countries referred to. There are, however, various animals, such as the lynx, the wolf, the beaver, the glutton, that are unknown in Britain. Of these the rein-deer is the most remarkable and celebrated. This animal resembles a stag, but is stronger; its antlers are stronger and more branched than those of the latter animal, and they also decorate the brows of the female. It is the camel of the north, the deep division of its hoofs being calculated for travelling over a snowy surface. The sledge, drawn by this animal, is extremely light, and covered underneath with deer-skin, in order to slide easily on the frozen snow. They easily accomplish 30 miles without halting, at the rate of 4 miles an hour; they can travel this distance without food; but they occasionally moisten their mouth in the snow as they proceed. This mode of conveyance, it is evident, can be performed only in winter when the snow is glazed over with ice. In the birds of Sweden there is little or nothing peculiar; nearly the same species abounds here that obtains in our own island. A similar observation is applicable to fish, which is very abundant, both along the sea-coast, and in the rivers and lakes. Leeches are peculiarly abundant, and form an article of export to this country. On the coast of the Baltic the stæmming is found, a species of herring peculiar to that sea.

In nothing is Sweden more celebrated than for its mines and mineral productions, including gold, silver, copper, iron, lead, marble, cobalt, zinc, coal, alum, and several precious stones. The average produce of the principal metals has been estimated as follows: 64 oz. of gold, 13,000 oz. of silver, 24,800 quintals of copper, 100,000 tons of iron, 431 quintals of lead, 22,000 quintals of alum, 35,000 tons of coal.* There are only two inconsiderable gold mines, of which the most important is at Adelfors, in the province of Smaland, discovered in 1737; but it seems to be nearly exhausted. With the exception of some silver veins discovered in Swedish Lapland, a mine of that metal at Salberg, thirty miles west of Upsal, is the only one known in Sweden. It contains about a hundred veins. Copper is found in various places, but the chief mines of this metal, which are in the province of Dalecarlia, have been wrought from time immemorial. The metal is not found in veins, but in great masses, and does not extend more than an English mile in circumference. The matrix of the ore is the saxum of Linnaeus, or rock and pyrites of iron. The richest part of the ore has been supposed to yield 20 per cent of copper; but as the poor and rich are blended, they average only 2 per cent. when brought from the mine, and 12 when smelted. The mine is private property, and is divided into shares. 1200 workmen are employed, namely 600 miners, and the same number in roasting and smelting the ore above ground. The mouth or opening of the mine, says Mr. Coxe, is extremely large, perhaps the largest in the world, being 1200 feet in diameter, or nearly three-quarters of an English mile in circumference; an immense chasm gradually enlarged to its present size by the excavations and frequent downfalls of the rock. The perpendicular depth is 1020 feet. But Sweden is most distinguished for its mines of iron. Those of Danemora, discovered in 1488, are particularly celebrated both for the abundance and for the superiority of that metal, called in England Oregrund iron, being exported thither from a part of that name where the Gulf of Bothnia joins the Atlantic. The pits are deep excavations, like gravel pits, and form so many abysses or gulfs. They, therefore, have no galleries, but are wrought in the open air. The richest ore yields

* The coal mines are not wrought to any great extent, from the quantity of timber used for fuel.

70 per cent of iron, the poorest 30; the collective mass averages one third of pure mineral. The number of miners in Sweden in 1825 amounted to no fewer than 28,256, including manufacturers, of which last the number is only about 6000.

Of the vast quantity of iron produced from the mines, about a fourth part is made use of at home, the rest being exported chiefly in the form of bar-iron and steel. There are large foundries for cannon and other pieces of artillery, as also works for making muskets and other small arms. The manufactures of copper and brass occupy very few hands. The manufactures, indeed, of Sweden are neither numerous nor important. From the superabundance of excellent timber, ship-building forms a most extensive and lucrative employment; and vessels of every species are sent from Swedish ports to many countries, particularly to those of South America. The other manufactures of the country are comparatively inconsiderable, and are carried on, not for exportation, but for family use. The true nature of division of labour is not well understood, or rather such division cannot in a poor and thinly inhabited country, such as Sweden, be carried very fully into effect; the Swedish peasantry make at home the clothing and utensils required for domestic purposes.

The foreign trade of Sweden has not of late been in so favourable a condition as it was twenty years ago, and previously to that time. Exports of iron and timber, which were her two most flourishing branches, have decreased to a great degree. The mines of Danemora have not of late been so productive; and the recent great extension of the iron mines of England has lessened the demand, as in England the inexhaustible stores of coal, and the ready command of inland navigation, are gradually rendering it independent of supplies from Sweden. With regard to the timber trade, the arbitrary restrictions which we have imposed on it, in order to give an advantage in this trade to Canada, have diminished, or almost annihilated our imports from the Baltic. Iron and timber, however, still form the staple exports of Sweden; the export consists of copper, pitch, tar, hemp, tallow, hides, saltpetre and alum. The chief imports are corn, wine, brandy, cotton, both raw and manufactured, silk, drugs, sugar, coffee, and other tropical products. In 1781, Mr. Coxe found the value of exports from Sweden to be L. 1,368,830 13s. 5d. and the imports to be L.1,008,392 12s. 4½d. In 1825, the tonnage of vessels trading between Great Britain and Sweden, entered inward and outward, was 104,968. *Chronol. Records of the British Royal and Commer. Navy*, by Cesar Moreau, p. 81.) Such tonnage was much less for the preceding nine years; but in 1814, it amounted to 180,755, and in the succeeding year to 167,112. Since 1825, we presume it has fallen considerably, owing to our diminished imports of iron and timber. This diminution of foreign demand for the products of Sweden is sufficient to account for the less rapid increase of population which has taken place there within the last four years.

The doctrines and ecclesiastical opinions, promulgated and enforced by Luther, were introduced into Sweden in the beginning of the 16th century. The Bible was soon after translated into the language of the country by Laurentius Petri, the first protestant arch-bishop of Upsal, who died at an advanced age in the year 1570. Several of the Swedish kings, particularly Gustavus Adolphus, who has been honoured with the appellation of Bulwark of the Protestant faith, have made most signal exertions for the maintenance of the reformed doctrines; and the Roman Catholic religion, which the Swedes regard with great abhorrence, has long been banished from the kingdom. Till the end of last century, when all religious intolerance was abolished by law, it would not have been safe for a Catholic priest to have made his appearance openly in the provincial districts of Sweden. The established church resembles that of England; and though some particular sectaries are to be found, they are far from being numerous or important.* It consists of one archbishop, whose see is that of Upsal, and eleven bishops, with several archdeacons. The whole number of clergy amounted in 1825, to 3,476. They are supported by the usual tithes; and their condition is very respectable. The parishes amounted to 2537, of which some, like the thinly inhabited parishes in the highlands of Scotland, are very large. There is one 150 miles in length by 48 in width. In Lapland some of the inhabitants are a journey of three miles distant from any place of worship. A convocation of the clergy virtually elects the prelates, by presenting the names of three to the king, of whom he must nominate one. Some of the parishes are under royal patronage; others are in the gift of private individuals, while some are consistorial, the clergyman being appointed by the votes of his brethren.

Of the literature of Sweden, though it was not brought to much perfection till about the middle of the 17th century, we can speak in terms of high commendation; indeed, in few countries in Europe has this important subject been more assiduously attended to. It is a rare occurrence to meet with a Swede, however low in rank, unable to read, education being there as generally diffused as in Scotland or Switzerland. A law, in truth, exists, declaring that every person, whether male or female, in the kingdom should be taught this necessary accomplishment. The number of public instructors paid by government in 1825, was 968, in addition to at least an equal number whose remuneration is obtained solely from their employers. Orders have recently been given by the king to establish schools on the Lancasterian system. Government, indeed, is doing all in its power to introduce improvements in teaching; and pays no less than L. 60,000 annually, in the shape of salaries, allowances to the poorer students, &c. The clergy take all seminaries of learning, particularly schools, under their particular jurisdiction, and labour by liberal attention to promote the object which such institutions have in view.

* The number of Jews is only 450, being more than a half less than are to be found in any other country in Europe.

Sweden can boast of two universities, those of Upsal and Lund. Of 1426 students who were attending the former in 1827-8, 126 are of noble rank; 332 are sons of clergymen; 227 sons of burghers; 226 of civil officers, not noble; 87 of military officers, not noble; and 207 of other persons of rank. The university of Lund is attended by 631 students in nearly the same proportions. In addition to these more dignified seminaries, there are twelve *gymnasia*, which latter are meant as intermediate between schools and colleges. The number of academies for the promotion of sciences amounts to twelve, all of which publish transactions, and of which those of Stockholm, Gottenburg, and Upsal are the most celebrated. A society of antiquaries was founded so far back as the year 1668; a medical society twenty years afterwards; the royal society of Upsal in 1720; and the royal academy of sciences in 1739. In 1753, an academy was instituted for the investigation of the language, history, and poetry of Sweden. Sweden can boast of some names that have obtained an eminent place in the literary, but particularly the scientific history of Europe. Queen Christina, in the 17th century, encouraged Grotius, Descartes, and other celebrated writers, to reside in her dominions. And though some of these distinguished persons did not remain long in Sweden; yet continued so long as to sow the seeds of science and literature, and to diffuse a taste for intellectual pursuits. The impulse thus given to the cause of letters, has since, though with some exceptions, been steadily promoted by government. In natural history, Sweden can exhibit the names of Linnaeus, Scheele, Tilas, Wallering, Quist, Cronstedt, Bergman. In history, Dalin and Laderbring have highly distinguished themselves. In remote times, John and Olaus Magnus rose to eminence as writers in the same department; but their works are too fabulous to be deserving of much attention. In lexicography, the name of Oehrling is well known. Baron Swedenborg, though eminent both in science and general literature, is better known as a theological writer, and as the founder of a sect that bears his name. The study of the Belles-Lettres has not been neglected, particularly in recent times, and it promises ere long to be very successfully cultivated. New publications amount to between 300 and 400 annually, of which one fourth are translations.

The native language of Sweden, which superseded that of the Fins, the original inhabitants, is a a dialect of the Gothic. "The Danes, Swedes, and Norwegians," says Dr. Murray, "are the posterity of the Teutonic or German tribes. They all speak varieties of one original dialect, of which the purest specimen is found in the Edda, a collection of mythological poems made in Iceland about the year 1120. The general character of this dialect is great purity of terms as to signification, certain peculiarities of inflection, which have arisen from the operation of time on a language long separated from the cognate dialects of Germany, and a curtailed or abbreviated form of many words. As to the figure of the words and their inflections, it is much more corrupted than the Saxon, the Alamannic, or even the modern German. The Scandinavian appears to have been a distinct dialect long separated from the German, so far back as the time of Jornandes, in the year 540."—(*Hist. of European Language*, ii. 479.) This language is spoken in its greatest purity in Dalecarlia. In the southern parts of the kingdom, several German and French words and expressions have been incorporated with the vernacular tongue; while in Lapland, the Finnist, or the language of the original inhabitants, still predominates.

The national character of the Swedes is highly respectable and interesting. They are remarkable for great simplicity both in manner, in dress, and in feeling. They are eminently hospitable, honest, contented, industrious, brave. The population being thinly scattered, and communication with strangers not being very frequent, they, like the Scottish Highlanders and the Welch, are attached to ancient usages, and traditionary legends; and their tendency in this respect is found to be considerably inveterate, not being easily removed or modified by recent improvement. The weakest point in their character, however, is an immoderate indulgence in the use of ardent spirits. This indulgence is confined chiefly to the lower orders: a considerable quantity of corn is made use of every year for the purpose of distillation. But with this trifling exception the character of the Swedes is entitled to the highest commendation. The following extracts contain much interesting matter respecting both the character and condition of this people, and though long, would lose much of their value by being abridged or changed. "Upon entering a cottage," says Mr. Coxe, "I usually found all the family employed in carding flax, spinning thread, and in weaving coarse linen, and sometimes cloth. The peasants are excellent contrivers, and apply the coarsest materials to some useful purpose. They twist ropes from swine's bristles, horses' manes, and bark of trees, and use eel skins for bridles. Their food principally consists of salted flesh and fish, eggs, milk, and hard bread. At Michaelmas they usually kill their cattle, and salt them for the ensuing winter and spring. Twice in the year they bake their bread in large round cakes, which are strung upon files of sticks, and suspended close to the ceilings of the cottage. They are so hard as to be occasionally broken with a hatchet, but are not unpleasant. The peasants use beer for their common drink, and are much addicted to malt spirits. In the districts towards the western coast, and at no great distance inland, tea and coffee are not unusually found, which are procured in great plenty, and at a cheap rate, from Gottenburg.

The peasants are well clad, in strong cloth of their own weaving. Their cottages, though built of wood, and only of one story, are comfortable and commodious. The room in which the family sleep is provided with ranges of beds in tiers, one above the other: upon the wooden testers of the beds in which the women lie, are placed others for the reception of the men, to which they ascend by means of ladders. To a person who has just quitted Germany and been accustomed to tolerable inns, the Swedish cottages may perhaps appear miserable hovels: to me, who had been long used to places of far inferior accommodation, they seemed almost palaces. The traveller is able to procure many conveniences, and particularly a separate room from that inhabited by the family, which could seldom be obtained in the Polish and Russian villages. During my course through those two countries, a bed was a phenomenon which seldom occurred, excepting in the large towns, and even then not always completely equipped: but the poorest huts of Sweden were never deficient in this article of comfort,—an evident proof that the Swedish peasants are more civilized than those of Poland and Russia." (*Travels*, iv. 333-5.)

"My journey from Undevalla," says Mr. Conway, "was made on a Sunday; and judging from the concourse of people who thronged the road, and particularly from the multitude assembled in a churchyard, which lay close to it, I had every reason to conclude that the Swedes are a church-going people. * * * I was exceedingly pleased with the respectable appearance of the peasantry. I know they are poor, wretchedly poor, but they had neither forgotten the way to the house of God, nor omitted in their poverty to provide decent apparel for their appearance there. * * * From a height over which the road passed in the course of this day's journey, I counted no fewer than eleven churches in sight at the same time. From other specimens than that which I have mentioned, I have no reason to doubt of their being all well filled." (*Personal Narrative*, 286-7.)

The following extract, which shall be the last, is still more interesting. "In passing along the Swedish roads," continues the same sensible writer, "the traveller frequently sees a charity-box fixed at the way side; and it is a beautiful trait in the character of that nation, worth all their records of glory and deeds of arms, that there is no instance of one of these boxes being plundered. The poor in Sweden are well provided for, both by these receptacles for casual alms-offerings, and by a regular parish provision; but to recur to the honesty of the Swedes. I think it may safely be averred that Sweden is the most remarkable of any of the European nations. On account of this virtue, doors are constantly left upon the latch. Horse stealing and sheep stealing are utterly unknown. Of sacrilege there is no example upon record; and indeed, excepting at Stockholm and Gottenburg, where a taint of foreign manners may be expected to obtain, every description of property may be considered as safe from dishonesty. (Ib. ib.)

With regard to the condition of the Laplanders Mr. Coxe observes, "the people are partly settled, and in part wild and roving; the latter live in tents made with coarse cloth; the former are fixed in small villages near the lakes, and chiefly follow fishing.* They build their cottages somewhat in the shape of a cone; and they are all constructed of wood. In summer their clothes are made of coarse cloth; in winter of the skins of rein-deer. In spring their food consists principally of the eggs of water-fowl, which are extremely plentiful in those parts; in summer and autumn, of the birds themselves, and of various others of the partridge tribe; and in winter, of the milk and flesh of the rein-deer and dried fish. Bread, which till lately was totally unknown to them, now makes a part of their usual diet. The Laplanders before their conversion to Christianity, possessed no books or MSS. though they knew many traditional histories and songs of ancient heroes and princes who once ruled over them, involved, however, in great uncertainty, and mixed with the most fabulous accounts." (iv. 61-4.)

The revenue of Sweden, though comparatively small in regard to that of other countries, is equal to the expenditure. It is little more than one million sterling. In England every individual is calculated to contribute to the revenue of the country L.3, 13s. 4d.; whereas in Sweden so small a sum as 9s. is the average individual contribution. The national debt, some years ago, amounted to L.6,000,-000, due chiefly to bankers and merchants in Hamburg; it has since been gradually reduced to L.1,380,000, owing entirely to Swedish subjects, and, it is thought, may be paid off by the operation of a sinking fund in fourteen years.

With an income and expenditure so small, the military and naval force cannot be supposed to be great. The military force, though never very great, has been extremely variable. The troops which crossed the Baltic along with Gustavus Adolphus, did not exceed 10,000 men, of whom the greater part were mercenaries. It has since that time amounted to 50,000, with 30,000 of reserve. At present, in a time of peace, it is very much reduced, consisting of 31,000, including both infantry and cavalry. There is, in addition to the regular army, a national force or militia, which is always maintained in an efficient state, and which is composed of about 20,000 men. The naval force has of late been much neglected. In 1799, there were twenty sail of the line; in 1806, thirty; and at present there are only six, and eight or ten frigates. There is, however, a considerable number of gunboats, and other flotilla calculated to convey land forces. The number of marines of all kinds is 10,000.

The government of Sweden, like that of Britain, is a limited monarchy, declared hereditary in the male line of the reigning family, but in case of a failure of male heirs in that line, a successor is to be nominated by the king, with the consent of the people. The civil list for the maintenance of the king and his household is about L.50,000; that of the crown prince, or king's eldest son, a third of that sum. The legislature consists of four classes, those of the nobles and landholders, of the clergy, of the deputies of towns, and of the peasants. Each of these classes has a speaker; the archbishop of Upsal being officially the speaker of the class to which he belongs, while the others are nominated by the crown. The king has a *veto* on the enact-

* Swedish Lapland contains 1,921 inhabitants, of whom 931 have flocks of rein-deer; 379 lead a wandering life. (*Revue Encyclopedique*, for February 1829, p. 374.)

ments of the legislature, but no bill can pass till it has received the sanction of three out of the four classes. The introduction of a bill, or a motion for a new law, as in Britain, may be made by any member, as well as by a minister of the crown. The diet which these classes form must meet by law every fifth year, but oftener, if convened by the king. Their power and privileges are similar to those of the British Parliament. The executive administration also resembles very much that of England; each department having its own board or head; in this department of government, division of labour has been carried to a very laudable extent.

Sweden possesses only one small colony, viz. that of St. Bartholomew, an island in the West Indies, about fifteen miles in circumference, ceded to Sweden by France in 1783.

On the history of this country we do not intend to enter minutely, as it has already been given collaterally under the articles BRITAIN, DENMARK, POLAND, RUSSIA; to which we refer the reader. Of its ancient state little is known with certainty. The original inhabitants were a colony of Finns from the banks of the Volga, and the vicinity of Mount Caucasus. And about three hundred years before the Christian era, they were driven from their northern settlements by the Teutones, a people who came thither from Germany, and who either expelled the original inhabitants, or became incorporated with them. Except in the northern extremity of Lapland, however, every trace of the Finns has long been obliterated. The present Swedes, therefore, as well as the Danes and Norwegians, are of Teutonic or Gothic origin; and the term Scandinavia, or Land of Caves, was conferred on the extensive regions which now form these three nations, from the practice of the inhabitants dwelling in rocky caverns. (Jornandes *de rebus Geticis*, c. 3. Murray's *European Languages*, i. 12, 153; ii. 478).

This country was not converted to Christianity till the end of the eleventh century, when this happy event took place by means of missionaries from England. It renounced the errors of popery, and adopted the reformed doctrines, five centuries afterwards. Sweden, though meanwhile it had various forms of government at different periods, remained free till the year 1392, when Margaret, queen of Denmark, styled the Semiramis of the north, conquered it by policy and by force of arms, and made one kingdom of these three vast states. This conquest was not destined to be permanent. Sweden was the victim of wars and insurrections; and was alternately free and enslaved for upwards of a century; at the end of which time appeared Gustavus Vaza, a young man, descended from the ancient kings of the country; and, abandoning the forests of Delecarlia, where he had concealed himself, he aspired to become the deliverer of Sweden. His attempt was successful; the Danes were expelled, and Gustavus was himself elected king of the country of which he had been the liberator. He introduced the reformation into Sweden; and was in many respects a man superior to his age. He had the influence to get the crown declared hereditary in his family, who, with various degrees of eminence and merit, have continued till within these few years to enjoy it. He died in 1560, after a glorious reign of thirty-seven years. Anxious to strengthen the throne by an alliance with the family of some of the neighbouring powers, he endeavoured to accomplish that object by the marriage of his son Eric, who succeeded him, to Elizabeth queen of England. The offer, as is well known, was rejected.

The successors of this enlightened restorer of Swedish liberty were, with few exceptions, not worthy of him. They were all indeed endued with a chivalry and heroism not common even in ages when such attributes were regarded as the perfection of character; but they were devoid of sober judgment, of nice discrimination, and of sound policy. Their romantic spirit and enterprizes, as in the case of Charles XII. not unfrequently approached to the verge of infatuation or insanity; and tended directly to retard the progress of knowledge and civilization in the territories over which they ruled.

Of the descendants of Vaza, Gustavus Adolphus, on whom has been conferred the title of Great, was the most distinguished, and to whom we have already alluded in this article as the bulwark of the Protestant faith. He defended the Lutherans against the Emperor with equal bravery and good fortune. He made war, with success and with consummate skill, against Russia, Denmark, Poland, and Germany, and these great achievements he performed before he had completed his thirty-seventh year; at which age he fell in the arms of victory at Lutzen; carrying "to the tomb," says Voltaire, "the name of Great, the regrets of the north, and the esteem of his enemies."*

He was succeeded by his daughter, Christina, to whom we have before referred as a great patroness of learning and learned men. She became a Catholic; and relinquishing her crown, retired at the age of thirty-seven to Rome, where she passed the remainder of her life in the centre of the arts which she loved, and for which she had renounced sovereignty.

The history of Charles XII., who has not inaptly been called "an illustrious madman,"—his successive victories over the Danes, the Poles, the Russians, his ultimate defeat at Pultowa, his confinement in Turkey, his escape, and his death at the siege of Frederickshall, are well known to every reader, and need not to be told here. Nor is it necessary to enter on the history of any of his successors. The extensive conquests which Sweden had made beyond the Baltic were gradually taken from her during the course of the last century. The late Gustavus IV., on the French revolution, entered into an alliance with Great Britain against

* Gustavus Adolphus had the discrimination to commit the management of the government to the illustrious Axel Oxerstiern, one of the great statesmen of Europe, and who enjoyed the confidence of three successive Swedish monarchs. He died in 1651. His nephew, Benedict Oxerstiern, was scarcely less celebrated. He held offices of dignity and responsibility under four successive monarchs, and died Chancellor in 1702.

France; and when, in 1808, Russia joined her forces to those of the latter kingdom, he broke off an alliance with that power; and on the invasion of his territories by the Russians, lost Finland, which has since (1809), continued dissevered from Sweden. The result of this war was not merely this loss, but the dislike of his people, and resentment of the nobles. The Duke of Sundermania, who was at the head of the discontented party, conceived and executed the plan of dethroning Gustavus, and of investing himself with his honours. This was easily effected: not the least disturbance took place on account of it; and the Duke assumed the crown under the title of Charles XIII.

Charles changed the government from a despotic to a limited monarchy. He made peace with Russia. He joined himself to the allies against France. By a treaty made in 1814, and confirmed in the subsequent year at the congress of Vienna, Norway was added to his dominions, on condition of his ceding to Prussia Pomerania and the island of Rugen: Finland was finally guaranteed to Russia; and Sweden was confined within the bounds which we have already described. It may here be mentioned, that when Norway was united to the country which we are describing, her independence, as to government, laws, and institutions, was solemnly stipulated: a full account of which may be found under the article Norway. Meanwhile, in 1810, General Bernadotte, a Frenchman, had the influence to get himself declared Crown-prince of Sweden; a choice which, though at first it excited general surprise, has proved very judicious, from the prudent and liberal character of that celebrated person. In 1818 Charles XIII. died, and Bernadotte quietly ascended the throne, under the title of Charles XIV. This monarch has indeed shown himself worthy of the dignity conferred on him. He has patronized and promoted, as previously stated, every species of internal improvement. He has constructed canals, erected schools, and done all in his power to promote the cause of education. A new civil and penal code is in progress. The public hospitals have not been overlooked; six useless ones have been suppressed; every modern improvement or discovery is immediately introduced. And, under his enlightened sway, Sweden, though, from inherent physical causes, she can never rise higher than a power of the second order, is rapidly advancing in real prosperity and influence, and is affording an example of improvement and of enlightened policy, which many nations more highly favoured in point of climate and physical advantages, would do well to imitate.

See *Travels* by Coxe, Wraxall, Thomson, Conway, Brooke, Rae Wilson; *Revue Encyclopedique* for Feb. 1829. Cantzler. *Mem. sur les Affaires Polit. et Econ. de Swede;* also the works of Puffendorf, Vertot, and Voltaire, respecting Sweden. *Edin. Annual Register* for 1815.

SWEDENBORG, Emanuel. This eminent and most remarkable man was born at Stockholm, in Sweden, Jan. 29, 1689, and died in the city of London, March 29, 1772. His father, Jesper Swedberg was Bishop of Skara, in West Gothland. and superintendent of the Swedish mission in England and America, a man of extensive learning and great piety. In the year 1719, Emanuel Swedberg, on account of his learning and usefulness, was elevated to the order of nobles, and his name was then changed to that of Swedenborg. He was educated at the University of Upsal, and was even in his youth remarkable for his application and assiduity in the study of philosophy, mathematics, natural history, chemistry and anatomy, together with the ancient and modern languages. Although even in youth he was seriously disposed, and thought much on religious subjects, yet he says he was by Divine Providence kept from reading dogmatic and systematic theology; and it was not until the latter part of his life that he learned the Hebrew language, in order to study the scriptures. He was thus, he says, prevented from imbibing the unfounded opinions and inventions of men. In 1716, at the age of 28, Swedenborg was appointed by Charles XII. Assessor Extraordinary of his Board of Mines. The diploma appointing him to the office states "that the king had a particular regard to the knowledge of mechanics possessed by Swedenborg:" and in Dr. Norberg's history of that monarch, many interesting conversations are related between Swedenborg and Charles.

From 1716 to 1720, Swedenborg's time was principally spent in travelling. He visited the Universities of England, Holland, France and Germany. In 1721 he undertook a scientific journey for the purpose of visiting the mines and smelting works of Europe. During this journey he became acquainted with the Duke of Brunswick, who published, at his own expense, Swedenborg's Opera Philosophica et Mineralia, in three volumes. The first volume is entitled "Principles of Natural Things, or New Attempts at a Philosophical Explanation of the Phenomena of the Elementary World." This volume is divided into three parts: the *first* treats of creation in general; the *second* treats on magnetism and the variations of the magnetic needle; the *third* treats of the sun and its vortex, of the creation of the planetary earths from the sun, of Paradise and the first man. He here mentions *seven primary planets;* this discovery being more than 40 years before Dr. Herschel. The 2d volume of this work is entitled, "The Subterranean or Mineral Kingdom, or a Treatise on Iron, and the methods which are adopted in various parts of Europe for the liquefaction of iron and converting it into steel, &c." The 3d is entitled "The Subterranean or Mineral Kingdom, or a treatise on copper, and brass, &c."

In 1740 he published "Œconomia Regni Animalis; the Economy of the Animal Kingdom." The first part treats of the Blood, the Arteries, the Veins, and the Heart; with an Introduction to Rational Psychology. The 2d part treats of the motion of the brain, of the cortical substance, and of the human soul.

In 1744-5, he published "Regnum Animale." The first part of this work treats of the viscera of the abdomen, or the organs of the lower regions. The 2d part, of the viscera of the breast, or of the organs of the superior region. The 3d part treats of the skin, the touch, and the taste, and of organical forms in general. In these works, Œconomia and Regnum Animale, he made many important discoveries in anatomy and in the circulation of the blood, and which have been attributed to more modern authors. It was Swedenborg who first discovered the existence of a passage of communication between the two lateral ventricles of the cerebrum. The above works are the principal philosophical writings of Swedenborg. There are minor ones, of which it is not necessary to take notice.

In the year 1743, at the age of 54 years, Swedenborg declared that he was gifted with spiritual illumination, and was called by the Lord to open to men the spiritual sense of the Holy Word; and thus be the means of instituting a New Church, signified by the New Jerusalem in Revelation.

In a letter from Swedenborg to the Duke of Hesse, he says, "in your gracious letter you ask how I attained to be in society with angels and spirits, and whether that privilege can be communicated from one person to another. Deign then to receive favorably this answer. The Lord, our Saviour, had foretold that he would come into the world: and that he would establish there a New Church. But as he cannot come again into the world in person, it was necessary he should do it by means of a man, who should not only receive the doctrine of this New Church in his understanding, but publish it by printing; and as the Lord had prepared me for this office from my infancy, he has manifested himself before me, his servant, and sent me to fill it. This took place in the year 1743. He afterwards opened the sight of my spirit, and thus introduced me into the spiritual world, and granted me to see the heavens and many of their wonders, and also the hells, and to speak with angels and spirits, and this continually for 27 years. I declare in all truth that such is the fact. This favour of the Lord in regard to me has only taken place for the sake of the New Church, the doctrine of which is contained in my writings. The gift of conversing with spirits cannot be transmitted from one person to another, unless the Lord open the spiritual sight of that person."

From the time he was thus called of the Lord he devoted all his time and substance to writing and printing his theological works. In order to have his works printed he travelled to Holland, France, and England. In this latter country he died on the 29th March 1772. The principal theological works of Swedenborg are the Arcana Cœlestia, in 12 vols. 8vo. True Christian Religion, 2 vols. 8vo. Heaven and Hell, one vol. 8vo. Conjugal Love, 1 vol. 8vo. Divine Providence, 1 vol. 8vo. Apocalypse Revealed, 2 vols. 8vo. Apocalypse Explained, 6 vols. 8vo. The Last Judgment, 1 vol. 8vo. Divine Love and Wisdom, 1 vol. 8vo. Besides these there are many smaller works; but they appear only intended as introductions to the others, or as abridgments of their contents. In these works the following doctrines are developed. 1. That there is but one God, one in essence and one in person, in whom there is a Divine Trinity like soul, body, and operation in man, and that the Lord and Saviour Jesus Christ is that one God. 2. That the humanity derived from the virgin was successively put off, and a Divine humanity put on in its stead: and this was the glorification of the son of man. 3. That redemption consisted in the subjugation of the powers of hell, whereby man was delivered from the bondage of evils and falses, and that it was thus an actual work on the part of the Lord, for the sake and happiness of man. 4. That faith alone does not justify and save man: but he must have faith, charity and good works, and thus, by the actual union of will and understanding, knowing, loving and doing the commandments, become regenerated. 5. That the sacred scripture or Word of God is divinely inspired in every particular, and contains a natural, spiritual, and celestial sense, and is thus applicable to angels in heaven, as well as to men on earth: and that the letter of the Word is in every part purely correspondential: and therefore the science of correspondence, or the analogy between natural and spiritual things, is the key whereby the Word is opened in its genuine spiritual sense. 6. That man enters immediately after death into the spiritual world, leaving his body, which will never be reassumed: and continues to all eternity a man in a human form, with the possession of all his faculties. Death is therefore a continuation of life: and according to man's prevailing love, such is his state hereafter. The love of the Lord and the neighbour constitutes heaven; and the love of self and the world constitutes hell: for heaven and hell are not places, but states. 7. That the last judgment spoken of in the New Testament, was effected by the Lord in the spiritual world in the year 1757; it being a judgment upon those in the world of spirits who had been of the former church: the good were then elevated to heaven, and the evil cast down into hell. Thus the way was prepared for the second advent of the Lord, which was a coming not in person but in the power and glory of his Holy Word, and a new spiritual influx being communicated, a New Church would thereby be established. This is signified by the old heaven and the old earth passing away, and the new heaven and the new earth being formed. These are the leading doctrines contained in Swedenborg's Theological Works. But three of his principal works are chiefly designed to explain the scriptures in the spiritual sense, and in these, together with several of his large works, there are interspersed, Memorable relations of things seen and heard in the heaven of angels and in the world of spirits. Swedenborg on all occasions unhesitatingly declared that he had intercourse with the spiritual world: and many facts are related by those personally acquainted with him to prove the truth of his assertion: but he himself always refers alone to the nature of his writings and the things contained in them as sufficient to prove to any one that he was so favoured of the Lord. A short time previous to his decease, he was asked by the Rev. Thomas Hartley, Rector of Wynwick, if all he had written was strictly true, he replied "I have written nothing but the truth as you will have it more and more confirmed hereafter all the days of your life; provided you always keep close to the Lord, and faithfully serve him alone, in shunning evils of all kinds as sins against him, and diligently searching his Word, which from beginning to end bears testimony to the truth of the doctrines I have delivered to the world." In a letter to the king of Sweden, Swedenborg says, "I have already informed your majesty, and beseech you to recal it to mind, that the Lord our Saviour manifested himself to me in a sensible personal appearance; that he has commanded me to write what has been already done and what I have still to do: that he was afterwards graciously pleased to endow me with the privilege of conversing with angels and spirits, and to be in fellowship with them. I have already declared this more than once to your majesty, in the presence of all the royal family, when they were graciously pleased to invite me to their table with five senators and several other persons; this was the only subject discoursed of during the repast. Of this I also spoke afterwards to several other senators; and more openly to Count de Tessin, Count Bonde and Count Hopken, who are still alive and were satisfied of the truth of it." During the life time of Swedenborg there were many eminent men in Europe, who gave credit to his mission and were the warm advocates of his doctrines. Among these may be mentioned Dr. Gabriel Andrew Beyer, Professor of Greek Literature and member of the Consistory at Gottenburg; Dr. Rosen, an eminent Clergyman of the same city; Mr. Robsam, Director of the Bank of Stockholm; Christopher Springer, Swedish Consul at the Port of London; Dr. Messiter, an eminent Physician in London; General Christian Tuxen of Elsineur, in Denmark; John Andrew Van Hopken, prime minister to the king and secretary to the Swedish Royal Academy of Sciences; Mr. Œttinger, Superintendent of the royal mines in Sweden; and the Rev. Thomas Heartly, Rector of Wynwick in Northamptonshire, England. All these gentlemen were personally and intimately acquainted with Swedenborg, and their letters &c. show their undoubting confidence in Swedenborg's spiritual communications. The receivers of his writings are considerable in Europe and America. All his theological works have been translated into English, and many of them into German and French. We will conclude this notice with an extract from a letter of Count Hopken to General Tuxen. "I have known Swedenborg for two and forty years, and sometime since daily frequented his company. A man who like me has lived long in the world, and even in an extensive career of his life, may have numerous opportunities of knowing men as to their virtues or vices, their weakness or strength; and in consequence thereof, I do not recollect to have ever known any man of more uniformly virtuous character than Swedenborg; always contented, never fretful or morose, although throughout his life his soul was occupied with sublime thoughts and speculations. He was a true philosopher and lived like one: he laboured diligently, lived frugally without sordidness; he travelled continually, and his travels cost him no more than if he had lived at home. He was gifted with a most happy genius and a fitness for every science, which made him shine in all those he embraced. He possessed a sound judgment upon all occasions; he saw every thing clearly, and expressed himself well on every subject." Roche.

SWEET SPRINGS, post village and watering place, situated in the northeastern part of Monroe county, Virginia, and on a mountain elevation of at least 2400 feet above the Atlantic tides; 84 miles NW. by W. from Lynchburg; 204 miles W. from Richmond; and 263 miles SW. by W. from W. C. These fountains are on the extreme higher southwestern sources of James river. Darby.

SWIFT, Jonathan, D. D. the illustrious Dean of St. Patrick's, was born in Dublin on the 30th of November 1667. The house, (No. 7, Hoey's Court) in which he first saw the light, is still pointed out with reverence. He was a posthumous child, his father, of the same name, who, among other employments, held the office of steward to the society of the King's Arms, having died eight months before the birth of his son. His mother was Abigail Ericke, of Leicestershire, a lady whose ancient genealogy was her principal dowry. On the death of her husband, our author's mother found herself left utterly destitute. She and her son were supported by the charity of their relations, some of whom were sufficiently wealthy. Under such circumstances, the subject of this sketch "early adopted," says Sir W. Scott, "the custom of observing his birth-day as a term, not of joy, but of sorrow, and of reading, when it annually occurred, the striking passage of Scripture, in which Job laments and execrates the day upon which it was said in his father's house 'that a man child was born.'"

In his infancy he resided for three years at Whitehaven with a nurse, who, out of fondness for the child, had taken him with her, when called to the town by the commands of a dying relation. This circumstance constitutes the foundation of the erroneous opinion that he was a native, not of Ireland, but of England. At the age of six, he was sent to the school of Kilkenny, where his name, cut in school-boy fashion upon the desk or form, is still shown to strangers. From Kilkenny he was removed to Trinity College, Dublin, in the year 1682, at the age of fourteen. At this seminary he was remarkable neither for studious habits, nor attention to the college discipline, nor for correctness of moral conduct. The truth is, he soon became notorious for great laxity of behaviour, and incurred the open displeasure, and had to submit to the censure of the heads of the college. He read and studied rather for amusement and to divert reflection, than with the zeal of acquiring knowledge His reading, however, though desultory, must have been varied and extensive, since he is said to have already drawn a rough sketch of the *Tale of a Tub*; which yet did not appear till the year 1704. Owing to his want of taste for logic, he was so ignorant of that science, reckoned at that time indispensable for an academical degree, that on examination he was found ignorant even of the necessary syllogistic forms, and obtained the degree of A. B. by *special favour;* a term used in the university to denote want of merit. He continued at college three years after procuring this title, and during that time he applied himself more assiduously to study, regularly devoting to it eight hours a day.

Meanwhile the death of Godwin Swift, his uncle, and principal supporter, caused him to leave college, after a residence there of seven years: when he paid a visit to his mother, who then lived at Leicester, to consult her about the future course of his life. Sir William Temple having married a relation of Mrs. Swift's, and having been long intimately acquainted with some members of Swift's family, he was recommended by his mother to that celebrated person for advice. Sir William received him with kindness; and, being pleased with his conversation and intelligence, detained him two years in his house, not as a dependent companion but as a confidential friend. Here he was introduced to the acquaintance of King William, whose friendship and confidence he gained. In the meantime he obtained the degree of A. M. from Oxford; and having had some misunderstanding with his patron, he forsook his house; and, going to Ireland, obtained orders and a curacy, through the secret influence, it is supposed, of the friend from whom he had parted. The curacy he soon after resigned, and returned to the roof of Sir William Temple, where he continued to reside till the death of this illustrious man: an event which Swift mentions in his Journal in the following terms: "He died at one o'clock this morning, (27th January 1698-9), and with him all that was good and amiable among men." Sir William bequeathed to him a small legacy in money, and entrusted him with the charge of his MSS., and, during his last illness, had warmly recommended him to the notice of the king. The MSS. were published under the superintendence of Swift, with a dedication to William. As our author was not immediately promoted by the court, or rather was overlooked, he relinquished the Revolution or Whig principles, which he had before entertained, and began to connect himself with the opposite party, to which he afterwards remained faithfully attached, and whose views he so powerfully promoted by his pen. He, ere long, though from a different quarter, obtained two livings in Ireland; and, in 1713, he was elevated to the deanery of St. Patrick's, Dublin, the highest preferment he ever gained. This situation he owed to his abilities, and to those talents for satire which he had enlisted so eagerly in the service of the administration, and which led him to those numerous political compositions, in prose and verse, which form such a considerable portion of his works.

On the death of Queen Anne, in 1714, and the triumph of that party from which he had withdrawn, he lived in retirement till the year 1720, when he gave to the world a political pamphlet, relative to Ireland, entitled, "*A Proposal for the universal use of Irish Linen.*" This work, while it gained him the enmity of the ministry, rendered him extremely popular in the eyes of his countrymen; and this popularity was further increased by his celebrated Letters, under the title of *M. B. Drapier*, published in 1724, and written with a view of opposing the introduction of Wood's copper coinage, the metal being so debased as to be worth only a third of its nominal value. "From this important era," says Johnson, "he was the oracle of the traders, and the idol of the rabble. The *Drapier* was a sign; the *Drapier* was a health; and which way soever the eye or the ear was turned, some tokens were found of the nation's gratitude to the *Drapier*."

His political reputation and his political influence were now very high. But he had not meanwhile neglected other studies of an elegant or miscellaneous nature; and, not to mention other publications, in 1727, appeared "*Gulliver's Travels;*" a production that was universally read and admired; and which does not seem to have lost any of the popularity which it so early obtained.

But amid his studies and his publications, another subject never ceased to engross a large share of his attention, and his name is connected in a most extraordinary manner with the tender passion. The story of Stella and Vanessa is known to every reader, and needs not to be repeated here. In this part of his life there is the same obstinacy and disregard to the proprieties of society that marked his character in every other respect. Both these ladies predeceased him: events which successively made a deep impression on his mind, and had a tendency to bring about that awful malady to which he had long been verging, and to which he at last fell a prey. The first stage of his disease was that of violent and furious lunacy. From this stage, aggravated by severe bodily suffering, he passed to that of perfect idiotcy. During the course of three years he is known to have spoken only once or twice. At length he died without a struggle, on the 19th of October 1745, in the 78th year of his age.

Swift was a man of original genius, of varied but not profound learning, of fine taste, of great talents for wit and satire, capricious in his friendship, charitable to the poor, not mindful of favours, whimsical, obstinate, misanthropic, avaricious. The best edition of his works is that recently published by Sir W. Scott, with an excellent Life prefixed. (T. M.)

SWIMMING is the art of suspending and sustaining the body in water, and of making motion either forward or in any direction, by means of the arms, legs, &c. This art, which is common to savage with civilized nations, and which must be nearly coeval with the formation of man, is understood only by a very few of those who practice it. Though with the Greek and Romans it was not unusual to characterize the uneducated by saying, *neque literas neque natare didicit*, yet swimming has very seldom been a regular branch in the education of youth.* All persons who practice this art, even those who excel in it the most, have been self-taught, and their eminence in it has been the result not of fixed rules, but of trial and perseverance.

Swimming, however, though the nature of it, and the principles on which it depends, have seldom been much attended to, is by no means a recondite or difficult art. The very contrary indeed may almost be said to be the case. The human body has been ascertained by experiment to be lighter than the same bulk of water; that is, the human body when immersed in water, displaces a quantity of that fluid heavier than itself. The body, therefore, when put in water, would necessarily float, if allowed to remain inactive. Mr. John Robertson, (*Philosophical Transactions*, vol. i, p. 30,) performed a variety of experiments on the gravity of the human body. He weighed ten different individuals, comparing their weight with the quantity of water displaced by their bodies, and the result was as follows:—"Excepting two, every man was lighter than his equal bulk of fresh water, and much more so than his equal bulk of salt water; consequently," he concludes, "could persons who fall into water have presence of mind enough to avoid the fright usual on such accidents, many might be preserved from drowning." Mr. Robertson, in illustration of his theory—and many similar illustrations might be given—mentions the case of a young man of thirteen, little acquainted with swimming, who, having fallen overboard from a vessel in a stormy sea, had presence of mind to turn immediately on his back, and thus remained a full half hour quietly floating on the surface of the water, when he was picked up.

Dr. Franklin's opinion on the gravity of the human body, when compared with water, is well known, and is most sound. He thinks that the solid parts of the human body, such as the legs, arms, head, are specifically somewhat heavier than fresh water, but lighter than salt; but that the trunk, particularly the upper part, from its hollowness, is so much lighter even than fresh water, that the whole of the body taken together is too light to sink wholly either in fresh or salt water. He says, that a body immersed in water would sink up to the eyes,† but "that, if the head be leaned back, so that the face looks upwards, all the back part of the face being then under water, and its weight consequently in a great measure supported by it, the face will remain above water quite free for breathing, will rise an inch higher every inspiration, and sink as much every expiration, but never so low as that the water may cover over the mouth." He states, besides, that clothes give little additional weight in the water, though when out of it, and drenched, the case is quite otherwise. The reason why a body sinks when drowning is, that the hollow part of the trunk, &c. being filled with water, the specific gravity of the body is so considerably increased, that it is weightier than the quantity of water it displaces.

Under such circumstances, if the equilibrium be not destroyed, the weightier parts of the human body would sink deepest in the water, while the contrary parts would continue on the surface, or not sink far below it. Owing to the buoyancy of the trunk, the upper part of the body is the lightest; for though the head is heavy, yet not so heavy as to counterbalance the trunk. The natural position, therefore, which, if the equilibrium be not interfered with, a body would assume in water, is that erect one which it obtains on land.

But the great difficulty is to maintain the equilibrium in question; to accomplish which nothing is so necessary as absence of fear, and the most complete self-command. A person should have a firm and sufficient conviction that the body, if left to itself, naturally floats, and that violent and irregular motion and struggling have a direct tendency to destroy this natural position. Indeed, the same struggling and throwing of the limbs which we see persons have recourse to in dangerous cases in the water, would, if practised on land, deprive the body of the faculty of locomotion, or of retaining its erect posture. Every swimmer knows that by keeping his body perfectly quiescent and upright, and by throwing his head back, so as to rest on the surface, his face will remain entirely above the water, and respiration will be as easy and free as if he were on land. It is mentioned, that when a sailor was thrown overboard, the captain, with great presence of mind, called out to him, "keep your hands down in the water." He obeyed the call; the head kept above the surface, and the due balance of the body was thus obtained. To acquire and to preserve this due balance of the body, the arms should indeed be extended laterally under the surface of the water, with the legs separated, the one stretched forward, the other backward. This position being obtained, motion backward or forward, or swimming, is to be learned gradually; indeed, it almost follows as a necessary consequence; and a very little practice will make a person a considerable adept in the art. In swimming forward, the body must be kept a little oblique, though the less so the better. The truth is, that the best swimmers maintain in water an attitude almost as erect as when they walk or run on land. The motion is produced by the motion of the arms and legs, which are extended and drawn in alternately. In swimming backward, the face requires to be uppermost, and while the motion forwards is made by the action of the arms and legs, the latter only is employed in backward motion, the hands being generally folded across the breast. There is yet another mode of swimming either backwards or forwards; and that is by treading as it is called, or by moving the feet only; by which a person seems to walk as on land.

* Oronzio di Bernardi, to whom we owe one of the best systematic works on swimming, was appointed to teach this art in the Royal Naval Academy of Naples.

† This opinion is corroborated by that of a very able writer in *The Quarterly Review*, who states, that "when the human body is immersed, one-tenth of its weight will remain above the water in salt, and one-eleventh in fresh." (No. 67, p. 38.)

In this mode, the body is nearly perpendicular, and the arms are generally folded, or the hands are clasped and held above water. "I know by experience," says Dr. Franklin, "that it is a great comfort to a swimmer, who has a considerable distance to go, to turn himself sometimes on his back, and to vary in other respects the means of procuring a progressive motion." Swimming on the back is also useful in cases of cramp in the leg,—an affection to which a person is often exposed, and which not unfrequently proves fatal. A good swimmer can easily resist the fatal effects of cramp, by turning immediately on his back and jerking the affected limb for a little in the air. But before recourse can be had to this remedy, one must be thoroughly devoid of fear, and be fully convinced that the natural tendency of the body is to float, it being lighter than the quantity of water it displaces. We may here observe, that in addition to the swimming backward or forward, there are many other fanciful positions and motions adopted by persons who are masters of the art and completely devoid of fear. In learning to swim, it may also be observed, recourse is often had to corks, bladders, planks, &c. But it is perfectly evident that such expedients are unnecessary: they are only used for the purpose of giving confidence in the power of the water to support the body; and the confidence, as shown above, can be more easily and more effectually obtained otherwise. Practice, without any of the auxiliaries referred to, will have more effect in teaching to swim than any other expedient whatever.

To a novice in the art, it is almost incredible to what perfection swimming can be brought. A good swimmer can urge himself forward by each stroke a distance equal to the length of his body. There are various ways of recruiting the strength in water by changing the position; and thirst and hunger are less severely felt than on land, owing it is probable to the quantity of the bracing liquid imbibed by the pores of the body. Under such circumstances a good swimmer can advance at the rate of three miles an hour, and continue for two or three hours in water. This, however, it is evident, must depend much on the temperature of water and on the climate. Persons have been known to perform the extraordinary distance of thirty miles at a stretch; and it is recorded that Nicolo Pesce, the famous Neapolitan diver, performed the incredible distance of fifty miles on the coast of Calabria. Nay, water had become so much like his native element that he is stated to have spent five successive days and nights in it with perfect impunity. Bernardi's pupils, on the eleventh day of their instruction, were able to accomplish an uninterrupted circuit of six miles.

Diving, or the power of descending either perpendicularly or obliquely under water, is a species of swimming to which we have not yet adverted. It is astonishing to what perfection it can be brought by practice. The inhabitants of Otaheite excel so much in this art, that when a nail is thrown into the sea, they can leap after it and catch it ere it gain the bottom. Pearls and shell fish, &c. are brought from the bottom of the sea by divers; and in ancient times divers were not unfrequently employed to destroy the ships of the enemy under water. Nor is it found to be a difficult feat. All good swimmers can dive less or more; but great correctness and eminence in it can be obtained only by daily practice. In springing from a height into the water, great precaution is required so to dispose the body as to avoid any unfavourable concussion from the water. To prevent the body from receiving injury from this concussion, the limbs should be kept firm together, the head protected by the hands clasped over it, so as to present a sharp edge, the body presenting the shape of an arrow, the hands and head entering first, the feet last. The eyes should always be kept open under water, by which every object can be discerned, and rocks and other interruptions avoided. For a very full account of this subject, we refer to the article Diving.

Many speculations have been entered into with regard to the relative natural aptitude of man for swimming compared to other animals. Man, we readily confess, labours under considerable inferiority in this respect, though by experience he can at length attain to much greater perfection in the art than many of the lower animals. Fish of all kinds possess natural facilities for swimming, such as the air-bladder, or bodies flat and thin, or long and flexible, assisted in every case by the fins, which latter are peculiar to them. Water indeed is the element natural to fish; and their form and structure are wisely adapted by providence for answering this purpose. The brute creation, though incomparably inferior to fish in this respect, are yet superior, at least during the first years of their existence, to the human race. They are, in the first place, incapable of fear, and in the second place, their head is exceedingly light in proportion to the rest of their body. It contains little brain, and it abounds in sinuses, so that its relative weight is so inconsiderable that they can easily keep their mouth and nose above water and respire freely. In man, on the contrary, the head, which is full of brains, and contains no cavities, is exceedingly heavy compared with the rest of the body: and the great difficulty which he experiences in swimming is to counteract this specific gravity and keep the organs of respiration above water. To attain this object is the perfection of swimming; and when it has been attained, man, though possessed of natural disadvantages, is superior to all animals, except fish, in this nice and useful art.

See the treatise of Bernardi, which has not yet appeared in an English form, but of which an excellent abstract, combined with much new matter, may be found in the *Quarterly Review*, No. 67. See also the *Philosophical Transactions* for 1757, No. 50; Dr. Franklin's *Essay on Swimming*, and *Thevenot L'art de Nager*. (T. M.)

SWINDEN, Van, J. H. a celebrated natural philosopher, was born at the Hague, on the 8th June 1746. His father, an eminent barrister, intended to bring up his son to the same profession, and with this view he watched his early education with the tenderest care. The young Van Swinden, however, soon showed a disposition to studies of a different kind; and he took peculiar delight in calculating, drawing, watch-making, and mechanical pursuits. At an early age he was sent to the university of Leyden, where he had the good fortune of meeting with Mr. Hennert, then private lecturer in Leyden, and a staunch Eulerian analyst, who initiated his friend into all the intricacies of the modern calculus.

At the early age of twenty (1767), when he was called to the chair of natural philosophy in the university of Franeker, he opened his lectures with a discourse, *De causis errorum in rebus philosophicis.*

At Franeker, the tranquillity of a small town gave full scope to his ardour for study. He would often not stir from home for weeks together, and all his time was divided between his closet, his pupils, and his observations. This overstraining of his faculties had its usual effects; his health was impaired, and the mineral waters of Spa, Aix-la-Chapelle, Pyrmont, were frequently resorted to, in order to restore his strength, and above all, to drive him from his studies.

The subjects of meteorology, electricity, and magnetism, then particularly engaged his attention; and he applied himself with unremitting zeal to such observations as were likely to throw some new light on these interesting subjects. Amongst his earliest writings, is his *Tentamen de Magnete*, published in 1772, in which he exposes his mathematical theory of what he calls the *punctum culminans.*

During the long space of ten years, the magnetic variation was actually observed every *hour of the day* by M. Van Swinden or his pupils. With equal care, during thirteen years, he kept an exact register of the barometer, thermometer, and hygrometer. No circumstance relating to atmospheric phenomena escaped his attention; no aurora borealis appeared during his residence in Franeker but what was accurately observed. Parts of his house and garden were arranged as an observatory. His friends, his pupils, even his servants, sustained the parts of observers during such absences as he was compelled to make. Even in other parts of the country he procured observers, to whom he gave directions and encouragement. By these means, he collected an immense number of facts relating to the subjects of his investigation, whilst by unremitting study, and an excellent memory, he acquired a degree of learning which may almost be said to be unrivalled.

His *Recherches sur les aiguilles aimantées*, to which the Academy of Sciences of Paris adjudged the prize, (1777,) contain such a vast number of observations, and such a variety of curious facts relating to magnetical phenomena, as are seldom found in any writer on natural philosophy. When the Academy of Bavaria (1776) proposed as a prize question the investigation of the analogy between magnetism and electricity, Van Swinden received the *program* so late as to leave him only a few days to prepare an answer to the question. But he had thoroughly considered the subject. The experiments required had been made long before; and the first medal was awarded to him. This paper, together with some others on the same subject, he translated afterwards from Latin into French; and they are well known to philosophers under the title of *Memoirs sur l'Analogie de l'Electricité et du Magnétisme*, 1784.

The *Journal de Physique*, the *Journal des Savans*, the Memoirs of the Academies of Berlin, Paris, of the Royal Society, of the Academies of Turin, Brussels, Haarlem, Petersburg, contain many of his papers. When Charles Bonnet's *Contemplations de la Nature* were translated into Dutch, M. Van Swinden made many additions and notes, which Bonnet judged so important as to have them inserted in subsequent French editions of his work.

Among all these various occupations which took up Van Swinden's time at Franeker, he applied himself with assiduity to various branches of mathematics, as political arithmetic, the doctrine of chances, mortality, tontines, &c. In the works of the Haarlem Society, he gave a new demonstration of Newton's formula of the binomial theorem.

In 1785, he accepted the situation of professor of philosophy at Amsterdam. Amongst the new duties imposed upon him were mathematical lectures. He explained the elements of geometry, and indeed of mathematics in general, in an excellent work, which would have established his fame as a geometer, if it had been written in a language more generally known. In this book, the strictness of demonstration of the ancients is united with practical illustrations, the use of mathematical instruments, and the history of the science. In the last edition of his work, published in 1816, it is striking to find how the venerable author, then far advanced in years, knew and had studied even the most recent publications.

Another work, which he began to publish after he was removed to Amsterdam, is more generally known. The *Positiones Physicae*, as far as they are published, are allowed to rank amongst the best elements of natural philosophy.

Some time after he came to Amsterdam, he was elected one of the directors of the school for the education of seamen. With equal ardour he managed the concerns of the school for the blind; and the interests of the Walloon Church, to which he belonged, found in him a ready and zealous promoter.

As early as 1787, the present minister of marine of the Netherlands had instituted a commission for correcting charts, introducing improvements in navigation, and publishing useful books on nautical subjects. Van Swinden was its chairman. In that capacity he caused the first accurate nautical almanack published in Holland to be printed. He wrote an excellent and extensive work on the theory and practice of finding the longitude by lunar observations, and another on the use of nautical instruments.

In 1798, Van Swinden was one of the two deputies sent from Holland to the Scientific Congress at Paris respecting the new system of weights and measures.

After his return from that capital, he published an elaborate and learned work on the subject of weights and measures, and he greatly contributed to make the new system adopted in the Netherlands.

It was about that period that he was called from his studies to the most eminent functions. Van Swinden himself was soon convinced that politics were not for him, nor he for politics. In that period he had the satisfaction of making government resolve to order a general accurate trigonometrical and astronomical survey of the country; which has since been ably executed by General Krayenhoff. In less than a year, one of those political discussions then so frequent on the continent, drove our author from office, and he cheerfully returned to his studies and resumed his wonted occupations. But when Napoleon gave the management of our affairs to his brother Louis, the new king treated Van Swinden with particular favour, and pressed him eagerly to enter again into political life. This, however, he constantly and firmly declined. At Louis's desire, he framed the plan of the present Royal Institute of the Netherlands. He was at first president, and took a most active part in all its proceedings.

When Holland became a part of Napoleon's immense empire, Van Swinden retired as much from the public eye as was practicable. The king of the Netherlands honoured him with his confidence on many occasions, and, as a Councillor of State, he faithfully discharged his duty. Respected and beloved by his countrymen, full of activity and life, he was suddenly seized with an illness, which he soon felt to be fatal. With that strength of mind which sustained him through life, he foretold and awaited its close; and in his last moments he displayed the calmness, serenity, and resignation, which become a man and a Christian. He expired on the 9th March 1823.

The following is a list of the principal works of this philosopher:—*Dissertatio de Attractione*, 1766. —*Cogitationes de Variis Philosophiae Capitibus*, 1767.—*De Philosophia Newtoniana*, 1779.—*De Hypothesibus Physicis, quomoda sint e mente Newtoni intelligendae*, 1785.—*Tentamen Theoriae Mathematicae de Phaenomenis Magneticis.* Lugd. Bat. 1772, 4to.—*Observations sur le froid rigoureux de Janviero*, 1776. Amst. 1777, 8vo.—*Recherches sur les aiguilles aimantées et leur variations. Memoires Presentés à l'Academie des Sciences de Paris, t.* 8.—*Dissertation sur la Comparaison des Thermometres*, 1778, 8vo.—*Observations Meteorologiques faites à Franeker pendant l'année* 1779. Amst. 1780, 8vo.—*Description of the Orrery made by Eise Eisinga in Friesland.* Franeker, 1780, 8vo. (Dutch.) A new edition of this work is in the press.—*Recueil de Memoires sur l'Anologie de l'electricité et du Magnetismé.* La Haye, 3 vols. 8vo. 1784.—*Description du Planetaire de M. Adams*, 1786. Plano.—*Positiones Physicae*, vol. i. and vol. ii. part 1. Harderovic, 1786, 8vo.—*A Treatise on Finding the Longitude by Lunar Observations.* (In Dutch.)—*A Treatise on the Use of Hadley's Octant and Sextant*, 1788, 8vo. (In Dutch.)—*Explanation of the Nautical Almanack*, 1788, 8vo. Dutch.—*Elements of Geometry*, 1790, 8vo. The last edition appeared in 1816.—*Report on the Census of Amsterdam*, folio, 1795.—*On Weights and Measures.* Amsterd. 1802, 2 vols. 8vo.—*Lectures on Van Laun's Planetarium, Tellurium, and Lunarium.* Amsterd. 1803, 8vo.

Besides these works, many papers by Van Swinden are printed in the Transactions of learned Societies. In those of the Royal Institute of the Netherlands, there is one in the first volume, on the laws of atmospherical pressure. In the third volume of the same collection, there is a paper in which our author maintains the rights of Huygens, as inventor of the pendulum: of this a translation has been given in Dr. Brewster's Journal. See Professor Moll's *Life of Van Swinden* in the *Edinburgh Journal of Science*, vol. i. p. 197.

SWITZERLAND.

SWITZERLAND, the ancient Helvetia, an inland country towards the south of Europe, is bounded on the west by France; on the north by Germany, or, to speak more correctly, by the grand duchy of Baden and the kingdom of Wirtemberg; on the east by the Austrian province of Tyrol; and on the south by Italy or the Sardinian and Austrian Italian territories. It is situated between 45° 50′ north latitude, and between 6° 5′ and 10° 35′ west longitude. Its length from east to west, from Mount Jura to the Tyrol, is 205 miles; from the Lake of Como on the south, to the Rhine on the north, its breadth is 125 miles. Its form is nearly oval. Its superficial extent, which is nearly equal to two-thirds of Scotland, amounts to 18,000 square miles.

The country is divided into cantons, of which the number has been various at different times, but which at present amount to twenty-two. The following is a list, with their respective capitals and population.

Cantons.	Capitals.	Pop. in 1826.
Geneva.	Geneva, .	52,500
Pays de Vaud.	Lausanne, .	170,000
Neufchatel.	Neufchatel, .	51,500
Basil or Bale.	Basil or Bale, .	54,000
Argovia or Argau.	Arau, . .	150,000
Zurich.	Zurich, .	218,000
Schaffhausen.	Schaffhausen, .	30,000
Thurgovia or Thurgau.	Fraunfeld, . .	81,000
St. Gall.	St. Gall, . .	144,000
Appenzell.	Appenzell, . .	52,500

Cantons.	Capitals.	Pop. in 1826
Fribourg.	Fribourg,	84,000
Berne.	Berne,	350,000
Soleure.	Soleure,	53,000
Lucerne.	Lucerne,	116,000
Underwalden.	Stantz,	24,000
Uri.	Altorf,	13,000
Zug.	Zug,	14,530
Schwitz.	Schwitz,	32,000
Glaris.	Glaris,	28,000
Vallais.	Sion,	70,000
Grisons.	Coire,	88,000
Ticino.	Lugano,	102,000
	Total Population,	1,978,000

Switzerland, however, originally comprehended only fifteen cantons; of which eight were formed in the 14th century; the remaining five in the 18th. The names of these are Schwitz,* Uri, Underwalden, Berne, Zurich, Lucerne, Glaris, Zug, Appenzell, Schaffhausen, Fribourg, Soleure, and Bale. This union gave rise to the Helvetic republic, so well known in history. Those territories, now joined to it under the name of cantons, were originally subject or allied to it. The French, in 1798, having taken possession of the country, and wishing to increase the number of their partizans, added six new cantons; viz. the Pays de Vaud, Argau, Ticino, Thurgau, the Grisons, and St. Gall. This number, augmented to nineteen, continued til! the downfall of Bonaparte, when, in 1815, by the Congress of Vienna, three new cantons were added, viz. Geneva, the Vallais, and Neufchatel, making altogether 22, their present number.

There is no country in Europe whose physical appearance is more magnificent, sublime, and diversified, than that of Switzerland. Mountain ridges covered with eternal snow, beautiful and romantic lakes, and verdant vallies, traversed by romantic rivers, silent forests and roaring cataracts, blended with all the varied pictures of gigantic nature, are the characteristics of this interesting country, and render minute description almost impossible.

It is particularly distinguished by its mountains. Even those cantons that are regarded as the most level, viz. Thurgau, Basil, Berne, Zurich, Schaffhausen, Soleure, and Fribourg, present mountains that rise between 2000 and 3000 feet above the level of the sea. The Alps form the most striking and elevated range, not only in Switzerland, but in Europe. This celebrated range, which traverses Switzerland in almost every direction, especially in the south and east districts, extends nearly 600 miles in the form of a crescent, with various inequalities, from the river Var, which separates France from Italy, to the Hadriatic, presenting generally an abrupt face towards Italy, and sloping more gradually on the opposite side. Their principal peaks are Mont Blanc, the loftiest mountain in Europe, 15,646 feet; Mount Rosa, supposed to be only 100 feet lower; Cervin, 13,800; Jungfrauhorn, 13,730; Schrekhorn, 13,812; St. Bernard; St. Gothard; Simplon, over which is the great military road formed by Bonaparte. Though Mont Blanc is the highest, St. Gothard may be regarded as the nucleus, for, though not remarkable in height, it merits this distinction, that the rivers which rise in it and the surrounding group, flow towards every point of the compass. The summit of all these mountains is covered with eternal snow, the snow line in Switzerland at the 46th degree of latitude having been discovered to vary between seven and eight thousand feet above the level of the sea. The sides of many of these stupendous eminences are clothed with glaciers, large masses of ice, formed by the consolidation and partial melting of the snow. These glaciers occupy the plains or hollows of the mountains; their formation takes place about the snow line, or line of perpetual congelation; though, in a winter of unusual severity, they extend considerably lower. "The glaciers," says Mr. Coxe, (*Travels in Switzerland*, i. 41-2.) may be divided into two sorts; the first occupying the deep valleys, situated in the bosom of the Alps; the second clothing the sides and summits of the mountains. As to the first, when the plane on which they rest is horizontal, or only gently inclined, the chasms are but few and narrow; the traveller crosses on foot without much difficulty." Their lower extremities, where they approach the valleys, are in a constant state of solution, giving rise to brooks and rivers, and are maintained, without any apparent diminution of size, by the gradual descent of the masses at the rate of several inches daily in summer. The channels of all the rivers, therefore, that have this origin, are fullest in summer, when ice and snow are melting in great abundance. In their external character, the glaciers present the most varied and fantastic forms, sometimes exhibiting the appearance of a city of crystal, with glistering spires, columns and turrets. Their number is immense, it having been reckoned that there are no fewer than 400 of them in the range along the south of Switzerland. Some of them are known to extend from twenty to thirty miles in length, by one or two in breadth: their depth cannot be so easily ascertained, but is supposed to vary from 100 to 600 feet;† while their total superficial extent has been calculated at 1200 square miles, their formation, it may be added, requires the action of cold to such intensity, that they are peculiar to the Alps, with the exception of a small but elevated tract of the Pyrenees, and a few spots of the mountains of Norway and Lapland. None are found in any other part of Europe.

The action of the sun on these glaciers in summer, so dissolve them, that not unfrequently huge masses, called avalanches, are disunited, and roll

* From this country, distinguished in the struggle for independence in the beginning of the 14th century, the whole country obtained its present name.

† "This depth," which is that calculated by M. Ebel, and has gained the support of M. de Saussure, "must," says M. Simond, "in some places, exceed very much six hundred feet. The minister of Grindelwald assured Professor Wyss, that, having thrown stones into some of the fissures of the ice, he counted twelve or fourteen seconds before they reached the water at the bottom, indicating a depth of 3000 feet, to match the horizontal dimension of 200 square miles, the superficial extent."—(*Travels in Switzerland*, vol. i. 211; see also Coxe's *Travels*, i. 38, for some curious conjectures on the formation and state of the glaciers).

down the declivities to the valleys below, with awful and destructive rapidity, destroying the plains, and overwhelming habitations, villages and forests. These avalanches have sometimes been known to roll down inclined planes of more than twenty miles in length. Avalanches, in the shape of loose dust, or snow frozen but not congealed into one continuous mass, are the most dangerous, on account of the great space they involve, and the whirlwinds accompanying them, which are often so very violent as to tear up trees by the roots, and demolish houses; while an avalanche of compact snow or ice, only strikes a narrow field; the latter sort takes place in spring and summer only; the former in winter.*

From the melting of the snow which covers the mountains, and from the descent of the avalanches, no country in Europe is better provided with rivers than Switzerland. And, from the same circumstance, as previously mentioned, these rivers in summer swell a third or a fourth above the usual size in winter. If we estimate their relative length of course, the Rhone is the most considerable river in Switzerland; and is, besides, the greatest river in Europe, after the Danube and the Volga. It rises on the north-east side of Mount St. Gothard, and, after receiving the waters of a surprising number of streams, it passes through the lake of Constance. It flows thence in a western direction to Basil, before arriving at which place it is augmented by the waters of the Aar, the Reuss, the Limmat, the Thur, the Glatt, the Birs, on the side of Switzerland, not to speak of those on that of Germany. From Basil its course is nearly northward, and it at length loses itself in the German ocean, after a course of 700 miles. The Rhone is next in importance. It rises within five miles of the Rhine, and after flowing through the canton of Vallais, it passes through the lake of Geneva, and, after a course of 500 miles, falls into the Gulf of Lyons. These two majestic rivers either take their rise from glaciers, or are essentially fed by them. In addition to the streams that are tributary to the Rhine, and some of which are large and important, we may mention the Ticino, which takes its rise in St. Gothard, but, unlike the Rhine and Rhone, flows southward, and, after receiving the waters of several streams, and passing through the lake Maggiore, falls into the Po; the Inn which, after flowing through the Grisons, the Tyrol, and separating Austria and Bavaria, joins the Danube; the Adda, which, passing through the Grisons, and directing its course into Italy, loses its waters in the Po.

As connected with the rivers, the lakes require next to be mentioned. Many of them, not confined to the plains, or the mountains, are situated on high table-land, or among mountains of considerable altitude. The following enumeration will show their relative height. The lake of Como stands 692 feet above the level of the sea; the lake of Constance, 1151; Geneva, 1225; Zurich, 1364; Zug, 1406; Neufchatel, 1428; Lucerne, or lake of Four Cantons, 1438; while that of Thun is elevated no less than 1897 feet, being fully a third higher than those of Geneva and Constance, and two-thirds above that of Como. There are many other lakes, such as those of Lugano, Wallenstadt, Brientz, Sarnen, Sempach, Joux, Morat, Bienne. The three last, like Neufchatel, discharge their superfluous waters into the Aar by the Thiele. All these lakes form a superficial extent of 314 square miles. They contain fish, such as pike, trout, salmon, lota, and umber, the last being a very delicate fish, occasionally exported to Paris, and sometimes sold for so high a price as 12*l*.

The climate of Switzerland, as may be inferred from our previous statements, is extremely varied. The extreme cold of the mountains we have already mentioned. Many ravines and portions of valleys are inaccessible, even in summer, to the direct action of the sun; and the immense masses of ice or snow which fall from the mountains on the plains, and remain on them, occasion great variation in the temperature, even in places that otherwise would be genial. The lakes have somewhat of a similar effect. In winter, too, the cold in the valleys is more severe than in most parts of France or Germany; a circumstance which undoubtedly results from the vast accumulation of snow and ice on the mountains. But this is the most unfavourable view of the subject. The valleys and the bases of the mountains exposed to the south, enjoy all the warmth of an Italian sun, and display all the heat and luxuriance of vegetation that characterize more southern climates. Such places produce grapes and the finer fruits in great abundance, and are often resorted to on account of their peculiar sweetness and salubrity. But in this country heat and cold, vegetation and sterility, border on each other, and form the most striking contrast. While, in the plain, the peasantry are engaged in the labour of harvest, the grain is slowly advancing towards maturity, or probably may not be in the ear, on the higher grounds. Nay, so much is this the case, that it has not been inaptly said, snow may be lifted in one hand, while flowers are plucked with the other. Various, however, as the climate is, the mean temperature may be known, when it is stated that at Berne it is about 40° of Fahrenheit, at Zurich about 39°, and at Geneva 40°.

The laborious character of the Swiss has done much for the agriculture of the country. Lofty and most unpromising spots have been cultivated, though they are so inaccessible that manure has to be carried to them, not in the usual way by means of mules or horses, but on the shoulders of the cultivators. Vines and rich pasturages are to be found in places of very narrow dimensions, surrounded by naked rocks or sterile precipices. Cultivation is carried almost to the very verge of the ice and snow lines. The country produces wheat, rye, barley, oats, maize, flax, hemp, tobacco. The stock of corn produced, owing chiefly to the variable nature of the climate, is not sufficient to supply the inhabitants; and by consequence, a considerable quantity requires to be imported. In some rugged districts indeed, the produce is so scanty that the inhabitants are almost strangers to the use of bread, but subsist chiefly on the produce of their dairies. "In Switzerland, as in France," says an intelligent

* See *Travels in Switzerland*, vol. i. 211; see also Coxe's *Travels*, i. 38.

traveller, "arable land lies fallow every third, fourth, or fifth year. The courses are, first, ploughing for wheat, three or four times in one year, without a crop: second, a crop of wheat the next year, which returns generally five and a half for one: third, barley: four, esparsel, (sainfoin) or some other artificial grass; then ploughing again for wheat without a crop. The turnip and sheep system is said not to answer here."—(Simond's *Travels*, i. 35.)

The rearing of cattle forms one of the greatest sources of national subsistence in Switzerland. In spring the herds are driven to the mountains, for good pasturage is obtained as high as the snow and ice lines; and after remaining there till the beginning of winter, they are gradually brought back into the plains, and more sheltered districts. A cow, according to M. Simond, yields in the summer, on an average, six measures of milk daily, each weighing three pounds of seventeen ounces. Cheese, butter, tallow, hides, form some of the chief articles of export from Switzerland.

Of fruits, vines, chesnuts, prunes, peaches, walnuts, cherries, are the most common. In colder situations apples and pears grow; while in the southern valleys the almond and fig are to be found. "The general appearance of the country," says M. Simond, "is very woody, owing to the great number of walnut trees, which grow to an immense size. Every village, farm-house, and gentleman's residence, is surrounded with them. You travel under their shade; and woods, or rather groves, of ancient or very picturesque forest trees are not uncommon."—(*Travels*, i. 35-6.) The vine, it may here be mentioned, grows in the valleys, or on the banks of the rivers or lakes, and terminates at the height of 1700 feet above the level of the sea. The oak succeeds it, and rises to the height of 2800; the beech comes next in order, and flourishes 1200 feet higher than the oak. The firs are found 5500 feet above the level of the sea.

The mineral productions of this country it is not difficult to describe. The Alps are composed chiefly of granite, of a grayish ash or bluish colour, and in some places mixed with marble. Calcareous strata, alternate with layers of fine sand, are common. These mountains also disclose porphyry, marble, and alabaster. Iron, lead, zinc, cobalt, bismuth, arsenic, and antimony, are found in various places, both in veins and in masses, but are not much cultivated. Rock-crystal is very common, and forms an article of export. Sulphur is found in many places; as also coal; and several rivers, the Rhine, the Aar, the Adda, and the Reuss, carry down gold. Strata of lignites or bituminous wood are wrought in several valleys, and the inhabitants use it for fuel. Mineral springs, of which the principal are those of St. Maurice, in the Grisons; Gurnigel, in Berne; Pfeffers, in Thurgau, abound in Switzerland more than in any other European country.

We have spoken of the fish, and the large cattle with which Switzerland abounds. Horses, mules, and oxen are used for the purposes of husbandry. Goats, sheep, and hogs are reared in great abundance. The weasel, pole-cat, ferret, badger, and squirrel are common. Of game, the white hare, the same sort as that in Siberia, the chamois, and the marmot, which last is considered a great delicacy, are the most important. The other animals are the fox, the hamster, a species of rat prized for its skin, different kinds of martens, the wild boar and the bear, the last being found chiefly in the mountains of the Vallais. Crows, eagles, vultures, are also common.

The manufactures of Switzerland cannot be expected to be either very numerous or very extensive. Yet they are not inconsiderable. The cotton manufactures of St. Gall have been noticed by every traveller, and are the most extensive in the whole country. If the circumstance stated by M. Ebel be correct, that in the canton of St. Gall alone, from thirty to forty thousand women were employed in embroidering muslin, the whole manufacturing population in that canton must be extremely great. There are also cotton works in the cantons of Zurich, Berne, and Appenzell. Linens of every kind of fabric, as also silks and woollens, are manufactured in Switzerland. Clocks and watches have long formed a staple produce of their industry and skill.

Switzerland possesses considerable facilities for commerce, though she has not very eminently gained the character of a commercial nation. Not only are the Rhine and the Rhone, but some of their Swiss tributaries, navigable, thus connecting the country with Germany, the Netherlands, and the German ocean, on the one hand; and on the other, with France and the Mediterranean. Cattle, hides, and the produce of the dairy, are the chief exports from the pastoral districts; while the exports arising from manufactures are watches and clocks, linen, cotton, and woollen cloths, and in a small degree silks. Pharmaceutical plants form a considerable branch of exportation.

The national character of the Swiss has deservedly been the subject of praise on the part of writers of every kind. Though the country consists of a variety of states, some of them formerly independent, and each varying in institutions and manners somewhat from the rest, yet the character of the people is almost unvaried, being amiable and simple. They are eminently remarkable for their love of country, a feeling certainly common to them with others, but which they seem to possess to a degree altogether unrivalled. This may arise in no small measure from the romantic features of their native land; for it seems to be an invariable principle, that patriotism is strong in proportion as the country to which it refers is distinguished by such features.* "This unconquerable passion," says Mr. Pinkerton, "seems to arise in part from

* "And even those hills that round his mansion rise
Enhance the bliss his scanty fund supplies;
Dear is the shed to which his soul conforms,
And dear that hill which lifts him to the storms.
* * * * * *
Even the loud torrent, and the whirlwind's roar,
But bind him to his native mountains more."
Goldsmith.

a moral sensibility to the enchanting ease and frankness of the native manners; and in part, from the picturesque features of the country, the verdant hills contrasted with Alpine snows, and delicious vales watered by transparent streams, scenes nowhere else to be discerned in such perfection, and which must powerfully affect the imagination,—the parent of the passions." The Swiss, indeed, possess this passion in so remarkable a degree, that, though no people emigrate more, there are few who do not return to their native land to lay down their bones beside those of their fathers. This love of country is liable to be excited and called into action by circumstances apparently trifling. Hence, in the French armies, composed of Swiss mercenaries, the tune called the Rance des Vaches, which in their youth they had heard so often sung by the Swiss milkmaids when they went to the pastures, was carefully interdicted, because it melted the rough Swiss soldier into tears, and not unfrequently led to desertion. The Swiss have long been as much distinguished for bravery as for patriotism. This virtue has been often eminently and successfully displayed in maintaining the independence of their country; and as mercenaries, they are regarded as forming the best soldiers in Europe. Like other people in a comparatively rude state of society, they are fond of traditions and of ancestry, and feel great reverence for ancient customs and institutions. Their love of freedom is extraordinary; and they are always ready to risk or sacrifice their life in defence of it. "The human mind, however," says a modern writer on Switzerland, "is made up of so many contradictions, that in this country, where liberty has been established for several ages, some remains of the worst of governments are suffered to remain; justice is privately administered, and the torture is still in use." They are fond of labour, by which they have surmounted every disadvantage of soil and climate, and have spread fertility and beauty over spots which nature seems to have meant for everlasting barrenness. They are farther characterized by great simplicity of manners, by an open and unaffected frankness, by hospitality, honesty, and all the virtues of private life. Crime is rare; and instances of capital punishment seldom occur. The Swiss in general are not given inordinately to dress; yet in some cantons sumptuary laws have been framed to prevent idle ornament. Different costumes, the origin of some of which is very ancient, prevail in different districts. The dress of the women, however, generally consists of a short ample petticoat of dark brown; red sash; blue stockings seen as high as the knee; large flat hat without a crown, tied under the chin. Games of chance are prohibited; but gymnastic exercises form the daily amusements of the young; they engage in the race, in wrestling, in throwing the dart, or shooting at the target. Although the Swiss cannot be regarded as a very poetical people, they are devotedly fond of music; and of all the arts, it is most carefully cultivated. The observations which we have made under this head are chiefly applicable to the rural and pastoral class of the people. The manners that obtain in the large towns are considerably different, and are rapidly becoming similar to that state of society, which, under similar circumstances, prevails in general Europe. The men are tall, robust, and well made; the women are handsome, modest, frank, and agreeable in conversation.

We cannot conclude this portion of our subject without referring to the *goitres*, wens, or excrescences on the neck, to which in certain districts the Swiss are so liable. These excrescences are of incredible size, varying, as Mr. Coxe assures us, from the size of a walnut to almost the bigness of a peck loaf. They are not hereditary, as has been alleged, because many persons whose parents were free of them, have either been born or have become goitrous. Of the causes of goitres there have been various conjectures. The notion that snow-water occasions them is totally devoid of foundation; for on that supposition they would be most common in the interior and southern portions of the kingdom; which is not the case. They are as common in the north as elsewhere; and, besides, goitres are found to obtain, not merely in the champaign districts in the north of Italy, and in the neighbourhood of Naples, but in several parts of the East Indies, where snow is unknown. Nor is the opinion, that they owe their origin to the concentrated heat of the climate, and to the stagnation of the air, better founded. The truth is, it seems now to be universally believed, that the excrescences in question are to be attributed to the carbonate of lime, or *tuf*, as it is called in Switzerland, with which the springs are impregnated. The following illustration of this opinion, in the correctness of which subsequent writers most fully agree, we owe to an intelligent traveller, to whose work we have so often referred. "A surgeon, whom I met at the baths of Leuk," says Mr. Coxe, "informed me that he had not unfrequently extracted concretions of *tuf-stone* from several goitres; and that from one in particular, which suppurated, he had taken several flat pieces, each about half an inch long. He added, that the same substance is found in the stomach of cows, and in the goitrous humour to which even the dogs of the country are subject. The same gentleman assured me that in the course of his extensive practice, he had diminished and cured the goitres of many young persons by emollient liquors and external applications; that his principal method, in order to prevent them in future, consisted in removing the patients from the places where the springs are impregnated with *tuf* or calcareous matter; and, if that could not be contrived, by forbidding the use of water which was not purified. He confirmed the report that infants are occasionally born with guttural swellings; particularly those whose parents are goitrous; and remarked that one of his own children had at its birth a goitre as large as an egg, although neither he nor his wife, who were both foreigners,* were afflicted with that malady. He had dissipated it by external reme-

* "In the former instance, goitres may, though perhaps erroneously, be termed hereditary; but in the latter, where the parents are both foreigners, and not goitrous, can scarcely be derived from any other cause than the aliment of the mother.

dies,* and, since that period, had invariably prohibited his family from taking the spring waters, unless they were distilled, or mixed with wine or vinegar, by which means he was able to preserve them from those humours in the throat that were extremely common among the natives of the town which he inhabited."—(*Travels*, i. 401-2). Goitres, we may conclude by mentioning, are most common in the cantons of Berne, Lucerne, Friburg, and Vallais, but particularly in the last; and in all of them the carbonate of lime is found in solution in almost all the springs.

Goitres have been described as checking respiration, and rendering those afflicted with them indolent and languid. But this, it is feared, is not their only effects. They are regarded as producing idiocy, or, it is supposed that the same causes that produce the one, occasion the other, thus affecting both the mind and the body. This fact is certain, not only that idiocy prevails most where goitres abound, but that idiots are most frequently both goitrous themselves, and are descended of parents so afflicted. The truth, in fine, is that idiocy, whatever is the cause, and the one assigned is the most likely, obtains more in Switzerland, particularly in the Vallais, than in any other known country or district in the world.

Switzerland is remarkable for nothing more than for the means of education it possesses, and the consequent intelligence of its inhabitants. In this respect it is not inferior to the best educated countries in Europe. When the means of education are sufficiently ample in a country, from one-ninth to one-tenth of the population are attending school. In Scotland, where our parochial schools afford us such facilities, the proportion undergoing education is below that average. In England, the deficiency is still more apparent. In France not more than the 28th part of the people are enjoying the blessings of education; while in the Pays de Vaud the proportion is one-eighth, being more than the average; so that the inhabitants of this district have been pronounced the best educated in Europe. The state of schools, however, is different in the different cantons. In none of them, however, is this important subject neglected; but education is more generally diffused among the catholic than the protestant states. The most improved plans of instruction, such as that of Bell and Lancaster, have been introduced; and every means have been used to promote the great object in view,—the education of the people. Nor has Switzerland merely introduced the plans of others; she has, with great success, tried methods of her own, and has thus lent her aid to the great cause of education. The celebrated school of Pestalozzi, at Yverdun, in the Pays de Vaud, has been visited and celebrated by every traveller. This was the first seminary in which the intellectual system, as it has not inaptly been called, or that system which consists, not in mechanical routine, as is still too common in schools, but in illustrating the rationale of every subject taught, and of cultivating the mental faculties, had its origin, and was brought to great perfection. It embraces also the plan of mutual instruction on the part of the pupils, as recommended by Bell and Lancaster. Of the old and new systems, as ascertained in this canton, the comparative result is most clearly favourable.

By the Old System.	*By the New System.*
40 out of 100 read well.	50 out of 100.
37 do. wrote well.	59 do.
21 do. understood orthography.	80 do.
15 do. arithmetic.	31 do.
38 do. catechism.	49 do.

Nor is the establishment termed the School of Industry, of Mr. Fellenberg, at Hofwyl, in the canton of Berne, less celebrated than that of Pestalozzi. The object of this seminary is to combine scholastic education with industry; which at Hofwyl is agricultural, but which might, in towns for example, be manufacturing, or of any kind whatever. We have not time to examine into the real merits of this scheme, for an account of which we refer to Simond's *Travels*, (vol. i. 407-20,) and to an excellent article in No. 64 of the *Edinburgh Review;* but we may mention that, like that of Pestalozzi, it has given a great impulse to education throughout the country, and has produced some very eminent scholars. Pupils of the highest rank come to it from Germany, France, England, &c.—Of the other seminaries in Switzerland the character stands high. In most of the cantons education is a matter of state, and is under the immediate protection of government. Not to speak of the schools in the country districts, most of the large towns enjoy similar most efficient institutions; and in Zurich, Berne, and Lausanne, there are academies or colleges of great reputation. The universities of Basil and Geneva have long been celebrated, and can exhibit in the list of their pupils and professors some of the greatest names in Europe. Since the revival of learning, Switzerland can boast Zuinglius, and Oecolampadius, Bullinger, and Beza, the reformers; Hans Holbein, the celebrated painter;† Ischudi, who died in 1592, and who has been characterised by M. Simond, as "the first and greatest historian in Switzerland;" Paracelsus, the physician and alchy-

* We may here mention that Dr. Coindet of Geneva has recommended the use of iodine as a specific for the cure of goitre. The truth is, burnt sponge was long applied with considerable success to remove the excrescence in question before the cause of its efficacy was known; and it is only of late that iodine has been discovered to exist in it. The same substance has been detected in various mineral springs, the waters of which have been found efficacious in that disease. The form in which it is used are the tincture, and the hydriodate of potassa, the dose of each being about ten drops. It is also appliedby friction as an ointment, mixed with lard, in the proportion of one drachm of iodine to three of the latter substance.

† Though a native of Basle, Holbein may be regarded as more an English than a Swiss artist. Neglected by his native country, he came to England in the 30th year of his age, under the patronage of Henry VIII. where he continued the remainder of his days. He died in London of the plague in 1554, aged 58. He may be said to have been the founder of the art, in which he excelled, in Britain.

mist; Turretine; Ostervald; Conrad Gesner, and his descendant John Gesner, both naturalists; Solomon Gesner, styled the Theocrates of Germany; also Bodmer, "justly denominated," says Mr Coxe, "the father of German literature;" Hottinger, the historian; Senebier, the literary historian; Bonnet, the naturalist and metaphysician; Mallet, the historian and antiquary; Leonard Meister, the historian; Albert Haller; the two Bernoullis, mathematicians; Saussure and de Luc; Zimmerman; Rousseau; Lavater; Euler; Necker. Physical philosophy and natural history, profane history and antiquities, biography and bibliography, are the branches in science and literature most cultivated in this country.

The public libraries of Switzerland are such as become the literary character of the country. Those of Berne, Geneva, Basil, Zurich, Lucerne, are the most extensive and the most valuable. Their collections vary from 30,000 to 60,000 volumes, of which many are rare, some are unique. They contain many important manuscripts, literary, historical, and classical;* many medals and curiosities; and some of the best editions of the classics, particularly the early impressions of the 15th century. These manuscripts embrace a great number of the letters of Zuinglius and the early reformers. There are many other libraries belonging to colleges and public bodies, some of them of great extent and importance. Libraries belonging to private individuals are very common, and not inferior to those of any other country, one individual being mentioned by Mr. Coxe as possessing a collection of no fewer than 15,000 volumes, all valuable, many of them rare, no fewer than 700 having been printed in the 15th century. Botanical gardens, museums, and scientific collections are numerous. There are many literary, philosophical, and scientific associations in Swizerland, as well as others, whose object it is to promote agriculture and internal improvement. Berne, Geneva, Lausanne, Zurich, Basle, Lucerne, and many other places can boast of such societies. "The Swiss," says M. Simond, "have just revived a custom dropped during the last anxious period of a revolution, that of an annual meeting of their learned men, principally naturalists, in each of the cantons successively. The object, moral and political, as well as scientific, is to bring together, during three days, distinguished men of the different parts of the union, who otherwise would have remained personally unknown to each other."—(*Travels*, i. 319.) Communications are received, and memoirs and papers are read, and discussions of every kind take place, as in other scientific associations. Such meetings, while they show that physical investigations are of national importance, are calculated to promote emulation, if not in one sense, to reward it.

In Switzerland there are 130 printing presses scattered throughout the cantons, of which Geneva has the greatest proportion. These presses, however, are not always fully employed. There are several scientific and philosophical journals published. The number of newspapers amounted in 1826 to 28, of which 22 were written in German, four in French, and two in Italian. A considerable proportion of these papers appeared twice weekly; but only one, (*The New Gazette*, a Zurich publication,) thrice a week. In some cantons a rigorous censorship exists over the periodical press.

It is evident from the foregoing head, that the three languages there mentioned must be spoken and understood in Switzerland. But the German is more commonly used than any other; and the greater number of the eminent authors of the country have written in that language. In the southern districts Italian is in use. French obtains in the west, namely, in the cantons of Geneva, Pays de Vaud, Neufchatel, and in part of those of Berne, Fribourg, Soleure, and Vallais. German is spoken throughout the remainder of the cantons. But in several of these cantons, the lower orders make use of another language, consisting of several dialects, slightly different from each other. It is regarded as the ancient language of the country, and is held in high estimation by thōse among whom it prevails. It is a branch of the Celtic, with the admixture of several words of Greek and Latin derivation.

The reformed doctrines, as we have already hinted, were early introduced into Switzerland, and some of the earliest and most eminent reformers were natives of that country. It was from Geneva, where Calvin and Beza taught, that Knox, the Scottish reformer, introduced the presbyterian polity into this country. The different cantons, however, are very different in regard to religious character and dicipline, the catholic faith being yet retained by about one-third of the whole population. The cantons of Soleure, Fribourg, Lucerne, Zug, Schwitz, Underwalden, Uri, Ticino, and Vallais, still continue popish. Those of Argau, Glaris, Thurgau, St. Gall, Appenzell, and the Grisons, are partly catholic and partly protestant. The other cantons are protestant. Though illiberality and persecution have been, even of late, displayed in this country, toleration seems to be now permanently established. The following table gives a relative view of the different religious sects in 1821. The protestants, we may remark, generally entertain the doctrines of Calvin.

* In the library of Zurich are three Latin letters from Lady Jane Grey to Bullinger. They are written with her own hand; they breathe a spirit of the most unaffected piety; and prove the extraordinary progress which that unfortunate and accomplished princess, though only in the 16th year of her age, had made in various branches of literature. The Greek and Hebrew quotations show that she was well acquainted with these languages. These letters, though given in several publications, are not printed with any regard to accuracy. (Coxe, i. 96.)

Cantons.	Protestants.	Catholics.	Anabaptists.	Jews.
Zurich,	191,700	1,350		
Berne,	300,500	41,700	900	
Lucerne,		103,900		
Uri,		12,000		
Schwitz,		34,900		
Underwalden,		21,800		
Glaris,	25,815	3,285		
Zug,		15,000		
Fribourg,	5,100	67,400		
Soleure,	4,200	49,200		
Basil,	45,900	5,900		
Schaffhausen,	26,900	200		
Appenzell,	41,200	13,800		
St. Gall,	81,829	61,371		
Grisons,	49,000	34,000		
Argau,	76,500	68,800		1,700
Thurgau,	63,900	19,000		
Ticino,		95,000		
Pays de Vaud,	155,000	3,200		
Vallais,		67,400		
Neufchatel,	50,000	2,200		
Geneva,	27,430	14,400		270
	1,144,974	739,406	900	1,970

Switzerland, though a republic, does not form one great community like Greece or Rome; but, like the United States of America, it is a confederacy, or combination of several petty states, each being distinct and different from the rest. All the Swiss cantons, however, are independent, possessing, by an inherent right, the privilege of managing, respectively, their internal and private affairs; but their several constitutions are so different that they may, in this respect, be classed in the following manner: I. Neufchatel, which, till the year 1815, belonged to Prussia, is the only one in which monarchial forms of government are modified by republican institutions. II. Schaffhausen, Zurich, Basil, Soleure, Berne, Lucerne, and Fribourg, form aristocratical governments; in which several privileged families possess the direction and management of public affairs. III. Thurgau, Argau, St. Gall, Pays de Vaud, Geneva, Vallais, and Ticino, are representative republics. And IV. the people of Appenzell, Zug, Schwitz, Uri, Glaris, and Underwalden, live under a democratic government: the citizens form general assemblies, nominate their magistrates, and deliberate on the interests of the republic. The general interests of the Helvetic republic, such as the conclusion of foreign alliances, the defence of the country, &c. are managed by a general assembly or diet, composed of deputies from each of the cantons, and which holds its meetings successively at Berne, Zurich, and Lucerne. At these diets all matters are decided, by a plurality of votes, excepting declarations of war and treaties of peace, which require three-fourths. The diet assembles at least annually, but oftener when necessary.

The Swiss are quite a military people. Every artizan is a soldier, or must be enrolled in the national militia, at the age of twenty, and be clothed according to the military uniform of his canton. Each canton, in the event of a war, furnishes a contingent; and all the contingents amount to 33,758 men. The Swiss, in military affairs, have for centuries been remarkable for a very peculiar practice, namely, letting out troops for hire to foreign powers, on the condition of their forming separate regiments, and not intermingling with the troops of any other country. This practice was acted upon so recently as during the late war, and in Spain till 1820. Swiss mercenaries have gained a name for valour and skill inferior to that of no other country. To provide for the maintenance of the army, and for other expenses, the cantons impose on themselves a tax in proportion to their relative population and resources. The revenue of the confederation, cannot, on this account, be great; indeed it was so small in 1826 as L.500,000; but the debt was only the fourth of that sum, or L.125,000.

Of the towns of Switzerland we mean not to give any account, as of the most important of them such an account has already been given under the proper articles. None of them are large. Geneva, the largest, contains only 25,000 souls; Berne, the next in size, 17,600; Basil, 16,300; Zurich, 10,400; Lausanne, 10,220; the rest contain fewer, varying from 9,000 down to 1,700, the population of Altorf.

The history of Switzerland, previously to the time of Cæsar, may be regarded as unknown or uncertain. It may, as has been believed by one class of writers, have been visited and colonized by the Greeks, who founded Marseilles several centuries before the time to which we refer. This opinion has been supposed to gain countenance from statements made by Herodotus and Appolonius Rhodius; and an expression made use of by Cæsar seems farther to corroborate it. *In castris Helvetiorum tabulae repertae sunt, litteris Graecis confectae*, (*Comment. de Bell. Gall.* lib. i. cap. xxix.) But whether the opinion be correct or otherwise, cannot now be ascertained. Nor do we stop to inquire. At the dawn of authentic history, we find the country inhabited by the Helvetii and the Rhaetii; the latter inhabiting, in addition to Swabia and the Tyrol, what afterwards formed the Swiss cantons of Appenzell, Glaris, Uri, and the Grisons; the Helvetii occupying the remaining cantons. These people were of Celtic origin; and remains of the Celtic language, which was long their native speech, still exist. Their defeat by Cæsar is well known. They were afterwards ranked among the people subject to Rome, and were exposed to all the hardships which such a connexion always imposed on conquered nations.* On the downfall of the Roman power, the Helvetians, like the other people of Europe, were overrun by hordes of barbarians; they were successively conquered, and nearly extirpated by various tribes, the Alemanni, the Franks, the Huns, the Burgundians. From the beginning of the eleventh

* Aventicum was the capital of the country in the time of the Romans. It is now called Avenches, and is situated in the Pays de Vaud. Its walls can still be traced, inclosing a space about five miles in circumference, part of which are occupied by the present town. It can boast of many magnificent remains.

century, the provinces which now constitute Switzerland, began to be regarded as an appendage of Germany; and are mentioned in history as receiving at different times certain privileges and immunities from the head of that empire. These, however, did not proceed from the spontaneous policy of the emperors: they were wrested from them in consequence of the repeated applications and urgent remonstrances of the Swiss themselves, who seem from the earliest periods to have abhorred dependence, and to have been animated with principles of liberty. In truth, the inhabitants of Uri, Schwitz, and Underwalden, (three territories known by the name of the Waldstetten) possessed from time immemorial the right of being governed by their own magistrates, and of enacting their own laws; they had always declared themselves averse to the authority of the emperor's representative among them; and when, like the rest of the country, they did consent to acknowledge this officer, it was on the condition that he would govern according to law, and make no encroachments on their rights and privileges. Usurpation, however, followed after usurpation, till at length the whole country was reduced under the power of the house of Austria. Tyranny in truth was carried to the utmost extent, and freedom seemed to be for ever extinguished in Helvetia. But it was checked, not destroyed; its spirit still continued to linger among them; and at length it burst forth with a greater energy than ever. A confederacy to shake off the yoke of their oppressors, and to achieve the independence of their country, was formed in 1307 by three individuals, natives respectively of the three cantons that composed the Waldstetten. The conspiracy was embraced with delight by all to whom it was communicated; the names of the heroes who organized it have ever since been revered throughout Switzerland; and the spot where it was first formed is regarded as sacred. The revolution which was contemplated, was accelerated, or rather secured, by the insults shown on the part of Gessler, the representative of the Emperor, to William Tell, one of the early conspirators, and the greatest of Swiss patriots, and by the intrepid spirit he showed in return. Tell was taken prisoner by his oppressor; but while being conveyed on the lake Lucerne to Kussnacht, the residence of the latter, he made his escape, and hastening by land, surprised the tyrant near his castle, and shot him on the spot with an arrow. This brought matters to a crisis. The Waldstetten at once availed themselves of the advantage they had gained; the intestine troubles of Austria prevented that power from taking effective retaliatory measures; the authority of the empire was thrown off; and the independence of the oppressed country established. On the 7th of January 1308, the people of the Waldstetten assembled, and took an oath of perpetual alliance.

Every thing connected with the history of William Tell is interesting. He was born of humble parents, at Burglen, in the neighbourhood of Altorf, the capital of Uri; and was married to a daughter of William Furst, one of the three original conspirators. On the spot on which Tell landed when he escaped from Gessler, a chapel was erected, thirty-one years after his death, to commemorate the event. In the interior of the building, the most celebrated actions of the patriot's life are coarsely painted. He fought at the famous battle of Morgarten, of which we shall immediately speak. Instead of courting places of emolument or distinction, he refused them when offered to him. The highest official dignity he accepted was that of first magistrate of Burglen. His death, which happened in 1368, when he had attained to advanced years, was accidental, and took place in connexion with an event not unworthy of his patriotic life. He was drowned in attempting to rescue a boy who had fallen into a stream which passes by his native place. He left behind him a name the most illustrious in the Swiss annals.

But Austria, though, as previously mentioned, she could not effectually oppose or prevent this revolution, adopted measures for this purpose, so soon as her intestine commotions would permit. In the year 1315, Leopold, Duke of Austria, marched against the independent cantons with an army of 20,000 men. Nor were the patriot band, which, though few, were undismayed, unprepared to receive them. The latter amounting only to 1400, seeing that their invaders were intending to force their way into their liberated territory at Morgarten, a narrow pass formed by the lake Algeri, and a neighbouring mountain, resolved to make a stand at this formidable strait: and, after imploring the divine assistance, they took up an advantageous position on the mountain. The result, which, in some measure, recals to our minds the battle of Thermopylae, was as glorious to the patriots, as it was worthy of their cause. The whole Austrian army was either killed or dispersed; while the loss of the Swiss is not estimated at more than fourteen. This defeat settled the question between the two countries. In the same year the three cantons of the Waldstetten confirmed at Brunnen the alliance recently formed: and the Helvetic confederacy dates its foundation from this period, namely, the year 1315. It consisted at first of the three cantons already mentioned: during the course of the same century, Berne, Zurich, Lucerne, Glaris, and Zug, joined the confederacy; and other five, namely, Appenzell, Schaffhausen, Fribourg, Soleure, and Basil, in the beginning of the 16th, thus forming the thirteen cantons so well known in history.

Meanwhile, indeed so early as the eighth century, christianity was introduced into this country, by two Scotsmen, educated at the famous monastery of Iona, founded by St. Columbus. The reformed doctrines were also early introduced; and the name of Switzerland is intimately connected with the history of the Reformation.

The history of the Swiss confederacy ceases to be interesting for many centuries subsequent to the union of the thirteen states. These states, notwithstanding intestine quarrels about religion, continued to flourish, to cultivate and enjoy the friendship of each other, and to be at peace with the other states of Europe. It is not till the year 1798, that the history of the Helvetic confederacy began again to be connected with that of the surrounding countries. Contrary to the express treaty concluded between France and the country under review in 1792, the French Directory made a hostile descent on the canton of Basil in the year 1797. The Directory, without any other motive than the hope of plunder, excited, says M. Schoell, a revolution in Switzerland, and under pretence of being invited by one of the parties, they sent troops into that country; overturned the existing order of things; and under the title of the Helvetic Republic, established a government entirely subject to their authority.

Such was the downfall of the ancient constitution. The Swiss, enslaved by the Directory, made several bold efforts to regain their former independence, but in vain. Nor were they firmly united, else success might have crowned their exertions. Two parties, which had long existed, though they had not openly avowed themselves, now appeared, and Switzerland experienced a series of revolutions in which the unionists, or aristocratical party, and the federalist or democratic alternately had the ascendency. A civil war now tore this country, so long peaceful and happy. A French army, under the command of Ney, again entered it, and established (1803,) a constitution, not of a kind wished for by the majority of the people, but recommended by Bonaparte, now consul of France. This constitution is known in history by the name of *the Act of Mediation;* and Bonaparte, putting himself at the head of it, commanded the able cooperation of the Swiss in his future wars. Switzerland, as before mentioned, now included nineteen cantons; the constitution of each of which was more or less democratic; while the equality of the citizens formed the basis of them all. Under such circumstances, with the exception of some partial commotions, did this country continue till the success of the allied forces emancipated her from the grasp of her conqueror. Immediately on this event, the cantons were far from being agreed as to the future constitution of the country. A civil war, indeed, was likely to be the consequence. But the Congress of Vienna, which met in 1815, and fixed the boundaries of the different countries of Europe as they now stand, prevented this calamity, by taking the case of Switzerland into their consideration. They did for her more than her best friends could have expected. They restored her independence. They made, as stated in the beginning of this article, an addition of three new cantons to her territory. They granted to her that constitution of which we have already given an account.—Under all these advantages, however, the Swiss cantons cannot be looked upon as greater than a third rate power; but in other respects, particularly with regard to literature, education, and civil privileges, she is not inferior to almost any of the first powers in Europe.

See the Articles AUSTRIA and FRANCE: Muller's *History of Switzerland:* Koch's *Revolutions de l'Europe,* with Schoell's *Continuation; Travels in Switzerland,* by Ebel, Coxe, and Simond: Saussure's *Voyages dans les Alpes; Annual Register* for 1815. (T. M.

SYDENHAM, THOMAS, a celebrated physician, was born at Winford Eagle in Dorsetshire about the year 1624, and was the son of a gentleman of independent fortune. He was sent to Oxford in 1642, and after taking degrees there and also at Cambridge, he practised in Westminster. He died, December 1689, in the 65th year of his age. A very full account of him as a medical writer has already been given in our Article MEDICINE, Vol. XII. p. 730.

SYDNEY, a town of New Holland, and capital of New South Wales. It is situated on the two necks of land which form Sydney cove. The town, which has now considerable regularity, covers a great extent of ground. The public buildings are handsome, and there are many excellent houses, though the greater number are of a mean aspect. The government house is a handsome building. A bank was established here in 1817, and there are two excellent public schools for the education of children of both sexes. The expense of it is defrayed by a tract of land of 15,000 acres, stocked with horses, cattle, and sheep, a part of which, both land and stock, is given in dower to every female that marries with the consent of the committee. There is here an auxiliary Bible Society and a Sunday School institution, which were instituted in 1817. Besides the public schools there are various private seminaries for boarding and educating the children of the wealthier inhabitants. Population about 8000. East Long. 151° 25′. South Lat. 33° 15′.

SYENE, SIENNA, or ASSUAN, a celebrated town in Upper Egypt. The principal antiquities here are a small temple, supposed to be the remains of Eratosthenes's observatory, the remains of a Roman bridge, and the ruins of the Saracen town. The latter include the city wall, built of unburned bricks, and defended by square towers, several mosques with lofty minarets, and many large houses in a state of wonderful preservation. There is a castle at Syene, commanded by an aga, but it is poorly defended. There is also a handsome stone quay. East Long. 32° 54′ 34″. North Lat. 24° 5′ 23″. See ASTRONOMY. Vol. II.

SYLLA, See ROMAN EMPIRE, Vol. XVI. p. 401.

SYMPIESOMETER, from συμπιεζω, *to compress,* and μετρον, *a measure,* is a barometrical instrument invented by Mr. Adie of Edinburgh, for measuring the weight of the atmosphere by the compression of a column of hydrogen gas enclosed with a column of almond oil. A drawing and description of it have been already given in our Article METEOROLOGY, Vol. XIII. p. 166. See the same Article, page 178.

SYRACUSE, an ancient city and republic in Sicily, celebrated for its splendour, its wealth, and its military prowess; but now most illustrious as having been the birth place and residence of Archimedes, whose genius and labours have survived the memory of all its other greatness.

The ancient city of Syracuse was surrounded by a treble and almost impregnable wall 18 miles long, and contained four considerable cities, Acradina, Tyche, Neapolis, and the Island of Ortygia.

Acradina, (See Acradina, Vol. I.) situated on the shore, was separated from Neapolis and Tyche by a wall of extraordinary thickness and altitude. Tyche was built between Acradina and the steep and rugged hill called Epipolæ, and contained the great gymnasium and several beautiful temples, particularly that of Fortune. Ortygia was united to the other cities by a bridge, and contained the palace of Hiero and the magnificent temple of Diana and Minerva. Neapolis, or the New City, formed the western extremity of Syracuse, and was defended by high ground. The principal ornaments were the temples of Ceres and Proserpine, a theatre and amphitheatre, and the statue of Apollo Temnites, afterwards carried to Rome.

Syracuse had also four fine harbours, separated by the island; the greatest, which was 5000 paces in circuit, and about two miles long and one wide, was formed by a point of the island Ortygia on one side, and on the other by the little Island and Cape Plemmyrium. Its entrance was 590 paces wide. It ran into the very heart of the city, and was called *Marmoreo* from its being encompassed with marble edifices. The lesser harbour is on the North East of Ortygia, and near it is still shown the site of Archimedes's house, and the tower from which he burned the Roman galleys.

Modern Syracuse occupies the south-east corner of the ancient city, and contains Ortygia, and part of Acradina. It is surrounded by a wall, and is defended by draw-bridges. Though the streets are narrow, yet they are tolerably regular, and the houses are upon the whole pretty well built. The ancient temple of Minerva has been converted into the cathedral of the city, and is dedicated to the Virgin Mary. The ancient amphitheatre still exists and attests its former grandeur. It is 300 feet long by 200 wide, and the arena, the sides and passages, were all cut out of the solid rock. A part of the long wall built on the north side of the city by Dionysius still remains. It is seven feet high, and 10 feet thick. The catacombs of Acradina still exist. They are about a mile long and eight feet high, containing many tombs and sepulchral caverns. The Ear of Dionysius is a gulf or cave 170 feet long by 60 high, and from 20 to 35 wide, possessing a powerful echo. The fountain of Arethusa still discharges the contents of a river, and that of Cyane, a few miles from the town, sends out a copious stream. In the year 1810, a beautiful statue of Venus, without the head, was dug out of a heap of ruins under a tree, and by a little expense other objects of antiquity might easily be obtained. An hospital, with a number of churches and convents are the only other objects in the city. The exports from the town are wax, wheat, oil, hemp, and slates. Population 14,000. East long. 15° 27-3'. N. lat. 37° 3'. See our articles Archimedes, Vol. II. p. 307. Athens, Vol. III. p. 27. Burning Instruments, Vol. V. p. 51.

SYRACUSE, a fine flourishing post village and seat of justice, Onondago county, New York, situated on the Erie canal at the point where the Salina side canal leaves the main trunk, 25 minutes north of west from Albany; 47 miles W. from Utica, and by post road 342 miles a little E. of N from Washington city.

The village of Syracuse stands at the foot of a range of hills, out of which and flowing to the north issues Onondago creek, which about two miles below enters the lake of the same name at the village of Salina. In a state of nature the space between the hills of Syracuse and the Onondago lake was an alluvial flat, liable to annual inundation, but the side canal which connects the Erie trunk with Lake Ontario by way of the Oswego river, has been extended from Syracuse and into Lake Onondago by a series of locks at Salina.

The side canal assists to drain the flats which are also desiccated by other drains, and by an operation at its outlet, which has lowered the level of Onondago lake. The salines or salt flats are at the village of the same name. When the writer of this article visited these places in 1823, the operations of draining the flats, those on the Onondago canal, and the erection of extensive pans to make salt by solar heat, were all in a state of forwardness.

SYRIA, a province in the Turkish empire, consists of five pachaliks; viz those of Aleppo, Tripoli, Damascus, Acre, and Palestine. It is 150 leagues long and 35 broad, and contains about 5256 square leagues, and the population is reckoned at two and a half millions. See Aleppo, Palestine, Damascus, Palmyra, and Turkey. See also Volney's *Travels in Syria*, and Clarke's *Travels*, vol. ii.

SYROS or Syra, an island in the Grecian archipelago, about 36 miles in circuit, and 14 long. The town of Syra is built on the summit of a lofty hill, so conical that it resembles a vast sugar-loaf covered with houses. The quay, with several warehouses, is at the base of this cone. Near the harbour, which is tolerably good, there are some ruins, and it is said that many ancient marbles are buried behind the magazines. The modern town probably occupies the site of the ancient Acropolis. The streets of Syra are dirty and narrow; and the old fountain still exists near the town, discharging its limpid water from the solid rock. The productions of the island are wines, figs, cattle, barley and wheat. The inhabitants, who are all Greeks, profess the Catholic religion. Population 4000. East Long. 24° 34'. North Lat. 37° 22'. See Clarke's *Travel's*, vol. iii. p. 424-433.

SZEGEDIN, a large town of Hungary, in Csongrad, opposite to the conflux of the Theyss and Maros. The principal public buildings are a theatre, a work-house, several hospitals, a monastery of Minorites, a school of the Piarist monks, a gymnasium, and a small academy for philosophy. The principal manufactures are woollen goods, leather and toys. The trade is carried on by a number of barges, some of 250 tons. The exports are corn, cattle, wool, tobacco, and timber. Cattle are imported from Turkey, and salt from Transylvania. The town is surrounded by a mound and moat and is defended by a brick wall. Population, 26,000.

T.

TABASCO, river of Mexico in the state of Tabasco. This stream, as delineated on Tanner's Map of Mexico, rises in the mountainous chain between Guatemala and Chiapas, and flowing thence 150 miles, curves to the northeastward, enters Tabasco, and falls into the southern part of the Gulf of Mexico, after an entire comparative course of 300 miles, between latitudes 16° and 18° 30′ N.

TABASCO, state of the Republic of Mexico, bounded on the east by Sumasinta river, separating it from Merida or Yucatan; on the south it has the state of Chiapas; west the eastern extremity of Vera Cruz; and on the north the Gulf of Mexico. As laid down on Tanner's Map of Mexico, it is about 150 miles long from east to west, with a mean breadth inland of 60, area 9,000 square miles.

The declivity of Tabasco is to the northward, and drained in that direction by Tabasco, St. Pedro, and Sumasinta rivers. Lying between latitudes 17° 20′, and 18° 30′ N. and longitudes 14° and 16° 30′ W. from the meridian of Washington city. Population 80,000.

Hermosa, the capital, stands on Tabasco river about 40 miles inland from the Gulf of Mexico, N. Lat. 17° 46′; Long. 16° 37′ W. from W. C. Population 5,000.

TABASHEER, the name given to a siliceous substance of vegetable origin, which possesses very remarkable properties, both optical and physical. In the *Philosophical Transactions*, p. 1819, and in the *Edinburgh Journal of Science* for April 1828, No. xvi. p. 285, Dr. Brewster has given a full account of these properties, so that we shall content ourselves with giving a general abstract of them.

"Bamboo-manna" (says Dr. Wilson* the learned secretary of the Asiatic Society of Calcutta,) "is known in the Materia Medica of the Hindus by a variety of appellations, implying simply its being the produce of the bamboo, or denominating it from some of its sensible properties, the *milk*, *sugar*, or *camphor* of bamboos. The name in ordinary use is *Bansa-rochunu*, the ornament of the bamboo, corrupted in the vernacular dialect to *Bunslochan*. The name in use amongst the Mahommedans of India is *Tabasheer*, an Arabic word, explained by Meninski, *liquor, specie sacchari concretus in arundine Indica majore, et quasi petrefactus; in India, saccar Bambu* (sugar of the Bamboo,) *dicitur, pro quo cineres nodorum aut radicum vulgo distrahi solent*.

According to the Sanscrit works on medicine, such as the Bhava Prakas and Raja Nighant, the bunslochun is slightly austere, astringent, and sweetish to the taste. It possesses cooling and demulcent properties, allays thirst and fever, and relieves cough and difficult breathing. It sweetens the humours, and is serviceable in jaundice and leprosy. Its chief virtues, however, and those for which it is mostly esteemed, are supposed to be of a restorative nature, and it is highly apprized as an aphrodisiac.

In the markets of Calcutta it is found in three states. The best is termed *Patnai*, being brought from Patna, and is in small compact pieces of a milky-white colour, having the lustre of emanel, and being semitransparent. It is termed *Nilkunthi*, from its bluish tinge, and *Paharika*, from its being brought from the *Pahar*, or hills to the westward of Behar. The second sort is of a dead white colour, without lustre or transparency, and much more friable than the preceding. It is termed *Chheluta*, the Bengali corruption of Sylhet apparently, whence it is well known that this substance is procured. The third and worst kind is termed *Desi* or country; it is white; with a yellowish tinge, less friable than the second sort, but without lustre or transparency. The last is said to be soluble in water; the two first are not. An artificial bunslochun is also manufactured from chalk.

The following information respecting the Pharica or hill tabasheer, has been received from Captain Playfair, residing at Hazareebagh.

Bunslochun is found at Zelda, Boondoo, sixty miles from Huzareebagh, at Luka Kole, 100 miles from thence, at Palamow and at Nagpore.

It is found in the small hill bamboo. In a clump of fifty or sixty, only five or six contain the substance.

From each bamboo one or two rutties (four or five grains) are usually obtainable. It very rarely happens that four anas (from forty to fifty grains are procured.

It is found in the same bamboo of different qualities. The best sort is of a bluish white colour and glossy surface. An inferior kind is of a chalky white without lustre, and the worst sort is brown and even black.

The raw material is sold at ten rupees a seer; but it is prepared for use, and in that state sells from forty to fifty rupees per seer.

The only preparation, however, is its imperfect calcination.

A quantity is placed in an open vessel of baked clay upon a fire of charcoal, which is urged with bellows till the vessel and its contents become of a red heat. The manna first becomes black, but when raised to a red heat, emits a fine diffusible aroma.

It is kept red hot for some time, occasionally stirred with an iron spoon, and sometimes another vessel is inverted over that in which it is contained.

* In a MS. communication sent to Dr. Brewster, by George Swinten, Esq who has, at great trouble, sent him the finest collection of specimens of Tabasheers in existence.

The fire is then allowed to subside, and as it cools, the bunslochun resumes its white colour.

An ounce and a half, treated in this manner, was reduced to an ounce. The process lasted three quarters of an hour.

"The substance is sent to market in this state, and is taken in powder as a tonic, or chewed with betel, with a view to renovate the constitution."

As tabasheer, says Dr. Brewster, is found only in a small number of bamboos, (*arundo bambos*,) we cannot regard it as a secretion from the plant in a healthy state. An intelligent native of Vizagapatam, who had inspected several hundred bamboos, observed, that in every joint which contained the tabasheer there was a small perforation evidently made by an insect; and he conceives that the exterior juices of the plant find their way through this opening, and drying up form tabasheer. This observation, however, is by no means correct. I have found tabasheer in many joints where there was no perforation; and as the perforations are never lined with the siliceous matter, and have no accumulation of tabasheer at either end, they can have performed no part either in secreting or conveying the juices of the reed.

An examination of the joint or internode of the bamboo will probably lead us to a more satisfactory explanation. The culm or stalk of the bamboo represented by MN, Fig. 1, consists of a number of concentric rings. The outer rings, AC, BH, shown in section, are continued through the length of the reed, notwithstanding the little annular protuberance which marks externally the place of the internode AB. The inner rings, DE, GF, however, the innermost of which is a delicate membrane, do not pass onwards, but are interrupted by the internode, and turning round at EF, they form the roof of the cavity DEFG, joining the similar membrane on the side FG. Between AE and FB, where the concentric rings diverge, the space left between them is filled up with a soft spongy mass, which forms the substance of the internode AB. As the sap ascends between AC and ED, it must be stopped partially at the internode between A and E, part of it passing A, and part of it being either absorbed by the spongy mass between AE, and remaining there, or passing through it to the opposite side of the stem.

But, however this may be, the juices of the plant are collected at the internode, and could not possibly penetrate into the inner tube while the inner ring and membrane are sound, as in the healthy plant. When this membrane, however, is destroyed or rent by disease, or when the whole internode is in a state of mal-conformation, as I have found it, the juice or milk at the joints is immediately extravasated, lines the roof EF, or the bottom DG of the inner tube, and forms tabasheer by its subsequent induration.

The quantity of tabasheer, therefore, does not depend on the size of the reed, but upon the diseased state of its joints; and the greatest quantity was found in one where the internode is completely disorganized. Captain Playfair has mentioned four or five grains as the usual quantity. In the bamboo now alluded to the quantity is fully twenty grains.

By the cutting down and transporting of the bamboo, the tabasheer encrusted upon the roof or bottom of the cavity is detached, and is always found in separate pieces of different sizes. Its existence in any individual bamboo may therefore be known by the rattling noise which takes place by shaking the reed. A portion of it, however, often adheres to the place of its formation, and we may sometimes detect it in the pores of the spongy mass from which it has exuded. The largest piece of tabasheer are generally impressed with the inner membrane of the reed upon which it has been formed.

In opening different bamboos, the included tabasheer presents various appearances. When the tube has been perforated with holes, it has a brown dirty aspect, arising no doubt from the admission of dust; and the perforating insects are often found among the fragments. When there are no perforations, the tabasheer is clean and pure, presenting a great variety of aspects, depending probably on the nature of the juices, on the manner in which they have been extravasated, and on the time in which their induration has been effected. The different varieties of tabasheer may be thus enumerated.

1. The finest variety, which is also the rarest, is of a delicate azure blue colour by reflected light, and of a faint yellowish hue by transmitted light. It is easily crushed between the fingers, and it has an aerial and unsubstantial texture, which we look for in vain in any other solid. It has its counterpart in the mineral kingdom in some of the finer semiopals, which approach to the precious varieties.

2. Another variety of tabasheer reflects a yellow tint like that of molybdate of lead, and transmits a light of a reddish yellow tinge. It resembles greatly some of the yellow semiopals.

3. A third variety is nearly white, with a slight tinge of blue, and is translucent at the edge like cacholong.

4. A fourth variety resembles chalk, and is perfectly opaque.

Although these are the forms in which tabasheer generally occurs, yet several peculiarities of structure present themselves in the examination of numerous specimens. In some I have observed a layer exactly like jasper, and in one specimen the surface is covered with a brilliant enamel possessing all the lustre of pure quartz.

The chemical composition of tabasheer is still involved in some uncertainty. That which Dr. Russell brought from India in 1790, and which is similar to that sent by Mr. Swinton, consisted according to Mr. Smithson, of *pure silex;* but Fourcroy and Vauquelin* having examined a portion of what Baron Humboldt brought from South America in 1804, found it to consist of seventy parts of silex and thirty of potash. Dr. Turner,† who at Dr. Brewster's request, made a new analysis of the Indian tabasheer, found it to consist entirely of silica, with a minute quantity of lime and vegetable matter.

Its specific gravity varies from 2.060 to 2.190. The translucent variety of tabasheer loses 3.84 per cent. and the transparent variety 4.58 by a red heat, losses which it does not recover by exposure to the air.

It feels gritty in the mouth like magnesia, with a slightly nauseous taste. It dissolves readily in a solution of pure potash, even after being heated to redness.

When we plunge any of the varieties of tabasheer in water, an effervescence takes place, owing to the rapid escape of air from its pores; and when this has ceased, the transparent and translucent varieties have their transparency and translucency greatly increased, but the chalky kind retains its opacity. The quantity of water imbibed by the tabasheer exceeds in weight the tabasheer itself, and the space occupied by the pores is to that occupied by the solid particles nearly as $2\frac{1}{2}$ to 1.

The chalky tabasheer, which does not become transparent by the absorption either of oil of cassia or water, readily imbibes the fat oils, and with oil of beech-nut it becomes as transparent as glass, but it requires a considerable time to displace the air from its pores. These results are perfectly analogous to those which we obtain with hydrophanous opal, and I have also succeeded in giving transparency to the chalky silex from the Giant's Causeway, by long immersion in oil of beech nut.

If, instead of immersing the tabasheer in water, we place a small drop upon the most transparent variety, the drop is instantly absorbed, but the spot which it occupies becomes as white and opaque as if it had been covered with white lead. This extraordinary property, which is not possessed by any of the siliceous minerals, will be explained when we have treated of the optical properties of this substance.

The opaque tabasheer, which has become transparent by absorbing oil, exhibits a very curious phenomenon by change of temperature. If it is laid upon a piece of cold lead, it becomes suddenly opaque, and if it is restored to a warmer situation, its transparency as suddenly returns. These effects obviously arise from the great expansion and contraction of oil by heat. When the oil retreats from the surface of the specimen, the mutual attraction of its own particles accumulates them in one place, instead of permitting them to remain in a state of contraction in separate pores, as might have been expected. When the greater part of the oil has been expelled from these specimens by heat, the tabasheer exhibits a beautiful veined structure, the veins being sometimes parallel, as in the onyx, and sometimes curved, as in the agate. This effect arises from the different degrees of porosity in the different veins, in virtue of which some of them absorb more oil than others. The limits of each vein are thus rendered visible in the very same manner as the veins of burned chalcedony, which has absorbed oil from the lapidary's wheel, may be displayed in all their beautiful inflexions, although in its natural and transparent state it did not exhibit the slightest trace of such a structure. It is from the same property of some of the amorphous siliceous minerals that the lapidary is able to develope, and to colour, the veins of particular agates, and that the artist can execute the finest drawings, which actually lie beneath the surface of certain porous specimens of chalcedony.

The absorptive power of tabasheer is not confined to fluids. It draws into its pores solid bodies in a minute state of subdivision. If we wrap a piece of it in a bit of paper, and burn the paper, the tabasheer will come out of it of a glossy black colour, transmitting only red light, like a piece of smoked glass. By repeating this operation twice or thrice, it becomes so deeply black as not to admit a ray of the meridian sun. By exposing the specimen to a white heat the black matter is discharged, and the tabasheer is restored to its former appearance and properties. When the blackened tabasheer is plunged in water it disengages the included air, but with less rapidity than before, because there is less air to disengage; and when it is broken and pounded, its fracture and its powder are black. If the black matter has not insinuated itself copiously into the heart of the specimen, this portion is of a bluish slate-colour. When slightly wetted in this place it becomes *white*, and when saturated with water it becomes *jet black*. This, however, is an illusion; for though it does appear absolutely black, yet it is, in reality, made translucent by the absorption of the water. This translucency allows the white light, which the nucleus formerly reflected, to pass on to the black coating, where it is absorbed, —an effect analogous to what takes place in a black inkstand, in which it is impossible to distinguish ink from water by looking at the surface of the fluid.

One of the most remarkable properties of the tabasheer is its low refractive power, which is lower than that of any other body, whether solid or fluid, as will be seen from the following table:—

	Index of Refraction.		Index of Refraction.
Air,	1.000	Flint glass,	1.600
Tabasheer,	1.111	Oil of cassia,	1.641
Water,	1.336	Diamond,	2.470

Hence it appears, that the refractive power of tabasheer is actually nearer that of air than that of water. The index of refraction given above is the lowest that I have obtained; but specimens of greater specific gravity have higher refractive powers, as will be seen from the following measures:—

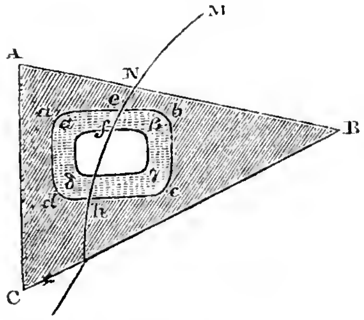
* *Mem. de L'Institut*, tom. ii. p. 382, an. 1806.

† Dr. Brewster's Journal of Science, No. xvi. p. 335, 1828.

Tabasheer,	1.1114	Tabasheer,	1.1503
do.	1.1145	do.	1.1535
do.	1.1292	do.	1.1825
do.	1.1454		

The specimen of tabasheer which I have described as covered with a brilliant enamel, possesses great hardness; and from the measure which I have taken of its angle of maximum polarization, I have no doubt that its refractive power approaches to that of the semiopals.

The determination of the low refractive power of tabasheer enables us to give a satisfactory explanation of the curious fact already mentioned, that a small drop of water produces white opacity, while a greater quantity renders it perfectly transparent. If ABC is a prism or piece of tabasheer, we may suppose one of its pores, highly magnified, to be represented by *a b c d*. This space is filled with air, and when a ray of light MN, enters the separating surface AB at *e*, and quits it at *h*, it suffers so little refraction, that the tabasheer allows us to see objects distinctly through it. Let us now suppose that a small quantity of water is introduced into the pore *a b c d*, so as not to fill it, but merely to line its circumference with a film which terminates at $\alpha\ \beta\ \gamma\ \delta$. Then the light which passes from water into air at *f*, and again from air into water at *g*, will suffer a comparatively great refraction, and will be considerably scattered in all directions. Hence the tabasheer must appear opaque. If we now saturate it with water, so as to fill the pore *a b c d*, the refractions at *f* and *g* are removed, and the ray *e f* will pass on to *h* unobstructed, so as to experience no change of direction, except the small one which takes place at *e* and *h*, where it enters and quits the fluid.



It may now be asked, whence comes the silex which circulates so abundantly in the juices of the bamboo? If we consult our best writers on chemistry and botany, we shall find it ranked as a "foreign ingredient," which the plant had derived from the peculiar soil in which it vegetated. Those who examined the drawings and descriptions of the distribution of silex in the *Equiselum hiemale*, which I submitted to the Society some years ago, will concur with me in the opposite opinion, that the silex is an integral portion of the plant itself, and probably performs some important function in the processes of vegetable life."

For farther information on this subject, see the *Phil. Trans.* 1790, p. 2739; 1791, p. 368; 1819, p. 283, Humboldt's *General Narrative*, vol. i. Introd. p. xiii. note, and Dr. Brewster's *Journal of Science*, vol. xvi. p. 285 and 335.

TABREEZ, or TAURIS. See PERSIA, Vol. XV. p. 455, and Kinneir's *Geog. Mem. of Persia*, p. 250.

TACITUS, CAIUS CORNELIUS, a celebrated Roman historian, was born about A. D. 57, at Interamna, now Terni. His father was procurator of Belgium, and so high was the reputation of his son, that in the twentieth year of his age, Julius Agricola gave him his daughter in marriage. He was successively Prætor and Consul; but history has not preserved either the circumstances or the time of his death. He lived on terms of the most intimate friendship with Pliny. His principal works are his "Annals," containing the History of Rome from the death of Augustus to that of Nero;—his History embracing a period of twenty-eight years, from A. D. 69 to 96; his Life of his Father-in-law, Cn. Julius Agricola; and his Treatise on the Manners of the Germans. The style of Tacitus is remarkable for its precision, its energy, and its dignity, and he is peculiarly entitled to the name of a philosophical historian. Among the best editions of Tacitus, are those of Rome, 1515, folio; of Gronovius, 2 vols. 4to. 1721; of Ernest, 2 vols. 8vo. Lip. 1752 and 1771; of Brotier, 7 vols. 12mo. 1776.

TACTICS, NAVAL.

We regret that our limits will not permit us to do justice to this very important subject, associated as it is with all that is glorious in our beloved country,—with the most illustrious names of modern times; and calling up in glowing colours the victories of St. Vincent, of the Nile and Trafalgar. Our continental rivals have long denominated us the giant of the seas. Our fleets have covered every ocean—the thunder of our floating bulwarks has resounded from every quarter of the sphere;—our gallant admirals have exemplified by a brilliant and continued practice, all that the most enlightened theories can teach; and there is hardly a page of our Naval History but is filled with achievements which have crowned our naval heroes with immortal honor and renown.

Naval tactics consist of such evolutions of a fleet, as shall at once insure its own safety, and under every possible condition, annoy and conquer the enemy. The writers on Naval Tactics have commonly laid down five orders of sailing, one order of battle, and one order of retreat. Of the five orders of sailing it may be remarked, that that is the best in which the course of the fleet is least impeded, and from which the desired order of battle can be the most readily and quickly formed, and as experience has proved the fifth to be the best, we shall introduce it to the reader's notice in Fig. 1, in which the fleet is divided into three columns, each of which is ranged in a line parallel to the close-hauled line upon which they are to form the order of battle. Generally the van-guard forms the weather column, commanded by the vice-admiral; the centre division commanded by the admiral, forms the centre column; and the rear guard commanded by the rear admiral constitutes the lee column. This arrangement, however, is sometimes altered for particular purposes. The genius of a Nelson cannot be cramped by arbitrary rules.

Order of Sailing.

It is obvious, that whatever order of sailing be determined on, in any case, the most rigid attention to its execution should be observed. The columns and the vessels, for this purpose, should preserve their proper distances. The commanders of each division, and each succeeding ship should keep themselves reciprocally abreast of each other; every vessel occupying, with respect to its immediate leader, the distance originally laid down by the admiral. It may be remarked, that the distance between the columns will be correct, if the first of any column, and the last ship of the next column form an angle of two points with the line on which they are moving. This order of sailing is preferred, because it unites all the advantages of the others, without their defects. The whole fleet is rendered more compact by it, signals can be better observed, and the order of battle can be more readily accomplished from it. It may be added, that in case of a very numerous fleet, the separate divisions may be formed into two or three columns, each chief being placed a little in advance of the middle of his own proper division. This arrangement is represented in Fig. 2.

It is an important object in this order of sailing, to regulate the distance of its columns. To determine this distance indeed, their length must be previously known. In Fig. 3, let the perpendicular CG be raised to the column CF, and equal to it in length. Join FG, and make FH equal to FC. Then will GH be the proper distance of the columns. This will be apparent, when we consider the van C, and the rear E to be equally to windward, and that EC is at right angles to the direction of the wind. The angle BFC being also 22° 30′, is the half of CFG; and, therefore, the triangles BHF and BCF are equal and similar; and BC equal to the intervals of the columns, is equal to BH or GH, according to the construction.

The same result may also be obtained by a numerical computation, by the following rule: *From the square root of double the square of the length of the column, substract the length of the same column, and the remainder will be the interval between the columns.* Or, as an approximate rule, the following is sometimes applied: *Take $\frac{5}{12}$ths of the length of the column, and the result will be nearly the distance of the columns.* These rules are illustrated in the following example.

Suppose a fleet to consist of three columns, and six ships in each column, to determine the proper interval of the columns, the distances between the ships being 100 fathoms, and the length of each ship from the jib-boom end, to the fly of the ensign 46 fathoms.

The length of the column in the present case will be 776 fathoms. Applying the first rule, its square will be 602176, and the square root of the double of this amounts to 1097. Subtracting from this last result the given length of the column, and there will remain 321 fathoms for the interval between the columns. By taking $\frac{5}{12}$ths of the length of the column, according to the second rule, there results 323 fathoms for the distance of the columns, which is sufficiently near for practice.

If the distances between the columns should at any time be given, the converse of the last rule will afford a ready method of determining the necessary lengths of the columns, viz. by multiplying the given distance by 12, and dividing the result by 5.

It may, however, happen that the columns have been already formed independently of the preceding rules, and that it is necessary to determine their interval. Suppose, by way of example, that a fleet consists of 12 ships in a column, and therefore of 11 intervals between the ships. Then we shall have,

	Fathoms.
12 ships at 46 fathoms each . . .	552
And 11 intervals at 100 fathoms each .	1100
The length of the column being therefore	1652

And to find the distance between the columns, let the bearings of the leading ship of one column, with the sternmost ship of another column be taken, and which may be denominated the angle of position. This may amount to thirty degrees, and hence we shall have, by the ordinary rules of trigonometry,

As the cosine of the angle of position, 30°	9.9375306
∶ the sine of the same angle	9 6989700
∷ the length of the column 1652	3.2180100
	12 9169800
	9 9375306
∶ the distance between the columns 954 fathoms	2.9794494

Our nautical friends will readily perceive that the same might have been worked by a traverse table, employing the length of the column as a difference of latitude, and the distance of the columns as a departure.

Order of Battle.

There is no method of preserving order in battles at sea, but by keeping upon a line, not quite close hauled, a-head of each other, and under very moderate sail. The distance between each ship varies according to circumstances, from one third of a cable's length to about 100 fathoms. Thus, in Fig. 4, let AB, A′B′ represent two hostile fleets drawn up in order of battle; CD, C′D′ their frigates and fire ships, the latter being distributed a-breast of the van, the centre and the rear, and protected a-head and a-stern by some frigates. These latter lines, it will be observed, are so arranged as to be to windward, when the enemy is to leeward, and *vice versa.* Beyond these are the two parallel lines EF, E'F', composed of hospital ships, transports, &c. and protected by frigates both a-head and a-stern.

The order of Retreat.

The order of retreat is seldom if ever rendered necessary to our gallant sailors, although the splendid retreat of Cornwallis affords a proof, that we have admirals who can conduct one with honour and success. Of course it can only be rendered necessary in the presence of a very superior enemy. The general principle is illustrated in Fig. 5, in which the fleet is arranged in two lines, AB, BC forming an obtuse angle, the admiral forming the angular point to windward, in the centre of his fleet. The frigates, fire-ships, transports, &c. are placed EF, FG, between the two lines to leeward. The course of a retreat is generally before the wind; but the fleet may go more or less large, according to the exigency of the moment.

To form and manœuvre the different orders without changing from or into another order.

It is a most important principle in naval tactics to become perfectly acquainted with the different methods of forming and manœuvring the several orders of sailing, without changing into another order; and many important advantages would result to the British navy by forming miniature fleets and squadrons of boats, and training the youthful aspirant for naval honours, to just perceptions of the nature of every evolution.

Our limits will only permit us to name the principal manœuvres connected with the fifth order of sailing with the figures which respectively illustrate them.

Figs. 6 and 7. Tacking the columns in succession either by day or by night.

Fig. 8. Veering the columns in succession.

Fig. 9. Plying to windward in column.

Fig. 10. To interchange the centre and weather columns.

Fig. 11. To interchange the weather and lee columns.

Fig. 12. To interchange the centre and lee columns.

Fig. 13. To permit the weather column to pass to leeward.

Fig. 14. To permit the lee column to pass to leeward.

For a complete explanation of these refer to Steel's *Naval Tactics.*

Of keeping ships in their respective stations.

When an admiral, by signal, orders a particular manœuvre to be performed, it is the duty of every captain and inferior officer to see it carried into perfect execution, and to preserve his ship in the station that may be allotted to her, whatever may be the order of sailing determined on. For this purpose the naval-square has been contrived to assist our gallant seamen in their splendid duty. Suppose Fig. 15 to represent a horizontal section of a ship, and EF to represent a portion of the longitudinal axis running through the keel, and ABCD a square, formed so that EF may run through the intersection of its diagonals. Now the angles DGE and CGE are each twelve points or 135°, which is equal to the two courses close hauled on a wind. Let therefore these angles be bisected by the lines GH and GI, which will represent the direction of the wind, when close hauled, upon either tack. Hence, if a ship is running in the direction EF upon the starboard tack, her close hauled course upon the larboard tack will be in the direction of the semidiagonal GC. And if she be running in the direction of FE upon the larboard tack, her close hauled course upon the starboard tack will be in the direction of the semi-diagonal GD.

To apply this to the case of a fleet in three columns, close-hauled, the columns coinciding in the direction of the wind, in order to beat to windward with greater facility, let Fig. 16 be referred to, in which the naval-square is connected with the middle ship of the centre column. Then must the coinciding ships in the columns be kept in the directions GH or GI according to the tack and the wind; while the ships of each column must be in the direction of EF or parallel to it.

To form the line of battle.

Ships, from a variety of causes, are sometimes scattered, and therefore to form readily the line of battle is an operation of the first importance in naval tactics. The general principle is, for the ship which is destined to take the lead, to run to leeward of the whole, then to haul the wind, upon the tack directed, carrying an easy sail. Each of the other ships then makes sail, according to her distance, and chases the ship which is to be immediately a-head of her, and hauls in her wake, in the line on which the van ship is moving. Fig. 17 represents the case of a line of battle already existing, and in which it is required to form the line on the other tack without tacking in succession. This is performed by all the ships of the line veering together; the rear ship hauling her wind on the other tack, and standing on, while all the others go two points free on the other tack, and haul up, as they successively gain the wake of the leading ship. The rear ship thus gets into the van. For the line to veer in succession, the van ship veers round, and steers four points free upon the other tack, and when clear of the rear ship, she springs her luff, and gets close-hauled. The rest follow, and haul in succession.

It is also an important evolution in naval tactics to be able to interchange the different squadrons of a fleet with each other. Steel has given some interesting examples illustrating the interchange of the centre and van squadrons, the centre and rear squadrons, and the van and rear squadrons; how also the van may pass and form the rear, and how the rear may pass and form the van.

The most beautiful system of evolutions is developed, when an attempt is made to change from one order of sailing to another. We regret that our brief limits will only allow us to select two cases.

And *first*, to change from the fifth order to the line of battle on the same tack, the weather column passing to the rear. This is represented in Plate DXVIII,* Fig. 18, and to accomplish which, the lee column brings to, or keeps only steerage way, as close to the wind as possible. The centre column bears away together two points, and forms on the line a-head of the new centre squadron. The weather column veering together, and going seven points free on the other tack, will gain its station in the rear under an easy sail. Another case may be selected to change from the fifth order to the line of battle on the other tack. This is illustrated in Plate DXIX, Fig. 1, wherein the weather column begins the evolution by tacking in succession. The centre and lee columns stand on till their respective leaders can tack in the wake of the line, when they tack in succession. The two columns to leeward must carry an easy sail, lest they draw too near the rear of the weather column. Should that, however, be the case, the leader of the centre column must be careful and keep somewhat to leeward of the sternmost ship of the weather column, and the leader of the lee column must act in the same manner by the centre columns; or they may stand on beyond the wake of the column immediately to windward of them respectively, and tack to windward. They may then take their stations and form the line with facility.

Of manœuvring in the fifth order of sailing in six or nine columns.

On this important branch of the subject we can only briefly remark, that when fleets are numerous, their order of sailing is usually in six or nine columns, instead of three; that is, the van is divided into two or three columns, and so are the centre and rear. If the fleet be in six columns, the admirals place themselves abreast of each other, somewhat a-head and in the middle of the interval of their respective columns; or, if the fleet be in nine columns, they place themselves at the head of their respective centre columns. In either case, each squadron must manœuvre itself in the same manner as if it were in three columns. With a numerous fleet, many advantages result from increasing the number of columns, since the signals can be better seen, and every evolution can be performed in a less time, particularly in that important case of reducing it to the order of battle.

We select two examples by way of illustration. Let it be required to change from the line of battle to the fifth order of sailing on the other tack, the van squadron forming to leeward, the centre to windward, and the rear in the centre. This beautiful evolution is represented in Fig. 2, wherein the van makes sail, and tacks in succession; the column brings to, or carries a very easy sail. The leader of the centre column, which is now to form to windward, tacks as soon as the last of his column passes astern of the new lee column, and is followed in succession by his division. The leader of the rear, which is to form the centre column, tacks, either when abreast of the leader of the windward column, or when his centre ship passes astern of the lee column, or when he has the centre ship of the lee column in a line at right angles with the wind. When the rear has tacked, the lee column fills, and all the columns make the necessary sail, for regulating the order.

Secondly, let it be required to change from the line of battle to the fifth order of sailing on the other tack, the rear squadron forming to windward, the van squadron as centre column, and the centre squadron to leeward. This evolution is denoted by Fig. 3, in which the van and centre tack in succession, and pass on under easy sail. The rear, which is to be to windward, carries sail, and tacks in succession, when its leader has the headmost ship of the lee column in a line at right angles with the wind, or when its centre ship passes a-stern of the centre column. The columns then make suitable sail to regulate their distances.

To change and re-form upon changes of wind.

In the preceding inquiries, we have supposed the wind to remain constant, both in its intensity and direction; but we know that the best conceived plan of naval tactics may be rendered abortive by a change of condition in one of these causes. A sudden calm may render every ship motionless, or an alteration in the direction of the wind may require a new system of evolutions to be performed.

We must here limit our inquiries to the single but most disadvantageous change of wind that can happen to a fleet in a line of battle, and that is when it comes forward, the order being in such a case with difficulty reformed, particularly if the enemy be in sight. If the wind comes forward from one to six points, and it is intended to keep the fleet on the same tack, each ship having fallen off, the whole line brings to, excepting the headmost ship, which immediately bears away a certain number of points. This number of points is known by deducting from eight points one half of the points which the wind has changed; thus, if the wind has come forward five points, deduct half that number from eight, and the remainder five and a half points will remain, as the number the ships are to run large. The headmost ship then, having fallen off, and bore away, the ship which follows her fills and bears away as soon as she brings her leader to bear on the close hauled line. Each ship proceeds successively in the same manner, and in the end they altogether haul their wind in the wake of their leader, when they get upon the close hauled line with the sternmost ship, which then fills and stands on close hauled, not being under the necessity of bearing away. This is illustrated in Fig. 4. Steel gives some other methods of accomplishing the same object, some of which are advantageous, and others not, and to which we must refer our readers.

If the wind comes a-head more than six points, and less than twelve, the fleet, changing the tack, will manœuvre in the same way as if it had come a-head not more than six points. If two fleets are

* The number of this Plate (DXVIII) should have been placed immediately before "Fig. 1," in the second line of page 643, as all the figures mentioned in pages 643 and 644 (from Fig. 1 to 17 inclusive) have reference to it.

in sight in this case, that advantage of the weather-gage will be gained by the fleet that was before to leeward.

We must close this part of our subject with the interesting inquiry, how to change from the line of battle to the order of retreat, the wind coming forward. This may be done whether the wind come forward or aft, by first re-forming the line of battle, and then changing from that to the order of retreat. This is the most certain, but not the shortest method. It has, however, this advantage, that it does not so quickly communicate the intention to the enemy.

This double manœuvre requiring, however, considerable time, and as circumstances are not always favourable, it may be performed in the manner represented in Plate DXIX, Fig. 5, and which may be described as follows. The fleet having fallen off, the leader of the van goes four points free, while the rest of the ships stand on together close hauled, in order to gain the wake of the leader and each other respectively. When the centre ship has arrived at the angular point, that is, in the wake of his second-a-head, that wing is formed. The other wing will be easily formed, if (the first wing continuing to sail four points free) the ships of the other wing bear away four points free together, running on parallel courses with the first wing. The ships of the wing now forming must adapt their sail to place themselves on the proper line of bearing, which will be effected when each first, second, and third, &c. ship of one wing bears, from the corresponding ship of the other wing, in a line perpendicular to the direction of the wind.

Of cutting the enemy's line.

The splendid consequences that resulted from Lord Rodney's cutting the French line on the 12th of April 1782, afforded the most ample and satisfactory proofs of the advantages of the theory which Mr. Clerk of Eldin was the first to demonstrate as possible, and of which Paul Hoste seemed to have had some indistinct glimpses. We shall therefore conclude our paper by an account of the series of manœuvres which has rendered this battle so illustrious in the history of naval tactics.

On Monday the 8th of April 1782, signal was made from the British cruisers off Fort Royal Bay, Martinico, that the French fleet, attended by a number of transports, were then under way. The British fleet immediately weighed from Crosse Islet Bay, St. Lucia, and stood after them to the northward, under the west end of Martinico, and soon got sight of part of their men of war. The pursuit was continued, during the night, with all the sail that could be made, directed by the enemy's night signals, the wind blowing a fresh gale at N.E. by E. At two in the morning the Valiant, being to windward, discovered the enemy under the north end of the Island of Dominica. At three o'clock the fleet brought to by signal, the enemy at that time bearing nearly north.

In Fig. 6, A represents the British fleet at two in the morning of the 9th of April, discovering part of the French fleet, under the north end of Dominica at F. At three o'clock, brought to by signal; at half past five, the signal was thrown out to prepare for battle, the line to be formed at two cables length asunder, and the fleet to fill and stand on. G, the position of the French fleet at five in the morning, on the starboard tack, working to windward in the channel, between Dominica and Guadaloupe, where they had a steady breeze. H, one of the enemy's ships, at this time so far to leeward, that she must have been taken, had not the wind failed us, while she had it so fresh as enabled her soon to recover her station.

In Fig. 7, A represents the van of the British having at length gained the breeze, fetched up with the centre of the enemy, still upon the starboard tack, when they were fired upon about nine o'clock, and for an hour sustained a distant cannonade from as many of the enemy's ships as could be brought to bear upon them. The centre and rear of the British fleet was at this time becalmed under the island of Dominica, as B. F represents the French, not all in order of battle, some of their ships endeavouring to work to windward.

In Fig. 8, it will be perceived, that A, the centre of the British, having afterwards gained the breeze, joined the van about noon. The rear, which had been becalmed at C, at length got into line as D; and a cannonade continued for an hour and three quarters. F, the position of the enemy, who during all the time kept at such a distance as showed that they meant to disable,—a species of tactics which our opponents the French have too often showed for their own honour a determined disposition to persist in,—as soon as they saw the junction of the whole British fleet. Hauled off to windward, tacking from the van, as indicated by the course H H. At G will be perceived the enemy's fleet of transports, stretching away to windward of the Saints. The enemy did not at first appear to have suffered much; but soon after, one of them seemed to be crippled; and afterwards two of them were found to have received so much hurt, they were obliged to bear away for Guadaloupe to refit, and hence were not in the action of the 12th.

Fig. 9, denotes the British fleet on the morning of the 11th, having in view two disabled ships at G., under the island of Saints, and which were chased into Basse Terre, Guadaloupe. Soon after, two others were discovered far to windward, and disabled at H, near the north end of Dominica. A general chase was then ordered, four of the enemy's ships being at this time visible at I, from the Formidable's mast head, Lord Rodney's ship. On the Agamemnon and others, at B, coming near the ships at H, the French admiral, Count de Grasse, though far to windward, bore down as at F, to protect his two disabled ships. The Agamemnon and her consorts advanced in the pursuit; but upon the signal for all cruisers to return, they took up their proper positions in the line.

We now come to the splendid and eventful day of the 12th. At two in the morning, the British fleet being at A, Plate DXX, Fig. 1, after having run to the southward from B, their position the evening before, having taken advantage of the wind as at W, which generally hauls to the northward in the West Indies in the evening. At the last mentioned hour, having tacked to the northward, the French were discovered broad under their lee-bow, in some confusion at F. One of their ships was directly to leeward at G, with her bow-sprit gone, and her fore-mast across her fore-castle, towed by a frigate, the wind being E.S.E., as at Z.

At C, is represented the Monarch and Valiant going down from the rear to engage the disabled ship with her consort, which compelled Count de Grasse to edge down as at H, to their protection. The van of the British, about four or five o'clock, was at D, leading on the starboard tack; and the admiral, judging Count de Grasse might now have got so far to leeward, by the last mentioned movement, that it could not be possible for him to avoid an action, the Valiant and Monarch, the ships in chase, were ordered into their stations.

The French, aware of their situation, formed on a larboard tack; and the wind afterwards coming about from E.S.E. to nearly east, as at Y, they conceived hopes of gaining their usual fighting distance, more especially as their van at this time began to point to windward of the British.

The lines A and F, in Fig. 2, denote respectively the positions of the British and French fleets, at half-past seven in the morning, the Marlborough, the leading ship of the British van, having fetched the fifth* ship of the enemy's line. In this situation she was fired on, and the signals for close action and to close the line, were thrown out.

The consequence of the preceding manœuvre was a disposition resembling Fig. 3, wherein the van of the British fleet ranged slowly and closely along the enemy's line, each ship giving and receiving a heavy fire. The enemy's fleet at F, it will be perceived, had gained the wind, and were ranging in an opposite direction to our own. The British admiral's ship, the Formidable, having reached the enemy's fourth ship from their van, began a close action within half musket shot, continuing it close along the enemy's line, under an easy sail, till an opening appeared at the third ship astern of the French admiral, which afforded the opportunity of cutting their line in twain, completely separating the van from the rear, and forcing the headmost ship of their rear division, then coming up to leeward, as at G, thus affording a complete and triumphant proof of the accuracy of the principles that Clerk had so ably advanced. This is represented in Fig. 4, in which A is the Formidable, the British Admiral's ship; F the Ville de Paris, bearing the flag of the Count de Grasse; B the van of the British still ranging along the remaining part of the enemy's rear; C the rear of the British line following up after the admiral; H the last ship of the French van stretching past the rear of the British line.

In Fig. 5, the Formidable, Namur and Duke are shown at A, B, C, after having cut the line, and keeping up a powerful raking fire on the ships of the rear division of the enemy before forced to leeward, and which are now making the best of their situation by going off before the wind at G. F represents the van of the enemy, stretched past the rear of the British line, and preparing to break into two divisions. H denotes the middle division making to the west.

The subsequent positions of the two fleets become now of the greatest interest. So soon as the van division of the enemy had stretched past the rear of the British line, in bearing away, it broke into two divisions; one, consisting of seven ships, steering west as at H, Fig. 6, and which we may now call the middle division; the other taking a S.S.W. course, consisting of about 12 or 13 ships, and where Count de Grasse was himself, making the southern division of flight, as at F. A denotes Lord Rodney's ship, with part of the centre, putting about in pursuit of the enemy's van; and B, the rear of the British line, performing the same evolution. The signal for the rear to close with the centre being soon after made, both these divisions followed in pursuit of the southern division F.

The object now with the Count de Grasse, in the division last referred to, was to obtain a junction with the other divisions of the fleet at G and H. This was apparent by his abandoning his S.S.W. course, which he first pursued at Fig. 7, and turning his ship's heads to the northward as at F, and to form a new line of battle. A natural effect of this change, of course, was an alteration in the course of the centre and rear of the British fleet to the position AB, thereby causing the two divisions to approximate. The Count soon perceived this, and accordingly, at about two in the afternoon, he resumed his original direction as at I. The two fleets, therefore, at this moment occupied the following positions: A and B, the centre and rear of the British fleet, were in pursuit of the southern division of the enemy. The van of the British fleet continued in the same course as at C. The rear division of the enemy continued to advance to the westward, as at G; and the middle division of the enemy, not being pursued, repaired their damages under an easy sail.

Fig. 8 represents the two fleets again under the most interesting circumstances. The southern division at six o'clock, having been outsailed by their pursuers, turned their heads again to the northward, and the result was, that the centre and rear of the British fleet formed on each side of it. Five ships were taken from the enemy, the Ville de Paris striking at sunset to the Barfleur and Canada.† At this time Count de Grasse had got above five leagues to the westward and leeward of the field of battle; and night coming on. Admiral Rodney thought proper to give over further pursuit.

It may be necessary to add, that the rear division at G had, at this time, advanced above ten leagues to the westward and to the leeward of the field of battle; and that I, the middle division of the enemy, consisting of seven ships, having waited

* There is some little doubt whether it was between the third and fourth ship the line was cut, or between the fourth and fifth ships. It is however of little moment.

† Lord Rodney observes that the Count de Grasse in the Ville de Paris, behaved most bravely. His ship was entirely crippled, and three British Admirals were very near him, when he struck his flag. The French Admiral did all that so singular and unlooked for a circumstance as the cutting of his line in twain would permit.

for, rejoined the ships of the southern division, which afterwards effected an escape.

Such was the result of this new and splendid evolution. It may be asked, however, why did not the British admiral follow up his able attack, and make the signal for a night battle? He did so; but on looking about him—prudence in a conqueror being even much more necessary than in ordinary men, he observed that his fleet was greatly dispersed; that two of his 90 gun ships were greatly disabled; his own, the Formidable, greatly damaged; that his van and centre were also much hurt; that none of the prisoners from the captured ships were taken out;—that a very dark night of twelve hours was coming on—weighing all these—and the science of naval tactics is made up of contingencies—he thought it most prudent to make sure of the victory, and not run the risk of a reverse of fortune, or the danger of a night battle, wherein his own fleet might receive more damage from one another than from the ships of the enemy; that by running to leeward in the night, the enemy might deceive him, by ordering some of their frigates to hoist the lights of their admirals, and steer a course to lead the British admiral from them; and as the night was extremely dark, being the first day of a new moon, they might have hauled their wind to the north or to the south without being seen; at the same time they most carefully concealed all lights whatever. The British fleet, moreover, by pursuing, might have found themselves far to leeward in the morning, without the possibility of their getting to windward, by the crippled condition they were in. These reasons, and his experience of a night battle, induced the admiral to secure his splendid victory, and not to hazard a reverse of fortune. Rodney, therefore, made the signal for the British fleet to bring to, on the starboard tack, then so dark that one ship could not see another. Day light the next morning proved the wisdom of that signal; for, notwithstanding it was the duty of every ship to obey it, thirteen made sail, yet not one of them fired a shot, or came up with an enemy. This was a convincing proof of what might have happened had the whole fleet gone to leeward, and the enemy have hauled their wind; not only the captured ships might have been retaken, but some of the British crippled ships captured. Every sailor and man of science will acknowledge the wisdom of this decision.

Some of Mr. Clerk's observations on this splendid victory are deserving of much attention, and we shall therefore, introduce them to our readers. First, the difficulty will be remarked of an enemy's fleet making an escape to windward. Secondly, that the crippling of some of his ships will be a necessary consequence of the efforts made to effect this escape. Thirdly, that the protection given to ships crippled in consequence of these efforts, as it was the cause of bringing on the actions of both the 9th and 12th, and had nearly produced an action on the 10th, will also be a cause of bringing on an action on all future occasions of the like nature.

The attack made by the British in the action of the 9th, may be considered as an example of the simple attack, and shows how little may be expected from any rencounter between two fleets on the same tack, when an attempt shall be made from the leeward.

The judicious movement made by the British fleet, from a northerly course to a southerly one, on the night between the 11th and 12th, as it shows the advantage that may be made by a change of wind, at the same time shows the necessity of attention to such periodical changes. Indeed it was by this means only that the British fleet got within reach of the enemy on the morning of the 12th of April.

From the facility also with which Admiral Rodney's ship kept her wind, and forced her passage through the line of the enemy, and the necessary consequence that the headmost ships of the rear division must thereby be forced and driven to leeward, should with certainty establish, that breaking an enemy's line, by an attack from the leeward, is not only a practicable measure, but a measure attended with little additional danger or risk of shipping; and that with the same facility, and with equal probability of success, it might have been attempted, in former rencounters. And although Admiral Rodney, in either of his former rencounters of the 15th or 19th of May 1780, had not been convinced of the importance of this manœuvre—still, having been the first to put it in execution on the 12th of April, he has acquired a name renowned over the whole world.

The consequences resulting from cutting the enemy's line on this occasion, as they may be regarded as affording complete illustrations of the importance of Mr. Clerk's principles, may also be admitted as a proof of what ought to be expected in future on every similar occasion.

The hurry and precipitation with which the rear division of the enemy made their escape through the gap in the British line, as it showed their apprehension, should also be a proof of the danger of their situation.

The effort to escape, made by the van division of the enemy, as it confirms the general position, their desire of evading a conflict, confirms also the superiority of British seamen, which seems, indeed, to have been incontestible from the beginning of the whole affair to the end.

It must, however, be added, that the manner by which the van of the British was rendered almost without effect, shows that the rear division of the enemy, and not the van, ought to have been the object of pursuit. This is demonstrated by Clerk in his *Attack with the Centre*, part II. pages 180—183.

The proximity of the rear of the British to the rear division of the enemy, should sufficiently point out the object of pursuit they also should have chosen.

The British van and rear not having therefore been prepared to take advantage of their necessary mutual proximity to the rear division of the enemy, was a loss.

The rear division of the British also, by having been obliged to put about ship, in pursuit of the van of the enemy, already got some miles distant, is a full confirmation of the hypothesis laid down, that the pursuit of a rear division, cut off from the van of an enemy's fleet passing on contrary tacks, ought in general to be preferred.

Finally, the facility with which the rear of the British came up with the flying van of the enemy, shows that there was no inferiority in the sailing of the British ships.*

With this we most reluctantly close a subject which has much to recommend it to the attention of the young sailor; much to the higher officers of the navy, and much to the board of admiralty which presides over the naval destinies of the country. We might have added that there is much to recommend it even to the attention of the man of science, and to the historian, who may review the brilliant pages of our maritime exploits. To the young sailor, in particular, it will afford the most useful and salutary lessons, and prepare him for all the difficult and ever varying circumstances of his splendid profession. Nelson, amidst the fatigues of his arduous duties, found an agreeable relaxion in the important pages of Clerk,† and was perpetually forming schemes how he might successfully accomplish the conquest of an enemy, in every variety of position. The bright example of the immortal conqueror of the Nile and Trafalgar, ought ever to be present to the young officer's view. By making the subject of tactics a frequent object of contemplation, Nelson's energies were ever in action to meet the vicissitudes of his perilous duties. In whatever position he found the enemy, his ready and comprehensive mind seized all the great points of action, and having communicated his brilliant purposes to the captains of his fleet, stimulated the lowest sailor by the immortal signal, "ENGLAND EXPECTS EVERY MAN TO DO HIS DUTY."

TADCASTER, supposed to be the *Calcaria* of the Romans, a town of England, in the West Riding of Yorkshire, situated principally on the south side of the river Wharf, which is crossed by one of the best stone bridges in the country. The town is neat and well built, the streets being arranged in the form of a cross, and formed by the roads to York, Wetherby, Leeds, and Pontefract. The public buildings are an ancient church, an hospital for twelve persons, and a free school, both founded by Dr. Oglethorpe, and a respectable building for Sunday schools. There are some traces of a trench round great part of the town. The river Wharf is navigable to the bridge for sailing vessels, which supply the town with necessary commodities. Population of the township in 1821:—390 houses, and 1651 inhabitants. See the *Beauties of England & Wales*, vol. xvi. p. 621—629.

TAFILELT. See MOROCCO, Vol. XIII, p. 782, and BARBARY, Vol. III. p. 250.

TAGANROCK, a town of European Russia, on the N. W. coast of the Sea of Azof. It stands on the cliff of a lofty promontory; all the best houses are in the suburbs. It possesses a fortress, a harbour, a naval hospital, a lazaretto, and naval and commercial courts. It carries on an extensive trade. Its exports are caviare, butter, leather, tallow, corn, Siberian iron, fish, tar, and canvass. Its imports are fruits, Greek wine, shawls, tobacco, coffee, silk and precious stones. About 387 vessels, besides coasting ones, were employed in 1817. In 1817 the importation of foreign gold was 5,582,247 rubles, and merchandise to the value of 2,658,645. The value of the exports was 11,979,700, and of the imports 9,321,053 rubles. The town once contained 70,000 inhabitants, but now the population is only 6000. Dr. Clarke saw here people of 15 nations. East Long. 38° 39'. West Lat. 47° 12' 40''. See RUSSIA; also Clarke's *Travels*, vol. i. p. 327, and Rordanz's *European Commerce*, pp. 660 and 670.

TAIN, a royal burgh and county town of the shire of Ross, is situated on the south side of the firth of Tain or Dornoch, which separates Ross from Sutherland. It is conjectured that the name is derived from the term *Thane*, as the Thanes of Ross are said to have occupied the adjacent lands. As the town is situated in a Gaelic district, it has also a particular name in that ancient language. Some derive its appellation in Gaelic, *Baldhuich* or *Baile Dhuthuich*, from *baile*, a town with a combination of letters resembling the names of *Duthas* or *Duthac* annexed, and literally signifies the town of Duthas. This derivation is rendered probable from the ruins of a small chapel in the immediate neighbourhood, called *St. Duthas Chapel.* To this chapel it is said "king James IV., in way of penance, travelled on foot from Falkland, with uncommon expedition, resting only a short while at the monastery of Pluscardine, near Elgin." Others spell the name of the town Ball'n 'dhuic, which literally signifies the county town. But the Gaelic tongue seems so flexible, that derivatives from it cannot be much depended on. The oldest charter extant, confirming the rights of Tain, and dated 1587, was given by king James VII., and it is there stated that the ancient charters of the burgh were burnt by some Irish rebels. From an inquest dated 20th April 1439, held for the special purpose of ascertaining the antiquity and liberties of the burgh of Tain, it "was found that all the inhabitants within the aforesaid liberty of Tain, and all their goods whatsoever, are under the special protection of the Apostolical See, and that the said immunity was first founded by the deceased most illustrious king of Scots, Malcolm Canmoir of blessed memory." The town is small, and, like most old towns, is built without much regard to regularity. The population is at present somewhat less than 2000, but is gradually increasing. There are no manufactures of any consequence carried on in the town, and the trade consists chiefly in

* Much has been said on the inferior construction of British men-of-war. How comes it that we have conquered so many of our opponents, under circumstances so exceedingly diversified?

† We recommend Admiral Ekins's Naval Battles to the attention of our readers, excepting some of his remarks relating to Clerk.

supplying the country with goods brought from a distance. This want of manufactures may, in some measure, be accounted for, from the want of a proper pier where goods might be landed with safety. Notwithstanding this want of trade, the state of the town and country is such as to support two thriving branches of the British Linen Co. and Commercial banks. There is a good jail here, and an excellent building for debtor's rooms and courts of justice have lately been annexed to it. There is a large and commodious church here, sufficient to accommodate all the regular hearers in the parish. The people are very much attached to the established church; and what is very singular, there is scarcely a dissenter in the whole parish. In the old church, which is still a fine old building, there is a very curious carved pulpit which was presented by the regent Murray to the town of Tain.

By the exertions of a few public spirited gentlemen connected with the county, an excellent academy was, in 1813, established by royal charter at Tain, in which the fundamental branches of classical literature and science are taught by a rector and three teachers. It is impossible to observe the numerous and great improvements which have taken place in Tain within the last sixteen years, without connecting them with the establishment of this institution, which will prove one of the greatest blessings conferred on this part of the country, and will transmit to posterity the names of its founders as the greatest benefactors of the county of Ross. (W. R.)

TALAVERA, an ancient town of Spain, in New Castile. It stands on the Tagus, which is crossed by a bridge of 36 arches, and 1200 feet long. It contains some good churches, four hospitals, and a classical and theological academy. The manufactures are silk, soap, hats and earthenware. Population about 800.

TALAVERA, Battle of. See Britain, Vol. IV. p. 684.

TALBOT, county of Maryland, bounded S. and SE. by Choptank river, separating it from Dorchester county, Maryland; E. by Choptank and Tuckahoe rivers, separating it from Caroline county; N. by Queen Anne county; and W. and SW. by Chesapeake bay. Greatest length almost exactly on one degree E. of the meridian of Washington city, and from the southern angle on Choptank river 25 miles, to the northern angle on Queen Anne. The western part is so much indented by small bays extending inland from Chesapeake bay as to render the mean width difficult to determine, but the aggregate land area being 250 square miles, the mean breadth will be about 10 miles. It lies between Lat. 38° 34′, and 38° 56′ N. and between Long. 0° 42′ and 1° 10′ E. from W. C.

The whole county is a peninsula between Choptank river and Chesapeake bay, but is again cut into three minor peninsular sections by Choptank, Tread Haven, and St. Michael's bays. Surface generally flat, but with a slight southern declivity. So much is it indented by small creeks or inlets, that it is probable not a single point within its boundaries is three direct miles from a navigable water.

By the post list of 1831, Talbot county had post offices at Easton the seat of justice, and at St. Michaels, Trop, and Wye Mills.

Easton, the county seat, stands near the head of Treadhaven bay, about 50 miles SE. from Baltimore, by post road; 47 miles SE. by E. from Annapolis, and 84 a little S. of E. from Washington City. N. Lat. 38° 46′, and Long. 1° E. of the meridian of Washington City. Easton is a seaport and considerably the largest town of the eastern shore of either Virginia or Maryland. Population, 1830, 12,947.

Whether the discrepancy arises from a defective mode of taking the census, or from a real diminution, the population of Talbot county of Maryland appears to have decreased in the decennial period from 1820 to 1830; as at the former epoch the aggregate was 14,389, but at the latter, only 12,947, showing a difference of 1442.

TALBOT, county of Georgia, bounded by Marion county S.; Muscogee SW.; Harris W.; Merriwether NW.; and by Flint river separating it from Upson, NE. and Crawford E. The greatest length from the extreme eastern angle on Flint river, to the northwestern between Harris and Merriwether 47 miles; and the superficial area being 600 square miles the mean width is about 13 miles.

This county extends from Lat. 32° 35′ to 32° 54′, and in Long. from 7° 10′ to 7° 54′ W. from the meridian of Washington City.

The western and southwestern parts reach over the summit level between Flint and Chattahooche, and give source to brief streams flowing westward into the latter river; the body of the county, however, has an eastern declivity towards the Flint.

It is a county of recent formation, and by the post list of 1831, had only two post offices; one at a place called Liberty, and the other at Talbotton, the seat of justice. As laid down on Tanner's United States, Talbotton, the seat of justice in this county, is situated on a small creek of Flint river, and stated in the post office list of 1831 as 112 miles distant from Milledgeville. On Tanner's Map the distance is about 90 miles in a direction SW. by W. from Milledgeville to Talbotton.

TALLAFERRO, county of Georgia, bounded N. by Oglethorpe county; NE. and E. by Wilkes; SE. and S. by Hancock, and W. by Greene. Length from south to north 17 miles; mean width 8, and area 136 square miles. Lying between latitudes 33° 28′, and 33° 43′ N. In Long. the 6th degree west from the meridian of Washington traverses it and divides it into two not very unequal portions.

Declivity to the southeastward and drained in that direction by the higher confluents of Little river and Great Ogeechee river. According to Tanner's United States, this is the least extensive county of Georgia, and by the post office list of 1831, had only one post office, that of Crawfordville, the county seat, which, as laid down by Tanner, is situated between Little river and Great Ogeechee river, and by the post road, 47 miles NNE. from Milledgeville, and 52 miles a little N. of W. from Augusta. N. Lat. 33° 32′. Long. 5° 58′ W. from Washington City.

TALLAHASSE, post town, seat of justice for Leon county, and seat of government for the territory of Florida, is situated about 30 miles inland and north of St. Mark's Bay of the Gulf of Mexico; about 50 a little E. of N. from Ocklockonne Bay, 200 miles NW. by W. from St. Augustine, a similar distance a little N. of E. from Pensacola, and by calculation on Mercator's principles, S. 36° 10′ W.; 725 statute miles, but by post road 896 miles from Washington City. N. Lat. 30° 27′; Long. west from W. C. 7° 30′.

Tallahasse is recent in its foundation, the first buildings were erected there during the summer of 1824. The first legislature which sat in this new born city held its session in the winter of 1824-5. In 1825 it was incorporated a city. So rapid was the augmentation of its population, that when John Lee Williams published his "*View of West Florida*" in 1827, he estimated the inhabitants at 800.

Mr. Williams concludes his notice of Tallahassee by observing,—"Few towns in America have increased more rapidly; and population and improvement continue without any abatement. It might in a few years become a charming place of residence, though it will probably never become a place of great commercial importance."

Judge H. M. Brackenridge, from personal observation, thus describes the valley of Tallahasse.

"Instead of being a plain of unvaried surface, it resembles the high lands above the falls of the rivers in the Atlantic states, and is beautifully diversified by hill and dale, and rendered picturesque by the number of lakes, whose pure waters reflect the forests of oak which frequently clothe the sides of the hills, down to their very margins. These lakes receive a number of streams, which flow from the higher grounds and loose themselves in their placid bosoms. The largest of them are called the Iamony, Jackson, and Mickasukey, but there are many others of a smaller size, affording many beautiful situations for country residences, where the naturally open groves of oak, hickory, beech, and magnolia grandiflora, surpass in magnificence the proudest parks of the English nobility. The soil of the uplands bears a strong resemblance to the best part of Prince George's county, Maryland; and the face of the country is not unlike the south side of the Potomac near Washington City. In the vallies there is a much heavier growth of timber, and frequently deep cane-brakes. There are also frequently to be met with, grassy ponds, surrounded by glades, which afford excellent pasturage.

"The only regret which I feel in contemplating this beautiful region, is its very limited extent—an Oasis, which appears to have been formed by nature in one of her most sportive and fantastic humours. The general substratum, perhaps a few feet above the level of the sea, is a soft limestone of recent formation. In the pine wood plain, which stretches towards the high lands of Tallahasse, the stone is often found in masses on the surface.

"By the last census (1826), Tallahasse contained about eight hundred inhabitants, and five or six mercantile establishments, which do an extensive business. The country begins to wear the appearance of cultivation; good roads are made in all directions, and carts, wagons, and carriages are constantly travelling them."

With due allowance for a natural warmth of description in the accounts given by emigrants into a new country, we may regard Tallahasse and the immediate vicinity as a delightful section of the southern part of the United States, but as Judge Brackenridge acknowledges, it is an Oasis.

TALLAPOOSA, river of the United States in Georgia and Alabama, rises by two branches in the Cherokee territory of the former state, and flowing thence southwestward, traverses Carroll county, and entering Alabama, bends to SSW., the two forks uniting, and the latter course continued about one hundred miles over the Creek territory, to near the eastern border of Montgomery county. At the latter point the stream abruptly bends to the west, and pursues that general course 25 miles to its junction with the Coosa at or near Coosauga, to form the Alabama. The entire length of Tallapoosa, by comparative courses, is about 150 miles, but the mean width of its valley does not exceed 25: area about 3750 square miles, and lying between 32° and 34° of N. lat., and between the valleys of Coosa and Chattahooche rivers.

TAMBOURING. A full account of this manufacture, and of Duncan's Patent Tambouring Machine, was given by the inventor of the latter, in the Article CHAINWORK, Vol. V. p. 588, 597.

TAMWORTH, a borough and market town of England, in Staffordshire, situated at the conflux of the Thame and Anker, the former of which divides the town nearly into two equal parts. The town is large and well built, and its principal buildings are two stone bridges, a fine church, several meeting-houses, an hospital, a grammar school, and an old castle. Its manufactures are superfine narrow woollen cloths. Calico printing, tanning, and brewing are carried on to a considerable extent. It sends to parliament two members, who are chosen by about 250 voters. The population of the borough and parish in 1821 was 7185.

TANGENCY. See FLUXIONS, Vol. IX. and TRIGONOMETRY.

TANGIERS, anciently TINGIS or TINJA, is a seaport town of Fez in Morocco, situated at the western entrance to the Straits of Gibraltar. The bay, which is defended by five old batteries, is encumbered by the ruins of the moat and fortifications which were destroyed by the English in 1686. The town subsists chiefly by supplying Gibraltar with cattle and vegetables. W. Long. 5° 50′. N. Lat. 35° 42′.

TANGIPAO, or as usually pronounced, Tanzipaho, river of the United States in the states of Mississippi and Louisiana, has the most remote northern sources in Amite and Pike counties of the former, from whence it flows SSE., and entering Louisiana, separates the parish of St. Helena from that of Washington and St. Tammany, finally falls into the northern side of Lake Pontchartrain, after a comparative course of between 70 and 80 miles.

In the higher part of its course within the state of Mississippi, the valley of Tangipas lies between those of Amite and Bogue Chitto; but in the lower section within Louisiana, between the Chifuncte and Tickfolah vallies.

TANNIN. See CHEMISTRY, Vol. V. chap. VI. sect. III. p. 702, 703. See also p. 756.

TANNING is the art of converting into leather the gelatinous parts of the skins of animals by impregnating them with tannin. The skins chiefly employed are those of bulls, oxen, cows, &c. which are converted into leather for the soles of shoes, and those of calves, seals, &c. which are converted into leather for the upper leathers of boots and shoes, saddles and harness. The method of manufacturing these different kinds of leather is as follows:

1. *Method of manufacturing butts or barks.*—The heaviest and stoutest of the bull and ox hides being selected for the purpose, they are allowed to lie in a heap for two or three days, and are then hung up on poles in the smoke house, kept, by means of a mouldering fire, at a temperature somewhat above that of the atmosphere. A slight putrefaction takes place, loosens the epidermis, and renders it easy to separate the hair and other extraneous matter from the true skin, by the *fleshing knife*, with which it is scraped on a convex board, called a horse. The hides thus cleaned are then *raised* or steeped in water containing a little sulphuric acid. The effect of the acid is to distend the pores of the skin, and prepare it for the reception of the tanning.

The hides are now removed to a pit, and laid one above another, with a stratum of powdered oak bark below each, and the pit is filled with the tannin lixivium or ooze prepared from oak bark and water. Here they remain for a month or six weeks, at the end of which they are taken out and replaced with fresh bark and ooze. After remaining three months, the operation is repeated three times or oftener at the same intervals. When they have thus sufficiently imbibed the tannin, they are suspended in a shed to dry, and when compressed with a steel instrument, and rendered firm and clean by beating, they are ready for sale, and are used for the thickest sole leather.

2. *Method of manufacturing crop hides.*—The hides are immersed for three or four days in pits containing a mixture of lime and water, being occasionally stirred up and down. When the extraneous matters have been removed by the flesh knife as above described, they are worked in water. They are now immersed into a weak ooze, and gradually removed to other pits with stronger ooze, being moved up and down, or *handled*, as it is called, once every day. At the end of a month or six weeks they are put into pits with a stronger ooze and a little powdered bark, and the process is repeated with fresh ooze and bark for two or three months. They are then put into larger vats, called *layers*, in which they are laid one above another in an ooze of still greater strength, and with a large quantity of good bark interposed. They remain here for six weeks, and they are then taken up and relaid with strong ooze of fresh bark for two months. This process may be repeated once, twice or thrice, according to circumstances, and when it is completed, the skins are taken out, dried, and smoothed as before. The sole leather used in England consists of the crop hides.

3. *Method of manufacturing the skins of calves and seals, &c.*—Hides of this description are kept in the lime pits for ten or fifteen days: the hair, &c. is then removed, and they are steeped in an infusion of pigeon's dung, called a *grainer*. Here they are frequently tumbled about and taken out and scraped, and at the end of a week or ten days they are removed into pits containing a weak solution of bark, where they go through the same process of handling, &c. nearly as crop hides, though they are seldom put down in layers. This operation lasts from two to four months. The skins are then dried, and the currier dresses and bleaches them for the different purposes to which they are to be applied. For farther information on this subject see "Dr. Macbride's paper, *Philosophical Transactions*, vol. ix. p. 111," vol. LXVIII, and that for 1803. See also Newton's *Journal of the Arts*, Jan. 1829, p. 219, for an account of a powerful tanning lixivium used in America, by J. Giles. It is announced in the Journals that M. Rapedius has discovered that 3½ lbs. of the bilberry or whortleberry plant, (*vaccinium myrtillus*) will tan a pound of leather which requires 6 lbs. of oak bark. This important experiment has been successfully tried at Treves.

TAPESTRY. See our article FRANCE, Vol. IX. p. 427. See also *Phil. Trans.* 1731, vol. xxxvii. p. 181, and Duhamel, *Art de Fair de Tapis.*

TAPPAHANOC, post village, and seat of justice, Essex county, Virginia, situated on the right bank of Rappahannoc river, by post road 109 miles a little E. of S. from Washington City, and 50 miles NE. from Richmond. N. lat. 37° 58′, long. 0° 10′ E. from the meridian of W. C. The site is low and flat, and in summer the inhabitants are liable to agues and fevers. It is, however, a place of considerable trade, as even large merchant vessels can ascend far above. The harbour at Tappahanoc is about 50 miles above the open Chesapeake bay.

TAR, a dark brown resinous juice, distilled from the pine. The Baltic tar, with which Great Britain is supplied, is thus made. Pine branches cut into billets are built up on the slope of a hill, in large stooks, and covered with turf; they are then set on fire, and while they burn with a smouldering flame, the tar formed by the decomposition of the resinous juice, which runs to the bottom, flows through a small channel, by which it is collected and put into barrels.

The Switzerland tar is formed by heating billets formed from the trunk of the tree freed from its bark. The ovens, which are about ten feet high, and six in diameter, are made of stone or brick like an egg placed on its small end, and a gun-barrel is fixed at its lower end, to carry off the tar. The oven is charged by bundles of billets, the interstices being filled up with chips, and a layer of chips being laid uppermost. It is then covered in with flat stones, forming a kind of vaulted chimney. The dry chips at the top are set on fire, and the chimney being entirely closed up with a large stone, wet earth is heaped on the stones at top, and constantly applied wherever the smoke is observed to issue. The general product is about 10 or 12 per cent. of tar, of the weight of the whole charge. The red wood and knots are found to furnish about one fourth of their weight in tar.

An account of the quantity of tar obtained by the destructive distillation of coal, will be found in our article Gas Lights, Vol. IX. p. 581.

TAPAJOS, or as pronounced according to English orthography, Tapahos, great river of South America, interlocking sources about Lat. 12° 30′ S. with those of the Guapare branch of Madeira, and with the extreme northern sources of Paraguay river. Assuming thence a course of N. N. E. upwards of nine hundred miles, falls into the Amazon, at Santerem, S. lat. 2° 20′.

The valley of the Tapajos lies between those of the Madeira and Xingu, and in an imperfectly explored region.

TAR, or as named in the lower part of its course, Pamlico, river of the United States, in North Carolina, has its most remote north-western source in Parson county, interlocking sources with those of Hycootee branch of Dan river, and with those of Neuse river. Flowing thence south-eastward over Granville, Franklin, Nash and Edgecombe counties, it receives a large northern branch, Fishing creek, from Warren and Halifax counties. At its reception of the water of Fishing creek, Tar river has flown by comparative courses about ninety miles, and thence with an extensive sweep to the southward, the original general course is maintained forty miles to the head of Pamlico bay, at Washington, in Beaufort county.

The Tar river valley, including that of Pamlico bay, is about one hundred and sixty miles in length, with a mean width of thirty miles, and lying between those of Neuse and Roanoke. Extending in Lat. from 35° 15′ to 36° 25′ N. and in Long. from 0° 25′ E. to 2° 15′ W. of the meridian of Washington city. It is navigable for vessels of nine feet draught to Washington, and for river boats to Tarborough, at or near the confluence of the two main branches.

TARBOROUGH, post village and seat of justice, Edgecombe county, North Carolina, situated on the right bank of Tar river, below the influx of Fishing creek, by post road, 72 miles a little N. of E. from Raleigh, and 252 a little W. of S. from W. C. N. Lat. 35° 53′, Long. 0° 36′ W. Darby.

TARASCON, a town of France, in the department of the *Bouches du Rhone*, situated on the Rhone opposite Beaucaire, with which it has a communication by a bridge of wood. It possesses several handsome churches; but the castle, a large building of hewn stone, and fortified in the Gothic manner, is the principal edifice. Woollen and cotton goods are manufactured, and a trade is carried on in wine, olive oil, and brandy. It is the chief place of the *Isle de la Camarque*. Population about 18,300.

TARBES, anciently Bigorre, a town of France, and the capital of the department of the Upper Pyrenees. It consists chiefly of a single street, in a beautiful meadow on the left bank of the Adour. The streets are tolerably broad, and the houses, which are of brick or gray marble, and slated, are not ill built. The cathedral, the churches, the episcopal palace, the theatre, and the hospital, are the principal edifices. The town is defended by a wall and an old castle. Paper and linen articles are manufactured here. Population about 8000.

TARES. See Agriculture, *Index*.

TARN, a department in the south of France, bounded by those of the Avignon, Lot, the Herault, &c. Its surface is a gently undulating plain, crossed by several chains of small hills. It derives its name from the Tarn, which rising in the department of Lozere, and traversing that of the Avignon, flows through the department into the Garonne. It is well watered by the Agout, which passes Castres, and falls into the Tarn below Lavaur. Its chief towns are,

	Population.
Alby, the capital,	9,649
Castres, - -	15,386
Gaillac, - -	6,465
Laveur, - -	6,237

There are here some mines of iron and coal, and a little silk is raised. Wheat, barley, maize, hemp, flax, and wines, are its chief productions. The forests occupy about 90 thousand acres. The contributions in 1803, were 2,693,820. The superficial extent of the department is 576,821 hectares. The population in 1822 was 313,713, and in 1827, 327,665, and the number of inhabitants for every 1000 hectares, was then 560. It contains about 50,000 protestants.

TARN and Garonne, a new department in the south of France, formed in 1808 out of part of the departments of Lower and Upper Garonne. The surface is a plain traversed by three chains of hills, the highest of which does not exceed 1200 feet. The productions are wheat, barley, maize, hemp, flax, wines, chesnuts, almonds and figs. Montauban is the capital. The superficial extent is 354,591 hectares. The population in 1822 was 238,143, and in 1827, 241,586, and the number of inhabitants to every 1000 hectares was 670.

TARQUIN. See Roman Empire.

TARRAGONA, a seaport town of Spain in Catalonia. It is situated near the mouth of the river Francoli upon a hill, and is defended by turreted walls. It has a large and elegant Gothic cathedral, with a magnificent chapel built with rich marble and jasper in honour of St. Thecla. Population about 7500.

An account of Sir J. Murray's descent upon Tarragona will be found in our article SPAIN in this volume. See also BRITAIN, Vol. IV. p. 706.

TARTAGLIO, NICHOLAS, an eminent Italian mathematician, was born at Brescia about the beginning of the 16th century, and died at Venice in 1557. An account of his labours and writings will be found in our articles GEOMETRY, Vol. IX. p. 653, and MATHEMATICS, Vol. XII. p. 439.

TARTARY, a name given to a very extensive tract of country in Central Asia, bounded by Arabia and Russia on the north, and the confines of China, India, and Persia on the south. It is divided into two great portions, *Independent Tartary* and *Chinese Tartary*.

Independent Tartary is bounded on the south by Balk and Khorasan in Persia, on the west by the Caspian, and on the north by the provinces of Oufa, Orenburg and Tobolsk in Asiatic Russia. The principal kingdom of Independent Tartary is Great Bucharia, which we have already described. The Khirghises occupy a great extent of territory on the north, and are divided into the Great, the Middle, and the Lesser hordes. The Great horde is estimated at 60,000 families, and the other two at 30,000 each, so as to give a population of above half a million. They live in huts and lead a wandering life, each horde being governed by a Khan. They occupy the whole country from the north end of the Caspian to the Talkan Lake. The Uzbeck and Turcomans occupy the vast sandy desert between the Aral and the Caspian, and the country on the upper Oxus. On the Taxartes, there is a fertile and thickly peopled territory belonging to the bey of Koukan, but very little is known of it. For farther information respecting this part of Tartary, see AFGHANS, ARAL, BALK, BUCHARIA, CABUL, CASPIAN SEA, SAMARCAND. See also PERSIA and RUSSIA.

Chinese Tartary embraces an immense extent of country of about 70 degrees of longitude, and 20 of latitude. It includes, on the north, Mongolia and Mandschuria; on the west, Cashgar; on the south, Thibet; and in the centre the territories of the Calmucks or Eluths. As almost nothing is known of the present state of these hordes, we must refer our readers to the articles BUCHARIA LITTLE, Vol IV. p. 773; CALMUCKS, Vol. V. p. 174; CHINA, PERSIA, and THIBET. See also ASIA, Vol. V. p. 513; PHYSICAL GEOGRAPHY, Vol. XVI. and RUSSIA, Vol. XVI, p. 519.

TASSO, TORQUATO, a celebrated Italian poet, was born at Sorreno on the 11th March 1544. At a school of the Jesuits at Naples, to which he went at the age of five, he made such rapid progress, that in the 7th year of his age he recited compositions of his own, both in prose and verse. At the age of 12, he entered the University of Padua, and so premature was the development of his intellectual faculties, that in his 17th year he received degrees in canon and civil law, philosophy, and divinity. Invited to Bologna by the celebrated Cesi, his talents became very conspicuous; but having composed a defamatory poem, he was deprived of his books, and thought it prudent to retire to Castelvetro, under the patronage of Count Rangoni. In 1562, at the age of 18, he published at Venice his poem of *Il Rinaldo*, a work on the plan of the Odyssey, which he dedicated to Cardinal D'Este, in consequence of which he was invited to the Court of Ferrara, where he is said to have carried on his great work of the *Gerusalemme Liberata*, six cantos of which were composed in his 17th year. In the year 1571, he accompanied the cardinal to the Court of Charles IX. of France, where he was well received; and, on his return in 1572, he caused his dramatic pastoral of *Aminta* to be represented. About this time seven cantos of his Jerusalem Delivered, which had been lent to his friends in MSS., were copied and disseminated through Italy; and in 1577, the 4th canto was printed at Genoa in a poetical collection. In 1580, portions of 16 cantos were printed at Venice; but in 1581 there appeared three editions of this great work, the last of which, published at Ferrara, is regarded as the most genuine.

The circumstances which led to this carelessness respecting his works sprung out of a mental disease under which he doubtless laboured. This state of mind has been ascribed to a rash affair of love which touched the honour of the family of Alphonso, Duke of Ferrara, and which terminated in the confinement of Tasso in a lunatic hospital by the order of that prince. After his liberation, he lived at Rome with Cardinal Cinzio Aldrobrandini, who obtained a pension for him from Pope Clement VIII. In this retreat, in 1593, he published his *Gerusalemme Conquisita*, which is a sort of recomposition of his former work. This zealous patron had arranged a solemn poetical coronation of the poet in the capitol, but his own illness interfered with the immediate execution of the plan, and an attack pregnant with danger disabled Tasso from receiving so high an honour. He was removed to the convent of St. Onofrio, where the consolations of religion were administered to him by his affectionate friend, and where he died full of piety and hope in April 1595, in the 51st year of his age. A monument was erected to his memory in the Church of St. Onofrio, by Cardinal Bonifacio Bevilacque.

Tasso was in person tall, active, and well proportioned. In society he was silent, grave, and polite, and kind and affectionate in all his social relations.

Besides his Jerusalem Delivered, and the other works already mentioned, he wrote his *Sella Giornata*, or works of the seven days, which relates to sacred subjects, the tragedy of Torremond, and a great number of treatises, dialogues, and letters on various topics.

Lord Byron has done honour to the memory of this great poet by his "Lament of Tasso," published in 1817, and to which he has prefixed the following notice:—"At Ferrara (in the library) are preserved the original MSS. of Tasso's Gerusalemme, and of Guarini's Pastor Fido, with Letters of Tasso, one from Titian to Ariosto; and the ink-stand and chair, the tomb and the house of the latter. But as misfortune has a greater interest for posterity, and little or none for the cotemporary, the cell where Tasso was confined in the hospital of St. Anna attracts a more fixed attention than the residence or the monument of Ariosto; at least it had this effect on me.

"There are two inscriptions, one on the outer gate, the second over the cell itself, inviting, unnecessarily, the wonder and the indignation of the spectator. Ferrara is much decayed and depopulated; the castle still exists entire; and I saw the court where Parisina and Cluzo were beheaded, according to the annal of Gibbon."

TASTE. This subject has been discussed so amply under our articles Beauty, Vol. III. p. 363–371, and under the Principles of Civil Architecture, Vol. VI. p. 414—423, that there is no occasion to resume it under the present head.

TAVISTOCK, a borough of England, in Devonshire, situated on the Tavy, over which there are two bridges. The church is spacious, and consists of four aisles, a chancel, and a tower raised on arches. It contains some bones of gigantic size that were found among the ruins of the abbey. The chief manufacture is that of serges. It is one of the Stannary towns. It sends to Parliament two members, who are chosen by about 110 votes. Population of the borough and parish in 1821, 5483.

TAUNTON, a borough of England, in Somersetshire. It is situated on the banks of the Tone, and consists of four spacious streets containing many good houses. In the market place, which is large and handsome, there is an appropriate market house and town hall. It contains two parish churches, and five dissenting meeting houses. The church of St. Mary Magdalen is a beautiful building, with a lofty dome 183 feet high, remarkable for its magnificence and elegance. The church of St. James is a plain but ancient building. There is here a free grammar school, two large alms houses, and an excellent hospital, built in 1772—1779. It sends to Parliament two members, who are elected by about 500 votes. Its manufactures consist of coarse woollen goods, silk, and ale. The ale is in high esteem. The Tone is navigable for barges to Bridgewater. There is here a theatre, and races are held near the town. A newspaper is published at Taunton. Population of the borough in 1821: Inhabited houses, 1503; families, 1706. Total population, 8534.

TAUNTON, Vale of. See England, Vol. VIII. p. 502.

TAUNTON. Capital of Bristol county, Massachusetts, on the west side of Taunton river, 21 miles east of Providence and 36 south of Boston. It is a pleasant town. Population in 1830, 5798. In 1652, the first extensive iron works in North America were erected in this town. The nail factories, when in full operation, can now turn out from eight to ten tons of cut nails per day. The first shovels that were made in this country were made here. Most of the bricks for this section of the country have long been manufactured in this town—between eight and nine million are now made annually. There are in the place seven cotton factories; two breweries; two printing offices, from which are issued two weekly newspapers and two juvenile papers; one rolling and slitting mill; one forge; one shovel manufactory; one copper and lead rolling mill; one paper mill; one carding and fulling mill. The calico establishment furnishes from 4000 to 5000 pieces per week, in a style equal to any manufactured in the country. There is also a manufactory of Britannia ware. We believe it is the only establishment of the kind in the country. It is about three years since it was commenced on a small scale. It is now grown into an extensive business. The ware is now pronounced, by competent judges, to be far superior to the imported article. It has already made its way into public favour; and the "Taunton silver" is now to be seen in most of our large cities, rivalling, in beauty and brightness, the standard metal. We ought not to close this article, without mentioning the court house, the stone church, and the Episcopal church, as being ornaments to the village; the last we believe to be unrivalled in this country for neatness and picturesque beauty. Darby.

TAURIDA. See Crimea, Vol. VII. p. 172.

TAXES. See England, Vol. VIII. p. 610.

TAY. See Perthshire and Scotland.

TAYLOR, Brook, an eminent English mathematician, was born at Edmonton near London in 1685. In 1701 he was entered a fellow commoner at St. John's college, Cambridge; and in 1708, in the 23d year of his age, he wrote a paper on the Centre of Oscillations, which is published in the Phil. Transactions for 1713. In 1709 he became LL.D., and in 1712 he was elected a fellow of the Royal Society, and in the same year communicated to them his curious experiment on the hyperbolic figure of water ascending between two glass planes. In 1714, when he had taken his degree of LL.D. at Cambridge, he was elected secretary to the Royal Society; and in the Transactions from vol. xxvii. to vol. xxxii. he published several excellent papers, principally on mathematical subjects. His principal works, however, are his *Methodus Incrementorum*, and his treatise *On the Principles of Linear Perspective*, both of which appeared in 1715. The first of these contains a curious theorem for expressing a variable quantity by all the orders of its differentials, and also a paper on the vibrations of a tense cord, in which he first established the isochronism of a vibrating string.* His Treatise on Perspective, which was reprinted with improvements in 1717, was the first in which this art was established on infallible principles.

In his intense application to study he lost his health, and was obliged to repair to Aix-la-Chapelle. On the death of his father in 1729, he succeeded to the family estate of Bifrons, in Kent; and in the year following he lost his wife in childbed. About this time he composed his *Contemplatio Philosophica*, the work of a Christian and a scholar, which was published by Sir. W. Young in 1773. He died of consumption in October 1731, in the 46th year of his age. His grandson, Sir W. Young, published his posthumous works, with a life of the author prefixed.

* See our article Acoustics.

TAZEWELL, one of the south-eastern counties of Virginia, bounded on the north by the Tug Fork of Sandy river, separating it from Logan county; north-east by Giles; east and south-east by Walker's mountain, separating it from Wythe; south by Clinch mountain, separating it from Washington; south-west by Russell, and west by Floyd county of Kentucky. Length from west to east 80 miles; mean width 20, and area 1600 square miles. Extending in Lat. from 36° 54′ to 37° 32′ N. and in Long. from 4° to 5° 12′ W. from W. C.

The central part of this county is a very elevated mountain table-land. The eastern part declining northeastward, and drained by confluents of Great Kanawha; the southern section gives source to Clinch and Holston rivers, the extreme northern constituents of Tennessee river. The western and much the most extensive section declines northwestwardly and discharges in that direction the extreme highest sources and branches of Sandy river.

Compared with the ascertained elevation of the water in Great Kanawha at the influx of the Greenbrier river, which is 1333 feet above the ocean level, the lowest elevation than can be given to the central mountain vallies of Tazewell must be 1500 feet, and the mean relative height of the arable soil of the county must be, at the lowest estimate, 1200 feet of similar relative height. This comparative height is equivalent to four degrees of latitude, therefore if we allow 37° 13′ as the central latitude of Tazewell we have 41° 13′ N. as about the mean of its winter climate, when compared with the Atlantic coast.

By the post office list of 1831, there were but three post offices in this large county. These were, Tazewell court-house, the seat of justice, Bluestone and Burkesgarden.

Tazewell court-house, or as named and laid down on Tanner's United States, Jeffersonville, is situated at the foot of Rich mountain, on the height of ground between the extreme source of Clinch river and that of Bluestone branch of Great Kanawha, about 150 miles northeast by east from Knoxville in Tennessee; and by post road 352 miles southwest by west from W. C., and 290 a little south of west from Richmond. N. lat. 37° 5′, Long. 4° 30′ west from W. C. In 1820, the space since laid out and formed into Logan county was included in Tazewell, and jointly contained 3919 inhabitants. DARBY.

TEA is the name given to the leaves of the Tea tree, an infusion of which in boiling water is now a favourite beverage among all civilized nations. The natural history of this valuable substance has been so fully detailed in our article CHINA, Vol. VI. p. 166---167, that it is unnecessary to resume the subject.

Nothing is more remarkable than the rapid progress of the tea trade, as appears from the following tables:

	Tea imported.		Tea imported.
1700	91,183 lbs.	1706	137,748 lbs.
1701	66,738	1707	32,209
1702	37,061	1708	138,712
1703	77,974	1709	98,715
1704	63,141	1710	127,299
1705	6,739		

During 100 years from 1710 to 1810 inclusive, there were sold at the East India Company's sales 750,219,016 lbs., the value of which was £129,804,-595; of the above quantity 116,470,675 lbs. were exported, and the remainder 633,748,341 retained for home consumption.

The following table, which has just been published, brings down the state of the tea trade in Britain to the present year.

Years.	Quantities retained for Home consumption. Lbs.	Net revenue of Customs and Excise. £	s.	d.
1789	14,534,601	562,038	14	5
1790	14,693,299	547,230	4	8
1791	15,096,840	607,430	8	4
1792	15,822,045	616,775	6	9
1793	15,244,931	609,846	5	6
1794	16,647,963	628,081	6	5
1795	18,394,232	695,108	5	9
1796	18,009,992	877,042	13	0
1797	16,368,041	1,028,060	9	7
1798	19,566,934	1,111,898	9	1
1799	19,906,510	1,176,861	9	9
1800	20,358,702	1,152,262	0	0
1801	20,237,753	1,287,808	2	6
1802	21,848,245	1,450,252	7	9
1803	21,647,922	1,757,257	18	4
1804	18,501,904	2,348,004	4	8
1805	21,025,380	2,925,298	17	4
1806	20,355,038	3,098,428	13	2
1807	19,239,312	3,043,224	11	3
1808	20,859,925	3,370,610	0	10
1809	19,869,134	3,130,616	14	9
1810	19,093,244	3,212,430	1	1
1811	20,702,809	3,249,294	0	9
1812	20,018,251	3,258,793	2	9
1813	20,443,226	Custom House records destroyed.		
1814	19,224,154	3,428,236	8	4
1815	22,378,345	3,526,590	18	3
1816	20,246,144	3,956,719	0	5
1817	20,822,936	3,003,650	18	7
1818	22,660,177	3,362,588	10	1
1819	22,631,467	3,256,433	12	10
1820	22,452,050	3,128,449	17	0
1821	22,892,913	3,275,642	17	6
1822	23,911,884	3,434,292	19	10
1823	23,762,470	3,407,983	1	8
1824	23,784,838	3,420,205	11	11
1825	24,830,015	3,527,944	4	11
1826	25,238,067	3,291,813	19	5
1827	26,043,223	3,263,206	19	3
1828	*26,790,481	3,177,179	8	0

Those who wish for farther information on this subject, will find an excellent account of the rise, progress, and present state of the tea trade in Milburn's *Oriental Commerce*, vol. ii. p. 520—542. See also Staunton's *Embassy to China*. Appendix to Dr. Latham's *Natural History of the Tea Tree*, 1772. See also ALIMENTS.

TECHE, river of Louisiana, rising in the northern prairies of Opelousas, N. Lat. 30° 40′. The

* This amount includes all tea shipped to Ireland for consumption in that country subsequently to the passing of the act 9th Geo. IV. cap. 44.

drains of these savannahs, after flowing 7 or 8 miles, divides into two channels; one flows northwardly into the Courtableau river, whilst the other pursues a southeastern course. This remarkable separation of currents is about half a mile below the upper Opelousas landing; and from thence the southeastern branch takes the name of Teche. Flowing between waters of the Courtableau and Vermilion rivers 10 miles, it receives an inlet from the latter under the name of Bayou Fusillier. The peculiar structure of the country, and the very near approach of the surface to a plain, is seen in these interlocking water-courses.

Below the influx of Bayou Fusillier the Teche leaves Opelousas and enters Attacapas; and in the residue of its course presents a stream with great specific resemblance to the Mississippi in the Delta. Though on a very reduced scale, the Teche, similar to its immense prototype, flows in long sweeping bends, with its banks above any other part of the adjacent country, the channel being the deepest valley. The adjacent water-courses rise from the very margin, and in a distance, following the channel, of 180 miles, the Teche receives no tributary stream.

With slight selvedges of woodland immediately on the stream, prairies extend along the entire right bank of Teche, and for more than one half of the higher part of its course, also along the left bank of this interesting river. The border sloping very gently from the high bank, from a quarter to a mile in width, is composed of the very first rate land, between latitudes 29° 44′ and 30° 40′ N. Below Lat. 30°, the climate admits sugar cane, and near the mouth a few orange trees begin to appear.

It is impossible to carefully examine the Teche without a conviction, that the time was when a much more extensive mass of water must have passed down a channel so very deep and wide as to appear out of all proportion to the quantity of fluid it now contains at any season of the year. The high margin of Teche may be regarded as the western boundary of the overflow of Atchafalaya and Mississippi combined; but from the colour of the alluvial banks of Teche it is more than evident that the waters of Red river, or at least a part, once passed down its channel—a phenomenon which has now entirely ceased.

Thus distinguished by peculiar features, the Teche, after a comparative course of 120, but if the actual course is pursued, falling little short of 200 miles, falls into Atchafalaya. Any vessel which can enter the latter over its outer bar, can ascend the former to New Iberia at the head of tide water. It may be noticed as a very characteristic feature of this part of Louisiana, that though the tides of the Gulf of Mexico do not exceed a mean of 2½ feet, yet that they ascend so deep into the country. Pursuing the channels of the two rivers, New Iberia is not much if any less than one hundred and fifty miles from the open Gulf. To New Iberia, which is a port of entry, vessels of 7 feet water can be navigated in perfect safety.

Articles of export from this river are chiefly cotton and sugar. Neat cattle are reared in great numbers in the adjacent prairies, but are in most part driven alive to the New Orleans market. DARBY.

TEHERAN. See PERSIA, Vol. XVI. p. 459—466.

TEIGNMOUTH, a seaport town of England in Devonshire, is a celebrated watering place situated at the mouth of the river Teign. It stands on a gentle eminence, and is divided by a rivulet into E. and W. Teignmouth, which form two parishes. The public assembly and billiard rooms form a handsome building in E. Teignmouth; and the theatre, which is in W. Teignmouth, is a neat structure. The church of E. Teignmouth is an old and respectable building situated near the sea. That of W. Teignmouth is a handsome octagonal building finished in 1821. A commodious market-place has been lately erected. The principal trade of the place consists in the exportation of pipe clay and the importation of coals, and in a commercial intercourse with Newfoundland. The ships employed are chiefly built here. The population of the two parishes in 1821 was 769 houses, 855 families, and 3980 inhabitants.

TELEGRAPH.

TELEGRAPH from τηλε *at a distance*, and γραφω *to write*, is the name given to a piece of mechanism for the rapid communication of intelligence by signals.

When we find that some of the most savage nations of modern times are acquainted with the use of signals, it would be absurd to suppose that the civilized nations of antiquity had not devised and put in practice regular methods of communicating intelligence both by fires during the night, and by movable objects during the day. The Prophet Jeremiah vi. 1. directs the children of Benjamin "to set up a sign of fire at Beth-haccerem, as evil appeared out of the north and great destruction;" and Eschylus, who lived about two centuries later, makes one of the soldiers in his *Agamemnon* descend from a watch tower at the top of the palace and announce from the fire signals the fall of Troy long before the return of the Greeks.

Polybius gives a full account of the πυρσειαι or fire signals of the ancients, and describes his own improvements on the method of telegraphic communication invented by Cleoxenus. Kircher in his "*Ars magna*," &c. distinctly describes a telegraphic experiment, and Schottus in his *Technica curiosa* proposes the application of the telescope to view posts erected upon an eminence. The Marquis of Worcester in Nos. 6 and 7 of his *Century of In-*

ventions enumerates a day and night telegraph among his contrivances: and Kessler in his *Concealed Arts* proposes to cut out characters in the bottom of a cask having a light placed within it, the characters being changed in succession in order to express single words, and whole sentences.

The earliest telegraph for general purposes appears to be that of our celebrated countryman Dr. Hooke, who has described it in the *Philosophical Transactions* for 1694. This contrivance consisted of more than thirty different bodies, each of which formed a distinct telegraphic sign or symbol, which were exhibited in succession upon an elevated apparatus. This apparatus, shown in Plate DXXI, Fig. 1. consists of three long masts or poles, two of which carry a screen A, behind which the thirty bodies hang upon rods or lines. These bodies, consisting of squares, centres, triangles, and made of deal, may, by the help of small lines connected with them, be exhibited at B, where a square is shown. In the night time torches, or other lights, were arranged in a particular order, and were substituted in place of the wooden figures. The characters, which thus represent the alphabet, may be varied, as Dr. Hooke observes, in ten thousand ways, whilst none but the two extreme correspondents shall discover the information conveyed.

Long after the publication of Hooke's contrivance, M. Amontons, an ingenious natural philosopher and member of the Academy of Sciences, brought forward, and submitted to trial, a plan of a telegraph which seems to differ in no respects from that of Dr. Hooke. He proposed to place the stations at such a distance that a telescope could command them. The signals to be seen through the telescope were either to be large letters of the alphabet, or figures to represent them, and he appears to have tried the plan before several persons of distinction in the court of France.

In the year 1767 R. L. Edgeworth, Esq. made trial of a new method of carrying intelligence. He made use of a common windmill for the purpose, and he arranged a system of signals produced from the different positions of the arms carrying the sails, the canvass being removed from one or more sails as the circumstances might require. In 1784 the same ingenious author brought forward his plan of a numerical telegraph, the signals denoting numbers, and each party having vocabularies in which all the words were indicated by the number which the signals represented.

Notwithstanding these various attempts to contrive and construct telegraphs, yet the practicability of these machines does not seem to have been distinctly recognised till the year 1794, when the activity of the National Convention called into play all the talents of the kingdom. M. Chappe* had the merit of introducing, on this occasion, under the name of the *Semaphore*,† what has been called in England the T telegraph, from its resemblance to that letter. It is represented in Fig. 2, where CD is a strong wooden mast carrying a beam AB, called the long indicator, which can be placed in any position round C as a centre of motion, by means of cords and pulleys. This indicator, which is about twelve feet long, and nine inches broad, carries at each extremity two lesser indicators AE, BF, which are likewise movable round A and B as centres, so that they can be placed in any position with respect to the long indicator AB. Each of the lesser indicators can obviously take five distinct positions with respect to the great one considered as fixed, viz. two at right angles to AC, two inclined 45° to AC, and one where it falls back upon AC and appears, so that we have thus $5 \times 5 = 25$ signals. But as AD may distinctly take four positions, one horizontal, one vertical, and one inclined 45° to the horizon, we have $4 \times 25 = 100$, for the number of distinct signals given by the semaphore.

In the semaphore constructed at Paris the first station was on the Louvre. The distance of the stations was three or four leagues, and an observatory was erected near the committee of public safety, to observe the indications on the Louvre. Although the semaphore of M. Chappe possesses great power, yet it is said to have been liable to mistakes, unless when wrought by experienced operators.

In 1794, Mr. R. L. Edgeworth proposed the telegraph shown in Fig. 3, which consists of four separate pointers, having the form of an isosceles triangle, with their base rather less than half the perpendicular, and movable round centres at the top of the vertical posts A, B, C, D. The four pointers are placed in a row, and the right hand one D represents *units*, the next C *tens*, the third B *hundreds*, and the fourth A *thousands*. Now each pointer can take *eight* distinct positions; seven of these denote figures, and the upright position of the pointer represents *o*, or zero. With the figures, as thus indicated by the telegraphs, are contained a vocabulary, with numbers opposite the words.

The Rev. Mr. Gamble produced, in 1795, plans of two telegraphs which are represented in Figs. 4 and 5. The first of them consists of five boards, one above the other, which, by opening and shutting, afforded a certain number of distinct signals. His second plan consisted of five beams of wood, each ten feet long. All the five moved round a common centre of motion, and as those motions were independent of each other, *one*, *two*, *three*, or *four*, could be exhibited at different degrees of elevation, in reference to a horizontal line, or with respect to each other, so as to furnish a great number of signals. One of these was erected in 1803, on one of the towers of Westminster Abbey, but has been long ago taken down.

In 1808 Major C. Le Hardy described a telegraph consisting of four pointers, or long arms, each carrying at its extremity a square wooden board. One of these represents units, another tens, another hundreds, and the fourth thousands. The indices move on a common centre, and each index board is placed at a different distance from the centre of motion, so

* M. Dupuis is said to have invented a telegraph in 1781.

† From σημα, *a sign*, and φερω, *to bear*.

that in turning round, these boards describe four circles of different radii. The inclination of the arm to the horizon indicates the number, and each has ten different positions. In order to identify these positions, a large frame, with ten radical bars, is fixed behind the pointers, and these are crossed by five circles, corresponding to the bulk of each index board.

Among other contrivances, similar to this in principle, may be numbered that of Dr. Garnet, who proposed to read off the inclination of the pointers to the horizon by a wire in the focus of a telescope, which, by turning the end of the tube brings the wire in a line with the pointer, (see Fig. 6,) and indicates its inclination upon a scale.

In 1795, Lord George Murray laid before the Admiralty his plan of a six shutter telegraph, which is shown in Fig. 6. This plan was in use during the whole of the late war, but in 1816 was replaced by a simplified semaphore.

The first French semaphoric telegraph which is said to have been erected on the palace of the Thuilleries in 1796, is shown in Fig. 8.

In the year 1796, Mr. Edgeworth proposed to simplify this telegraph, by using only one of the masts and one of the isosceles triangles, shown in Fig. 3, and at the same time proposed a two-armed telegraph, one of the arms having the form of a cross, and the other, that of a wood-cutter's sign, as shown in Fig. 9.

In the year 1798, MM. Breguet and Betancourt presented to the National Institute a new telegraph on a simple construction. It consisted only of a single piece, called the arrow, and one of whose extremities was terminated in a T, in order to distinguish it from the other end.

At the beginning of the war in 1803, there were erected a series of telegraphs along the coast upon the same principle as the radiated telegraph of Mr. Gamble. Each telegraph consists of an upright post, as shown in Fig. 10, carrying three arms exactly similar to each other, and each moving round an axis of its own. The distance between the centre of motion of two contiguous arms is a little less than double the length of one arm. The uppermost arm exhibits seven distinct positions, and the others have only six each.

One of the most ingenious and ardent improvers of the telegraph, is our countryman Colonel Pasley, who published in 1810 an account of the polygrammatic telegraph for day signals, which he had invented in 1803. He proposed to erect four posts, with arms complete, at every signal station, as shown in Fig. 11. In 1810, he described another on a new construction, shown in Fig. 12. This is precisely similar to the first, excepting that the pairs of arms used are placed upon one lofty post, instead of several short ones.

Considering the shutter principles inferior to that of the Semaphoric arms, Colonel Macdonald proposed in 1808, the machine shown in Fig. 13, the construction of which, and the reason for adopting it, are thus given by himself. "As *three* shutters give only seven mutations, it was found necessary to have recourse to *four*, which furnish *fifteen* changes. The four shutters were placed in a frame over each other, and worked in the usual manner. Shutters 1, 2, 3, and 4 shut in succession, for the highest gave numerals 1, 2, 3, and 4. To have the remaining numerals, it was requisite to combine or to exhibit two shutters closed together, or at the same time. Thus shutters 1 and 4 gave numeral 5. Shutters 2 and 4 closed, expressed numeral 6. Shutters 3 and 4 closed, yielded figure 7. The two upper shutters closed, represented numeral 8. Shutters 1 and 3 closed, denoted figure 9, and the two middle shutters closed, represented the 0 or cypher. As four shutters, acting as above, in a frame, would furnish a telegraph capable of giving only *one figure at a time*, it was requisite to have three conjoined frames, with four shutters in each frame, in order to be enabled to have the places of *units*, *tens*, and *hundreds;* or in other words, to be able to express any *three* figures *simultaneously*. On this simple principle I constructed my *twelve shutter telegraph for fixed stations*. Four of the five of the remaining combinations in each of the three sets of co-operating sets or frames, are given by exhibiting three shutters closed, as shutters 1, 2, and 3; 1, 2 and 4; 1, 3 and 4; 2, 3 and 4; the last or fifteenth mutation being furnished by closing all the four shutters. * * * There is a circular board over the middles or *tens-set* of shutters, and the application of it doubles power in particular instances, and is otherwise essentially beneficial."

In the year 1816, Sir Home Popham, who had distinghished himself by his improvements on navy signals, introduced a new semaphore, which was adopted by the Admiralty and substituted in place of the shutter telegraph. It is shown in Fig. 14, and is nothing more than two arms moving round separate centres upon the same post.

In 1818 Lieut. Colonel Macdonald invented and described a ball and six shutter telegraphs calculated to express any three figures simultaneously. It has an auxiliary ball above the middle row of shutters, and is surmounted by a semaphore for expressing the classes of words. The same ingenious author invented in 1817 a six ball and three figure telegraph, which gives 4095 combinations, and when conjoined with two of the semaphoric powers, not less than 1,048,575 combinations. See Fig. 16.

The most recent, and probably the best of all the telegraphs that have yet been proposed, is the Universal Telegraph, invented in 1822 by Colonel Pasley, who has given the following description of it:—

For the day signals the telegraph consists of an upright post of moderate height, of two movable arms fixed on the same pivot, near the top of it. and of a mark called the indicator on one side of it. See Fig. 17.

Each arm can exhibit the seven positions 1, 2, 3, 4, 5, 6, and 7, exclusive of its quiescent position, called "the stop," in which it points vertically downwards, and is obscured by the post. Fig. 17 represents the telegraph exhibiting the sign 17, the other positions, of which the arms are capable being dotted. The indicator merely serves to distinguish the low numbers 1, 2, and 3, from the high numbers 7, 6, and 5, so that this telegraph is not, like most others that have been proposed, liable to ambiguity or error, when viewed from different points in contrary directions*.

The use of the indicator will appear more evident on considering the resemblance between the small Roman letters b and d, or p and q, which if viewed in contrary directions, like telegraphic signs, could never be distinguished, one from the other, without some additional mark.

Fig. 18 represents the telegraph fitted up for making nocturnal signals. One lantern C, called the central light, is fixed to the same pivot, upon which the arms move. Two other lanterns are attached to the extremities of the arms. A fourth lantern I, used as an indicator, is fixed on the same horizontal level, with the central light, at a distance from it equal to twice the length of one arm, and in the same plane nearly in which the arms revolve. Hence the whole apparatus consists of two fixed and of two movable lights, four in all.

The number of telegraphic signs, combinations, or changes, which this telegraph is capable of exhibiting, are only 28, but these are amply sufficient for every purpose of telegraphic communication, whether by the alphabetical method, or in reference to a telegraphic dictionary of words and sentences. These signs are represented in Fig. 21, showing the appearance of the same combinations both by day and night.

In some few of the nocturnal signs, it will be observed, that one of the lights is marked black. This only happens when one of the movable lanterns is supposed to be in its quiescent position, hanging vertically down below the centre light. In this case, as the lantern may be exhibited on either side of the post, in may sometimes be seen, and sometimes not, by the distant observer. At first I proposed to interpose a couple of screens, one on each side of the post, to hide the lanterns altogether when in this position. Afterwards that idea was abandoned, it having been found, in practice, that it made no difference in regard to the clearness of the signs alluded to, whether the movable lanterns were seen or obscured, when in the position denoted by the black circles.

The indicator, both by day and night, being merely a mark and nothing more, which, when once seen, requires no farther attention to be paid to it; and the central light by night, and the post by day, being also merely guides to the eye; the signs of this telegraph are, in reality, composed of the combinations of two movable bodies only by day, and of two movable lights only by night, being the smallest number of parts, with which an efficient telegraph can possibly be formed: and in this diminution of the number of combinable parts, as well as in the unity of plan, consists the superior simplicity of this telegraph, as compared with other efficient telegraphs that have been proposed.

The arms and the indicator for the day signals are made of wood, framed and pannelled, for the sake of lightness. The indicator plays in a mortise, cut in the upper part of the post, and is let down into its horizontal, and raised into its vertical position, by means of a small rope, and a small pulley. The arms must be fixed externally, one on each side of the post, and must be exactly counterpoised, by means of light frames of open iron work, which become invisible by day, at a little distance, and which, even when viewed closely, do not impair the clearness of the telegraphic signs. This precaution is absolutely necessary, otherwise the arms will not remain in any given position, without being held by the hand, or stopped by some mechanical contrivance, which would be a very great inconvenience in the practice of signal making.

Motion may be communicated to the telegraphic arms, by means of an endless chain, passing round, and acting upon a couple of pulleys; one of which is fixed to the arm itself, and turns upon the same pivot, whilst the other moves upon a pivot, fixed to the lower part of the post. The chain consists alternately of single and double plates of an oblong form, and rivetted together at the ends, on the principle of a watch chain. The two pullies at the top and bottom being finished with great care, perfectly equal, and having projecting teeth, or studs, fixed in a groove in each, to engage the double or open parts of the chain, the telegraphic arm above will always follow to a hair's breadth, the movements of an index, or lever, below, attached to the lower pulley, which has a dial plate opposite to it, marked on the post, for the guidance of the operative signal man.

In the field, or on board ship, a leathern strap or a rope may be substituted in lieu of the chain, for the sake of economy; but as these expedients are incapable of the same accuracy as the former, the signal men, in working by them, must not trust to the indices, but must regulate the positions of the arms chiefly by the eye. The surface of the pulleys, when intended for a strap, must be moderately convex, those for the rope moderately concave, and both should be broader than when a chain is to be used. The leathern strap requires an extra pulley of a smaller size, for pressing in one side, and tightening it, when the telegraph is to be used. This pulley is fixed to a small lever attached to the middle of the post, and is thrown into action by a string.

When a rope is used, three turns of it are taken round each pulley, hauling it tight at the same time, after which the two ends, being previously preparpared with thimbles, or eyesplices, are brought towards each other, and made fast, by a lanniard, or smaller rope, passing through the eyes.

When the strap or rope is used, the lower pulley instead of having one short lever only, serving as an index, may have four such levers, so as to resemble a small windlass.

At the end of each arm, two light pieces of iron,

* The idea of the indicator, which was not a part of my original plan, but without which, I am now of opinion, that no telegraph is perfect, suggested itself in consequence of a remark made by my friend Captain John Tailour of the royal navy, who informed me that he had experienced the greatest inconvenience in using Sir Home Popham's ship Semaphores, from the signal men confounding the positions of the arms when seen in reverse.

meet in an angle of 45 degrees, forming an open triangle, to the vertex of which the movable lantern L is attached, by means of a pin. A cylindrical weight w must be fixed at the same time to the end of the iron counterpoise, to restore the proper equilibrium of the arms, which is, of course, deranged by the addition of the lantern. As the lanterns and weights, and in short, every addition necessary for exhibiting the nocturnal signals, are fixed at dusk, and removed by daylight, it becomes necessary, at permanent stations, that the roof of the signal house, over which the telegraph stands, shall be formed with a small flat terrace, accessible by means of a ladder or staircase.

In the intermediate stations of a permanent telegraphic line on shore, two lanterns are required to do the duty of the centre light, one on each side of the telegraphic post, because one lantern can, of course, be seen in one direction only, owing to an intervention of the post. These two, as well as the two movable lanterns, are fixed externally, at a sufficient distance from the plane of the arms, to prevent them from striking, as in Fig. 20, in which c c are the central lanterns, L L the movable lanterns, and w w the weights, added to counterpoise them.

The indicator light I may either be fixed to a separate post, as represented in Fig. 18, or it may be attached to a rod r, strengthened by a brace b, and guy ropes g g, as in Fig. 19, which is an elevation of the universal telegraph, fitted up for night signals, on a scale larger than that of the former explanatory figures. The apparatus now alluded to, having only one lantern to support, may be made extremely light. The end of the rod drops into a small open mortise at the head of the post, and has a semicircular groove on its lower surface, which is engaged by a horizontal bolt, driven through the sides of the post. A small rope fixed to the end of the rod, but omitted in Fig. 19, for the sake of clearness, is made fast to a cleat upon the post below, to prevent the rod from moving. The foot of the brace is secured to the post by a plate and stud.

This apparatus, which entirely depends upon the telegraphic post, and turns with it, may be fixed, or disengaged, in a moment, and is peculiarly adapted for ships, and for field service, in which the length of the telegraphic arm does not exceed from five to six feet. But at permanent stations on shore, where larger telegraphs would probably be used, the apparatus for supporting the indicator lamp should be a permanent fixture, to save the trouble of continually shipping and unshipping it. At such stations, if the signals were required to be made in various lines or directions, the pole for supporting the indicator lamp should be fixed to the post at bottom, so as to stand out from it obliquely, like a ship's bowsprit, with lifts, or ropes, to support it, leading to the top of the post, and a couple of guys to secure it from lateral motion. Hence one oblique spar only would be used, instead of the two pieces (namely, the rod and brace) before described. But as there may be many stations in a telegraphic establishment on shore, in which the signals require to be exhibited in one invariable line only, at all such stations, the indicator lantern should be fixed to its own separate post, which may either be placed vertically (as in Fig. 18), or obliquely, as may be considered most expedient.

Lamps for burning oil have recently been brought to such perfection, that a light of sufficient intensity, for any distance suitable for telegraphic purposes, may easily be obtained. In regard to form, if night telegraphs be adopted on shore, square lamps like those of mail coaches, but having the two glass sides opposite to each other, so as to show light in two directions only, would be the most proper. But for sea service the pattern called the "globe lamp," which has of late been generally adopted to the Royal Navy, in lieu of their former signal lanterns, appears to be decidedly the best. In this, the light is exhibited in every direction through a very strong globular glass, to which are fitted a copper top and bottom, pierced with air holes.

In respect to the dimensions proper for the parts of the Universal Telegraph, we ascertained by experiment, that the arms for the day signals should be about one foot in length per mile, in order to be distinguished by a common portable telescope of moderate power. This length is computed from the centre of motion to the end of the arm, not including the small part beyond the centre, called the head. By the above rule, a telegraphic arm, of six feet in length, may suffice for stations six miles apart; but generally speaking, in telegraphs intended for permanent stations, where the saving of the weight is less an object, it may be considered best to add a little to the dimension thus found.

The width of the arm need not exceed $\frac{2}{13}$ths of its length, and should not be less than $\frac{1}{7}$th or $\frac{1}{8}$th of the same dimension. The indicator for the day signals should be of the same width, but only $\frac{4}{5}$ths of the arm in length.

The height of the post should be such, that men, or other movable objects, passing near it, should not obscure the indicator, or arms, when the telegraph is erected on the deck of a ship, or in the field. But when placed on the roof a permanent signal-house, the projecting part of the post need not exceed the telegraphic arm, by more than $\frac{2}{3}$rds of the length of the latter.

It is desirable in all cases, that the telegraphic post should be capable of turning, so as to exhibit the arms in various directions. On board ship it must also be occasionally lowered. Hence it becomes necessary to step it upon a simple open circular joint of iron, fixed to the ship's side near the deck, and to secure it by an iron clamp, also of a circular form, attached to the rail, nearly in the same manner as the ensign staff of a man-of-war is usually fitted.

The telegraphs hitherto constructed upon this principle, are of two sizes. One having arms of $5\frac{1}{2}$ feet in length, with the lantern pivots placed $6\frac{1}{2}$ feet from the centre of motion. The other having arms of $2\frac{1}{2}$ feet in length only, with the lantern pivots three feet two inches from the centre of motion. The former are of a size suited to the largest class of men-of-war. The latter are perfectly portable, as the whole apparatus, including the night indicator, lanterns, &c. does not weigh more than 34 lbs. In clear weather, these small telegraphs make signals distinctly at the distance of three miles.

Supposing that telegraphic signals should be required on a sudden emergency, in some situation where there may not be time and means for making well finished telegraphs, in the manner that has been described, I have ascertained by experiment, that the most expeditious and satisfactory arrangement will always be to copy the regular construction, as closely as circumstances will permit. A post, with two planks for the arms, each worked merely by a couple of strings without pulleys, will constitute a day telegraph, and the addition of lanterns &c. will convert the same simple apparatus into a nocturnal telegraph. In both cases, the arms must be counterpoised by wood or iron, and also by weights, but in a ruder manner than was before described. To adopt balls or flags for day signals, or an immovable rectangular frame, with ropes and pulleys, for supporting the lanterns for night signals, which are the only other expedients that suggest themselves as a temporary arrangement, will, on trial, be found much less satisfactory than the rudest attempt at the counterpoised telegraphic arm.

It is well known, that telegraphs should generally be painted black, and that for permanent stations, they should always be erected, if possible, upon heights having no back ground.

Several telegraphic dictionaries have been composed by different authors, but of these, the one now used in the Royal Navy, which was compiled by the late Rear Admiral Sir Home Popham, appears, upon the whole, to be the most judicious. The number of words and sentences contained in it does not exceed 13,000; and yet there is seldom a deficiency of any useful word. Another author has composed a dictionary of a similar nature, containing upward of 31,000 words and phrases: and a third has composed a work containing more than 149,000 words, phrases and sentences. It may be observed, in regard to this subject, that the extension of a telegraphic dictionary beyond a certain limit is an evil, because in proportion to the number and length of the sentences contained in it, it becomes so much the more difficult to find any of them, without a vast loss of time.

Hence the advantages held out by the author of any very voluminous telegraphic dictionary, must always be in a great measure nugatory, unless the place of every phrase or sentence contained in it, could be known by intuition, which is impossible.

It is to be observed, however, that the comparative compendiousness, of Sir Home Popham's Telegraphic Dictionary, is partly owing to a practice, which he has carried to the greatest possible extent, but of which the other authors alluded to have availed themselves more sparingly, or not at all. I mean the system of classing under the same article of his dictionary, and thereby representing by one common signal, all the forms of the same verb, as well as every noun, adjective, or adverb, that happen nearly to coincide in sound, or are connected in signification. Thus the words, "agree," "agrees," "agreed," "agreeing," "agreeable," "agreeably," "agreement," "agreements," would all be denoted by one and the same signal, and comprehended under one article, in Sir Home Popham's Telegraphic Dictionary.

It is remarkable how very few ambiguities this sweeping method of classing the words of our language will be found to occasion in practice, as may be ascertained by taking any sentences, at random, out of a book, and applying Sir Home Popham's Telegraphic phraseology to them. And yet it cannot be denied, but that serious mistakes may arise at times from this system.

For example, the following phrases, "they are robbing," "they are robbed," and "they are robbers," although different in sense, would all be expressed by the same signal in Sir Home Popham's Dictionary. The phrases, "A robber has been executed," and "a robbery has been executed," would also be expressed by the same signal, and the phrases "they are going," and "they are gone," would likewise be confounded.

It is further to be remarked, that Sir Home Popham's Telegraphic Dictionary, being necessarily confined to the use of the Royal Navy, is not available for general service: and even if this restriction did not exist, it is evident, that if telegraphs were introduced into British India, or into any other of our foreign possessions, a number of military phrases and sentences, and a great number of local words and phrases would require to be introduced, which are not to be found in Sir Home Popham's book: and at the same time it might be desirable to obviate the degree of ambiguity, before mentioned in that work. This would require every verb to be expressed in two forms instead of one, and some of the nouns, adjectives, and adverbs, now classed under the same head with a verb, or with each other, to be expressed separately. For example, the word *Rob*, and others connected with it, which are at present all denoted by the same signal, might be divided into three distinct signals, in the following manner.

1st. *Rob*, *robs*, *robbing*, *robbery*, *robberies*, and to follow the same rule in regard to other verbs, including the present tense, the infinitive, and active participle, under the same head, and also any noun of the same sound, or even of kindred meaning, provided, in the latter case, that it be an action, passion, or any thing inanimate.

2d. *Robbed*, including always the past tense of the verb, and the passive participle, under one head, whether they be the same in sound or not.

3d. *Robber*, *robbers*, and to follow the same rule in regard to personal nouns, keeping them always distinct from the verbs.

It appears also advisable, that the adjective and adverb, when different in sound, although of kindred meaning, should likewise be separated from the verb. Hence it would be proper to separate the various words classed under the head *agree*, in Sir Home Popham's Telegraphic Dictionary as follows.

1st. *Agree*, *agrees*, *agreeing*, *agreement*, *agreements*.

2d. *Agreed.*
3d. *Agreeable, agreeably.*

If a select dictionary on Sir Home Popham's principle, were thus dilated, it would, in all probability, increase the contents of the work from 13,000, to about 25,000 words and sentences, and if the military and local phrases before alluded to, were likewise added, it probably might swell the amount to near 30,000. Upon the whole, I conclude, that a judicious Telegraphic Dictionary, composed on the most comprehensive plan, so as to embrace every contingency of the public service, both at home and abroad, ought not to contain so many as 40,000 articles. This inference may be considered the result of experience, inasmuch as it has been drawn from a careful comparison of the most elaborate works of that nature, that I have been able to procure.

Supposing a dictionary of this description to be composed, I would adapt it to the key of the Universal Telegraph, in the following manner.

The dictionary should be divided into five parts or classes, each containing one-fifth part of the total number of articles inserted. Thus, for example, if 30,000 articles, and 1000 blanks for unforeseen purposes, appeared necessary, let each division of the book contain 6000 articles, and 200 blanks.

Of the 28 signs, which the Universal Telegraph is capable of exhibiting, I would reject one, namely, position 4 of the day signals, in which one arm points vertically upwards, in the direction of the post prolonged; because it has been urged, that unless when viewed by a very experienced eye, it is liable to be confounded with the post, so as to be mistaken for the position called "the stop," in which neither of the arms is shown.

Of the remaining 27 signs, *one* should be used as an *Alphabetical Preparative, one* as a *Numeral Preparative,* and *five* as *Dictionary Preparatives,* each of the latter referring to its own distinct part, or class of the dictionary.

Thus there would be 7 preparatives, and 20 signs for general purposes. Each preparative would of course denote, not only the beginning of that word or sentence which is immediately to follow it, but also the end of the preceding one.

In representing the letters of the alphabet by 20 signs, the letters I and J, the letters K and Q, the letters S and Z, and the letters U and V, would be coupled together; but the letter F would require to be denoted by the two successive letters P H, and the letter X, by the two successive letters, C S or K S.

The number of signals, which may be made by three successive changes on the Telegraph, using the 20 disposable signs only, is equal to 8000, being the third power of 20; but as the beginning of each signal must be denoted by a preparative, without which the signal is imperfect, if the above 8000 articles be combined with the five dictionary preparatives before mentioned, it will be evident, that by never using more than four changes on the Telegraph, for any article of the dictionary, no less than 40,000 words and sentences may thereby be exhibited; but, as I remarked before, this number is greater than appears to be absolutely necessary, in a judicious and well composed Telegraphic Dictionary."

For farther information on the subject of telegraphs, see Polybius, lib. x. cap. 40. Vegetius *De Re Militari.* Kircher's *Ars Magna Lucis et Umbræ.* Schottus *Technica Curiosa.* Marquis of Worcester's *Century of Inventions,* No. 6, 7. Hook's *Philosophical Experiments and Observations,* by Derham. Lond. 1726, or *Phil. Magazine,* vol. i. p. 312. Hook's *Phil. Trans.* 1684. P. L'Hoste *L'Art des armee Navales.* Lyons, 1697. R. L. Edgworth's *Irish Transactions,* vol. vi. p. 125, and *Bibliotheque Britannique,* 1796, vol. i. No. 2. *Journal des Inventions et decouvertes,* 1793, tom. ii. p. 12, 14, and Nicholson's *Journal* vol. ii. p. 319. M. Chappe in Hutton's *Dictionary,* art. Telegraph, and Fourcroy's *Report on the System of Telegraphic communication in France* will be found in the *Moniteur,* 1795, No. 109, p. 449, ed. 2. Breguet and Betancourt in the *Bulletin de la Societé Philomathique,* No. 16, p. 125. M. Macarthur *Naval Chronicle,* 1797. Rev. J. Gamble's *Observations and Telegraphic Experiments.* Colonel Pasley, *Phil. Magazine,* 1807, vol. xxix. p. 292, *Id.* 1810, vol. xxv. p. 339, and his *Description of the Universal Telegraph.* Lond. 1823. Boaz's *Nocturnal Telegraph* in the Repertory of Arts, 1st series, vol. xvi. p. 233, or *Phil. Mag.* vol. xii. p. 84. Edelcrantz *On Telegraphs* in Nicholson's *Journal,* vol. v. p. 193, and *Journal de Physique,* vol. lvi. p. 468. Telegraph by the Human Figure in the *Memoires sur les Aveugles,* and in Nicholson's *Journal,* vol. vi. p. 164. Much important information on telegraphs, with an account of Colonel Macdonald's own inventions will be found in his *Treatise on Telegraphic Communication,* 1808; his *Exposé of the present state of Telegraphic Communication,* Lond. 1819, and his *General Telegraphic System and Dict.*

TELESCOPE. See Achromatic Telescope, Vol. I. p. 96, and Optics, Vol XIV. p. 594—602, and p. 769—789.

TELFAIR, county of Georgia, bounded NE. by Montgomery county; ESE. and S. by Appling: SW. by Ocmulgee river, separating it from Irwin: W. by Dooley; and NW. by Pulaski. Length from S. to N. 38 miles, mean breadth 22, and area 836 square miles. Extending in lat. from 31° 39′ to 32° 12′ N. and in long. from 5° 46′ to 6° 20 W. from W. C. The southern part of this county slopes to the southeastward giving source to many of the higher branches of Santilla river, which rise very near the margin of Ockmulgee river. The latter considerable stream forming the southeastern border of the county, thence enters and traverses it in a northeastern direction, serving as a common recipient for the confluents which drain the northern section towards Pulaski.

By the post office list of 1831, Telfair contained three post offices: Jacksonville, the county seat, Ashley's Mills and Copeland.

Jacksonville is situated in the southern part of the county, by post road 111 miles a little W. of S. from Milledgeville, N. lat. 31° 55′, long. 6° 4′ W. from W. C. Darby.

TELL, William. See Switzerland, p. 628.

TELLURIUM. See Chemistry, Vol. V. p. 665—735.

TEMPERAMENT. See Music.

TEMPERATURE of the Earth. See Meteorology, Physical Geography, Polar Regions, and Thermometer.

TEMPERING. See Steel, p. 461.

TENBY, a market and borough town of Pembrokeshire in Wales, situated at the mouth of the Bristol Channel. It consists chiefly of two streets, containing neat houses, built with stone and slated. The church, which is 140 feet long, has a large square tower, which with its spire is about 150 feet high. The harbour is commodious; the exports are coal, culm, and fish, the imports groceries, &c. This place has lately become a fashionable bathing place; and a neat theatre, assembly room, billiard table, and bowling green, cold baths, and warm and vapour baths, have been provided for the convenience of the visitors. In 1821 Tenby contained 302 houses, 373 families, 628 males, 926 females! and 1554 inhabitants.

TENEDOS, a rocky island of the Grecian Archipelago belonging to the Turks, who call it Bogtcha-Adassi. The finest wine is produced here. It is said to lose its colour but not its strength after fourteen or sixteen years. Muscadel wines, not inferior to those of Samos, are made in considerable quantities; about 600,000 okes of wine, valued at 30,000 piasters, are annually exported to Constantinople, Smyrna, and Russia. The town is situated on the slope of a hill, and the harbour is enclosed by a mole, and surrounded by a mountainous ridge. Olivier says that there are as many Turks as Greeks at Tenedos; but others reckon the Turks at 600 families and the Greeks only at 300. See Olivier's *Voyage dans L'Empire Othoman*, vol. i. chap. 24. p. 260, and Sonnini's *Travels in Greece and Turkey*, p. 505.

TENERIFFE, the name of one of the Canary Islands, situated on the west coast of Africa. In a long article on the Canary Islands in Vol. V. p. 259—265 we have already treated most of the general topics which relate to this island, and it remains only to notice some particulars which may be expected under the present article.

Teneriffe is of a triangular form, each side being about thirty-six miles in length, and chiefly consists of the Great Peak sloping down into the sea. It contains about 1540 square miles or 985,600 acres. It is divided in the middle by a ridge of mountains which have been likened to the roof a church, the peak forming the spire in its centre. Five-sixths of the island has been computed to consist of rocks, woods, and inaccessible mountains. According to Humboldt, the height of the peak is 1909 toises, or about 12,090 feet. The size of the crater on the summit is only 300 feet by 200, and its depth does not exceed 100 feet. The island is almost wholly volcanic, resting on a submarine volcano. The range of basaltic rocks which surround the island do not rise to a greater height than 500 or 600 toises, and through the midst of this formation the rocks which constitute the principal mass of the volcano, have been protruded from below. According to Dr. Daubeny, the modern lavas may be divided into two classes; 1st, Those which compose the nucleus of the mountain, and are of a trachytic character, have been forced up through the older basalt; and, 2dly, The products of the volcanic action to which this central mass furnished a vent. The last class are various. Those which have a stony aspect are low in position, and seem to have come from the flanks of the volcano, while the vitreous ones occur only near the summit at heights exceeding 8900 feet. They seem to have come from the adjoining mountain Chahorra, which is to the peak what Monte Rossi is to Mount Ætna, having been produced by a lateral eruption.

Von Buch is of opinion, that the great chimney in the peak preserves the island from those destructive eruptions which convulse some of the neighbouring ones; but though it may act as a safety valve, yet, as Dr. Daubeny observes, it is a dangerous neighbour to the towns at its base. In 1704 and 1706 lateral eruptions took place, which destroyed the harbour of Garachico, the best frequented harbour in the island. In 1798 Chahorra ejected lavas and scoriæ for three months, and as some of the fragments took from twelve to fifteen seconds to descend, they must have risen to the height of 3000 feet. Smoke constantly issues from the summit of the peak, and though it is never known to emit flames, yet sulphurous acid vapours are constantly exhaled from it, from several apertures near the lowest part of the crater. The interior of the crater is covered with yellow and white clay, and fragments of decomposed lava, under which are found beautiful octohedral crystals of sulphur.

Teneriffe is remarkable for the excellence of its climate, varying from the heat of the equinoxial regions to the colder climates of Europe. The scenery of the island is remarkable for its beauty. The date tree, the plantain, the sugar cane, the Indian fig, and the olive tree are cultivated. Wheat is reaped from the end of March to the beginning of May, and the bread fruit tree, and the cinnamon, cocoa, and coffee plants have been successfully cultivated. Above this productive region rises the region of the laurels, then the chestnut plantations, then the vast forests of pines, then the vast plain, like a sea of sand adorned with the odoriferous *retama*, and lastly the Malpays, covered with loose fragments of lava. At the extremity of the Malpays is the plain of Rambleta, with the crevices which discharge watery and heated vapours. Population about 100,000. For farther information respecting this island, see Captain Cook's *Third Voyage*, vol. i. p. 22; and *Embassy to China*, vol. i. La Perouse's *Voyage*, vol. ii. p. 226; Mr. Grey Bennet in the *Geological Transactions*, vol. ii.; Humboldt's *Personal Narrative*; Daubeny's *Description of Active and Extinct Volcanos*, p. 251; but particularly Baron Leopold Von Buch's *Physicalische Beschreibung der Canarischen Juseln*, Berlin, 1825, 1 vol. 4to, and a folio volume of Charts and Plates. See also the article Canary Isles, and the works there referred to.

TENIERS, David, a celebrated painter, and the son of David Teniers, who was also distinguished in the same profession. He was born at Antwerp in 1610, and died at Brussels in 1694. See our article Painting, Vol. XV. p. 266.

TENNANT, Smithson, a celebrated English chemist, was born at Selby in Yorkshire, on the 30th November 1761, and was the son of the Reverend Calvert Tennant, vicar of Selby. After receiving the elements of his education at Scerton, Tadcaster, and Bromley, he went to Edinburgh in 1781 to study medicine, and attend the chemical lectures of Dr. Black. In October 1782 he went to Cambridge, where he devoted himself principally to chemistry and botany. In the summer of 1784 he made a journey to Denmark and Sweden, when he paid a visit to the celebrated Scheele, with whose simple apparatus he was peculiarly pleased. In 1785 he was elected F. R. S., and in 1788 he took his degree of Bachelor of Physic. His mind was then occupied with chemical pursuits, and in 1791 he communicated to the Royal Society his discovery of a method of obtaining carbon from the carbonic acid. Being fond of travelling, he went to the continent, quitted Paris on the 9th of August, visited Gibbon at Lausanne, and after visiting Rome and Florence, he returned through Germany to Paris, which he found enveloped in all the horrors of the revolution. M. Delametherie, to whom he paid a visit, had the integrity to preserve for him some valuable property, which he found it necessary to put under his charge.

In the year 1796 Mr. Tennant took his degree of M. D., and in the same year he submitted to the Royal Society his paper on the quantity of carbonic acid in the diamond.

About this time he took a passion for farming, and for that purpose he purchased some uninclosed land in Lincolnshire. In 1797 he bought a property on the Mendip hills, near Chidder, where he built a house, in which he resided during part of every summer. In 1802 he discovered that emery was the powder of corundum, and in 1804 he discovered the two new metals of iridium and osmium, for which he received from the Royal Society the Copley medal of that year.

In May 1813 Mr. Tennant was elected Professor of Chemistry in the university of Cambridge, and in the spring of the preceding year he delivered his first and last course of lectures.

In September 1814 Mr. Tennant paid his last visit to the continent. From Lyons, Nismes, Avignon, Marseilles, and Montpellier he returned in November to Paris, where he remained till February 1815. On the 15th of February he arrived at Calais, and on the 20th he set out with Baron Bulow to embark at Boulogne. They went on board a packet on the 22d, but were driven back by adverse winds, and intended to make a second attempt in the evening. In order to spend the day they took horses to pay a visit to Bonaparte's pillar, about three miles distant, and having on their return gone to look at a small fort, on which the drawbridge over a fosse, 20 feet deep, wanted a bolt, they had no sooner got upon it than it gave way, and both of them, with their horses, were precipitated into the ditch. Baron Bulow, though stunned, escaped without any serious injury, but Mr. Tennant was found lying under his horse apparently lifeless. His skull and one of his arms were dreadfully fractured, and though when brought to the hospital he seemed to recover his senses, yet he died within an hour. His remains were interred in the public cemetery at Boulogne.

The following is a List of his Principal Papers in the Philosophical Transactions.

1. On the Decompositon of fixed Air, 1791, p. 182.
2. On the Nature of the Diamond, 1797, p. 122.
3. On the Action of Nitre upon Gold and Platina, id. p. 217.
4. On the different sorts of Lime used in Agriculture, 1799, p. 305.
5. On the Composition of Emery, 1802, p. 398.
6. On two Metals found in the Black Powder remaining after the Solution of Platina, 1804, p. 411.
7. On an easy mode of producing Potassium, 1814, p. 578.
8. On the Means of producing a double Distillation by the same heat, id. p. 587.
9. In the Geological Transactions, vol. i. 1811, he published an Analysis of a Volcanic Substance containing the Boracic acid.

For a full and minute account of the life of this eminent chemist, and accomplished individual, see Mr. Whishaw's Biographical account of him in Dr. Thomson's *Annals of Philosophy*, vol. vi. pp. 1 and 80.

TENNESSEE, river of the United States, draining the much larger portion of the state of the same name, and also a part of Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi. Speaking generally, Tennessee river is composed of Powell's, Clinch, Holston, French Broad, Tennessee proper, Hiwassee, Duck, and innumerable minor streams.

Powell's river, the extreme northern confluent of the basin, rises between Powell's and Cumberland mountains in Russell county, Virginia, flowing thence southwestward over Lee county of Virginia, and Claiborne and Campbell counties, Tennessee; joins Clinch river at Grantsborough, after a comparative course of one hundred miles. Powell's river draws its sources on the western side of the valley, from Cumberland mountain opposite to those of Cumberland river.

Clinch river has its remote sources in Tazewell county, Virginia, interlocking sources with those of Powell's, Sandy, Blue Stone, and North Holston rivers, and flowing thence southwestwardly over Russell and Scott counties, Virginia, enters Tennessee, wherein, after separating Hawkins, Granger, and Anderson from Claiborne, it enters Campbell and receives Powell's river as noticed above. Below their junction, the united water continues southwestwardly over Anderson and Roane counties to their union with the Tennessee at Kingston. The entire comparative course of the Clinch is 190 miles: 150 above and 40 below the mouth of Powell's river.

Directly opposite Kingston, Clinch receives from the northwestward, Emery's river, a comparatively small but important stream from Morgan, White, and Bledsoe counties. Including the minor valley of the latter, the entire valley of Clinch a little exceeds two hundred miles in length; but with all its constituents the valley is very narrow, as it in no place exceeds thirty, and scarcely admits an allowance of twenty miles mean width: area 4000 square miles.

Holston river rises in Tazewell and Wythe counties, Virginia, by two branches called relatively North and South Holston. North Holston, the most remote northeastern source of Tennessee, rises between Walker's and Clinch mountains, and flowing thence southwestwardly over Washington and Scott counties, Virginia, turns abruptly southward into Tennessee, and joins the South Branch at Kingsport, between Hawkins and Sullivan counties. The South Fork of Holston, issuing from Wythe, traverses Washington county, Virginia, and Sullivan county, Tennessee, unites with the North Fork as stated. The South Holston is augmented in Sullivan by a considerable branch of the Watauga. The latter rises in Ashe county, North Carolina, by several branches which pierce the Bald or Iron mountain in a northwestern direction. These streams unite in Carter county, and join the South Holston in Sullivan.

Below the union of its two main branches, the now navigable Holston maintains a southwestern course over Hawkins, Granger, and Knox counties to its junction with French Broad river above Knoxville. Still continuing the original course, over the lower part of Knox and between Blount and Roane, receives Tennessee proper from the southeastward, and turning thence to the northwest joins Holston at Kingston.

French Broad is a stream of considerable magnitude, deriving its highest sources from the western spurs of Blue Ridge, near the border of Greenville district, South Carolina, and opposite to the sources of Saluda and Savannah rivers. Pursuing thence a northern course over Buncombe county, it inflects to northwestward, traverses the Bald mountain, enters Tennessee, where, after separating Greene from Cocke county, it receives its main northern branch the Nolachucky on the border of Jefferson county. The Nolachucky issues also from the Blue Ridge, opposite to the sources of Catawba river, and flowing thence northwestward, drains the northern part of Buncombe county, pierces the Bald or Iron mountain, enters Tennessee, and traversing Washington and Greene counties, falls into French Broad between Cocke and Jefferson counties. Below the union of the two confluent branches, the general course of French Broad is to the westward, but with a sweeping curve to the south to the mouth above Knoxville. The entire length of the French Broad by comparative courses is about 140 miles: 100 above, and 40 below the mouth of the Nolachucky.

The valley of French Broad, including that of Nolachucky, occupies a triangle of 90 miles base, with 70 miles perpendicular; traversed nearly centrically by N. Lat. 36° and Long. 6° W. from Washington City.

Tennessee proper, though a minor constituent even when compared with the French Broad, has by the course of original discovery given a generic name to the valley. The extreme source of Tennessee is in Rabun county, Georgia. Issuing thence, from the northern spurs of Blue Ridge, by the name of Estato creek, it enters North Carolina between Haywood and Macon counties, and gradually winding from a northern to a northwestern course, receiving tributary creeks from both counties, but particularly the Tuckaseege from Haywood, traverses the gap between the Unika and Iron mountains, enters Tennessee, and, separating Monroe from Blount, falls into Holston opposite the southern part of Roane county. The entire comparative length of Tennessee is about 85 miles; of which 5 are in Georgia, and 40 in each of the other two states.

Hiwassee is the lowest stream deserving the name of a river which enters Tennessee from the left. This confluent has its extreme sources in Rabun county, Georgia, but yet small creeks, they enter Macon county of North Carolina, where they unite, and assuming a course of northwest by west, traverse the Unika or Iron mountain, enter Tennessee, and separating the Amoi district of the Cherokee territory from M'Minn county, falls into the main volume of Tennessee river, about 50 miles comparative course below Kingston.

The distinctive name of Tennessee is applied to the volume below the junction of Holston and French Broad. Already a large stream, it is, however, greatly augmented at Kingston by the influx of the Clinch. The general course of Clinch is maintained below Kingston, and continuing southwestward, by comparative courses, 160 miles, receiving the Hiwassee from the left and the Sequatchee from the right, Tennessee abruptly turns to northwest by west, and piercing Cumberland mountain, merges into its lower valley, after a comparative course, following either the Clinch or Holston, of 350, or by the French Broad, 300 miles. Including all the minor valleys, Upper Tennessee drains an elongated ellipse of 350 miles larger axis, and with a shorter axis of 120 miles. The larger axis extends in a direction a little E. of N. from the great bend at the passage through Cumberland mountain to the sources of Holston; and the shorter axis stretching from the sources of French Broad in the Blue Ridge to those of the extreme northwestern branches of Powell's river in Cumberland mountain. The area of the whole elliptical valley is about 24,000 square miles.

It would be very satisfactory to have been able to give the relative height of the extremes of this interesting physical section, but this result can be only stated by approximation. Without estimating the mountain ridges, the mean arable surface of Tazewell county of Virginia, has been estimated at 1200 feet; we may therefore assume at least 1500 feet as the relative elevation of the fountains of

Tennessee. The surface of the water passing through Cumberland mountain is at the utmost not more than 750 feet elevated above the Gulf of Mexico; but with that allowance, Upper Tennessee valley will have, on a plain of 350 miles, 750 feet fall, or something above two feet per mile. The real descent is probably rather greater than shown by this estimate.

Descending from the extreme fountains in Virginia, the valley widens as the mountains recede from each other, and again contract as the same chains again reapproach gradually towards each other at the northwestern angle of Georgia, and the northeastern of Alabama. At the latter point below the influx of Sequatchee, well known under the name of Nickajack, all the large confluents have united, and the Blue Ridge and Cumberland mountains have inclined to within less than forty miles of each other. Below Nickajack, in a distance of 60 miles, the valley becomes more and more confined in width, and without receiving a single creek of twenty miles course, the large volume pours down its mountain channel, the two chains still approaching each other until their actual contact forces the stream through a gorge of Cumberland.

If we suppose a traveller arrived on the bank of Tennessee, immediately below its passage through Cumberland mountain, and who had no knowledge of the geography of the higher valley, he would be far from suspecting himself on a stream draining 24,000 square miles, and formed by such constituents as Clinch, Holston, and French Broad. If such an observer had previously and completely explored the lower valley, he would in the supposed situation regard the main Tennessee as a mere branch.

The importance of this physical section has been fully developed, and may be safely compared with any other of equal extent on the earth in richness, grandeur, and variety of scenery; in fertility of soil, and salubrity of air, and purity of water.

Politically, Upper Tennessee valley contains, in Virginia, part of Russell, Tazewell, and Wythe counties, and all Washington, Scott, and Lee counties: in North Carolina part of Ashe, and all Buncombe and Macon, with the far greater part of Haywood county: in Georgia, with a section of the Cherokee territory, about one half of Rabun county: in Tennessee, with a section of the Cherokee territory, all the counties of Hamilton, Marion, M'Minn, Monroe, Rhea, Bledsoe, Roane, Knox, Sevier, Cooke, Greene, Jefferson, Granger, Hawkins, Washington, Carter, Sullivan, and Claiborne counties, with part of Campbell and Anderson counties; and in Alabama, with a triangular section of the Cherokee territory on the left, and about one half of Jackson county on the right bank of Tennessee river.

Advancing from S. to N. Tennessee is the first and far most important of a series of rivers which have corresponding curves. It is difficult to make the force of this observation clear to the mind by verbal description, but a single view on a map of the United States, will exhibit Tennessee, Cumberland, Greene, Salt, Kentucky, and Licking rivers flowing in channels which sweep in semicircles round each other; and, in fact, that part of Ohio river above the influx of Great Miami conforms to this remarkable system.

The volume of Tennessee has gained its extreme southern curve where it passes Cumberland mountain, and a small creek which enters above the pass is at its source the most southern fountain of the valley. It is here, at the head of Black Warrior river, that the two mountain chains of Cumberland and Blue Ridge merge into each other; and along the northern sources of Mobile the Appalachian system changes its distinctive character, and the confused masses of hills follow each other westwardly towards the Mississippi river over the states of Alabama and Mississippi. Below the Cumberland pass, the deflection of the river exceeds that of the mountains. The former flows NW. by W. 150 miles by comparative course, traverses under the name of Muscle Shoals, a minor chain, and at the northwestern angle of Alabama, and the northeastern of the Mississippi state, re-enters Tennessee, and curves to a northern course; which latter direction it maintains across a little more than two degrees of latitude to its entrance into Ohio, after an entire comparative course of 680 miles.

In a comparative channel exceeding 300 miles, Lower Tennessee does not receive from the left a single confluent above the size of a large creek; but on the opposite side, it is augmented in descending, by Pigeon-Rock, Elk, and Duck rivers, with numerous creeks.

Elk river rises in Franklin county, state of Tennessee, and in the northwestern spurs of Cumberland mountain; and flowing thence something W. of SW. over Franklin, Lincoln, and Giles counties, Tennessee, enters Alabama, where after passing obliquely over Limestone county, falls into Tennessee river in the SE. angle of Lauderdale county, and below the head of the Muscle Shoals, after a comparative course of upwards of 100 miles. It may be remarked, that the extreme sources of Elk river are within little more than 20 miles from the main channel of Tennessee, at a place called "The Suck," 25 miles above Nickajack, and following the latter stream 140 miles above their junction.

Duck river heads in the same region with the sources of Elk, but the former assumes a course a little W. of NW. and very nearly parallel to the opposing courses of Tennessee and Cumberland rivers. Rising in Warren county, Duck river traverses Bedford, Maury, Hickman, the northeastern angle of Perry, and falls into Tennessee in the southern side of Humphries county, after a comparative course of 125 miles entirely in Tennessee.

Below the influx of Duck, the channel of Tennessee rapidly approaches that of Cumberland on the right, whilst on the left the sources of Obion river flowing into the Mississippi, rise within 12 or 15 miles from the bank of Tennessee, confining upwards of 80 miles of the lower part of the valley to a width in no place 45 miles, and not averaging above ten or twelve miles mean breadth.

Taken as a whole, Lower Tennessee valley approaches the form of a trapezium: the western side, from the sources of Bear Creek in Alabama to the influx of Tennessee into Ohio, two hundred miles; and an equal distance along the northeastern side from the Ohio to Cumberland mountains at the source of Elk river. The southeastern and southern sides are also very nearly equal, or one hundred miles each; the whole figure comprising very nearly 17,600 square miles; of which the far largest proportion spreads above the mouth of Duck river.

If we except a small extent below the entrance of Tennessee river into the state of Kentucky, no part of Lower Tennessee valley is a tame level, though much less broken than the higher valley above Cumberland mountains. The soil of Lower Tennessee is also generally superior to that of the upper part. Limestone abounds more below the mountain chains.

Politically, Lower Tennessee valley comprises in Alabama, south of Tennessee river, a small section of Cherokee territory, on the east; the counties of Morgan, Lawrence, and Franklin, with a section of Chickasaw territory on the west; and north of Tennessee river all the counties of Lauderdale, Limestone, and Madison, with the western and larger portion of Jackson: in the state of Tennessee this section embraces all the counties of Franklin, Lincoln, Bedford, Giles, Maury, Hickman, Lawrence, Wayne, Hardin, Perry, and Humphries, with part of Stewart, Henry, Carroll, Henderson, M'Nair, Williamson, and Dickson: in Kentucky, part of Calloway and M'Cracken west, and of Livingston, Caldwell and Trigg, east of Tennessee river.

The entire valley of Tennessee comprises an extent of 41,600 square miles. If the valley of Tennessee is compared with the whole valley of Ohio, the former spreads over very nearly a fifth part of the latter, and gives to Tennessee the first rank amongst the confluent streams of the general recipient.

Amongst the peculiar features of Tennessee, the most remarkable is, that rising as far north as Lat. 37° 10', and curving thence southwardly to Lat. 34° 23', the channel again recurves back to its original latitude, and falls into Ohio river almost exactly due W. from the primitive fountains in Tazewell county; thus embosoming nearly the whole large valley of Cumberland, and part of that of Green river.

Geographically, Tennessee valley lies between N. lat. 34° 10' and 37° 10, and in long. between 4° 15' and 11° 40' W. from W. C. It is the first and largest, advancing from south to north, of those streams which gush from the elevated vales of the Appalachian system, and which flow westward into the great basin of the Mississippi.

In relative height above the ocean, if the mountains are included, there is a difference of from 1700 to 2000 feet between the extremes of Tennessee valley. The arable surface of Tazewell and Wythe counties in Virginia we saw estimated at 1200 feet; that of high water at the confluence of Tennessee and Ohio but little, if any, exceeds 300 feet, giving a difference of 900 feet to the cultivated surface. This comparison may be regarded as a nearly just mean, and is fully equal to two degrees of latitude, and in part accounts for the great difference of climate on the same curve of latitude near the Ohio and on the sources of Clinch and Holston rivers.

The current of every branch of Tennessee is very rapid, shoals are common, but direct falls rare. Of shoals, the most remarkable are those which have become so well known under the name Muscle Shoals, between the counties of Lauderdale and Lawrence in Alabama. These shoals are, at all seasons, difficult to navigate, though from the infrequency of accident, must be far less dangerous than usually represented. With all its impediments from shoals and rapid descent of the general plain, Tennessee valley is navigated downwards from very near the sources of most of its streams.

TENNESSEE, one of the United States of America, bounded by North Carolina E.; Georgia SE.; Alabama S.; state of Mississippi SW.; river Mississippi separating it from Arkansas W. and state of Missouri NW.; state of Kentucky N., and Virginia N. E.

If we commence the outline of this state on the southern boundary of Virginia, it will thence have a boundary:

	Miles.
In common with North Carolina, along the main spine of the Appalachian mountains, to the northwestern angle of Macon county,	168
Due S. along the western boundary of Macon county to the northern boundary of Georgia,	20
Due W. along the northern boundary of Georgia, and N. Lat 35° to the northeastern angle of Alabama,	90
Continuing the last noted line along the northern boundary of Alabama, to Tennessee river, and to the northeastern angle of the state of Mississippi,	145
Still continuing due W. along the northern boundary of the state of Mississippi, to the left bank of the Mississippi river,	110
Thence up the latter stream by comparative courses, opposite the territory of Arkansas and the southeastern angle of the state of Missouri,	100
Continuing up the Mississippi river to the northwestern angle of Tennessee, and the southwestern of Kentucky,	70
Thence due E. along the southern boundary of Kentucky, to the Tennessee river,	80
Thence up Tennessee river,	12
Thence by a line a little S. of E. along the southern boundary of Kentucky to Cumberland mountains and to the southwest angle of Virginia,	268
Along the southern boundary of Virginia to place of beginning,	108
Having an entire outline of	1171

Extending in Lat. from 35° to 36° 37' N.; and in Long. from 4° 39' to 13° 14' W. from W. C.

The longest line that can be drawn in one direction on any state of the United States, is a diagonal over Tennessee from the northeastern to the southwestern angle. This line is by actual calculation within a trifling fraction of 500 miles, and declines from the meridians by an angle of 77 degrees. The mean length of this state is about 400 miles, and the mean width being 114 the area is 45,600 miles; equal to 29,184,000 statute acres. This area exceeds the extent usually given to Tennessee, but following the most recent, and we may suppose, most accurate delineation on Tanner's Map of the United States, the estimate here given is very near the real superficies of this state.

By reference to our notice of Tennessee river valley, it will be obvious how greatly the physiognomy of the state is modified by its rivers. Dividing Tennessee into physical sections, and taking the mountains as lines of demarcation, it presents two unequal parts; one the smallest above, and another, the second and largest, below the Cumberland mountain chain.

The higher, and in point of extent relatively, the inferior section, is entirely comprised in the upper valley of Tennessee, and is in length diagonally from southwest to northeast, 280 miles, with a mean breadth of 57 miles; area 15,960 square miles, or very near the one-third of the state. This comparatively elevated and diversified region is amongst the most delightful portions of the American continent. Under the head of Tennessee river we have already remarked, that higher Tennessee had a winter climate modified by its superior elevation over the Atlantic coast and banks of the Mississippi river, or similar latitudes On lower Tennessee, cotton is a staple production, whilst the climate of the upper section is more congenial to cereal gramina and the grasses. The declivity of upper Tennessee is to the southwestward, and by a very rapid general descent. The declination of lower Tennessee is more gentle, and to the west of northwest.

Lower or western Tennessee is subdivided by its rivers into two sections. That part comprised in the valley of Tennessee river has been already noticed under the head of that stream; but to the northward of Tennessee valley, the state embraces a large and very important tract in that of Cumberland river. The latter tract is about 250 miles in length along the line between the states of Tennessee and Kentucky, with a mean breadth of 40 miles, and contains 10,000 square miles. That part of the state comprised in Lower Tennessee valley is about 170 miles long, with a mean breadth of 70, embracing an area of 11,900 square miles.

Including both upper and middle Tennessee, or the sections contained in the valleys of Tennessee and Cumberland rivers, we have an aggregate area of 37,860 square miles, of which 21,900 are comprised in the middle region.

The general declivity of lower or middle Tennessee is westward towards Tennessee river, as that great stream flows here in a channel near the base of the central plain. But passing, not only the channel, but the entire valley of Tennessee, we find a slope falling westward towards the Mississippi river, and drained by Obion, Forked Deer, Big Hatche and Wolf rivers. These small rivers have corresponding curves, first flowing northwestwardly, thence west, and finally southwest into their great recipient the Mississippi. This western inclined plane may be considered, both physically and politically, as West Tennessee, and comprises 7,740 square miles.

In its natural state the whole surface now included in Tennessee, was covered with a dense forest. The great features along its very elongated declivity of five hundred miles, are varied and strongly contrasted. East Tennessee, mountainous or very hilly, with excellent river soil, presents a most seductive picture to the eye. Middle, or central Tennessee, less bold in its physiognomy, but with a much larger proportion of productive soil, is followed by the western section. The features of nature, from the Cumberland chain, imperceptibly softening, until finally sunk into the annually inundated banks of the Mississippi. The state has, on all its parts, a sufficiency of soil to admit a dense and not very unequally distributed population. Agreeable to the return of the recent census of 1830, middle and western Tennessee, containing a surface of 29,640 square miles, had an aggregate population of 488,448. In 1820, the same surface had only 287,501 inhabitants, having increased almost 70 per cent in ten years.

The mean density, however, in 1830, was still only about 16 to the square mile, on a soil and surface where ten times the number would be far from reaching the natural capacity of support.

For the political subdivisions, or counties of Tennessee, with their respective population in 1830, see Art. U. S., Section TENNESSEE.

History.—The territory now forming the state of Tennessee, was, with a small exception on the northern border, included in the second charter of North Carolina, granted to Clarendon and others by Charles II. in 1664, but no white settlement was made so far westward until 1754, when a few families fixed themselves on Cumberland river, but were soon after driven away by the savages. The first permanent settlement in Tennessee was made by the founding of Fort Loudon in 1757. According to Flint's Geography and History of the Western States, Fort Loudon stood on Little Tennessee, one mile above the mouth of Tellico. This place is now included in Blount county. On Pownall's map, founded on that of Evans, the latter published in 1755, it is noted, that the farthest settlements of Virginia westward, in 1755, were on the heads of Bluestone, branch of New river or Great Kanawha, and on the heads of Clinch and Holston. Tennessee was then one wide wilderness. As noticed under the Article Tennessee river, the course of original settlement was from North Carolina into the valley of Tennessee proper, above its junction with Holston. Fort Loudon was then the cradle of Tennessee. This fortress was attacked in 1760 by the Indians, taken, and upwards of two hundred men, women and children massacred.

In 1761, the important campaign under Col. Grant broke the power of the savages. A treaty was made, which encouraged emigrants, and about

1765, settlements began to be made on Holston which gradually increased. Though harassed by savage warfare, the hardy frontier men penetrated deeper and deeper into the forest, and at the opening of the revolutionary war, were sufficiently strong to meet their savage enemies. Col. John Sevier was the hero of Tennessee at that period. In June 1776, the inhabitants, aided by a few Virginians, defeated the Indians. Hostilities continued nevertheless, between the parties, through the revolutionary war.

When in 1776, the first republican constitution of North Carolina went into operation, deputies from the western counties, now in Tennessee, appeared in the first state assembly.

The early settlements were entirely above the chain of Cumberland, and a party of hunters in 1779, found the country on Cumberland river in the fine region where Nashville now stands, a wilderness. Merged in the great border of frontier from Canada to Florida, the inhabitants on Tennessee river, first gained political importance, Oct. 7th, 1780, by their share in defeating the British and tories at King's mountain. In 1782, courts of justice were established and in the ensuing year a land office; and finally Tennessee obtained individual existence in 1784, by a cession of its territory to the United States. This act was legally repealed, but the historical effect remained in force. The people unwilling to remain under North Carolina, formed an independent government under the name of the state of Frankland. Anarchy succeeded. North Carolina claimed jurisdiction, and was resisted by the constituted authorities of Frankland. Power prevailed in the struggle, and the state of Frankland disappeared. The contest was marked by many acts of violence which were not terminated until after 1790, when North Carolina definitively ceded the territory to the United States. By a law of Congress, passed May 1790, the country of Tennessee was made a territory by the name of "*The Territory South of the river Ohio.*" The first printing press was established at Hagersville, Nov. 1791, and on the 5th of that month, was issued the Knoxville Gazette, the first newspaper of Tennessee.

The country advanced in population, and on the first of June 1796, Tennessee was formally admitted into the Union, as a state of the confederacy. Since her introduction into the family of republics, the progress of Tennessee in power and wealth, has been constant and peaceable. The late war between the United States and Great Britain, exhibited the troops of Tennessee as the worthy representatives of the heroes at the slopes of King's Mountain.

Government.—The legislative power is vested in a general assembly composed of two branches, denominated the senate and house of representatives, elected biennially. No person is eligible to a seat in either house, unless he shall have resided three years in the state and one year in the county, immediately preceding the election, and shall possess in his own right in the county which he represents not less than 200 acres of land.

The executive power is vested in a governor, chosen by citizens qualified to vote for members of the general assembly. The governor must be at least thirty-five years of age and possess a freehold estate of 500 acres of land, and have been a citizen or inhabitant of the state four years next before his election, unless he shall have been absent on the public business of the state or of the United States. His term of office is two years and until his successor shall be elected and qualified, but he is not eligible more than six in any term of eight years.

The judicial power is vested "in such superior and inferior courts of law and equity as the legislature shall from time to time direct and establish."

The general assembly by joint ballot of both houses, appoint the judges of the several courts, also an attorney or attorneys for the state, who hold their respective offices during good behaviour.

Article 3d, section 1st, of the constitution, thus defines the right of suffrage, "every freeman of the age of twenty-one years and upwards, possessing a freehold in the county wherein he may vote and being an inhabitant of this state, and every freeman, being an inhabitant of any one county in the state, six months immediately preceding the day of election, shall be entitled to vote for members of the general assembly for the county in which he shall reside."

Education.—For the advancement of classical education, the principal seminaries in Tennessee, are the Nashville University, at Nashville; East Tennessee College, at Knoxville; Greenville College, at Greenville, Green county; and the Western Theological Seminary, at Marysville, the seat of justice of Blount county.

Manufactures.—The principal manufactures are iron, cotton, hemp, cordage, paper, gunpowder, and maple sugar. In East Tennessee, there are many iron manufactories. In 1810, the value of the manufactories was reckoned 3,708,000 dollars. In 1813, 700 workmen were employed in manufacturing saltpetre in Bigbone cove, to the amount of 500 lb. daily. In 1820, the manufacturing population was 7860.

Tennessee carries on a considerable trade to the other states. The chief exports are cotton and tobacco, hemp, flax, horses, live cattle, Indian corn, saltpetre, ginseng, and iron. The imports are chiefly dry goods and groceries, brought in wagons to East Tennessee from Philadelphia and Baltimore, and from Pittsburg and New Orleans by the rivers. The number of persons engaged in commerce in 1820, was 882.

Chief Towns.—The principal towns are Murfreesborough, Nashville, and Knoxville. Nashville, the seat of government, about thirty-two miles N.W. of Murfreesborough, is agreeably situated on Cumberland river, which is navigated to the town by steam boats and vessels of 130 and 140 tons. Knoxville, the capital of East Tennessee, is situated on Holston river. The State bank is established here, with a branch at Nashville. The capital is 400,000 dollars. There is also a branch of the United States bank recently established at Nashville, with a capital of 1,000,000 dollars.

TENSAW, river of Louisiana, has its extreme source in Grand Lake, and in the southeastern angle of Chicot county, Arkansas. Grand lake is evidently a remains of an ancient bend of the Mississippi, and Tensaw river is as evidently a former outlet of that great stream, and consequently has a similar origin with Atchabalaya, Iberville, Plaquemine, and La Fourche. Issuing therefore from Grand lake, the Tensaw immediately below its efflux enters Louisiana, in the parish of Ouachita, and flowing thence a little S. of SW. and nearly parallel to the general course of the Mississippi, by comparative courses about 110 miles to its junction with Ouachita to form Black river. The Tensaw is the drain of the inundated tract, west from the Mississippi river and in the parishes of Ouachita and Concordia.

TEQUENDAMA, Cataract in the river Bogata, about 8 or 10 English miles to the N. W. of the city of Bogata, department of Cundinamarca, Colombia, South America. This very remarkable series of falls forming one vast cataract, occurs in a mountain stream issuing from the Paramo del Chigasa, and falling into the Rio de la Magdalena. A plan of Tequendama and admeasurement of its descent in feet, was sent, in 1790, to the king of Spain, by the Col. Commandant Don Domingo Esquiaqui. The results reduced to English feet were

First Fall,	$32\frac{1}{2}$
Second Fall,	$253\frac{1}{2}$
Third Fall,	$581\frac{3}{4}$
Entire Fall,	$867\frac{3}{4}$

Compared with similar phenomena, in height, Tequendama is only exceeded by the Stanblach near Lauterbrun in the Canton of Berne in Switzerland, which falls 900 feet; or, in quantity of water by Niagara, falling direct 162 feet. But combining actual elevation with comparative body of water, the Tequendama has no equal amongst the cataracts known to exist on this planet.

It is not a very unfrequent error to consider Niagara as having the greatest direct fall of any known cataract. The entire fall from the surface of Erie to Ontario, is only 333 feet. Catskill fall in New York, has a descent of 300 feet, and those of Montmorenci, near Quebec, of 246 feet. DARBY.

TERENCE, PUBLIUS TERENTIUS, a Roman writer of Comedies, was born at Carthage in B. C. 197. He came to Rome as the slave of one Terentius, whose name he took. His first comedy, the Andrio, was exhibited B. C. 166. His Eunuch was acted twice on the same day, and brought him 8000 sesterces, or about L.64. Six of his comedies are extant. When he had presented them to the public, he left Rome for Greece, and never returned. Some affirm that he perished by shipwreck. Among the best editions of this author, are those of Bentley, Cantab. 4to. 1726, Zeunier, Lips. 8vo. 1774, and Brunckius, Basil, 4to. 1779. See our Article DRAMA, Vol. VII. p. 705.

TERNATE, one of the Molucca isles, is about 21 miles in circuit, having a lofty volcanic mountain in its centre, which sometimes emits smoke and flame. It suffered greatly from earthquakes in August 1770. East long. 127° 10′, N. lat. 8° 50′. See MOLUCCAS, Vol. XIII. p. 693.

TERRA DEL FUEGO. See FUEGO, Vol. IX. p. 492.

TERTULLIAN, QUINTUS SEPTIMIUS FLORENS, the most ancient of the Latin fathers, was born at Carthage about the middle of the second, and died a little before the middle of the third century. He is the author of many works, of which his *Apology for the Christians* is the principal one. Its object is to show the injustice of the persecutions to which they were exposed, and the excellence of the Christian religion. The best editions of his whole works are those of Rigaltius, Paris, Feb. 1641; and of Semler, Hal. Magd. 6 vols. 1770—76.

TETBURY, a market town of England in Gloucestershire. It is pleasantly situated on an eminence near the source of the Avon, and consists of four well built streets with a large market house at their place of divergence. The church is handsome, consisting of an ancient tower with a spire and a modern body, which cost L.5000. There is also here a free school, an alms house, and a manufacture of woollen cloths. Races are held near the town. To the north of the town there is a petrifying spring. The population of the parish in 1821, was 527 houses, 580 families, and 2734 inhabitants.

TETUAN, See MOROCCO, Vol. XIII. p. 682.

TEWKESBURY, a market and borough town of England in Gloucestershire, is situated in the vale of Evesham, on the east bank of the Avon. The town consists of three spacious streets composed chiefly of brick houses. The high street is long, spacious, and elegant. The houses which are good, are chiefly modern, though some specimens of the ancient style remain. The principal building is the abbey church, a fine specimen of early Norman architecture, which contains many rich monuments erected to its patrons, or to the nobility who fell at the battle of Tewkesbury. It is 300 feet long, and the tower is 152 feet high. The other religious buildings are meeting houses for Independents, Quakers, Baptists, and Methodists. The town hall is a handsome edifice, the ground floor being appropriated for the quarter sessions, and the principal story for a banqueting or ball-room. The new jail is a neat building, and there is an elegant school house on Dr. Bell's plan. The house of industry is spacious. There are also here a free grammar school, an endowed charity school, several almshouses, a dispensary, a lying-in-establishment, and schools on the plans of Bell and Lancaster. The principal manufacture here is that of stocking frame work knitting, chiefly in cotton. Nails are likewise made, and a considerable malting business is carried on. There are several commodious bridges near the town, and that over the Avon is of great length. The town sends two members to parliament, who are elected by about 500 votes. The population of the borough in 1821 was 1044 houses, 1172 families, 865 families in trade, 122 ditto in agriculture, total population, 4962. An account of the battle of Tewkesbury will be found in our article ENGLAND, Vol. VIII. p. 467. See the *Beauties of England and Wales*, Vol. V. p. 683, &c.

TEXAS.

TEXAS. Previously to the revolution which secured the independence of Mexico, Texas formed one of the internal provinces (Provincias Internas) of New-Spain, which, with the adjoining province of Coahuila, constituted an important part of the intendancy of San Luis Potosi. This sub-division of New-Spain, then so called, comprehended the provinces of New-Santander, San Luis Potosi, New-Leon, Coahuila, and a large portion of New-Mexico. Thus stood the territorial limits of this part of Mexico when the government of that republic was organized. In 1822, this vast territory was, by a special act of the Mexican congress, divided into three distinct states, whose governments, respectively, were modelled in strict conformity to the federal constitution, then recently adopted. The states thus erected, were severally denominated, New-Leon, San Luis Potosi, and the Interior of the East. The two former retained their provincial names and limits unchanged,—the other embraced the provinces of New-Santander, Coahuila, and Texas. The great extent of the latter state, and the consequent difficulty of administering its internal affairs, soon rendered fresh changes necessary, and in 1824, the province of New-Santander was detached from this unwieldy member of the confederacy, and formed into an independent state, under the title of "Tamaulipas." The remaining provinces were at the same time united and erected into the state of "Coahuila and Texas." By the law which fixed the limits of these states, a considerable portion of Coahuila was annexed to the territory of Santa Fe, or New-Mexico.

No important change in the civil divisions of these states has since been made.

Having thus briefly traced the boundaries of this part of Mexico, as they existed at different periods, we shall proceed to define the limits of Texas proper, as they are at present known and recognised, by the Mexican government on the one hand, and that of the United States on the other.

Texas, the easternmost province of the state of Coahuila and Texas, is situated between the 27° and 35° of north latitude, and 16° and 26° of west longitude from Washington city, or 93° and 103° west of Greenwich. Bounded on the north by the United States territory of Arkansas and district of Ozark, from which it is separated by Red river; east by the state of Louisiana; south by the Gulf of Mexico and state of Tamaulipas, and west by the state of Chihuahua, the province of Coahuila, and territory of Santa Fe, formerly New-Mexico. The general outline of Texas may be thus described—length on the gulf coast, from the mouth of the Sabine to that of the Nueces, the south west limit of the province, 260 miles—up the Nueces to its source, 350—along the ridge which separates the waters of Rio Bravo from those of the Brazos, Colorado, &c. to its termination on Red river, 430—down Red river to a point due north of the western boundary of Louisiana, 560—thence due south, and along with that boundary to the Sabine, where it is intersected by the 32° of north latitude, 60—and down the Sabine to the place of beginning, 220 miles, making an entire outline of 1620 miles. The area of Texas, within the above described limits, as deduced from careful computation by reticulated lines, is 179,200 square miles, and is equal in extent to the states of Louisiana, Mississippi, Alabama, and South Carolina.

If we regard Texas as extending to the Rio Bravo, as erroneously represented by some of the old maps, its entire area would be increased to about 330,000 square miles, and would present an aggregate superficies, equal to the states of Georgia, Tennessee, and North Carolina, in addition to those above enumerated. Such an extension, however, is not warranted by any act either of the government of Mexico or that of the mother country. It would embrace two-thirds of Coahuila, which forms a distinct province of the state; nearly one-half of Tamaulipas; about one-third of the state of Chihuahua, and a large portion of the territory of Santa Fe.

Gulf Coast, Bays, &c.—Commencing at the outlet of Sabine lake, the coast of Texas assumes a direction towards the southwest, which it follows to Galveston bay, a distance of fifty miles. Galveston bay is formed by Point Bolivar, Pelican and Galveston islands, and is the most extensive opening in this part of the Gulf of Mexico. It affords a good harbour and safe entrance, having always twelve, and sometimes fifteen feet water on the bars. This bay extends about 35 miles in a northwest direction from Galveston island, by which and Point Bolivar it is completely land-locked; its mean breadth is fifteen miles, and covers an area of 525 square miles. From the eastern point of Galveston island, the coast extends in the same direction towards the southwest, for 30 miles, to the west pass or entrance of Galveston island sound. From the west pass the same course is maintained for nearly 85 miles, without any material variation, to Passo Cavallo, or entrance of Matagorda bay. About 20 miles southwest of Galveston inlet, the great river Brazos enters the Gulf of Mexico, and at a further distance of 12 miles, that of St. Bernard discharges itself into the same gulf. Matagorda bay is nearly equal in dimensions to Galveston bay, but is of an irregular form. The observations respecting the latter apply with equal force to Matagorda bay.

From Passo Cavallo, the coast still continues its direction towards the southwest, to Aransaso inlet, a distance of 60 miles. Midway between Passo Cavallo and Aransaso inlet, the Bay of Espiritu Santo approaches within two miles of the gulf, with which it often communicates during the prevalence of high easterly winds. This bay, with Aransaso, and a small bayou, which connects the former with Matagorda bay, detach a considerable portion of the soil from the main land, and form the Island of Espiritu Santo. The bay of the same name lies nearly parallel with the coast, and is distinguished only as the recipient of the rivers San Antonio and Guadalupe, which unite ten miles above the bay.

Due west of Espiritu Santo bay, and northwest of the island, lies the Bay of Aransaso, extending westward 30 miles, and of the mean breadth of about five miles. At Aransaso inlet the coast turns, and pursues a course due south 25 miles, to Copano, the outlet of Nueces river, and termination on the southwest, of the coast of Texas. About 30 miles from its outlet, the Nueces expands into a spacious bay, which is joined by another from the north, of nearly equal extent, and similar in form; the latter is called Papelote bay, from a small stream of that name which enters its western margin. Texas has a front on the Gulf of Mexico, of two hundred and sixty miles in extent, which, like most other parts of the gulf, is almost entirely destitute of good harbours. Its bays, with some exceptions, are generally shallow, and their navigation much impeded by saudbars and shoals, which are suddenly formed and as suddenly disappear. The bars at the river mouths are equally variable, and seldom afford more than from four to twelve feet water.

Rivers and Lakes.—*Red River*, which forms the entire northern boundary of the province, as well as that between Mexico and the United States, agreeably to the treaty of 1819, rises in the plains at the eastern base of the mountains of Anahuac, and after intersecting the western boundary of Texas in north Lat. 35° and west Long. 25°, pursues a course nearly east, until it is joined by the Kiameche; at its junction with the Kiameche, the Red river curves towards the southeast, and passes into and through the southwest quarter of Arkansas territory, thence into the state of Louisiana, and joins the Mississippi, near the 31° of north Lat. Very little is known respecting the sources of Red river, beyond Cantonment Towson, and indeed the section occupied by that establishment, is represented by all published maps several minutes further south than recent observations for latitude have placed it. The Baron Humboldt, in his account of New Spain, describes the rivers Rajo and Mora, the former rising 25 miles northeast of Tous in New Mexico, and the latter about the same distance east of the town of Santa Fe, as the sources of Red river. The hypothesis of Major Long, that the rivers in question are the head branches of the Canadian fork of Arkansas river, is more plausible, and will no doubt be verified when the country through which those streams flow shall have been subjected to an actual survey. The length of Red river, from its intersection with the western boundary of Texas, to that of Arkansas territory, is 560 miles, and its general course eastsoutheast. It drains an area in Texas of 18,000 square miles.

Sabine river, which forms a part of the eastern boundary of the province, emerges from a dense forest, in N. Lat. 32° 45′, and W. Long. 18° 30′, pursues a southeast course one hundred miles to the point where it is joined by Cherokee creek from the right. At a distance of 30 miles from the mouth of Cherokee creek, the Sabine is intersected by the boundary line between Texas and Louisiana, in N. Lat. 32° and W. Long. 17°. From this point the Sabine curves towards the east, and forms a section of an ellipse, again cuts the meridian of 17° west from Washington, and after a further course of 220 miles, enters the Gulf of Mexico through Sabine lake, in north Lat. 29° 30′. Sabine lake, a mere expansion of the Sabine river, is not more than five or six feet in depth, about twenty miles in length from north to south, and of the mean breadth of four or five miles. Its channel is found with difficulty among the innumerable sand-bars that present themselves, and serve to embarrass and perplex the navigator. A few miles from the discharge of Sabine lake, it becomes contracted, and enters the Gulf of Mexico by a pass scarcely half a mile in width. "This river," says Darby, "affords no navigable facilities worthy of notice. In ordinary tides, it has not more than three feet water on its bar, nor has the lake above five feet, and near its shore still less." Entire length of Sabine river, from its source to the Gulf of Mexico, 350 miles. General course south-southeast. Area of that part of Texas which is drained by the Sabine and its branches, 18,750 square miles.

Neches river has its sources in the salt springs, about N. Lat. 32°, and W. Long. 18° 26′, pursues a southeast course for 140 miles, when it is joined by the Angelina, from the north. At the junction, the Neches assumes a south course, flows 80 miles, and enters Sabine lake in N. Lat. 30°. "The navigation of Neches river," says Colonel Austin, "is good as far up as the Opelousas road," 25 miles above its entrance into Sabine lake. It is 600 yards wide 30 miles from its mouth. Its entire length is 220 miles, and general course southeast.

Trinidad river has its source in the Cross Timbers, in N. Lat. 33° 45′, and W. Long. 21°, and flows in a southeast direction, 160 miles, to the junction with its eastern branch, thence southeast, 60 miles, to another considerable branch, coming in from the east. Continuing the latter course a further distance of 170 miles, it enters the northeast angle of Galveston bay. The entire length of the Trinidad is 390 miles. General course, south-southeast, and it drains an area of 15,500 square miles.

San Jacinto river rises in N. Lat. 30° 45′, and W. Long. 18° 50′, pursues a southeast course for 100 miles, and falls into Galveston bay about 20 miles southwest from the mouth of Trinidad river. The Buffalo bayou, the largest branch of the San Jacinto, flows towards the east, and enters that river about 23 miles above its mouth. It is about 90 or 100 yards wide; "and affords," says Colonel Austin, "good schooner navigation to the head of tide at the forks, eight miles above Harrisburg." Area drained by the San Jacinto and its branches, 3,450 square miles.

Brazos river, the Tanpisarahco or main branch of the Brazos, rises in the great prairies, near the western confines of the province, in N. Lat. 33°, and W. Long. 25° 30′, and flows eastward, 130 miles, into the Great Saline lake of the Comanches. Saline lake is an expansion of the Brazos, and is formed by the innumerable salt springs which abound in its vicinity. The lake is about 20 miles in length from west to east, and of a mean breadth of four miles ; it presents to the traveller a cheering contrast to the monotonous and dreary aspect of the surrounding prairies, whose lengthened and unbroken surface seems to defy the utmost power of vision. Two large streams, the Tosohunova and Keriachehunova, the former coming from the northwest, and the latter from the southwest, enter and serve to augment the volume of Saline lake. Contracting again, at the eastern extremity of the lake, the Brazos resumes its eastern course, which it pursues about thirty miles, to the junction of the Incoqua river, which enters the former from the north. At the mouth of the Incoqua, the Brazos curves towards the northeast, and is joined by the Taray, from the south-west, 45 miles below the Incoqua. Here the river assumes and maintains a general direction towards the southeast, until it falls into the Gulf of Mexico, in N. Lat. 28° 53′, and W. Long. 18° 22′. Many streams successively enter the Brazos, between its source and final discharge into the Gulf of Mexico.

The length of Brazos river is 700 miles. General course southeast. Area drained, 50,000 square miles. The Brazos averages 300 yards in width to Brazoria, and 200 yards from thence to the Waco village. It is navigable at all times to the head of tide, a short distance above Brazoria. In high stages of the water, which frequently occur, small steamboats may ascend the river as far as San Felipe de Austin, 118 miles, and keel boats may reach the Waco village, 268 miles from the Gulf of Mexico. There is a bar at the entrance of Brazos river, thirty yards wide, on which six feet water only can be calculated on with certainty, although it often affords eight and sometimes nine feet. The banks of the Brazos, as well as those of its northern branches, are highly picturesque; and in ascending the mountain region, where the streams precipitate themselves down the rocky cliffs of San Saha, the scenery becomes peculiarly romantic and imposing.

Little Brazos rises a few miles to the east of, and flows nearly parallel with, its recipient. It presents a remarkable feature in the hydrography of this part of the country; its distance from the Brazos does not exceed five miles at any place, sometimes approaching within one mile of that river, and then receding as if unwilling to unite its waters with those of its great rival. Pursuing, thus, its southeastern course of 45 miles, it ultimately enters the left side of the Brazos, 206 miles from its discharge into the Gulf of Mexico.

San Andres Branch, heads in a hilly and sterile region, in north lat. 32°, and west long. 21° 15′, pursues a southeastern course, 100 miles, to the junction with its principal branch, the San Gabriel. At the junction, the San Andres assumes and maintains a direction nearly due east, to its entrance into the Brazos, a distance of forty miles below the forks.

Red Fork of Brazos river rises about 10 miles south east of the Towiash village, situated on the Wishetaw branch of Red river, in north lat. 33° 30′, and west long. 22° 40′, flows nearly east ninety miles, then assuming a south course, and passing through one of those immense prairies which stretch themselves in every direction, a further distance of 100 miles, enters the left bank of the Brazos.

Incoqua, the largest branch of the Brazos, has its numerous sources in the great ridge which divides the waters of the Colorado, Brazos, &c. from those of the Rio Bravo del Norte, about north lat. 34°, and west lon. 25°. Its general course is southeast, and entire length about 200 miles. It intersects the left bank of the Brazos 45 miles above the Taray, and 520 from the mouth of the former.

Tosohunova Branch, heads near the source of the Tempisaraco, and running an eastern course 110 miles, falls into Saline lake on the north side, 555 miles from the Gulf of Mexico.

Keriachehunova, the only remaining branch of the Brazos deserving notice, rises in common with the two streams last mentioned, at the foot of the great ridge, and flowing eastnortheast about 100 miles, unites with Saline lake, a few miles above the Tosohunova.

Very little is yet known of these streams—indeed, the same remark will apply to the entire region in which they take their rise. The delineation of the head waters of the Incoqua, Tosohunova, Keriachehunova, and other water courses in this quarter, can scarcely be regarded in any other light than as a mere sketch of the fancy—the whole of the northwestern portion of the province constitutes, with little exception, a *Terra incognita*, that may stimulate the enterprising inquirer to future discovery.

St. Bernard river, about 130 miles in length, has its source in north latitude 30°, and west longitude 19° 30′, about 35 miles west of San Felipe De Austin. Flowing in a southeastern direction 45 miles, it approaches within three miles of the Brazos; then curving towards the south, again inclines to the eastward, and passes about two miles west of Brazoria. After leaving the vicinity of that village, the St. Bernard turns abruptly, and pursues a south course until it enters the Gulf of Mexico. The St. Bernard is 100 yards wide to the head of tide, about 40 miles from its mouth. Its general course is southeast, and it drains an area of nearly 1500 square miles.

Colorado river has its principal sources among the western mountains; one of these heads in a large spring, north latitude 30°, and west longitude 23° 40′, and pursues a general northeast course, about 180 miles, to its intersection with the north branch, called Pasigano river. From its junction with the Pasigano, in north latitude 31° 30′, and west longitude 22° 10′, the Colorado flows in a southeastern direction, with occasional variations, to its discharge into Matagorda bay, which it enters a little to the southwest of old fort Matagorda, the landing place of the unfortunate La Salle, who was murdered in 1687 by one of his own men, and his colony at Matagorda broken up by a Spanish military force sent from New Leon. The Colorado, although somewhat less in size than the Brazos, is navigable to the hills above the upper road. Its banks are generally low, except among the hills, where, like those of the Brazos, they partake largely of the sublime and romantic character which marks the sides of that stream, and present to the eye of the traveller every variety of picturesque scenery, common to mountainous countries. Entire length of the Colorado, 569 miles; general course, southeast; area drained, 40,400 square miles.

Llano river, about 90 miles in length, rises in the vicinity of the silver mines of San Saba, flows northeast, and joins the Colorado at the base of the Great Peak, 255 miles above Matagorda.

San Saba river, one of the principal branches of the Colorado, rises in the mountains of Piedra Pinta, in north latitude 30°, and west longitude 23°, pursuing a northeast course above 120 miles: it enters the Colorado on the right, 272 miles above its outlet.

Pasigano river is the most extensive branch of the Colorado, being nearly equal in length to the main stream above its intersection with the former. The Pasigano rises in the Great Prairie, near the western boundary of the province, and interlocks its head branches with those of the Brazos. Passing through the lands of the Comanche Indians, it joins the left side of the Colorado 80 miles above Pecan river, and 354 from Matagorda bay. Entire length 190 miles; general course, southeast.

Aguila river rises in the mountains which form the boundary between Texas and the state of Chihuahua, and flowing through a broken and hilly region, which renders its course exceedingly precipitous, enters the Colorado 444 miles from Matagorda bay.

Frio river is the western branch of the Colorado; that from the south, although of less extent, is regarded as the main source of this important river; it heads in a large spring, which issues from the mountains, and forms a stream of considerable magnitude. The distance from the mouth of the Aguila to that of Frio, is 80, and thence to the great spring, 45 miles.

La Baca river, although of limited extent, derives importance from the circumstance of its forming a great part of the western boundary of Austin's colony, and the eastern limit of De Witt's lands. It rises in north latitude 30°, west longitude 20° 20′, and pursues an almost undeviating southeast course, to its discharge into the north arm of Matagorda bay. Entire length 130 miles; general course, south-southeast; area drained, 3100 square miles.

Guadalupe river has its source in the hills of San Saba, and is here called "Rio Verde," which name it retains until it is intersected by a branch flowing in from the northwest, called "Piedras;" thence it passes nearly due east, 70 miles, to the outlet of the great spring, 8 or 10 miles west of the upper road, where, curving gradually towards the southeast, a farther course of several miles, it enters the Bay of Espiritu Santo, due south of, and about 16 miles from the mouth of La Baca. The Guadalupe is navigable for small boats to the lower road at Goliad, above which it is very precipitous in its course, affording mill-seats, and abundance of water for irrigation and other purposes. It drains an area of 13,500 square miles, and has an entire length of 287 miles; its general course is southeast.

San Antonio river is a branch of the Guadalupe, but little inferior in magnitude to that river, rises a few miles to the south of the Rio Verde, and pursues a rapid course towards the southeast, under the name of Medina river, to its confluence with the San Antonio proper, 20 miles southeast of the town of Bexar. Continuing its southeastern course, the San Antonio unites with the Guadalupe about 10 miles from its mouth. It is navigable for boats of small draft to the lower road, but above that point it becomes rapid, and its course much obstructed by falls and cascades, which, while they serve to enrich the landscape, render the stream entirely unfit for navigation. Entire length 275 miles; general course, eastsoutheast.

Aransaso river is a small stream, about 60 miles in length; it is formed by several branches, which rise north of the road leading from Laredo to Goliad, pursues an eastern course, and passing the missionary station of Refugio, enters Aransaso bay.

Nueces river, the boundary between the province of Texas and state of Tamaulipas, has its sources interlocking with those of the Colorado, the first fountain of that river being but a few miles north of the springs from which the Nueces issues, in north latitude 29° 45′, and west longitude 23° 30′. From its principal source in the mountains of San Saba, the Nueces flows nearly south-southeast 60 miles, and then gradually turns towards the southeast, which course it continues to flow until it enters the Gulf of Mexico, in north latitude 27° 30′. Its entire length is 300 miles, and it drains an area of 12,200 square miles.

Rio Frio, the principal branch of the Nueces, heads near the source of that river, and running a southeastern course, enters the left side of the Nueces, 110 miles from the Gulf. Ascending the Rio Frio, the following streams successively present themselves: Puenta de la Piedra 3, Saparita 8, and San Miguel 18 miles above the mouth of Rio Frio. It was near the source of the Saparita, and a few miles south of the town of Bexar, that general Toledo was defeated in 1813. In Texas, although its geological structure, so far as it is known, would naturally lead us to expect interior lakes; yet, with the exception of Saline lake, none of any magnitude have yet been discovered within the borders of the province. Between the Nueces and Rio Bravo, in the state of Tamaulipas, a succession of salt lakes have been discovered. These lakes, although not belonging strictly to the country immediately under review, deserve particular notice, as they have since their discovery yielded, and will, no doubt, long continue to afford an ample supply of salt, not only for the country in their vicinity, but also for the consumption of the southwestern quarter of Texas. The salt lakes of Tamaulipas are situated about 30 miles northeast from Mier, a town of Tamaulipas on the Bravo. "The salt in these lakes," says Col. Austin, "crystallizes at the bottom in strata from four to six inches in thickness." Large quantities of salt are annually taken from them without producing any serious diminution. There are three large and several small lakes, altogether covering an area of 100 square miles.

Face of the country.—Although the southwestern quarter of Texas presents a broken and irregular appearance, no elevations deserving the name of mountain, in its enlarged sense, exist within its limits. In the adjoining province of Coahuila, mountains of great elevation extend in ridges, nearly parallel with, and at a mean distance of 70 miles southwest from, the Rio Bravo. The great peak near Monterey, is called "curra de la Silla," (saddle mountain,) from its resemblance at the top to a Spanish saddle, when viewed from the Salinas road.

The same chain acquires increased elevation near Candela, and can be seen at a distance of 80 or 100 miles, enveloped in clouds, and its high peaks covered with snow during a great part of the year. The entire country, for many leagues southwest of Monclova, is exceedingly mountainous, and generally destitute of timber. The mountain ranges of Texas, in which the Colorado, Guadalupe, and Nueces have their sources, are of the third and fourth magnitude. Those extending along the right side of San Saba river, are probably the highest; their elevations, however, are matter of mere conjecture, as no scientific means have yet been employed to obtain accuracy in this particular. A considerable elevation will no doubt be found on a careful measurement, at the sources of the Nueces, Guadalupe, Colorado, &c.; for while the streams above draw their waters from springs quite remote from each other, we find those rivers, together with the Puerco and several other branches of the Rio Bravo, rising within a circle of less than 50 miles in diameter; thus indicating an elevation far above the surrounding table land. From this nucleus, chains of mountains, or rather high hills, extend in every direction. The one most deserving notice, is that chain which divides the waters of San Saba, from those of the Llano, and is unquestionably a prolongation of the Ozark mountains of Major Long. Before it intersects the Colorado, it attains to an immense height, and forms what is called the "Great Peak," a few miles to the south of the mouth of San Saba, and near the right bank of the former river. Thence it ranges towards the north, separates the waters of Pecan and San Andres rivers, and turning eastward, terminates in a peak on the right bank of the Brazos, nearly opposite to the outlet of Noland river. A spur from this chain extends towards the east, and forms the dividing ridge between the Medina and the upper branches of the Guadalupe.

The great spring of Guadalupe, issues from the eastern end of this chain, which also gives rise to the fountains in the vicinity of Bexar. Another spur leaves the principal chain near the sources of the Guadalupe and Llano rivers, and becoming gradually more depressed, in its course towards the east, is finally lost near the great spring of San Marcas. A succession of sand hills extend from the latter, commencing at the source of the Piedernales, a branch of the Colorado, and passing towards the northeast, subside before they reach the bank of the latter. The fountain of San Lucia is situated in this chain, near the source of the Piedernales. The next chain in point of elevation, leaves the one just mentioned, at the first fountain of the Colorado, pursues a northwest direction, and joins the Guadalupe mountain of Humboldt, about 300 miles from its point of outset. This chain forms the boundary between Texas and the territory of Santa Fe or New-Mexico, and state of Chihuahua, and divides the waters of Rio Bravo from those of the Brazos and Colorado. Its mean elevation must be considerable, and will no doubt be found, on a careful examination, to exceed in height the mountains of San Saba, which are generally regarded as the most elevated. The third chain in the order, extends towards the northeast, divides the waters of Piedra Pinta from the San Saba and Conchas rivers, and is pierced by the Colorado, below its junction with the Pasigon. Thence it continues its northeastern direction, between the Piaroya and Ontejunova, joins the chain first described, near the source of Pecan river, where a spur leaves it, and passing between the Pecan and Wisshonca, forms a high peak, and then rapidly subsiding, terminates near the Colorado.

The fourth and last chain worthy of notice, extends southeastward, and separates the waters of the Medina and Rio Frio, a large branch of the Nueces. Near the source of the Rio Frio, a broken ridge leaves the main chain, passes towards the southeast, and divides the upper waters of Rio Frio from the Nueces. At the foot of this chain, and over the plain which extends on both sides of the Nueces towards the Gulf of Mexico, are found those countless droves of wild horses, which give animation to a region otherwise desolate and dreary. Most of the rivers which have their sources in the northeastern part of the province, flow through open plains of grass, into the marshes which line the southeastern coast of Texas, in common with the southern portion of the adjoining state of Louisiana. The whole of the northeastern part of the province is undulating, with hills of moderate elevation. These, however, entirely subside on leaving the forests, and near the gulf coast nothing is to be seen but a monotonous level of prairie and sea marsh. Advancing westward, a rapid improvement in the soil and general aspect of the country is perceptible. The lands near the coast become more elevated and dry; marshes, which abound to such an unlimited extent in the southeastern quarter, almost wholly disappear on approaching the valley of the Brazos.

West of the Brazos, and southeast of the mountain region, if it can be so called, extends a vast plain, whose inclination, as indicated by the water courses, is very considerable. As this plain approaches the alluvial border, its inclination sensibly diminishes, and a comparatively level surface is presented along the whole extent of this formation. Although the country between the coast and the lower road is very level, it is nearly free from marsh, and west of Galveston bay it is entirely so.

Northwest of the mountain region, which, as has been stated, lies in the central and southwestern parts of the province, immense prairies, covered with grass, and affording inexhaustible pasturage for cattle and horses, occupy the entire space between the "Cross Timbers" and the northern and western confines of the province. The Cross Timbers, so called, constitute a singular feature in the northern part of the province; they consist of a dense growth of forest trees, some of them of a prodigious height, and extend in a strip about 300 miles in length, and not exceeding 20 miles in mean width, nearly due north from the Waco village, on the Brazos, to the Arkansas river. This forest, which may be justly ranked among the natural curiosities of the country, forms, by its peculiar appearance, a striking contrast to the dull and monotonous prairies on either side. The lines which mark its limits are so completely defined, as almost to induce a belief, that art had been employed in giving form to this extraordinary work of nature.

Climate, soil, and produce.—In the central and northern parts of Texas, the climate is highly salubrious, and may, when its geographical position and southern exposure are taken into view, be regarded as a comparatively cold region. The winters, in those parts, as in the corresponding portions of Coahuila, are generally cold, and sometimes severe. Near the coast, and especially in the southwestern quarter of the province, the climate is greatly affected by the long droughts which prevail, and, in connexion with its relative depression, serve to increase its mean temperature far beyond what the difference of latitude between its northern and southern sections would lead us to expect. Rains in this quarter rarely fall, but when they do occur, they fall in torrents. The excessive rains that sometimes deluge, and the protracted droughts which occasionally parch, the southwestern parts of Texas and the northern portions of Tamaulipas, are among the most remarkable phenomena of physical geography. From these, and more local causes, the climate of Texas generally presents less uniformity of temperature than most other countries in similar latitudes. A great portion of the country is entirely exempt from those stagnant swamps and pools which constitute a fruitful source of disease in most of the southern states, where the periodical pestilence, and almost infinite variety of febrile affections, common to the maritime sections of those states, may be ascribed to the malignant effluvia of extensive swamps and marshes, which abound to an extent so frightful. This exemption from such receptacles of disease, gives to the province a decided advantage over its eastern neighbour the state of Louisiana, whose southern border consists almost entirely of sea marsh, intersected by stagnant ponds of all dimensions, which serve no other purpose than to engender disease. The entire structure of this province appears to be essentially different from that of Louisiana. In the latter, especially within a hundred miles of the gulf coast, the lands decline from the banks of the rivers, and fall into swamps, which uniformly maintain a lower level than the river banks. On the contrary, in Texas, the lands gradually ascend on leaving the streams, and are backed by rolling prairies, which afford in many places plantations of considerable extent. Beyond the alluvial border, which extends about 60 miles from the gulf coast, the prairies commence, and reach to the timbered uplands. The alluvial lands, particularly the borders of the large streams, are thickly covered with the different varieties of oak, elm, cedar-wood, alder, dog-wood, walnut; and every other species of timber, common to such regions, is found in great abundance east of the San Antonio; but west of that river it becomes scarce, many extensive tracts being completely destitute of this important article. These lands are interspersed with extensive cane brakes, and are considered by planters as well adapted to the cultivation of sugar, cotton, indigo, &c., and for grazing to an unlimited extent. Wheat, corn, and the various kinds of provisions, can be successfully cultivated throughout the whole of the northern parts of the province. The luxuriant growth of the cane in the southern part, justifies the belief that sugar will become one of its most important productions. Already has this valuable commodity been produced as an experiment in the vicinity of San Felipe de Austin, with the most flattering prospects of success.

Population and settlements.—The entire population of Texas, including the Indians, does not exceed 12,000 souls; and a considerable portion of this number is included within the limits of Austin's colony. The remaining part of the civilized population is confined chiefly to the towns of Bexar, Goliad, Nacogdoches, &c. In 1821, when the enterprising Austin commenced the settlement of the lands acquired by him, Texas was with few exceptions an entire wilderness, from the Sabine to the San Antonio. Its white inhabitants were few in number, and consisted of Spaniards and their descendants, together with some emigrants from the United States. The whole country was filled with hostile Indians, who, having no fixed residence, roamed unrestrained over the plains, committing with perfect impunity all kinds of excesses. Nacogdoches had been destroyed and abandoned; it has since however recovered, and the town and surrounding country are now in a flourishing condition.

Austin's colony was founded in 1820, by Moses Austin, the father of the present proprietor, under a grant obtained from the commandant-general of the eastern internal provinces. By the terms of this agreement, Mr. Austin was required to establish, within a specified time, 300 American families in the newly acquired territory; but, although many families from the United States had previously fixed themselves in Texas, the actual settlement of the colony was not begun until the year 1823, when Col. S. F. Austin, in consequence of the decease of his father, assumed the fulfilment of Mr. Austin's contract; and, under the sanction of the political authorities of Mexico, commenced the location of the emigrants. Such is, briefly, the history of this interesting community.

This colony, including the grant to Col. Austin, of 1827, embraces an area of 19,000 square miles; it is situated between the 28° and 31° of north latitude, and 18° and 21° of west longitude from Washington city, and is watered by the San Jacinto, Brazos, Colorado, La Baca, and some other streams of minor importance. San Felipe de Austin, the principal town, is built on the right bank of the Brazos, about 118 miles from its discharge into the Gulf of Mexico. The great road leading from New Orleans to Rio Grande, Monclova, &c. passes through, and divides the town into two nearly equal parts. The town and surrounding settlements, which are rapidly increasing in numbers, present a scene of active industry rarely met with in other parts of the province. Several good elementary schools have been established in the colony, and in those of San Felipe some of the higher branches of an English education are taught.

Brazoria, also a thriving town, is situated on the west bank of the Brazos, 24 miles above its mouth.

The town of Harrisburg, on the Buffalo bayou, a branch of the San Jacinto, promises to become a place of some consequence, and will no doubt figure in the future history of the province. Both Brazoria and Harrisburg are accessible from the Gulf of Mexico, by vessels of considerable burthen.

The colony has now a population of about 4000, consisting almost exclusively of Americans;—one steam saw-mill, and a considerable number of cotton gins. Its produce is sugar, cotton, wheat, rye, Indian corn, &c., with an abundance of timber of various kinds. The produce of the last season consisted of 1000 bales of cotton, 150,000 bushels of corn, and 140 hogsheads of sugar. The cotton raised in the colony is mostly shipped to New Orleans for a market, and the surplus corn and other produce are sent to Matamores, Tampico, and Vera Cruz. The greater part of the inhabitants are agriculturalists. Grazing receives a due share of attention, as it affords a handsome profit with very little labour, and no other expense than is attended by occasional herding. The local government of the colony is administered by officers elected by the settlers; these officers consist of an alcalde, who has civil and judicial jurisdiction, two regidores (aldermen), and one syndic, forming a municipal body, styled ayuntamiento, of which the alcalde is president. The alcalde and one of the aldermen are elected annually, and cannot be re-elected until two years after their retirement from office.

De Witt's colony lies immediately west of, and adjoining, that of Colonel Austin, the La Baca being the line of separation between those two colonies. It embraces an area of 3500 square miles, and is watered by the Guadalupe, which, with some of its numerous branches, serve to irrigate its soil. No settlements of importance have yet been made in this colony.

Ectar's Grant, so called. Much has been said in the public prints respecting a grant alleged to have been made by the Mexican government, comprising an area of nearly 63,000 square miles (40,000,000 acres). Where this immense tract is, or where it can be located, it is difficult to conceive, unless all the previous grants, which are numerous, shall be abrogated: should such a grant have been made in addition to those already located, there will remain but a small portion of Texas for future purchasers. Although it is well known that the Mexican government pursues a liberal policy towards actual settlers, in granting them lands on the most favourable terms, it can scarcely be credited, that a cession nearly co-extensive with the unappropriated parts of the province should have been sanctioned by that government, by which no title has recently been given, except to the class of purchasers just mentioned. Land can be obtained by emigrants with great facility from the empresario, (founder of the colony,) and from the commissioners of the government, under the colonization law, which authorizes the grant to families, who are actual settlers, of one Mexican league, equal to 4446 acres. Unmarried men can obtain the fourth part of that quantity, the expenses of which will not amount to four cents the acre.

Nacogdoches, Bexar, Victoria, and Goliad, formerly called Bahia, are the only towns remaining to be noticed. Nacogdoches is situated on the head waters of Neches river, in the eastern part of the province, and about 160 miles, in a direct line, from the gulf coast. It is on the great road leading from New Orleans and Natchitoches, in Louisiana, to the city of Leona Vicario, the capital of the state of Coahuila and Texas, and is 728 miles northeast from that city. Fort Nacogdoches, the germe whence the town of that name sprung, was erected shortly after the first settlement of the country, and was for a long period the only settlement in this part of Texas. The town itself never attained to any importance in point of population, and its commerce was chiefly confined to the supply of the garrison, and a small trade with the surrounding Indian tribes. Since its destruction in 1821, the town has been rebuilt, and the number of its inhabitants considerably augmented by emigrants from the United States.

Bexar, or San Antonio de Bejar, the former capital of the province, is situated on the western prong of Salado creek, an inconsiderable branch of the San Antonio river, 393 miles southwest from Nacogdoches, 153 west from San Felipe de Austin, and 335 miles north-northeast from Leona Vicario.

Goliad is situated on the right bank of San Antonio river, about 40 miles above its entrance into Espiritu Santo bay, and 115 southwest from San Felipe de Austin. Goliad, like Bexar, is a place of but little importance, although built more than half a century. Neither Bexar nor Goliad can be regarded in any other light than as mere villages. The latter possesses some advantages over the other from its proximity to the gulf, the San Antonio being navigable for vessels of small draft as far up as Goliad.

Victoria, on the left bank of Guadalupe, is a village of the smallest class, but is said to be improving.

The "Upper road," or that leading from New Orleans by Natchitoches, &c. to the city of Mexico, intersects the Sabine about 45 miles west from Natchitoches. After crossing the Sabine, it pursues a little south of west, until it reaches Nacogdoches; thence turning towards the southwest, it proceeds to Bexar, where it assumes a more southern direction, and intersects the Nueces about 150 miles from the Gulf of Mexico. In its course from Nacogdoches to the Nueces, this road successively crosses the Trinidad, Brazos, Colorado, Guadalupe, and San Antonio rivers. It is 98 miles from Natchitoches to Nacogdoches, thence to the Trinidad 78, thence to the Brazos 59, to the Colorado 60, Guadalupe 58, town of Bexar 40, Nueces 105, and thence to Leona Vicario 230 miles.

The Lower road, so called, leads from New Orleans, via Opelousas, to the town of Goliad. It crosses the Sabine 30 miles above its discharge into Sabine lake, and follows a south-west course, at a mean distance from the gulf coast of fifty miles, passes through San Felipe de Austin, and intersects the Nueces 469 miles from Opelousas.

Other roads have been opened. Among these are the following: from San Felipe de Austin to Brazoria 70, and thence to the mouth of the Brazos 25 miles, to the Old Fort on the Brazos 38 miles, to Harrisburg 45 miles, to Victoria 110, and thence to Goliad 22 miles,—to Matagorda 95 miles. Many improvements of this kind have been made, and some others are contemplated.

From the geographical position, and the character of its soil and climate, Texas will probably become the great vineyard of America. Every variety of grape, of the most delicious flavour, is found growing spontaneously throughout the entire province. On the table lands between the Cross Timbers and the sources of the Sabine, immense tracts of country are literally covered with the various species of grape, which attain to an uncommon size. The orange and other fruits, such as the fig and the different kinds of the raisin grape, will also find a genial soil in the southwestern parts of the province, where the climate and general nature of the atmosphere are admirably adapted to the exiccation of those fruits, especially that of the common fig. The latter is produced in great abundance in most of the southern states and Florida, but owing to the humidity of the atmosphere of those states, it rarely becomes sufficiently dry, for want of that peculiar warmth which is necessary to its preservation for commercial purposes; hence this valuable fruit, which constitutes an important article of commerce of Turkey, Italy, and some other countries, is cultivated in America merely for table use. The causes which have operated in the southern states to prevent the successful preparation of the raisin, do not exist to the same extent in Texas; we may, therefore, expect to find, some years hence, this useful article also among its most lucrative staples. See *American Quarterly Review*, vol. vii. 1830.

H. S. Tanner.

THALES, the founder of the Ionic school, was born at Miletos about 600 years before Christ. In quest of wisdom he travelled to Crete and to Egypt, and he is said to have acquired his mathematical and philosophical knowledge from the priests at Memphis. An account of his labours have already been given in our article Astronomy, Vol. II. p. 551.

THAMES. See England, Vol. VIII. p. 512.

THANET, Isle of. See Kent.

THEBES. A very full account, with descriptions and drawings of the remarkable antiquities of this city, have already been given in our article Civil Architecture, Vol. VI. p. 371 and p. 524, &c. See also Egypt, Vol. VIII. p. 222, &c.

THEMISTOCLES. See Athens, Vol. III. p. 19—22, &c. Greece, Vol. X. p. 66.

THEODOLITE is the name of an instrument for measuring horizontal and vertical angles in land-surveying. We have entered so fully into the details of the construction and adjustment of circular instruments under the article Circle, that it is unnecessary to give any account of the Theodolite, which differs from them only in name and application. See Circle, Vol. VI. p. 332. A description of Ramsden's Great Theodolite used in the trigonometrical survey, will be found in the *Philosophical Transactions*, vol. lxxx. 1790, with all the parts of it described in four large plates.

THEOLOGY.

THEOLOGY is the science which treats of the nature and character of God, and of the religious duties and hopes of man.

All mankind are interested in knowing something of the God whom they profess to worship. From the power which they ascribe to him, they must necessarily conclude that their fate is in his hands, and that their happiness or misery depend on his pleasure. It cannot, then, but be deeply interesting to inquire into the character of the supreme Ruler, that we may know how to secure his favour, and how to avoid such actions as may be displeasing to him. These considerations have always operated, and induced an anxious desire to become acquainted with the nature of God, as lying at the foundation of the duties and hopes of men.

In rude states, theology, in the form of superstition, is the only species of study which engages the attention. The priests, augurs, and divines, are thought to be the only persons possessed of useful knowledge; and they have, in general, great influence in the state, either by swaying the public counsels, or by lending the sanction of religion to the measures adopted. Of all the nations of antiquity, the Romans had the highest character as a religious people; and they were well entitled to their pre-eminence, in so far as regards the formalities of worship. As they arrived at vast power, without going through a previous process of refinement, their history exhibits the curious phenomenon of a most splendid system of external worship, connected with the most absurd and irrational creed.

The Greeks thought more deeply on the subject, though not to much better purpose. Many of their sages were substantially, if not professedly, atheists; for they denied the providence of God, and questioned the wisdom of his arrangements in the system of nature: others of them were pantheists, believing the universe to be God, and conceiving that all things were ultimately absorbed into his essence; an opinion which differs not widely from atheism, in its practical consequences; and the greater part of even the most orthodox among them, were fatalists, conceiving that the gods were only instruments in the hands of Fate, and that Jupiter himself had only the power of ascertaining, not of altering its determinations.

Almost the whole literature of Hindostan is theological. The national poetry turns on the incarnations and exploits of the gods; and the order of the priesthood enjoys a pre-eminence superior to royalty itself, having managed to retain the chief honour and consideration in the state, whilst it has transferred to another class all the trouble and odium of government.

These facts show the importance which has always been attached to the study of theology; and considering how intimately the subject is connected with the best interests and hopes of men, we cannot but perceive that the importance of the study has not been overrated. In fact, society cannot exist without some religious influence. The principles of rectitude have never been found, nor indeed have they ever been supposed to be sufficiently strong to resist temptation, when separated from considerations of religion; and imperfect as its influence is, the security of society arises more from the influence of religious belief, and the conscientious scruples which it produces, than from prohibitory statutes and penal enactments.

A subject of such deep and universal interest, must naturally have engaged the highest faculties of the human mind: but it is melancholy to observe to how little purpose they have been exerted. They who have left the most indubitable monuments of genius, and specimens of taste and eloquence which must serve as models; so long as elegant literature has any value in the world, have betrayed the most incredible ignorance on the subject of religion; and the value of revelation is manifest in this, that a school boy in a Christian country, and educated in Christian principles, has more accurate and more philosophical information respecting the nature and government of God, than is to be found in all the writings of the wise men of Greece and Rome put together.

The necessity of a divine revelation was virtually acknowledged by the heathens themselves. They considered the nature and will of the gods, as things necessary to be known, but as too vast for the human intellect to discover. Hence all their legislators who established their civil and religious polities, were regarded as *Theodidacti*, or taught of God. They would have reckoned it impiety to suppose that the knowledge of God could be acquired by the natural resources of human reason; and had they been sufficiently sensible of their ignorance and their misery, they might have concluded that a more perfect revelation than they had yet received, would, in due time, be communicated. For, if man is placed in the world for the purpose of happiness, as they very generally supposed, it was reasonable for them to expect that a specific rule would be given to conduct them to the end proposed, and that they should not be left entirely at the mercy of the varying and contradictory opinions of men. On a view of the whole case, indeed, it appears not so wonderful, that a general revelation should have been given, as that it should have been so long withheld.

Very satisfactory reasons, however, may be assigned why the gospel was so long withheld; at least, we can discover many important advantages to the cause of truth, resulting from this circumstance. There could have been no fulfilment of prophecy, had Christ been completely manifested immediately on the fall of our first parents; and Christianity would thus have been deprived of one of the strongest evidences of its divine origin and authority. Our Saviour and his disciples always laid particular stress on this species of proof, and dwelt on the completion of the prophecies, in the person of Jesus of Nazareth, as furnishing the most satisfactory evidence, that he was the Messiah whom the Jews expected. *We have found him*, says one of the first disciples, *of whom Moses in the law and the prophets did write, Jesus of Nazareth, the son of Joseph.* By the length of time, which elapsed between the fall of man, and the manifestation of the Son of God; and by a great variety of intervening prophecies and remarkable events, we are enabled to view the gospel, not as a detached and anomalous dispensation, but as connected with all the measures of the divine government since the beginning of the world. There were obstacles enough to the reception of the gospel, in the passions and prejudices of the human heart; these obstacles would have been increased in a tenfold degree, had the world been taken by surprise, without any previous intimation of the stupendous plan which was afterwards revealed. It would have been a strong objection to it, had men been able to say, "We never heard any thing of this before," and had its advocates not been able to show from prophecies, and a long train of preceding events, that the world had been prepared for the complete development of it in the person of Jesus of Nazareth.

Another advantage was gained by the length of time which intervened between the fall and the recovery of mankind. They had an opportunity of estimating the character and resources of human nature. Had the important information, afterwards communicated by the gospel, been imparted immediately after the fall, had it been diffused among the first race of men, and by them transmitted to their descendants, we should not have been able at this day to decide, whether we had derived it from a divine revelation, or from our own resources. But the ignorance, misery, and sin which overspread the world during the reign of heathen darkness, contrasted with the light, the purity, and the consolations of the gospel, show us how much we owe to the mercy and goodness of God, and give us the most humiliating view of our natural helplessness and sin. But though, for wise reasons, a general revelation was long withheld, a partial revelation was no less wisely given to a particular people, that the will and the gracious intentions of the Almighty might stand recorded; and that mankind might see that he had never forgotten their interests, but was steadily carrying forward the plans of his mercy, even when the world was lost in trespasses and sins.

Religion is usually divided into natural and revealed; but it is easier to make the division, than to fix the boundaries of each. The distinction, indeed, does not appear to be at all necessary; for it is obvious that the religion of nature, as it has been called, has no doctrines peculiar to itself, and none that it can challenge as its own undisputed property. The existence of a God and a future state, providence, prayer, and public worship, are supposed to belong to the province of natural religion, because they can be established by reason, and because they have found a place where no revelation was known to exist. But all these articles of faith and of practice lie at the very foundation of revealed religion; whose object is to explain them in all their bearings and tendencies on the characters and hopes of men; whilst, in the course of this process, it brings to light many important facts and doctrines, which had eluded all the scrutinies of human reason.

Revealed religion, then, embraces all that is claimed for natural religion, and a great deal more; and, whilst we are at no loss to point out doctrines peculiar to revelation, we cannot point out a single doctrine which we can pronounce to be peculiar to natural religion. We cannot be sure that even any part of the religious knowledge contained in the popular creed, or in the philosophical speculations of the heathen, is the produce of unassisted reason. It is not enough to say that they had no revelation, and therefore their religious knowledge must have arisen out of their own resources. In the early ages of the world direct revelation was imparted to few; but *traditional* information prevailed among all; in consequence of which, much knowledge, originally derived from revelation, might be diffused among mankind. This, at least, we may be certain of, that man, on his first creation, possessed the knowledge of God, either by revelation or intuition: it was not acquired by the usual processes of discipline and experience. Adam, on his creation, must have been endowed with knowledge, otherwise he would never have lived to acquire it, but would have fallen the victim of his own ignorance, before he obtained the knowledge useful to direct him. His children, however, were placed in very different circumstances; reared from an infancy of helplessness and ignorance, they gradually rose to the knowledge of God, in consequence of parental instruction. The information which they had thus received they transmitted to their descendants, who carried it with them into their various settlements, and thus diffused the knowledge of God over the face of the earth. The corruptions which speedily took place in religion, and the varieties of worship which prevailed among nations widely different from each other in situation and circumstances, are exactly such as might have been expected; whilst, at the same time, we may expect among all the varieties of religious forms and opinions, some features of resemblance to connect them all with primeval tradition.

We do not, however, affirm that the mind, enlightened by general knowledge, would not arrive, even without the aid of revelation or tradition, at some idea of a first cause, or presiding principle. It seems next to impossible for a mind which has formed a notion of power and causation, (and these surely are among the first and strongest impressions which the mind receives, and are perfectly plain to all but those who attempt to account for them,) not to conceive of a power superior to that of man, as necessary for the production and arrangement of the visible phenomena of nature. The mind, indeed, is marvellously backward to form right conceptions on this subject; for though the invisible things of God are clearly seen, being understood by the things that are made, yet men *changed the glory of the incorruptible God into an image made like to corruptible man, and to birds and to four-footed beasts and creeping things.* Rom. i. 20. But the question is not whether men could acquire *right* conceptions of God, but whether they could acquire, by unaided reason, any conception of him at all: and we cannot but think that a mind, though ever so little improved in general knowledge, must entertain some idea of a first cause, on contemplating the visible universe.

It is natural for a child when he looks on the visible heavens to ask, who made these things? He never supposes that they exist there without a cause: the first impression of unsophisticated nature is, that they have been produced; and the next step in the process of reasoning is, that they have been produced by some being possessed of power infinitely superior to that of man. Such, we think, would be the first impressions of the mind of man with regard to visible phenomena. But we are not sure but, if he carried his reasoning the length of philosophizing, he might reason himself out of these obvious impressions, and ascribe the whole to fate or chance; or might suppose that they have existed, and will continue for ever to exist, as we now see them. We apprehend, then, that all the religious knowledge which the unenlightened mind could receive would never rise above superstition; and they who affected a more liberal creed, or attempted to establish a more liberal system, found no other way of emancipating themselves from what they saw to be prejudicial, than by setting aside the idea of an intelligent first cause, and thus abolishing all religious obligation.

Although, then, we do not deny that the natural reason of man affords some light, yet it is evidently insufficient either for direction or consolation. It presents objects through an obscure medium, which so completely distorts and alters their real proportions, that, in many instances, it is little better than absolute darkness. Besides, whatever we may advance or admit as to the capacity of human reason for religious discoveries, rests entirely on theory and assumption; for in no one instance can we affirm, that it has made a single discovery of this nature. All the religious systems in the heathen world were evidently traditional: they are all connected with each other by some striking features of superstition, which are inventions and not discoveries, the figments of human fancy, and not the offspring of reason; and whenever the heathens make any approach towards a rational creed, it will probably be nearer the truth to ascribe their knowledge to some borrowed light derived from tradition or revelation, than to regard it as the result of their own investigation. Believing that all mankind are descended from a common stock, we may naturally expect some vestiges of a common creed, in consequence of traditional information. These resemblances and coincidences we observe in the sacrifices and rites of expiation, which were adopted by all nations. And farther, if we believe that the Bible gives the most ancient and the most accurate account of the primeval religion of men, and of the peopling of the earth, we may naturally expect to find a strong resemblance to the Scripture creed, among the various tribes of mankind, particularly in the earlier periods of the world. This resemblance can, in many instances, be distinctly traced. The history of the creation, for instance, as recorded by Moses, was adopted by all the nations of antiquity. Megasthenes, who lived in the time of Seleucus Nicator, affirms that all the doctrines of the Greeks, respecting the creation of the world and the constitution of nature, were current among the Bramins in India, and the Jews in Syria. We are inclined to think that Ovid must have had the sacred volume before him, (the Septuagint translation, no doubt,) when he wrote his account of the creation. The coincidence is too striking to be accidental. He first describes the chaotic state of matter, before the Creator arranged it in its various forms; the next step was to divide the heavens from the earth, and the earth from the waters: he then mentions fishes as the first living things of this world, and goes on to state the formation in the other creatures, till the work was crowned with man. In this account it is evident that the heathen poet has not only adopted the facts, but the order of the creation as given by the sacred historian; and when we consider what follows about the war of the giants, the general corruption of mankind, the universal deluge, the preservation of Deucalion and Pyrrha, &c. &c. it is impossible to doubt that Ovid has borrowed directly from Moses. In this case the plagiarism seems fairly detected. At the same time, Ovid gives the general account which was current among both Greeks and Romans; and therefore we have reason to conclude that they all borrowed from the same source. The imagination of the Greeks soon disguised the traditional accounts which they had received of the early history of mankind, with the most extravagant fables, and converted the early history of religion into a system of the most absurd mythology. They have done irreparable injury to ancient history by the mere circumstance of translating proper names, and then inventing a history to correspond with the translated meaning; whilst the Egyptians rendered any religious knowledge which they possessed perfectly inaccessible by the veil of symbols and allegories under which they concealed it. The only inventions of human reason in matters of religion have been to obscure what was plain, to mystify what was simple, and to degrade what was sublime, by unavailing attempts at explanation and refinement.

It is not an easy matter, then, to define the limits of reason in religion. What it can do we can only conjecture; having no certainty that there is one article of the religious creeds which have been current among men, that can be set down as the result of unassisted reason. Were we inclined to preserve the distinction between natural and revealed religion, we would not limit the former by attempting to draw a strict line of demarcation between it and the doctrines of revelation; but we would consider as within its province all those doctrines which, whether they have been the result of reason or not, are at least cognizable by it, and capable of being established by its deductions, though they may not have been discovered by its researches. This is extending the boundaries of natural religion, without encroaching on revelation: it is only giving reason the advantage of all the light which revelation has imparted, and considering as within its legitimate province those matured results which correspond with its dictates, though they may have originated in revelation. Of this kind are the doctrines respecting God, providence, a future state, &c. which have been set in the clearest light by revelation; yet our improved knowledge on these subjects is so perfectly conformable to the dictates of natural reason, that we can scarcely persuade ourselves but that reason, by its own efforts, might have reached them.

The doctrines peculiar to revelation are of a different description, and easily distinguishable from those mentioned above. The trinity, incarnation, atonement by Christ, resurrection of the body, &c. are doctrines not discoverable by reason. But we are not on this account to suppose that they are not proper subjects of reasoning. They may be established by argument, by ascertaining the genuineness and authenticity of the records in which they are contained, and the value of the testimony on which they rest; and by considering, at the same time, the reflex light which they cast on the government of God, and on the character and condition of men. We are farther to consider, that though the doctrines peculiar to revelation could not be discovered by human reason, nor, even after they are known, can they be comprehended by the human faculties, yet in no instance do they contradict the dictates of enlightened reason: they are above it, but not contrary to it. It would be absolutely impossible to believe a revelation which contradicts any ascertained principle of pure reason. This may be considered as an axiom in theology; for a revelation must come from the same being who has formed the mind of man and the constitution of nature; and we cannot conceive that the word of God can ever contradict his works, or that he should command us to believe any doctrine which the reason he has given us compels us to reject. But in admitting this axiom we must be extremely careful to free reason from the influence of the passions, and from the power of those prejudices which tend to bias its decisions, otherwise we will measure doctrines and facts, not by the standard of reason, but by the strength of our inclinations and feelings. Revelation has certainly nothing to fear from the strictest scrutiny, provided it be fairly conducted; but it has no chance before a prejudiced judge, against perjured witnesses, and a corrupted jury.

But from the influence which we have ascribed to revelation and tradition, in forming the religious creed of mankind, a greater uniformity of opinion may perhaps be expected; and it may probably be thought that some traces of all the doctrines of revealed religion ought to be found even amidst the mythology and fables of the heathens. Many contend that this is actually the case; but we think they carry their arguments too far. We hold that no traces of many of the important doctrines of revelation are to be found in the religious creed of the heathen; and for this reason, that these doctrines were withheld from the world, except in the obscure imitations of figure and prophecy, till the period of the Christian revelation; and therefore they could only be known where that revelation was announced and received. It has been said, for example, that the doctrine of atonement for sin was no new doctrine, since it has a place in the creed of all nations, inasmuch as they have all trusted in expiatory sacrifices. This, in a certain sense, is true: the practice of sacrificing has been almost universal, and its object has always been the remission of sins, or the procuring of blessings. It is difficult to account for this practice, as the offspring of reason: it is not difficult to trace it to the Scripture history; for we read that Cain and Abel, the first-born of the human race, offered sacrifices to God. It is not said, however, on what authority they did so. We are inclined to ascribe it to a divine injunction which is not recorded; the more particularly, as God afterwards saw it expedient solemnly to enjoin the practice to the Jews. If it is the offspring of reason, Cain must have the honour of the invention, as he is mentioned as the first who sacrificed to God.

But whether the general practice of sacrificing arose from this primeval source, or whether it is an invention within the ordinary reach of human reason, this at least is certain, that the Scripture doctrine of atonement through Christ was altogether a new doctrine, except in so far as it was announced in the predictions of the prophets. It is altogether beyond the reach of human reason; and appeared so strange, that, with all the aid of previous education, it was a stone of stumbling and a rock of offence, both to the Jews and Gentiles. We need not be surprised then, that the doctrine in this shape should have no place in the creed of the ancient heathen, since it was concealed even from the people of God, till *the fulness of time*, when every thing in the plans of providence was ripe for its disclosure.

We do not mean to attend any farther to the distinction between natural and revealed religion There are, no doubt, some grounds for the distinction, if not in reality, at least in our conceptions, and in our manner of viewing the subject. But we know not where the line is to be drawn; we are inclined to think, that if it is not an imaginary, it is at least a movable boundary, which will gradually disappear as we advance in knowledge; and when, at last, "we shall know even as we are known," the most mysterious parts of the Christian revelation will be found to be as essentially connected with the nature and government of God, as his providence, or any of his most obvious attributes. It is no mark of reason to affect to despise the resources of human reason; and still less to slight the light of revelation, which alone can conduct our reason to just and profitable conclusions. Reason is the compass by which we steer our course; revelation is the polar star by which we correct its variations.

We are to look to the word of God, then, as contained in the Scriptures of the Old and New Testaments, for the only sure rule of faith and practice. But there is this singularity in the sacred Scriptures, that we do not find in them a set treatise on any one of the interesting subjects which engage our attention as moral and religious beings. No attempt is made to prove the existence of a God; such an attempt would have been entirely useless, because the fact is universally admitted. The error of men consisted not in denying a God, but in admitting too many; and one great object of Scripture is to demonstrate, that there is but one. No metaphysical arguments however are employed for this purpose. The proof rests on facts recorded in the history of the Jews, from which it appears that they were always victorious and prospered so long as they served Jehovah, the name by which the Almighty made himself known to them; and uniformly unsuccessful, when they revolted from him to serve other gods. What argument could be so effectual to convince them that there was no god in all the earth but the God of Israel? The sovereignty and universal providence of the Lord Jehovah, are proved by predictions delivered by the Jewish prophets, pointing out the fate of nations and of empires, specifying distinctly the cause of their rise, the duration of their power, and the reason of their decline; thus demonstrating that *one* God ruled among the nations, and made them the unconscious instruments of promoting the purposes of his will. In the same manner, none of the attributes of God are demonstrated in Scripture by reasoning: they are simply affirmed, and illustrated by facts; and instead of a regular deduction of doctrines and conclusions from a few admitted principles, we are left to gather them from the recorded feelings and devotional expressions of persons whose hearts were influenced by the fear of God.

These circumstances point out a marked singularity in the Scriptures, considered as a repository of religious doctrines. The writers, generally speaking, do not reason, but exhort and remonstrate; they do not attempt to fetter the judgment by the subtleties of argument, but to rouse the feelings by an appeal to palpable facts. This is exactly what might have been expected from teachers acting under a divine commission, and armed with undeniable facts to enforce their admonitions.

But though there is no regular treatise in the Scriptures on any one branch of religious doctrine, yet all the materials of a regular system are there. The word of God contains the doctrines of religion in the same way as the system of nature contains the elements of physical science. In both cases, the doctrines are deduced from facts, which are not presented to us in any regular order; and which must be separated and classified before we can arrive at first principles, or attain to the certainty of knowledge; and in both cases, a consistent system can only be made out by induction and investigation. The very circumstance of no detailed system being given, renders it necessary to form one; for although a portion of religious and physical knowledge sufficient for the common purposes of life, may be obtained by traditional information, and men may work conveniently enough by rules without possessing much general knowledge; yet they who would teach with profit, must generalize, and they who would explain the ways of God must arrange the materials which are so amply furnished, but which are presented apparently without order or plan.

We would therefore consider all objections to systems of Divinity to be about as unreasonable as it would be to object to the philosophy of Newton, for having elucidated the laws of nature, and arranged the phenomena of the heavens. A man totally unacquainted with natural philosophy may get comfortably enough through life, for he can work by rule, though ignorant of the principles on which the rule depends. But when a change of circumstances requires a variety of practice, his want of science will appear, and his attempts at renovation will lead to misapplied labour, injudicious expense, and ultimately to disappointment. Ignorance of the principles of religion may be attended with still worse consequences. The ways of God are very complicated; the manifestations of his will are infinitely diversified, and sometimes appear as if they were opposed to each other; and it is only by an enlarged view of his dispensations, and a careful comparison of the procedure of his providence, that we can see the beauties and estimate the value of that revelation which he has given. It is the greatest of all mistakes to suppose that a revelation has been given to save us the trouble of thinking; its object is to teach us to think aright, to prevent the waste and misapplication of our faculties, but not to supercede their exercise. And though we are fully persuaded that no degree of study would ever have enabled men to arrive at accurate conceptions of God and of his government, without the aid of revelation, we are no less certain that revelation itself will not endow men with religious knowledge without study, meditation, and reflection. We do not mean to say that very profound study is necessary to make a good practical Christian: they who are imbued with the spirit of Christianity are led, as it were instinctively, to a conscientious discharge of its various duties; though they may, at the same time, be quite unable to give a connected view of its doctrines. But it is necessary that some should be able to do this; and we know no subject that requires a greater variety of talent, extent of information, and application of judgment, than the successful illustration of the doctrines and duties of Christianity.

In contemplating any perplexing dispensation, the mind of the uninstructed can only go the length of saying, *such is the will of heaven:* this is sufficient to produce acquiescence, and to silence any rising scruples in a mind not addicted to investigation. But in order to produce satisfaction and delight, the point in question must be reduced to some general principle, and shown to be perfectly consistent with the wisdom and goodness of God as recognised in other instances. The history of Job tends to illustrate these observations. He submitted, at first, because he knew that his sufferings were appointed by God; and even when he contended that they were unmerited on his part, he insisted no less on the prerogative of the Almighty to do what he pleased. But when God condescended to reason with him, he saw a different or rather an additional ground of submission, and acknowledged not only the sovereignty of God, but the wisdom and goodness which governed all his dispensations.

But even those who exclaim most against creeds and systems *must* form to themselves a system of some kind or other, out of the Sacred Scriptures; for the mind must endeavour to obtain a connected view of the doctrinal and practical information contained in them, and this is all that a system of divinity attempts; this is what every preacher of Christianity endeavours to exhibit in his discourses, and it would be just as reasonable to object to his oral instructions, as to a written record of his opinions, respecting the doctrines and duties enforced or inferred in the Gospel.

Were it not for the ignorance which obscures the reason, and the prejudices which pervert the judgment, and the doubts and anxieties which must be connected with a subject of such immense importance as the religious hopes of men, the perusal of the Scriptures would be sufficient both for instruction and consolation. But where there are so many sources of error originating in the passions which agitate the human mind, and when the subject is of such vast importance that the heart is afraid to trust its own surmises, it must at least appear a friendly office to point out the leading doctrines of Scripture, and to show their bearings on the duties and the hopes of men. The great head of the church saw it necessary to appoint apostles, evangelists and teachers for this purpose, and this is the object which every one ought to have in view in illustrating the word of God. There is also another point of view in which creeds, confessions, or systems, (or by whatever other name they may be called), are rendered necessary, viz. to obviate the misrepresentations of enemies, and to rescue the Gospel from the opprobrium brought upon it by the misconduct or absurdities of sects or individuals professing Christianity. This is the origin of the apologies of the early fathers, which are neither more nor less than expositions of the Christian creed, as it affects the opinions and practice of those who receive it. The grossest falsehoods respecting their tenets were propagated by their heathen adversaries, and, what was worse, the greatest discredit was brought on Christianity by numerous heretics who professed to adopt it. In these circumstances, the genuine followers of Christ found it necessary to give a detailed account of their faith and of the duties which resulted from it: and the same thing will be necessary so long as the enemies of Christianity shall seek to misrepresent it, or wicked men endeavour to make its sacred name a cloak for licentiousness.

Such being the character, and such the contents of the sacred volume, we are naturally led to inquire into its origin and authority. On this point the declaration of the apostle is perfectly explicit; he tells us expressly that *all Scripture is given by inspiration of God;* and it is absolutely necessary that it should be so from the circumstances of the case. We have seen that a revelation from heaven was necessary; and we have ample proof that such a revelation has actually been given. Assuming at present that this is the case, we would observe that it was absolutely necessary that this revelation should be recorded, and that the record containing it should be preserved from corruption by the superintending influence of the Spirit of God. What would it avail us to know that God had revealed his will to men, and unfolded prospects most interesting to our nature, had we not the assurance that we possess an authentic record of this communication, and an accurate account of its meaning and import? Had it been left to float down the uncertain channel of tradition, or to receive such colouring as the imagination or caprice of men might think proper to bestow upon it, it would soon have been perverted in its meaning, or abused in its application.

But it may be asked, were not ordinary means sufficient for this purpose? Were not men of honest and upright minds able to record the facts which they had seen, and the doctrines which they had heard? In answer to this, we must observe that the facts recorded in Scripture resemble the facts contained in any other history, except in regard to the explanation which is given of their cause, their tendency, and the end they are designed to accomplish in the economy of divine providence. This is what no man without the gift of inspiration can unfold.

In ordinary histories we must rest satisfied with such information as we can find: and generally speaking, the *facts* are accurately reported, whilst the whole train of reasoning on their causes and consequences (which constitutes the beauty and utility of history) is often entirely fallacious: and the most interesting and best written histories are often the least authentic; because the writers, in order to conceal their ignorance of the primary and final causes of events, substitute in the place of knowledge ingenious conjectures, or the romantic dreams of their own imaginations. In cases of this kind, however, error is, comparatively speaking, of little importance. The reasons and motives of actions, assigned by ordinary writers may, or may not be true, without materially affecting the comfort of society; and even a fictitious narrative, if drawn from the general storehouse of human nature, may be both amusing and instructive. But we cannot endure the idea of fiction or uncertainty, where our eternal interests are concerned; and as the reasonings and inferences deduced from the facts recorded in Scripture form the very essence of our religion, being the virtual enunciations of the doctrines on which we build our faith and our hopes, we never can be satisfied till we are assured that these reasonings and inferences rest on the basis of infallible truth. More than human wisdom, then, is necessary to give the right interpretation of Scripture facts, and to deduce from them their legitimate consequences; for we never could build our hopes with confidence, on doctrines which derive their authority merely from the opinions and interpretations of fallible men. It is as necessary to know that the record containing a divine revelation is uncorrupted and infallible in its formation, as it is to know that a revelation came originally from God; and we might as well be without a revelation altogether, as have one embodied in a record, on whose accuracy we cannot depend. In short, none but those who were inspired to announce divine truths were qualified to record them; and if we are satisfied that the prophets, evangelists and hagiographers, had communications from heaven, we may be certain that their writings, whose genuineness and authenticity are most fully established, convey an accurate representation of their heaven-inspired impressions to mankind.

These writings contain strong internal evidence that they proceed from no ordinary source. We see what distortion is given to Scripture facts, and what havoc is made of Scripture doctrines by those, in modern times, who interpret the Word of God according to their own fancy. And why does not the same variety of opinion prevail among the writers in the sacred volume? They were men of like passions with us; in matters of inferior importance, they did not always agree in opinion; nay, they sometimes represent the facts of Scripture in very different aspects; yet, with all this, there is not the slightest variation as to Scripture doctrine. Now this is exactly the reverse of what occurs in the case of ordinary writers, when several of them are recording the same event. They in general agree as to the statement of facts, whilst there is scarcely any such thing as agreement, with respect to their causes, or the inferences which are to be deduced from them.

We are not to suppose that the sacred writers did not exercise their own judgment in commenting on the events which they record, though there is such a striking agreement in their sentiments. But we have reason to conclude, that their understandings were enlightened, their imaginations chastened, and their minds purified by a superintending influence, when we see them always led to the same interpretation and the same conclusion, though the facts were presented to their senses, and are recorded in their writings in very different points of view. These facts, indeed, sometimes appear so inconsistent with each other, that, to save the credit of Scripture, in general, some have chosen to abandon the idea of its *complete* inspiration. This would be both a dangerous and unnecessary concession. For, first of all, this apparent discrepancy in the statement of facts, is the clearest proof that there was no collusion among the writers. Had they formed a design to impose on the world, nothing could have been more easy than to have preserved a perfect consistency as to the detail of facts. They were not cross-examined in a court of justice, and betrayed into contradictory statements: they wrote down deliberate accounts of what they had heard and seen, which they could easily have made to agree with each other, but which were evidently sent into the world without any communication, and without any concern, whether they confirmed or contradicted preceding statements. And, in the next place, the inconsistency is not real, but apparent; and in every case, where it has been supposed to exist, it will be found to originate only in our own ignorance. Particulars different, but not inconsistent; varied, but not contradictory, are presented to our view; and we are thus furnished with an addition of knowledge, not with an opposition of facts.

If we descend from general reasoning, and consider the particular parts of Scripture, we shall find the most decided evidence of their inspiration. Take, for instance, the books of Moses, and consider the nature of their contents. He established laws and ordinances of a most singular nature, totally different, in many respects, from any thing that had ever been seen in the world. That the whole nation should rest from labour every seventh day: that the whole land should lie uncultivated every seventh year, were regulations so contrary to common practice, and to general interest, that no man in his senses would have thought of enjoining them, without the certainty of being supported by divine authority. He does not recommend them by powerful eloquence, nor attempt to defend them as measures of policy: the only argument that he condescends to use, is, *thus saith the Lord;* and he appeals not to the reason, but to the senses of the Israelites, for the confirmation of his statements; directing them to the miraculous displays of power, by which God seconded all the institutions enjoined by his servant.

But we have the most decided evidence, that Moses not only acted but wrote by inspiration, or by the immediate direction of heaven. Where, for instance, did he find those sublime doctrines respecting the unity of God, and the purity of his worship, which we every where perceive in his writings? Not in Egypt where he was brought up; for though he was learned in all the wisdom of the Epyptians, they had no substantial knowledge on these subjects which they could impart. They had made some progress in physical science; and from their knowledge of the properties of matter, they were enabled to exhibit a number of tricks which astonished the multitude. But of all people on the face of the earth, they were the most absurd and preposterous in their religious creed; and Egypt, which has been called the cradle of the arts and sciences, may with equal propriety be styled the nursery of superstition and idolatry. Nor was there any other country from which the Jewish legislator could borrow his doctrines concerning the divine nature and government. His writings on these subjects stand *unique* amidst all the monuments of antiquity; and the very existence of such a system of doctrine and worship among the Jews at such an early period, is a proof that it must have been from heaven; for nothing like it had ever before been seen on earth; nor did the human mind, amidst its multifarious speculations, ever afterwards stumble on the same doctrines. They were so foreign to its views and prejudices, that it could not adopt them by imitation; and in attempting to describe them, uniformly misrepresented and debased them.*

After the books of Moses come the historical books, and no part of Scripture has more decided claims to inspiration, nor is there any part with regard to which that claim is more decidedly asserted. The writers announce, without the slightest hesitation, the mind of God in regard to the transactions which they record; and they unfold, without the smallest scruple, or doubt, the motives which actuated the minds of the principal actors. They do not seek the praise of ingenuity for shrewd or profound speculations as to the great moving causes of events; they never reason in order to show what is the most probable view of the subject, nor do they labour to win assent to their statements: they profess to record nothing but what God has communicated, and having given such information, their commission ends. Nothing has ever been found to contradict, but every thing to confirm their statements, which may be regarded as commentaries on the law of God to prevent its misinterpretation and misapplication by the ignorance and prejudices of men.

Next in order come the books which authors have called *Hagiographa*, or holy writings. These

* Witness the misrepresentation of Strabo, (lib. 16.) who, having informed us truly that Moses forbade to make images of the Deity, tells us farther, that he taught that the heavens, the world, and the nature of things, were themselves the only true God, ειη γαρ ἓν τυτο μονος θεος το περιεχον ημας ἅπαντας και γην και θαλατταν ὃ καλυμεν υρανον και κοσμον και την των οντων φυσιν. Juvenal falls into the same mistake, when he says of the Jews, "Nil præter nubes et cæli numen adorant." Sat. xiv. 97.

are Job, Psalms, Proverbs, Ecclesiastes, and the Song of Solomon. In the book of Job, much light is cast upon the dispensations of heaven, and many doubts and objections which might naturally rise in the mind are obviated. We are taught patience and resignation, from the consideration that we know not the end which God has in view by the visitations which affect us; but we are assured that all things are guided by unerring wisdom, and unchangeable goodness. These are the lessons inculcated in the book of Job, and they are the most important that can be learned by man.

The Psalms are a collection of sacred songs and hymns by a variety of authors, but by far the greater part by David, insomuch that the collection generally bears his name. They form a valuable record of devotional feeling; all the workings of the human heart are here displayed; the doubts and the fears, the joys and the transports which successively agitate the mind are here pourtrayed, and it will always find something here, to suit its varied shades of feeling, from the first aspirations after holiness, checked by ignorance, and inherent unbelief, to the complete triumph of faith, and assurance of hope. In short, the Psalms are the safest manual of devotion, and the most authentic, perhaps the only authentic journal of the thoughts and emotions which are excited in the mind under the varied dispensations of heaven.

The Proverbs contain a great variety of most excellent maxims of moral wisdom; and such a collection forming part of the canon of sacred Scripture, conveys to us this important truth, that the service of God ought to be combined with the soundest wisdom and discretion. The Proverbs of Solomon correspond so exactly with the maxims which enlarged experience sanctions, that some have said there was no need for inspiration to produce a collection of practical rules, so consistent with utility and common sense. But surely it is useful to know that such rules have the sanction of the Spirit of God; and that the headlong folly which cloaks its extravagances under the garb of religion is altogether alien from the Spirit of truth.

The book of Ecclesiastes contains a history of the experiments made by a man of great power and wisdom to secure happiness, by bringing into operation all the resources which wealth, power, and wisdom could supply. The result of his experience was, that "All is vanity and vexation of spirit," and that "To fear God and keep his commandments is the whole duty of man!" The first conclusion has been reached by many who had no pretensions to the wisdom of Solomon, whilst they have missed the latter and most profitable result of his experience.

The Song of Solomon has been more the subject of cavil, than any other part of sacred Scripture. From the absence of the name of God in it, and from the style of the imagery, which is luxurious and amatory, some have argued that it cannot be an inspired composition. This is a hasty, and we are persuaded an unfounded conclusion. It has, from the earliest ages, been considered as forming a part of the canon of Scripture. The Jews always regarded it in this light, and it never would have descended to our times, had it not been protected by its sacred character. Solomon was a very voluminous writer; "His songs were a thousand and five; and he spake of trees from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall; he spake also of beasts, and of fowl, and of creeping things, and of fishes." 1 Kings iv. 32. But none of his productions are preserved, but such as were of a sacred character. The style and imagery of the composition in question, however opposite to European taste, and to the notions of propriety adopted in modern times, form no objection, if they can be shown to be applied in Scripture to subjects confessedly spiritual and religious. This may be easily done: the forty-fifth Psalm presents the same imagery applied in a religious sense, and may be regarded as a pretty accurate abridgment of the Song of Solomon. And this composition seems to be referred to in the New Testament, when the apostle says, "I am jealous over you with a godly jealousy; for I have espoused you to one husband, that I may present you as a chaste virgin unto Christ." 2 Cor. xi. 2.

The writings of the prophets carry in their face the evidence of divine inspiration. We have only to show that prophecies predicting future events existed, and that the events foretold actually came to pass, to satisfy any rational mind that the information of the prophet must have been from heaven. Such facts as these occur not merely in a few instances, so as to induce a suspicion of conjecture, and of casual fulfilment. All the great events which have influenced the affairs of men are written *beforehand* in the records of prophecy; and the historian who comes afterwards, has only to fill up the great outline which had been previously drawn by the inspired prophet.

The writers of the New Testament Scriptures have no less decided claims to inspiration. Their Master assured them that the Spirit should be given to bring all things to their remembrance, and they did not write till this promise was fulfilled by the visible descent of the Holy Ghost on the day of pentecost. Friends and enemies have received the books of the New Testament as the undoubted writings of the authors whose names they bear; and when we consider the circumstances in which these authors were placed, without education or the usual opportunities of knowledge; and when, notwithstanding these disadvantages, we see them inculcating doctrines and precepts which leave far behind them all the instructions of human wisdom, it is impossible not to conclude that they wrote under the inspiration of heaven.

The Scriptures being the word of God, must naturally be regarded as the grand depositories of all religious knowledge: they teach us the doctrines which we are called upon to believe, the duties which we are to practise, and the hopes which we are warranted to entertain: they explain the nature and character of God, but they contain no laboured arguments to prove his existence. It would have been a mockery and misapplication of reason to have adduced metaphysical arguments to prove what was demonstrated to the senses. They who believe the facts of Scripture, which are so many records of the being and power of God, cannot possibly doubt his existence; much less could those who were the eye and ear witnesses of those extraordinary transactions. Did we find a single argument in the writings of Moses to prove the existence of God, beyond those drawn from the miracles which the Israelites saw, it would justly bring suspicion on the whole record; for what could be the use of reasoning where conviction was applied immediately to the senses, and palpable demonstrations daily afforded of the presence and power of God? In these circumstances, the absence of inductive reasoning is exactly what might have been expected, and strongly confirms the authenticity of the record, and the genuineness of the facts which it contains.

Though we are now placed in different circumstances, yet it cannot be necessary to spend much time in proving the existence of God: we are almost as sure of it as we are of our own; at least we may be as sure of it as we are of the existence of a rational soul in our fellow men. All that we see of man is a corporeal structure and material organs, composed of the same elements as external nature. Consciousness and feeling may give an individual a conviction that there is something in his constitution of a higher order and character. He can reason and plan, and manifest his feelings in a great variety of ways: hence he infers the existence of a principle within him, different from the matter of which his body is composed; and when he sees the same manifestations in the case of others, he concludes that there is the same power of feeling, reasoning, and executing. But the soul, which is the grand agent in all these transactions, he cannot see: he infers its existence only from the effects which it produces. Now, as we cannot possibly mistake the visible universe for the work of man, we are compelled, from the appearances of design, and the wise adaptation of means to ends, to ascribe it to a being possessed of power, intelligence, and goodness, inconceivably exalted above the faculties and resources of man. Thus, we see God as visibly in his works, as we discover the existence of an intelligent spirit in man from its various manifestations.

We pass over the various arguments, metaphysical and inductional, which have been adduced to prove the existence of God, and proceed to consider the information which the Scriptures have given us respecting his nature, character, and attributes. They uniformly, and in opposition to all the ancient nations, assert the existence of one God: and this unity of the divine nature is demonstrated by the universality of divine providence, as manifested in the fate of the different nations whose destinies are pronounced in Scripture, long before the prediction was verified by the event. This proves that one mind had the knowledge and disposal of the fortunes of the kingdoms of this world. Philosophy proclaims the same important truth, and shows such a unity of design and harmony of purpose, reigning throughout all the arrangements of the material world, as proclaim them all to be under the direction of *One* superintending mind. The same laws which regulate the motions of the heavenly bodies, operate on the surface of this earth, and show the heavens and the earth to be under one and the same governor.

The perfections of God in which we may share, or as they have been called his communicable perfections, are wisdom, power, holiness, justice, goodness and truth. His incommunicable, or his essential attributes, are his eternity, self-existence, immutability, omnipresence, &c. These may be called the attributes, or characters of his perfections, to which we can conceive no limits or bounds. In these attributes we cannot participate: they constitute the essential nature of Deity, and without them God would not be an object of religious homage and adoration. It might be highly interesting to contemplate a being just, and good, and wise, and holy; but no religious homage could be due to such a being, did his perfections admit of any limitations, or were he not infinitely removed above all chance, and above all change, and not affectable by any of the vicissitudes which attach to all created things.

The providence of God, or his care over the world which he has made, is proved by the existing state of the visible universe. To suppose that the world and its inhabitants can exist without the immediate care and superintendence of God, would be to suppose them independent of his power: but if we may venture to assign limits to the power of God, we would say that it is limited by this, that he cannot do any thing that is unworthy of himself, nor make any thing independent of his power. To create any being, or any thing absolutely independent, would be to impart his own incommunicable perfections; and this we may safely pronounce to be impossible: it exceeds even the power of omnipotence to make any thing as great as the uncreated Deity. In every thing, then, that lives or grows, or exists, we see not a natural efficiency, but a divine energy; even in the rudest mass of inanimate matter, we see a divine power; because it is held together, and retains its form and qualities, only in consequence of those laws which God has established, and which preserve their force, only because his will keeps them in operation.

Thus far, all that is taught in Scripture respecting the unity of God, and his universal providence, is confirmed by every argument of enlightened reason. In the government of the world, we see none of that discordance which marks divided empire; even those things which, at first sight, might appear as irregularities in the plan, are found, on closer inspection, to be essential parts of it, and to bear unequivocal testimony to the unity and overruling providence of God. But the Scriptures give us some information respecting the mode in which the divine nature subsists, which it does not appear that reason could ever have suggested. We allude to the doctrine of the Trinity, of which, we are inclined to think, no vestige can be found, except among those who have received it, directly or indirectly from the sacred Scriptures.

It is true that something resembling this doctrine is to be found in the mythology of some of the gentile nations. It seems to be acknowledged in the theology of Hindostan, in the characters of Brama, Vishnu, and Seva, whose image, in the most ancient representations, appears as a human body with three heads. A species of Trinity also was taught in the schools both of Pythagoras and Plato, and is largely insisted on by the followers of the latter. The doctrine of Plato on this subject is, that there are three principles in the Deity, goodness, intelligence, and vitality; and that these three, though distinct, are more *one* than any thing in nature of which unity may be predicated; as no one of them can be supposed without the other two. When Christianity began to prevail in the world, many Platonists embraced it; and when the doctrine of the Trinity began to be impugned, they attempted to defend it as a docrine of reason, by affirming that it was taught in the philosophy of Plato: whilst the unconverted Platonists maintained that the Christians had borrowed the doctrine from the Grecian philosopher. Had the language of Plato on this subject been as clear as that of his followers, we should have concluded that he had derived his knowledge from the traditions current among the Jews, and which had passed from them to other nations of the east. But, after all the labours of Cudworth, we cannot perceive that Plato teaches any thing resembling the Christian Trinity. Something more like to it appears in the doctrines of the Pythagoreans, as represented by Simplicius, who tells us that one of their authors describes the *First One* as being above every existing substance; the *Second One* as represented by Ideas, or Intelligible Species; and the *Third One*, as Vital or Psychical (ψυχικον) and partaking of the nature of both the former.*

But it is evident that this is a philosophical conceit, founded on opinions which had long been prevalent. In the esoteric doctrines of several of the ancient philosophers, the divine nature was considered as one and indivisible, immovable and unaffectable: at the same time they considered God as diffused through all things, and all things as partaking of the nature of God: hence they conceived his nature to exist both in the intelligible species, by which they supposed all things to be apprehended by the understanding, and also in the visible system of things which are the objects of our external senses. This gave a kind of triplicity of modification to the divine nature, which was nevertheless considered to be, in itself, simple and one.

This doctrine, or some notions of a similar kind, tended strongly to produce a perversion of the Christian doctrine of the Trinity, when the Platonizing philosophers began to embrace the Christian faith, and the errors arising from this source have continued to infect the faith of many professing Christians down to the present day. To give an enumeration of the heresies and conceits which have been entertained on this subject would only be to exhibit the weakness or the presumption of the human mind. All that is proposed is to give the history of the doctrine of the Christian Trinity; and to state the arguments from Scripture by which it is supported.

There is one thing connected with this subject which cannot but strike every person as remarkable. The Trinity is no where announced in the New Testament as a new doctrine, neither is it any where formally taught: it is taken for granted, or stated as a matter of course, and referred to rather as a thing that was well known, than as a doctrine which had been unheard of before.

Was this doctrine, then, known to the Jews under the Old Testament dispensation? It certainly is not expressly taught in the sacred writings, anterior to the Christian revelation; but it is pretty evident that the Jews must have had some notion of plurality as connected with the Divine nature. This is implied in the phraseology of Scripture, as when the Creator says, "Let *us* make man," and "the man is become as one of *us*." It ought also to be observed that the word *Aleim* or *Elohim*, which is translated God, is a plural noun, but is nevertheless generally joined by Moses, in his account of the creation, with a verb in the singular, to indicate, as is supposed, his knowledge of the mysterious nature of the Godhead.

The influence of the Spirit of God is often mentioned in the Old Testament Scriptures, and personal qualities are ascribed to it. The Spirit of God rested on the seventy elders and they prophesied, Num. xi. 26. Isaiah says, "The Lord God and his Spirit hath sent me." xlviii. 16. Numberless passages might be quoted to the same purpose, in which qualities and operations are distinctly ascribed to the Spirit of God as a person, and not as an energy of the Divine nature. And, in whatever way they came by their belief, it is no less certain that the Jews, previously to the time of our Saviour, ascribed a distinct personality to the Word of God. Thus in the apocryphal book of Wisdom, which is unquestionably ancient, and supposed to be the production of some Hellenistic Jew, who lived before the time of our Saviour, we find the following passage: "Thine Almighty Word leaped down from heaven, out of the royal throne, as a fierce man of war into the midst of a land of destruction." xviii. 15.

But the most decided evidence on this subject is to be found in the Targums of Jonathan and Onkelos; the one being a commentary on the prophets; the other on the books of Moses. They are both written in Chaldee; that of Jonathan was written, according to Calmet, about thirty years before Christ: that of Onkelos not long after it, and they are both, till this day, held in the highest estimation among the Jews. From these commentaries, then, on the Old Testament Scriptures, we learn in what sense particular passages were understood by the Jews. Onkelos says on Exodus xix. 3, that Moses "went

* Ουτος γαρ κατα τους Πυθαγορειους το μεν Πρωτον Ἑν υπερ το ον και πασαν ουσιαν αποφαινεται το δε Δευτερον Ἑν, όπερ εστι το οντως ον και νοητον, τα ειδη φησι ειναι το δε Τριτον, οπερ εστι ψυχικον, μετεχειν του Ἑνος και των Ειδων. Apud Cudworth, chap. IV.

up to meet the *Word* of the Lord," and again, in the 17th verse, he says, "Moses brought the people out of the camp to meet the *Word* of the Lord."* The Targum of Jonathan is equally explicit: on Deut. v. 5, he says, "Moses stood between them and the *Word* of the Lord:" and in the 23d verse, he says, "After ye had heard the voice of the *Word* out of the midst of the darkness," &c. which shows that the Word is to be understood in a personal sense, as distinguished from the voice of God.†

The same phraseology prevails throughout the work of Philo Judæus, *De Mundi Opificio*, in which he almost everywhere speaks of the Word of God as a person, and ascribes to him the creation of the world.

From these facts, then, we may reasonably conclude that St. John was stating nothing but the received doctrine among his countrymen, when he said, "In the beginning was the Word, and the Word was with God, and the Word was God; the same was in the beginning with God: all things were made by him, and without him was not any thing made that was made." No Jew of those times could possibly object to this doctrine. Nay more, the Jews positively expected the visible manifestation of this Word in the person of their Messiah. They would not have been offended at the doctrine that "the Word was made flesh and dwelt among us," had not Jesus of Nazareth, of whom this was predicted, appeared in a character, and in circumstances so very different from what they expected. This is apparent from the gospel history. When our Lord was accused before the Jewish council, the high priest said to him, "I adjure thee by the living God, that thou tell us, whether thou be the Christ, the Son of God." From this it is evident, that they expected the manifestation of "the Christ the Son of God." Our Lord answered the question indirectly by saying, "hereafter shall ye see the Son of Man sitting on the right hand of power, and coming in the clouds of heaven." This is an evident allusion to Dan. vii. 13, 14, where it is said, "And, behold, one like the Son of Man, came with the clouds of heaven, and came to the Ancient of Days, and there was given him dominion and glory and a kingdom," &c. On hearing our Lord apply these words to himself, "the high priest rent his clothes, saying, he hath spoken blasphemy, what farther need have we of witnesses?" Matt. xxvi. 64, 65. This incident proves two things; first, that the Jews considered the passage in Daniel, which our Lord applied to himself, as applicable to the Messiah; and, secondly, that though he is there called the "Son of Man," they nevertheless admitted that he was to be, in reality, "the Son of God," and to have a kingdom which should never be destroyed. This was the character which they recognised as belonging to the Messiah; and our Lord was judged guilty of blasphemy because he asserted that the words of the prophet were fulfilled in him.

A curious commentary on the vision of Daniel has recently been furnished us from the book of Enoch,‡ lately translated from the Ethiopic, by Bishop Lawrence. The work is evidently apocryphal, and was considered as such by the early Fathers; it is, however, unquestionably ancient: and there seems not the smallest doubt that it is a fair translation of the work quoted by Jude. We refer to it, as we have done to the other apocryphal writings, and to the writings of Philo Judæus, merely to illustrate the opinion of the Jews respecting a plurality of subsistences in the divine nature. That such an opinion prevailed among them is very clear from the commentary which the author of this book makes on the vision of Daniel. He has availed himself of the prominent facts and prophesies of the Old Testament Scriptures, and has represented them as seen in vision by Enoch, and related by him to his son Methuselah. The vision of Daniel, of course, was not to be overlooked, as it is evidently prophetic of great and remarkable events: and this author shows the interpretation which he, and, we may conclude, the thinking part of the Jews, (among whom, it is evident, his book was received as a work of authority,) assigned to the most remarkable circumstances in this prophetic vision. "There I beheld the Ancient of Days, whose head was like white wool, and with him another whose countenance resembled that of man. His countenance was full of grace like one of the holy angels. Then I inquired of one of the angels, who went with me, and who showed me every secret thing concerning this Son of Man—who he was—whence he was—and why he accompanied the Ancient of Days." Ch. xlvi. 1. In the remainder of this chapter, and the whole of the next, he continues to celebrate the praises, and proclaim the exploits of the Son of Man. In the 48th chapter the subject is continued, and in the 2d and 3d verses we find these remarkable words. "In that hour was this Son of Man invoked before the Lord of Spirits, and his name in the presence of the Ancient of Days; before the sun and the signs were created, before the stars of heaven were formed, his name was invoked in the presence of the Lord of Spi-

* See the Targum of Onkelos in Walton's Polyglot. Tom. i. p. 37.

† See particularly Allix's Judg. of the Jewish Church, for all the passages indicating plurality in the Godhead.

‡ Three copies of this work were brought from Abyssinia, by Bruce. He retained one to himself, and deposited one in the library of the King of France, and the other in the Bodleian Library at Oxford. No translation of the work into any modern European language has appeared till Bishop Lawrence published his English translation in 1821. A large fragment in Greek from the chronographia of Georgius Syncellus, was published by Scaliger. The work from which St. Jude quoted was extant in the second century. For Irenæus, who wrote in that century, distinctly alludes to events recorded in it and no where else, and Tertullian translates a long quotation from it. The Greek copy of the work, a translation probably from the Hebrew or Chaldee, seems irretrievably lost. Ao idea, however, prevailed in the beginning of the seventeenth century, that a translation of it existed in Ethiopia. But all attempts to procure a copy were unsuccessful, till the three above mentioned were brought into Europe by our countryman Bruce, the prince of modern travellers, whether we consider his courage, his prudence, or the intelligenco with which he conducted his researches. His copies contain the passages quoted by Syncellus and the Fathers, as well as that quoted by Jude; and there can be little doubt of their being fair translations of the original.

rits:" and at the 5th verse, he says, "therefore the elect and the concealed one existed in his presence before the world was created, and for ever." These passages are valuable as recorded testimonies of the belief of the Jews in the pre-existence and Deity of the person designated by Daniel, the Son of Man.

Nor is this all, in the 60th chapter a distinct allusion is made to a Trinity of persons in the Godhead. "He (the Lord of Spirits) shall call to every power of the heavens, and to all the holy above, and to the power of God. The Cherubim, the Seraphim, and the Ophanim, all the angels of power, and all the angels of the Lord, namely of the elect one, and of the other power, who upon earth were over the water on that day, shall raise their united voice," &c.

We see not the slightest reason for questioning the antiquity of this book, or the integrity of the text, on account of these obvious allusions to the Son and the Spirit. On the contrary, whatever may be thought of the genuineness and authenticity of the text in 1 John v. 7. we are persuaded that it states nothing but the common creed of the Jews at the time it was written, and that the most intelligent among them would have subscribed to the doctrine that "there are three that bear record in heaven, the Father, the Word, and the Spirit, and these three are one."

We can easily conceive that this text is an interpolation, since it is not found in some of the most ancient copies of the New Testament, and is not quoted by the ancient Fathers in their disputes with those who denied the doctrine of the Trinity.* But if it is an interpolation, (which, after all that has been written, we do not think sufficiently proved,) it is nevertheless an accurate statement of the generally received doctrine among the Jews. How they arrived at the knowledge of a doctrine not clearly taught in the law and the prophets, cannot be a question of much difficulty, when we consider that they had so many inspired teachers among them, who might deliver much in their instructions which they did not commit to writing, and who in illustrating the word of God, might explain the meaning of those passages in which the doctrine was implied, though it might be overlooked by an ordinary reader. It was, no doubt, in this way that the resurrection of the body, which is nowhere clearly taught in the Old Testament, was nevertheless universally received among the Jews, except by the sect of the Sadducees, long before it was so clearly revealed and demonstrated in the New Testament.

And it will not be denied that there was an obvious propriety in preparing the minds of men by previous instruction for the reception of a doctrine so highly mysterious and important as that of the Trinity. In consequence of the prevailing opinions on this subject, the Apostle Peter, when he witnessed the power and wisdom of his Master, had no hesitation in declaring, "we believe and are sure that thou art the Christ, the Son of the living God;" hence, too, our Lord had no occasion to enter into any explanation when he enjoined his disciples to "go and teach all nations, baptising them in the name of the Father, and the Son, and the Holy Ghost;" and from the same circumstance, Mary expressed no surprise when she was told that the Holy Ghost should come upon her. She was immediately satisfied, having heard before of the existence of such an agent.†

Having attempted to give a short history of the doctrine of the Trinity, it now only remains to adduce some texts from the New Testament in which the doctrine is either clearly stated, or obviously implied.

And surely nothing can be more explicit than the passage just quoted respecting the institution of baptism. This rite, as a token of regeneration, and as a sign of our being admitted to spiritual privileges and blessings, can only be administered in the name of God; for he alone can offer and ensure these blessings to mankind. But it is here expressly ordained to be administered in the name of the Father, of the Son, and of the Holy Ghost, to each of whom personal qualities are ascribed throughout the New Testament; when, therefore, we see all the three associated in a work that can belong only to God, the unavoidable inference is, that there are three persons in one Godhead. Indeed it seems to be as impossible to mistake the meaning, as it is to explain away the force of this plain text. The words of the Apostle, at the conclusion of the Second Epistle to the Corinthians are equally clear, and the inference deducible from them equally incontrovertible,—"the grace of the Lord Jesus Christ, the love of God, and the communion of the Holy Ghost be with you all." As if it had been to obviate the opinion which afterwards sprung up, that the Son and Holy Ghost are only particular manifestations or energies of the same person; the Son is here mentioned first, to show his inherent Godhead, and claim to religious adoration; and that there might be no possibility of confounding the three *subsistences* or *hypostases* of the Godhead as mere modifications of the same divine person, all the three are, on one occasion, repre-

* Without entering at all into the controversy respecting this text, it may be sufficient to give the following general statement of the grounds on which it rests. The verse has not, as yet, been found in any very ancient Greek manuscript of the New Testament; it is said only to be found in one copy of comparatively modern date, being supposed to be of the fifteenth century. Hence it is inferred that the verse is wanting in the copies from which the most ancient Greek MSS. have been transcribed, up to the autograph of St. John On the other hand, the verse is found in the most ancient copies of the Latin Vulgate, which the supporters of the text maintain to be a correct translation from a genuine Greek original. But the strongest evidence in favour of the text occurs in the writings of Cyprian, who died in 258, who seems directly to quote it; for he says in his treatise *De unitate ecclesiæ*, "Dixit Dominus, Ego et Pater unum sumus; et iterum, de Patre et Filio et Spiritu Sancto scriptum est, *Et hi tres unum sunt.*" This seems to imply that the text was found in Scripture, (for he says, *scriptum est*,) in the time of this father.

† Those who wish to prosecute this view of the subject farther, will find ample information in Bishop Bull's work on the Trinity, Cudworth's Intell. Syst. Book I. Ch. 4. Horsley's Letters to Priestley, Maurice's Indian Antiquities, vol. iv. passim, and Alix's Judgment of the Jewish church against the Unitarians.

sented at once, under sensible manifestations, and in very distinct characters and circumstances. "It came to pass that Jesus being baptized and praying, the heaven was opened, and the Holy Ghost descended in a bodily shape like a dove upon him, and a voice came from heaven which said, "Thou art my beloved Son, in thee I am well pleased." Luke iii. 21. Here the voice of God was heard from heaven, the Holy Ghost was seen descending, and lighting on him, who was pronounced to be the beloved Son of God. Again the Son and the Spirit are mentioned as distinct from the Father; and as distinct, too, from each other in their persons, and in their operations in bringing men to God. "Such were some of you; but ye are washed, but ye are sanctified, but ye are justified in the name of our Lord Jesus, and by the *Spirit* of our God." 1 Cor. vi. 11.

We shall have occasion afterwards, to notice particularly the divinity of the Son; and, therefore, we shall close this discussion on the Trinity with a few texts, tending to prove the divinity and distinct personality of the Holy Spirit. His Divinity is proved by the reproof of the Apostle Peter to Ananias, Acts v. 3, 4. "Why hath Satan filled thy heart to lie to the Holy Ghost? Thou hast not lied unto men. but unto God." And his distinct personality is proved by our Lord's words, Matt. xii. 31, 32. "All manner of sin and blasphemy shall be forgiven unto men; and whosoever speaketh against the Holy Ghost, it shall not be forgiven him, neither in this world, neither in the world to come."

If language has a meaning, and if the sacred records can be depended on for settling a point of faith. we must consider this passage as perfectly conclusive, as to the divinity and distinct personality of the Holy Spirit. He is God because men may be guilty of blasphemy against him, which cannot be said of any created being,—blasphemy can only be committed against God; and he is distinct from the Father and the Son, inasmuch as blasphemy against him is unpardonable, which is not the case when committed against the Father or the Son.

We do not reckon it necessary to proceed farther in adducing Scripture proofs of this doctrine. A vast number of texts equally applicable might be quoted, and the whole tenor of the New Testament Scriptures is in exact conformity with the obvious meaning of those passages which have been adduced. The opponents of this doctrine make a very unreasonable demand upon us, and require us to bring it down to the level of their understanding. They who make such a demand should forego all discussion respecting the nature of God, the principles of human conduct, and the ordinary phenomena of nature: for on all these subjects they must soon be involved in inextricable mystery. What, for instance, can we know of that God whose being and attributes we can demonstrate? He is self-existent, eternal, without beginning and without end, omniscient, omnipresent, illimitable. Can we comprehend the nature of a being possessed of such attributes? No: his nature is unsearchable, his ways are past finding out. But it may be said that this subject only transcends the power of our reason, while the doctrine of the Trinity contradicts its intimations. This is not the case. We are compelled to believe things as extraordinary and as incomprehensible by our faculties. The soul and the body make one person, yet we believe them to be totally different from each other in substance, nature, and qualities. Various faculties, how many we cannot tell, compose one mind, though they are very opposite to each other in their operations. Indeed, we are probably not acquainted with a single simple substance in nature. The air which we breathe is a triple compound; the water which gives fertility to the earth is composed of, at least, two ingredients; and the light, which used to be considered as the purest of all elements, is found to be a very complex substance.

These things are adduced not as proofs, but as illustrations; and they are brought forward in this view, to obviate objections, rather than to produce belief. The doctrine of the Trinity depends on testimony, rather than on reasoning; except in so far as reasoning is employed to establish the testimony by which it is supported: it rests on the same foundation with the general plan of revelation, and they must stand or fall together. But as all the objections to the doctrine are professedly founded on reason, these objections are done away when reason can point out analogous facts to meet the arguments which have been supposed to invalidate the doctrine. The eternal generation of the Son, for instance, has been objected to as not only incomprehensible, but impossible. To this Jortin (who is not over orthodox on the subject of the Trinity,) replies, that to deny the possibility of this would be to deny that God had the power of working from all eternity. Again it is said, how can the Son and Spirit proceed from the Father and yet be equally eternal with him? This has been answered by Pearson long ago, by an illustration drawn from the visible sun: for were we to suppose this luminary to be eternal, (which is, at least, a possible supposition,) then the rays which proceed from it must be eternal also.

All the attributes and perfections of the Deity are manifested in the works of creation, providence, and redemption. The curiosity of men has led them to inquire what has moved the divine mind to these manifestations of wisdom, power, and goodness. As all the actions of men arise out of certain purposes which they have formed, and certain objects and ends which they have in view, we are naturally led to conclude that the same must be the case with the ways of God; they must have an origin, and they must be designed to accomplish certain ends. In other respects there must be a wide difference between the ways of God and the ways of men. We are influenced by motives, suggested by circumstances over which we have no control; the actings of the Almighty arise out of his own free will, uninfluenced by external circumstances, inasmuch as his purposes were formed before the foundation of the world, regulating, and not following the course of nature and of providence.

It is needless to attempt to conceal that no subject has excited more controversy that this: it forms the grand point of debate between the Arminians and Calvinists. Though we do not entertain any hopes of being able to put an end to the dispute, we nevertheless think it necessary to state the question; and we shall not be disposed to make any apology, though we should be discovered to bear more to one side than to the other.

The doctrine of predestination, which arises out of this subject, is unquestionably taught in Scripture (vide Rom. viii. 29. Eph. i. *passim.* 2 Thes. ii. 13. 1 Pet. i. 2.) It is also held as a fundamental doctrine by the Church of England, the Church of Scotland, and many other churches, and is necessarily connected with the fore-knowledge of God. "Whom he did foreknow, he also did predestinate." It will be proper, however, to remark that we may fall into great mistakes in talking of the *fore*-knowledge of God: for with him there is neither *fore* nor *after;* all things are eternally present to him; and by him, and in him, all things subsist. The language and the conceptions of men are formed on entirely different principles. We employ three principal tenses to mark the flight of time, and the course of our ideas, viz. the past, the present, and the future. But the grammars of men cannot limit the conceptions of the Almighty, whose existence is commensurate with eternity; "with whom a thousand years are as one day, and one day as a thousand years."

We can with difficulty form a conception of this, yet it is demonstrable that it must be so. It flows necessarily from the eternity and self-existence of God. All things being ordained by him; all the parts of the present dispensation being connected with, and adapted to each other; and no power being able to alter or withstand what he has decreed in his wisdom, and in his might, the whole system of things must necessarily be present to his mind. He sees those things, to which we would ascribe only a *possible* existence, as actually existing; and as the architect sees all the parts and proportions of the future palace, in the plan which he has formed in his own mind, before a single stone of the building has been laid, so the eternal architect saw, before the foundation of the world, the proportion, order, and use of every part of the visible system of things, which appear to us only in succession, and at distant intervals, and perplex us greatly in all our attempts to account for them.

In conformity with the ideas which have now been thrown out, we would rather say that predestination flows from the omniscience, than from the *fore-knowledge* of God. Nobody can doubt that he knows every thing that is come to pass. We see how intimately he was acquainted with the fate of nations when he announced beforehand the events which were to befal them. No one of these predictions ever failed. Now, whether we say that he merely foreknew these events, but decreed nothing concerning them; or affirm that they were fixed by his absolute decree, on either supposition, the result must be the same; they could not but happen as God had foreknown and foretold.

For God to predestinate, then, or to foreknow, seems to amount to one and the same thing; unless we run into the impiety of supposing that God foreknows things over which he has no control, which he did not plan, and which he cannot prevent. Such a supposition is altogether inconsistent with the sovereignty of God, as the ruler of the universe, and the disposer of all events. It is true, indeed, that foreknowledge, among men has no influence on the events which are foreseen. We may be so well acquainted with the character and disposition of individuals, that we may know, almost with absolute certainty, what they will do in given circumstances. We may be sure that pride will mislead one man, avarice another, and ambition a third; that one will be enslaved and led astray by vanity, and another by the lure of sensual indulgence. But though we may know all this with absolute certainty, yet our knowledge has no influence on the fate of the parties. The same would be true in regard to God, had he as little to do with the government of the world as we have; and did he come by his knowledge in the same way that we do. But his knowledge is the result of his own free will, which ours is not: we come to the knowledge of things by accident, or by application; but God knows all things from the beginning, because in him all things subsist; he knows every event before it is unfolded in the course of his providence, because it forms part of his eternal plans: in short, he knows all things, because he has ordained them.

The opposite scheme, or what has been called the Arminian view of this subject, does not remove a single difficulty, whilst it is attended with some inconsistencies which do not encumber the Calvinistic plan. It goes on the supposition that the decrees of God are fixed in consequence of the known characters of men, good or evil; that those, for instance, whom God foresees that they will be virtuous and obedient, he decrees to eternal life; whilst those who are foreseen to be contentious and disobedient are decreed to everlasting punishment. Thus, both on the Calvinistic and the Arminian hypothesis, decrees are admitted; for it is impossible to read the Scriptures and not perceive it to be a fundamental doctrine, that every thing which comes to pass is fixed and determined in the eternal counsels of God. The parties differ only in the way in which his decrees are to be explained. The Arminian scheme seems to make the counsels of God depend on the will of feeble man; and to countenance the idea that he may have done so much for the human race, and yet that it may be all in vain; that men may not choose to believe, and that, therefore, the intention of the Almighty may be defeated; all which notions seem directly contrary to the language of Scripture, which says, "whom he did predestinate them he also called," (Rom. viii. 29.) and as many as were ordained to eternal life believed." (Acts. xiii. 48.)

The great argument against the Calvinistic views on this subject is drawn from certain conceptions which men have formed respecting the divine character. It is argued, for instance, that it is inconsistent with the benevolence of the Deity to decree any one to eternal misery. The apostle (Rom. ix.) answers this objection by resolving the fate of men into the absolute sovereignty of God; and turn which way you will, or adopt what view of the subject we please, we shall find that we must land in the same conclusion at last. If misery is to be the portion of any in the future world (and this has never been denied by any) it may just as well be affirmed that it is inconsistent with the goodness of God to make creatures who he knew would be miserable, as to maintain that it is inconsistent with his benevolence to doom them to misery by his absolute decree.

They, then, do not remove a single difficulty who say with the church of England, and some other churches, that God does not predestinate any man to misery, because predestination does not condemn but save men, inasmuch as all men were under a curse, and liable to punishment, to which they must have been subjected, had not God, in his eternal counsels, resolved to save a certain number, whilst the rest were *passed over*, and left to the fate which sin had brought upon them. This is merely disguising the difficulty; to *pass over* any in the decree of election is the same as to doom them to hopeless reprobation; it is attended with all the same consequences, and can be explained only on the same principle, viz. the sovereign will of God.

It is farther argued that the doctrine of absolute decrees is calculated, on the one hand, to drive men to despair, or, on the other, to encourage arrogance and presumption; that those who conceive themselves doomed to misery, must be driven to desperation; whilst those who conceive themselves ordained to life will be careless and presumptuous. It is easy to get rid of this objection. The decrees of God can have no influence on human conduct, whilst they are unknown; and in so far as they are made known, the tendency is salutary, calculated to encourage virtue and repress vice and immorality, for this is his fixed and irreversible decree, that the man who lives humble and holy, and dies in faith and hope, shall inherit eternal life, whilst "the unbelieving and disobedient shall not see life, but the wrath of God abideth on them." (John iii. 36.) So far every man may know, and ought to know, the decrees of God; and he should not seek to know more. Were every man permitted to read his fate, as written in the unalterable records of heaven, there would be an end at once both to the restraints on vice and to the encouragements to virtue.

But, in concluding this subject, we would observe that the difficulties which encompass it do not arise out of the Scriptures; they arise out of some of the most obvious doctrines of natural religion; and they are greatly lessened, and some of them almost entirely removed by the light of revelation. It may be observed, for instance, that it is decreed concerning every man that lives, that he shall be happy or miserable in the future world. This is a doctrine which never has been doubted; all men, in all ages, have admitted a state of rewards and a state of punishments beyond the grave, in the one or the other of which, every human being must have his future portion. This is a settled point, in which all are agreed. Supposing, then, that we had know nnothing more than this, and had never heard of predestination and election, would our anxieties have been less than they are, and would we have been perfectly at ease with regard to our future prospects? No, the heathen who knew nothing about God's eternal purpose to save those who believe on his Son, were deeply anxious and perplexed about their condition in the future world. "Shall I give my first born for my transgression, the fruit of my body for the sin of my soul," is the inquiry of a heathen, and of one deeply anxious to secure his soul's salvation, and willing to make great sacrifices in order to accomplish it. This inquirer was more rational in his views than many professed Christians; for he concluded that something was to be done that he might enter into life, whilst many who profess the faith of Christ seek to ascertain their future condition by prying into the hidden counsels of God, and instead of acting as he has commanded, sit moping and disconsolate, waiting till he shall be pleased to reveal to them his secret purposes. This is altogether unreasonable; God has made no secret of his purposes in regard to any man living. "He hath showed thee, O man, what is good." "If thou wouldst enter into life, keep the commandments." "Do these things, and thou shalt never fail."

God having determined in his eternal counsels to manifest his attributes and perfections, he gave birth to the visible creation; and having stored the earth with abundance, and replenished it with living things, he, at last, crowned his work by creating man, and constituting him lord over this lower world. He was made in the image of God, which implies that he was free from natural infirmity and moral imperfection. His body was then immortal; he was to be subjected to death only in case of disobedience. His fall was accomplished through the temptation of the devil, and he instantly became liable to death, and the subject of moral corruption. The punishment was not confined to himself. "In Adam all died," both naturally and morally. The fountain head being polluted could not be expected to send forth a pure and limpid stream; it would have been contrary to every thing which we observe in the analogy of nature to suppose that man, the prey of death and sin, should produce a pure and immortal offspring; and there is no more difficulty in conceiving how we should derive sin, disease, and death from Adam, than there is in conceiving how the various tribes of animals have the tempers, defects, and vices which belong to their species. On these points we cannot dwell, as we must hasten to consider the nature of the remedy which God, in his wisdom, had provided, and which was rendered necessary by the helplessness and desperate depravity of men.

Some of the wiser among the heathens had expressed their belief that a divinely inspired teacher was necessary to instruct mankind in their duty. The Jews had a firm persuasion that such an instructor would be sent; they viewed him, however, in a higher light than that of a mere teacher, and considered him as commissioned by God to redeem them from the power of all their enemies. This belief was fostered by the particular circumstances in which they were placed. It is probable that had they preserved their power and importance among the nations, they would have paid too little attention to the prophetic declarations respecting the great deliverer who was promised to them. But they had been for several hundred years a humbled and depressed people. This made them scan, with the nicest attention, all the intimations of the prophets respecting this remarkable personage; and they were so completely versant in all the records concerning him, that they had ascertained the very time when, in conformity with predictions whose inspiration was universally acknowledged, he ought to be expected.

This deliverer was known by the name of *the Messiah*, or the Christ, (both of which words signify *anointed*) long before the appearance of Jesus of Nazareth. He had been designated by this title by the prophet Daniel, who pointed out, in very intelligible terms, both the time of his appearing and the end for which he lived and died. Dan. ix. 24, &c. Accordingly the Jews were living in anxious expectation of the advent of the promised Messiah. Nor were they the only people who entertained such hopes; the Samaritans also had the same expectations, as appears from the words of the Samaritan woman in her conversation with our Lord. She does not appear to have been remarkably distinguished either by knowledge or virtue, yet she was perfectly acquainted with the expectations which generally prevailed respecting the Messiah. "I know," says she, "that Messias cometh, who is called Christ; when he is come he will teach us all things." John iv. 25. Suetonius farther informs us, that an opinion was prevalent over all the east, that a person was to come out of Judea who should obtain the government of the world. This expectation he supposes to have been fulfilled in the case of Vespasian, who went from Judea to mount the throne of the Cæsars.* Tacitus mentions the same circumstance.†

This prevailing opinion accounts for the circumstance of the wise men coming from the east to Jerusalem, to inquire for him who was born King of the Jews. They had seen some extraordinary meteor, or luminous appearance in the heavens, perhaps the same which shone round the shepherds in the plains of Bethlehem on the night of the Saviour's birth; and they concluded that it was a signal to announce the birth of the expected Messiah. When they reached Jerusalem, the same luminous appearance directed them to the house where Jesus was, and they offered him the gifts and homage which were due to a king.

We can be at no loss to ascertain the origin of these opinions and expectations. A continued chain of prophecies and supernatural communications, extending from the time of Adam to the last of the prophets, had prepared the minds of the Jews for the manifestation of the Messiah. The time marked out for the completion of these predictions falling in with the period of our Lord's birth, we read in Scripture of two impostors who availed themselves of the prevailing expectation, and collected a number of partizans to support their pretensions to the character and honours of the Messiah. Acts v. When John the Baptist appeared, he publicly assumed the character of a prophet; and his pretensions were instantly and universally acknowledged. No prophet had appeared in Israel since the days of Malachi, till the appearance of John the Baptist; a dreary interval of about four hundred years. John was therefore joyfully hailed as a prophet, and "all men mused in their hearts of John, whether he were the Christ or not." Luke iii. 15.

In these circumstances, and in the midst of these expectations, Jesus was born at Bethlehem, in conformity with the intimations of prophecy, though to appearance he was born there from the accidental circumstance of Joseph and Mary being called up to be enrolled at Bethlehem, the principal city of their tribe.

Though descended from the family of David, he was born in humble circumstances, and had no attractions of wealth or dignity to recommend him in the eyes of his countrymen. This proved a great obstacle to the reception of his doctrine among the Jews; and, indeed, more than they have been inclined to think, that it would have been more consistent with the character of a heaven-commissioned teacher, to have had more weight and authority, in order to give more extensive influence to his doctrine. But if the plan is from God, we may rest assured that the circumstances in which it was developed were the most proper, and most conducive to promote the end in view. This, indeed, seems to be a point that may easily be demonstrated. For, in the first place, his humble condition gave mankind the most favourable opportunity of examining his pretensions. Their imaginations were not seduced by the imposing circumstances of high reputation, of high rank, and of powerful family connexions. The prejudices of his countrymen were all on the other side; they received his doctrines with distrust, and fortified their unbelief by such observations as these, "Is not this the carpenter's son? Is not his mother called Mary? and his brethren James, and Joses, and Simon, and Judas? and his sisters, are they not with us? Whence then hath this man all these things?"

Is it not obvious that all these circumstances, which excited, at first, such strong prejudices against the person and the doctrines of our Lord, contribute most powerfully to strengthen that evidence by which his religion was ultimately established? Had he been received with immediate acclamations as the promised Messiah, his success would have been ascribed to popular delusion, and

* Percrebuerat Oriente toto vetus et constans opinio, esse in fatis, ut eo tempore Judea profecti rerum potirentur. Vita Vesp. c. 4.

† Pluribus persuasio inerat antiquis sacerdotum literis contineri eo ipso tempore fore ut valesceret Oriens profectique Judea rerum potirentur. Hist. b. 5.

to the want of a cool and dispassionate scrutiny of his pretensions. But it is clear that every inch of ground was disputed, and the world did not yield till it was absolutely subdued by evidence which it could no longer resist.

But farther, the humble condition of Christ was peculiarly appropriate to his character as a teacher; and had he been differently circumstanced, he could not have fulfilled some of the important objects of his mission. Viewing him as a teacher, what would have been the consequence had he been surrounded with outward pomp and splendour? It would have defeated all his instructions, and he could not have "left us an example that we should follow his steps." Had he been in the circumstances supposed, he could not have said, "Learn of me, for I am meek and lowly;" "I come not to be ministered unto, but to minister." He could not have commanded his disciples to deny themselves, and take up their cross and follow him. Such an injunction would have been quite inappropriate had he been placed in circumstances where self-denial was never exercised, or where patience and fortitude were never required. He was placed in circumstances which afforded an ample display of all those virtues which we ought to imitate. Had he appeared as a temporal prince, his followers would have been intoxicated with vanity and ambition: had he appeared in the radiance which usually accompanied the manifestation of angels, men would have been deterred from approaching him, and would have deemed it presumption to attempt to imitate him; but he exhibited an exemplification of all the virtues which he recommended, and being surrounded by the wants and all the external evils which accompany our nature, he has left the most perfect pattern of meekness, resignation, patience, and fortitude.

If a teacher, then, was to be sent from heaven for the instruction of mankind, which even Socrates conceived to be necessary, it is impossible to conceive him placed in more favourable circumstances for discharging this important part of his office than those which marked the whole life and ministry of Jesus of Nazareth.

But we must look a little more minutely into his character before we proceed to consider the great work which he came to accomplish. In this investigation we must be guided by the intimations of Scripture, subjecting them to the rules of sound criticism, and not forgetting the most essential of all rules, viz. to make Scripture its own interpreter, and to explain the passages which appear obscure, by reference to those whose meaning is incontrovertible. A very different plan, however, is adopted by one Christian denomination. For they who call in question the divinity of Jesus are forced to take their stand on texts of doubtful meaning, which they interpret according to their prejudices and preconceived opinions, and then endeavour to reduce the plainest texts of Scripture to a standard which has no existence but in their own fancies.

The first intimation of the personal dignity of Jesus is conveyed in the annunciation of the angel to his mother, "The Holy Ghost shall come upon thee, and the power of the holiest shall overshadow thee; therefore, also, that holy thing which shall be born of thee shall be called the Son of God." Luke i. 35. There is here a style and formality entirely novel; nothing like it was ever said of any of the ordinary children of men. Our translation does not convey the full force of the original, which is literally "the born holy" (το γεναμενον άγιον) shall be called the Son of God. This marks his filiation to God, by a character not applicable to any of the sons of men. He was born holy; and this cannot be predicated of any ordinary mortal, who is conceived in sin, and shapen in iniquity. Ps. li. 5. This inborn holiness of Christ was necessary to the efficacy of his atonement; for it would be in the highest degree absurd to suppose that a creature, possessing the sinful infirmities and imperfections of human nature, should be able to make an expiation for the sins of men.

But the text which has been quoted only leads us to conclude, by legitimate inference, that Jesus could not be the Son of Man by ordinary generation. The Evangelist John goes a great deal farther, and commences his history of the life of Christ with these remarkable words, "In the beginning was the word, and the word was with God, and the word was God: the same was in the beginning with God; all things were made by him, and without him was not any thing made that was made." I have already endeavoured to show that St. John uses this language in conformity with the received notions among the Jews, who always spoke of the Word as a divine person. It would be sufficient, then, to show that the sacred writer applies the designation of *the Word* to Jesus of Nazareth, to satisfy us of the view which he entertained of his character. On this point he leaves us in no doubt; for in the course of a few verses, he says, "the Word was made flesh, and dwelt among us, and we beheld his glory, the glory as of the only begotten Son of God, full of grace and truth." Thus, then, St. John describes Jesus of Nazareth by the appellation of the Word; and the Word he identifies in every respect with God; he was with God, and he was God. This text is important in more views than one; for it not only asserts the divinity of Jesus Christ, but points out most distinctly a plurality of persons in the Godhead; it affirms, in the first place, that the Word was with God, to indicate a diversity of persons; and, in the second place, that the Word was God, to point out an identity of essence.

This is one of those clear and decisive texts which one would think it impossible for ignorance to misunderstand, or sophistry to pervert. But this does not hinder the determined prejudices of the Socinians from attempting to explain away the pre-existence and deity of Christ, as indicated in this text. To accomplish this hopeless object, they explain the words "in the beginning" as applying not to the beginning of creation, but to the beginning of the Christian dispensation; it was not till then, they say, that the word was with God; and thus they affirm that Christ had no existence till he appeared in the flesh to instruct mankind. This is a fair specimen of Socinian criticism, and we may judge what degree of deference is due to it, when we see the patrons of this system affirming that he, of whom the evangelist declares that he made the world and all that is therein, had no existence till he was born in Bethlehem. That a deist should hold such an opinion is natural and intelligible; but it exceeds all reasonable indulgence that persons should pretend to form their creed on the Scriptures, and yet should go directly in the face of their most obvious meaning.* They will say, indeed, that they found their arguments on criticism: they do so, but it is such criticism as Socinian interpreters only can admit; it is contradicted by the whole authority of the learned of all ages and nations; and before their system can prevail, they must have influence not only to supercede all the existing versions of the New Testament in the different languages of the world, but they must set aside all the received lexicons and glossaries, and get the world to adopt a new system of Socinian Greek. In fact, according to the mode of interpreting employed by these theologians, the New Testament, instead of being a revelation of divine truth, is an *enigma*, concealing under its most obvious meaning a series of puzzles which would require more than an Œdipus to unriddle them. And if this record of our faith was not written under the influence of inspiration, as Socinians contend, an inspiration would, at least, be necessary for every one who interprets it according to their method; for he must leave the obvious meaning, and torture every obnoxious text till it can be reduced to the standard of Socinian orthodoxy.

We shall adduce a few plain passages declaratory of the divine nature of Jesus Christ, and then we shall consider the collateral evidence by which these declarations are confirmed.

It is admitted by all, that Jesus called himself, and allowed himself to be called the Son of God. "We believe, and are sure, says St. Peter, that thou art that Christ the Son of the living God." But it will naturally enough be inquired, what is implied in the title of *the Son of God*. Its full import no mortal can explain: but that our Lord meant it to imply his equality with God, is sufficiently clear, if language has any meaning; and it is no less clear that both his disciples and his enemies understood it in this sense. Thus when the Jews murmured because our Lord had healed a man on the Sabbath day, John v., he thus addressed them, "My father worketh hitherto and I work." Upon this we are told "the Jews sought the more to kill him, because he not only had broken the Sabbath, but said also that God was his father, *making himself equal with God*." Such was the meaning which the Jews attached to his assertion that God was his father. Is he at any pains to correct these impressions? Does he tell them that they had affixed a wrong meaning to his words? Quite the reverse; for he immediately addresses them in language more explicit than before; and confirms the inference which they had drawn respecting the high dignity which he had assumed. "As the Father raiseth up the dead and quickeneth them, even so the Son quickeneth whom he will. For the Father judgeth no man, but hath committed all judgment to the Son, *that all men should honour the Son even as they honour the Father*."

Again, in the tenth chapter of John, our Lord says, "I and my Father are one." The Jews considered this blasphemy, and immediately took up stones to stone him. Upon this he said to them, "Many good works have I showed you from my Father; for which of those works do ye stone me? The Jews answered him saying, for a good work we stone thee not, but for blasphemy, and because that thou, being a man, makest thyself God." It would have been an easy matter for our Lord to have vindicated himself from the heavy charge of blasphemy, by disclaiming the inference which the Jews drew from his words; but instead of this, he only states additional arguments to confirm them in the conclusion which they had formed, for he says, verse 37, "If I do not the works of my Father, believe me not; but if I do, though ye believe not me, believe the works, that ye may know and believe that the Father is in me, and I in him." The works to which he alludes were the miracles which he publicly performed. It is impossible to admit the reality of these miracles without admitting at the same time his pretensions to a divine character in their full extent; and the reality of these miracles was never doubted by those who had the best opportunities of judging. The Jews and all the first adversaries of Christianity never attempt to deny them; on the contrary, they endeavour to account for them on the supposition that they were wrought by magic, or by the power of the devil, a mode of explanation which a modern infidel would be ashamed to adopt.†

Admitting, then, that our Lord actually performed these wonderful works, we must likewise admit that they afford complete confirmation of his extraordinary pretensions. For he must have performed them either by a power inherent in himself, or derived from God. If he possessed power in himself, his divine character is, by that very circumstance, completely established; for God alone is possessed of proper and inherent power; or if he derived his power from God, in that case the Father is bearing attestation to the doctrines of his Son, and declaring that his pretensions to a divine character, and to divine honours, are well founded; for the Almighty would never lend his power to establish a falsehood, or to countenance pretensions which interfered with his own glory.

It is impossible for any one who reads the gos-

* Besides the first verses of the Gospel by John, we refer the reader to the following passages, all of them expressing the pre-existence, and many of them the deity of Jesus. John i. 15—30, iii. 13—31, vi. 62, viii. 58, xvi. 28, 1 Cor. xv. 47, 2 Cor. viii. 9. Those who wish to see the Socinian interpretation of these passages, and the refutation of it, may consult Dr. Hill's (of St. Andrews) Lectures on Divinity, vol. ii. p. 23; a work deserving the attention of every student of Divinity.

† Jortin observes that the Christians were called *Malefici*, Magicians, by Suetonius, which is a virtual acknowledgment of the miracles which they performed.

pels with attention, to entertain the smallest doubt that Jesus Christ decidedly and unequivocally asserts his claim to a divine nature. It is true, indeed, that he very frequently calls himself the "Son of Man;" and we are taught, by the general strain of Scripture, to consider it as essential to his mediatorial character that he should assume the nature of man. "In all things it behoved him to be made like unto his brethren, that he might be a merciful and faithful high priest in things pertaining to God, to make reconciliation for the sins of the people." Heb. ii. 17. But as has been well observed,* there is a manifest peculiarity in the frequency with which our Lord assumes the designation of the "Son of Man;" he was guarding against the error of denying his humanity, which was not long of creeping into the church; he therefore assumes an appellation which none of the ordinary sons of men ever think of applying to themselves, because in their case it would be ridiculous to announce as a truth, what, in fact, is a truism, and never was denied by any human being. But there might have been room for doubting it in the case of our Lord, who exhibited such unequivocal proofs of divine power and omniscience. He therefore assumes an appellation peculiarly honourable to our nature, and implying a truth essential to our comfort; and by the frequency with which he repeats it, he shows that he was more anxious to be considered man, than afraid of being denied to be God.

It is very singular that almost all those who have questioned or denied our Lord's divinity, have bestowed high praise upon him as a wise and virtuous man, and as an enlightened teacher of morality. But they who do not allow him to be more than man, ought, like the Jews, to consider him as a blasphemer, for he publicly and repeatedly taught, and indeed it seemed to be the point on which all his doctrine hinged, that he and his Father were one; and he declined not the homage of religious adoration, when Thomas addressed him, after his doubts were removed, in language appropriate only to the Deity, "My Lord, and my God." Does our Lord rebuke Thomas for using language which was positively impious if applied to any mere man? If there is any rebuke implied in our Lord's reply, it is because Thomas had been too tardy in recognising the truth which he at last avowed. "Thomas, because thou hast seen me, thou hast believed; blessed are they who have not seen and yet have believed." John xx. 29.

This part of the argument might be carried to much greater length, and might be strengthened by a great number of quotations from the gospels, all equally decisive as to our Lord's divinity. But it cannot be necessary to multiply texts on this subject; neither ingenuity nor sophistry can explain away the plain import of the passages already adduced; it is not in the power of language to express more clearly these important truths, that Jesus in his lifetime advanced claims to a divine nature; that his apostles recognised these claims; that his enemies publicly charged him with blasphemy for advancing them; and that on such occasions he not only did not withdraw them, but supported them by additional arguments.

The testimony of Pliny is not unimportant to show how early divine honours were paid to Christ. In a letter to the Emperor Trajan, giving an account of the transactions in his province, where the Christians had become numerous, he states the manner in which he had proceeded with them; he mentions that he had inquired into their particular opinions, and that his information on this point amounted only to this, that "they were accustomed to meet on a stated day, before it was light, and to sing a hymn to Christ, as to God."† Dr. Priestley engaged in the desperate undertaking of attempting to prove that the early opinions concerning Christ were unfavourable to his divinity. He has been answered by Dr. Horsley, and has been absolutely overwhelmed and crushed by the force of his arguments and the extent of his learning.‡

But in maintaining the divine nature of Christ we are not to forget his humanity. It is an essential article in the orthodox creed that he is both God and man. And so intimately are the two natures connected, and yet so distinct are they in their properties, that he is sometimes spoken of in Scripture, as possessing only the attributes of God; and at other times as endowed exclusively with the feelings and faculties of man. He is "God over all blessed for ever;" and he is also the "man of sorrows and acquainted with grief." Sometimes he manifests his divine power, and multiplies a few loaves and fishes, so as to be sufficient for the supply of five thousand people. At other times we read of his being faint and hungry, and destitute of the ordinary comforts of life. Sometimes, when speaking of himself as man, he seems to state limitations both to his power and his knowledge; at other times he asserts all the prerogatives of divinity, and lays claim to the same honours which are due to the great Father of all. But all these passages are easily understood, if we bear in mind that Jesus had a proper divinity as well as a proper humanity: and that the same thing cannot be predicated of these two natures. Each of them has a distinct character not applicable to the other.

There is also a third character in which he appears, viz. that of a mediator, which has a distinct and appropriate office, and of which certain circumstances may be predicated which are not applicable to Christ either in his divine or in his human nature, when separately considered. Thus when he says that *he can do nothing of himself but as he is commanded by the Father*, he speaks of his mediatorial office, in which a definite work was given him to perform, and from which he could not possibly deviate without frustrating the work of God, and deserting the enterprise which he had undertaken. In this respect, a limitation was laid even on his own omni-

* See Magee on the Doctrine of Atonement and Sacrifice.

† Affirmabant hanc fuisse summam vel culpæ suæ, vel erroris, quod essent soliti stato die ante lucem convenire; carmenque Christo, quasi Deo, dicere secum invicem. Plin. Epist. Lib. 10.

‡ See Horsley's Letters to Priestley.

potence; and he was bound to fulfil every article stipulated in the eternal covenant between him and the Father. Yet, in all this, his power was restricted only by his own will; and he submitted to a voluntary humiliation, and a voluntary relinquishment of power, that he might accomplish a work which could not by any other means have been effected.

Though we ought carefully to abstain from all attempts to explain the manner of the Incarnation, yet it is neither improper nor unprofitable to consider the consequences which have resulted from it, and even to illustrate them by analogies drawn from sources of knowledge more immediately within the reach of our faculties: and I have no hesitation in saying that the Incarnation of the Son of God, instead of appearing an objectionable doctrine, presents to us the most interesting, perhaps the only intelligible view of the Almighty, and of the duties which we owe to him. When men take what they are pleased to call a philosophical view of the nature of God, they are soon lost and overwhelmed in the immensity of the subject; for what conception can we form of a being without beginning and without end; without appetites, without passions, without bodily form; incapable of being injured by our sins, or benefited by our services? Such a being as this (and it is only as such that the light of reason can recognise God,) must appear rather as an abstract conception of the mind, something resembling the fate of the heathens, than as an object of love, gratitude, and adoration. On this account, the most philosophical inquirers, who have not had the light of the gospel for their guide, have been bewildered in the vast generality of the subject; and have regarded the supreme being rather as an object of speculative contemplation, than as entitled to the affections and the worship of his creatures. The ignorant and uninformed fell into an opposite error. They could form no conception of God, but as of a being resembling themselves; and hence they represented him by forms and images adapted to their prejudices and feelings. All these inconveniences and sources of error are removed by the Incarnation of the Son of God, which was manifested in condescension to our weakness, to show the tender care, the paternal love, the constant providence of our heavenly Father.

We have now a definite object of worship, in the person of the Son of God, in whom "dwelt all the fulness of the Godhead bodily," who was once a visible and tangible object of affection; who still retains, at the right hand of God, the human nature along with the divine, and who is still establishing additional claims to our gratitude and love, by making continual intercession for us. We have now, as it were, a palpable object of worship, accommodated, as far as possible, to the circumstances of our nature and of our feelings, exhibiting, in our form and likeness, all those splendid and divine qualities which are calculated to excite religious homage, and all those feelings of brotherly kindness and charity, which ensure our love and our imitation.

In short, the incarnation of Jesus Christ, though it involves a mystery far exceeding our comprehension, is nevertheless in perfect conformity to the preceding dispensations of God. Under the law, God was pleased to establish certain visible representations of himself to aid the conceptions of the Jews, and to remind them of his presence: the ark, and the cherubim, and the cloud, were viewed with the most profound veneration, as emblems of the divine presence: and besides this, God often condescended to converse with men in a visible form, and to give to them immediate intimations of his will. But certainly a much more lively and interesting, and impressive representation of the divine majesty was given in the Incarnation of Christ, by which "The Word became flesh and dwelt among us and we beheld his glory, the glory as of the only begotten of the Father, full of grace and truth."

Instead, then, of having any doubt whether we ought to yield religious homage to the "Son of Man," we ought to conclude that there is no other way of worshipping God, with acceptance, but through him. There is a vast emphasis of meaning in our Lord's words, when he says, "I am the way, the truth, and the life, no man cometh unto the Father but by me." These words not only imply that Christ is the way by which men come to the enjoyment of God in his heavenly kingdom, but that there is no other way in which we can form any accurate conception of him, or yield to him a rational service. "No man hath seen God at any time; the only begotton Son which is in the bosom of the Father, he hath declared him." This is the nearest approach to an open vision of the Almighty that ever has been, or can be made by mankind in the present world. We cannot behold him in his glory, for no man can see his face and live. But we see his glory shining with a mild radiance, and a qualified lustre, in the person of his Son, not so intense as to prevent us from approaching him, or deter us from imitating him; but drawing us to God by the most powerful attractions, and teaching us to aspire to the imitation and the enjoyment of the Father of our spirits. We are thus brought near to God by the incarnation of his Son, who assumed our nature that we might rise to the resemblance of his; and, by imitating his example and imbibing his spirit, might at last vindicate our claim to the glorious title of sons of God.

The prophecies which Christian authors have interpreted as fulfilled in Christ, are admitted on all hands to have existed long before he appeared on earth. They are publicly cited by his apostles, in their discourses to their countrymen, and appealed to as affording the most unexceptionable evidence to the truth of the Gospel.

To the Jews such evidence ought to have been decisive. They knew the history of the prophecies: they themselves had the keeping of them; and they had embraced them as forming the foundation of their hopes: they could therefore entertain no suspicion that they had been fabricated for any particular purpose. The prophetic writings were sufficiently clear to warrant certain conclusions, such as the appearance of the Messiah, the time of his advent, the universality and perpetuity of his kingdom. On these points there was not the slightest ambiguity; they are stated in the most unequivocal language, and they formed a part of the creed of the Jews several centuries before the time of Jesus of Nazareth.

But whilst the leading features of the prophecies respecting the Messiah were so clear, the details or the filling up of the scheme were involved in intentional obscurity, that men being left to their own volitions, and unconstrained and uninfluenced by the foreknowledge of events, might become the unconscious instruments of accomplishing the designs of heaven. Had the Jews distinctly understood the predictions respecting the death of Christ, and known that it was to be an essential circumstance in the character of the Messiah that he should be crucified by those whom he came to save, it would have been impossible for such an event to have been accomplished. They would not have put to death one whom they received as the Messiah: their reception of him would have been altogether inconsistent with such an act of violence, and they would not have insisted on the crucifixion of one whom they deemed an impostor, lest by this very act they should strengthen his pretensions. This, therefore, was "The wisdom of God in a mystery, which none of the princes of this world knew, for had they known it, they would not have crucified the Lord of Glory." 1 Cor. ii. 8.

This obscurity in the prophecies of Scripture must not be supposed to bear the most distant resemblance to the studied ambiguity of the heathen oracles. These were only consulted with regard to events immediately future; men take little interest in what is very remote in its date and consequences: there was, therefore, the utmost need for caution, lest, by a rash response, the credit of the oracle should be weakened or destroyed. The answers were, accordingly, so contrived as to flatter the hopes of the inquirer, and, at the same time, to save the credit of the oracle in case of failure. There is a most remarkable difference between such responses and the oracles of God. The latter are never ambiguous with regard to events immediately future, whose occurrence is determined by circumstances which have already happened, though their result and issue may be entirely unknown to men. Thus, Jeremiah made no mystery of the captivity of the Jews which was to take place in his own time; whilst to comfort them, he announced its termination, after a lapse of seventy years. In the same manner our Lord declares that Jerusalem should be utterly destroyed, before the generation which heard the denunciation should pass away. The same observation applies to all the prophetic announcements in Scripture, which apply to events immediately future. The intimations of Joseph to Pharaoh, of Daniel to Nebuchadnezzar, of Samuel to Eli; are delivered without the slightest ambiguity, or attempt at concealment. No provision is made for evasion in case of failure; the credit and the safety of the person who announces the will of heaven are fairly staked on the issue; and in all these cases, the result has been such as to produce implicit faith in the predictions respecting distant and darkly intimated events.

But there is not the same clearness of meaning when the prophecy relates to events of remote date, and of momentous importance in the history of the world, or of the church of God. It is then veiled in figure, in allegory, and in mystery; though we may discern a dark outline we cannot complete the picture; and we must wait with patience till it stands revealed by the evolution of events, which completely interpret the previously intimated counsels of heaven. The use of such prophecies is rather to convince mankind of the constant universal providence of God, than to lift the veil from futurity; and whenever an event occurs which, by the circumstances attending it, can be proved to have been foretold, that event bears the signature of heaven to its truth, and its importance in the economy of providence.* In short, it seems to have been the intention of the Almighty that events should explain the prophecy, rather than that the prophecy should make mankind fully acquainted with future events. It is evident that the prophet, in foretelling distant events, had no inducement to affect mystery where there was no danger of being detected, and where he had so many opportunities, had he been an imposter, of advancing his interest, by flattering the prejudices of his countrymen, or of indulging his malignity by terrifying them by unequivocal denunciations of judgment.

Indeed, there is every reason to think that the prophets themselves were unacquainted with the meaning of many of the most important predictions which they delivered. They had visions and dreams in which certain representations seemed to pass before their view, and certain words seemed to reach their ears. They knew they were under a prophetic influence, and that they were bound to record faithfully what they had heard and seen. But they gave themselves no concern about the interpretation; nor do their countrymen ever press them for an explanation of their dark and mysterious intimations. They related all that God had been pleased to reveal, and they would have deemed it presumption to have pryed farther into the secrets of heaven. God reserved to himself the interpretation of his own counsels; and, by the events of his providence, demonstrated that he ruled in the armies of heaven, and regulated the affairs of the children of men.

The first prophetic intimation of the Messiah is supposed to be contained in the promise that the seed of the woman shall bruise the head of the serpent. The promise is afterwards renewed to Abraham, for it is said that in him all the families of the earth should be blessed. This promise has never received a literal fulfilment, by any temporal blessings conferred on the human race, by the natural seed of Abraham; but it has been completely fulfilled, or is in the progress of being fulfilled, by the

* Gibbon calls prophecy an *argumentum ad hominem*, applicable only to the Jews who believed in its truth. We, on the contrary, contend that it is an evidence equally applicable to all who admit that the prophecy existed before the event which explains it.

blessings which Christ, his lineal descendant, according to the flesh, has conferred, and is still conferring on the human race. The prophecy of Jacob on his deathbed, has been universally understood by Jews and Christians to apply to the Messiah. "The sceptre shall not depart from Judah, nor a lawgiver from between his feet, till Shiloh come, and unto him shall the gathering of the people be." This prophecy defines with considerable precision the time of his appearing. Moses, shortly before his death, said to the Israelites, "The Lord thy God will raise up unto thee a prophet, from the midst of thee, of thy brethren, like unto me; unto him ye shall hearken." This prophecy is applied by the Apostles (Acts iii. 22) directly to Jesus of Nazareth.

The prophet Isaiah (ch. liii.) points out more particularly the peculiarities in the character and history of the Messiah, his innocence, his sufferings, and the object which was to be accomplished by them. The sixty-nine weeks of Daniel, which were to elapse between the rebuilding of Jerusalem and the cutting off "Messiah the prince," mark still more definitively the time of his suffering. In the interpretation of this prophecy, all divines consider a day as representing a year; and, according to the most accurate chronology, by calculating on this plan, the time of the Messiah's death will be found to be exactly defined.

We stop not to point out how completely these prophecies have been fulfilled. Almost all the prophecies, too, speak distinctly of the rejection of the Jews, for a season, at least, and the calling in of the Gentiles. How was the latter event ever to take place under the narrow and exclusive system of Judaism? The ordinances and ceremonies appointed to the Jews, were rather intended to keep them separate from the rest of the world, than to induce other nations to adopt their ritual. But the prophets announced a more liberal dispensation, by which all men were to be brought to the knowledge of the truth.

As an evidence of Christianity, prophecy has several advantages over miracles. A miracle is not generally presented more than once to the senses; a prophecy can, at any time, be steadily examined by the eye of the understanding. The evidence arising from the fulfilment of prophecy gathers strength by the lapse of time; and the great events which are successively evolved, in the course of providence, have all the effects of a miracle to strengthen our faith in a divine revelation. The Apostle Peter states, as the ground of his own conviction, the miracles which he had seen, and the voice which he had heard on the mount. So far as he himself was concerned this was quite sufficient; he states, however, another species of evidence more accessible to all mankind. "We have also a more sure word of prophecy; whereunto ye do well that ye take heed, as unto a light that shineth in a dark place, until the day dawn, and the day star arise in your hearts." (2 Peter i. 19.)

Modern infidels pay the highest compliment to the prophecies when they affirm them to be fabrications written after the events which they pretend to predict. This amounts to a confession that the events and the prophecies correspond with each other; and when this is admitted, it is the easiest thing in the world to prove the antiquity of the predictions. On this point the Jews and the Christians are as one; and though the former have suffered so much on account of their rejection of the true Messiah, whose pretensions are founded on the Law and the Prophets, yet nothing has been able to make them justify their unbelief, as modern sceptics affect to do, by denying the antiquity or authenticity of the Scriptures which testify of him.

It is a singular and striking feature in the evidences of Christianity that it founds its pretensions on the very records which the Jews had, for so many ages, been accustomed to respect: and it shows their reverence for the sacred volume, that though it contains so many distinct prophecies to convict them of obstinacy and wilful ignorance, they have yet never attempted to corrupt the sacred text, and make it more conformable to their prejudices. The vigilance of the Christians, indeed, would have rendered it impossible to execute such a design; for they instantly adopted the Jewish scriptures as their own, and guarded them with the most jealous care, as displaying the gradual development of that wonderful scheme which was perfected by the mission and sufferings of Jesus of Nazareth. The Jews felt themselves pressed by the authority of their own scriptures; but they did not dare to alter the original record. There was a translation, however, of the Hebrew scriptures in Greek, now commonly known by the name of the Septuagint, which was in very general use among the Jews in the time of our Lord. This translation had been used by the Jews residing in the Gentile cities, for upwards of two hundred years before the birth of Christ. It is chiefly from this version that the heathen authors derived their knowledge of the Jewish law, and of the doctrines of scripture; and we may judge of the accuracy with which it is executed from the circumstance of its being quoted by the writers of the New Testament. The Jews, finding this version as hostile to their notions as their own original scriptures, encouraged a new translation into Greek; but no effort has ever been able to subvert the clear evidence which stands against them in their own scriptures.

But the evidence resulting from prophecy is not to be confined to the predictions contained in the Old Testament scriptures. The prophecies delivered by our Lord and his apostles are equally conclusive to the same purpose. We allude merely to the unequivocal predictions which he delivered respecting the destruction of Jerusalem, and the rapid progress of his religion. The former event was not improbable from the character of the Jews; the latter was in the face of all human probability.

Yet, notwithstanding the low and suffering condition of Jesus, and the opposition and animosity which his doctrine excited, he uniformly expressed the most perfect confidence in the ultimate success of his religion. He compared it to a grain of mustard seed, which, though very minute at first, increases rapidly till it becomes a tree, and the fowls of heaven take shelter under its branches. The illustration is beautiful and appropriate, and has been verified by the event. He might have compared it to the oak which springs from the acorn, and, in process of time, becomes the ornament of the forest. Such an illustration would have pointed out the small beginning and ultimate stability of the gospel. But the mustard seed was a more appropriate emblem of the rapid growth and advancement of Christianity in the world. This certainly was an event little to be expected on any calculation of human policy. The religion of the Jews, with which Christianity was at first confounded, and from which it is not altogether distinct, was an object of contempt among the heathen nations, on account of its peculiarities and exclusive spirit, and the Jews themselves were viewed with a dislike bordering on abhorrence. How unlikely was it then that a religion, founded, as the heathens believed, on the peculiar institutions of the Jews, (though these, in reality, had been appointed with a reference to it,) should so speedily triumph over all the forms of religion which then existed in the world, which had been consecrated by the strains of the poet, mixed up with the civil institutions of the state, associated with the feelings and prejudices of the people, and protected alike by the arms and the eloquence of their votaries? Yet all these forms of religion vanished almost as rapidly as enchantments are supposed to do when dissolved by the counter-spell of some more powerful magician.

As Jesus Christ publicly claimed a divine character, and divine honours, he would have been destitute of the strongest evidence of his pretensions, had he not had the power of working miracles. When the evangelist declares that "by him all things were made," it would have amounted to a falsification of such pretensions, had he never demonstrated his power over the works of his hands. In consistency with this idea we find that whilst the prophets, under the Old Testament dispensation, referred all the miracles they wrought to the immediate power of God, the Apostles no less uniformly refer all their miracles to the power of Jesus of Nazareth; which is itself a demonstration that they conceived him possessed of divine power, and that they thought it not derogatory to God to perform miracles in the name of him whom he had sent.

It is farther to be observed that Christianity, (including under this name the religion of the Bible at large,) is the only system of religious worship professedly founded on miracles. Our Lord publicly appeals to them in confirmation of his doctrine, and as proofs of his divine mission. "I have greater witness than that of John," says he, "for the works which the Father hath given me to finish, the same works that I do bear witness of me that the Father hath sent me." John v. 36. All religions, indeed, have pretended to miracles; but with them they are continued; they are not referred to the infancy of the system which they are brought to support: they gain credence only after it has reached its full maturity, when superstition or political jugglery can give easy currency to pretended miracles which fall in with the national taste, humour and established prejudices.

Now consider the circumstances under which the Christian miracles are said to have been wrought, and observe how striking is the contrast. They are ascribed to the author of Christianity, and to his immediate disciples, to whom he delegated the task of converting the world. But with them they stopped: at least we have no sufficient evidence of a well-attested miracle, performed by their immediate successors: and none but the *charlatans* of the church of Rome, have ever pretended that they extended beyond their times. In the worst ages of this corrupted church its members began to revive pretensions to miracles, and obtained easy credit on account of the besotted ignorance of the people. Christianity rejects such miserable shifts; and being "built on the foundation of the prophets and apostles, Jesus Christ himself being the chief corner stone," it cuts off all attempts at quackery and imposition in after times, by with-holding from all the exercise of miraculous gifts.

We may safely affirm that it was absolutely impossible for such an extraordinary religion to be established in the world without miracles; and therefore God did not make such an unreasonable demand on our belief as to require our assent to it, without the most extraordinary and satisfactory proofs: he did not require us to receive on light grounds, and imperfect evidence, a religion which was to be "the savour of life unto life, or the savour of death unto death," but he exhibited demonstrations of power sufficient to convince even the senses of the generation to which the gospel was first addressed, and to satisfy the reason of all succeeding generations of the world.

But it is inconsistent with the plans of divine providence that miracles should be long continued; and it would be foreign to the constitution, and adverse to the interests of the human mind, were miracles interposed where the object can be obtained by the judicious exercise of the powers which God has given us, aided, as he has promised they shall be, by the influences of his Spirit: which influences, however, are given only to assist, not to supersede our exertions. Whilst, therefore, miracles were absolutely necessary to demonstrate the important truth that Christ "had power to forgive sin," for nothing less could have produced this conviction; it was not necessary after this point was established, that miracles should be continued; but a religion being fairly introduced, consistent with reason, and adapted to the wants, and to the best interests of men, we are left to form our opinion concerning it, from an attentive examination of the evidence on which it was originally founded, from its conformity to the general plans of divine providence, and from its adaptation to the circumstances of human nature. And if we examine the authentic documents in which the facts and doctrines are recorded; and attend at the same time to the evidence which an unprejudiced conscience must bear to the utility and intrinsic excellence of the doctrines and precepts of Christianity, we will be persuaded that no higher evidence of its truth can reasonably be demanded, or can, in the nature of things, be afforded. If a miracle were required to solve every doubt, the remedy would soon lose its efficacy; for the more frequently it was repeated, the weaker it would become, as was illustrated in the case of the Israelites in the wilderness, who, though fed and conducted every day by miracles, seem to have been no more affected by them than by the ordinary phenomena of nature.

In the establishment of a religion of such high pretensions as Christianity, which offers eternal life to those who receive it, and denounces the most awful judgments against those who reject it, we have a right to expect the strongest evidence that can possibly be afforded, consistently with the plans of God's government: and if we had our option as to the nature and extent of the necessary proofs, the mind can conceive nothing more decisive than the miracles performed by our Lord and his Apostles. But we cannot be so unreasonable as to expect that those signs and wonders are to be repeated to every successive generation: if any man will still require a sign from heaven to confirm his faith, he can only be gratified through the medium of candid and diligent inquiry into the nature and evidence of the miracles recorded in Scripture.

With regard to our Lord's miracles, the first thing deserving notice is that they were publicly performed; and that the account of them, in the very form in which it has come down to us, was circulated among the men of that generation which had witnessed them.

It ought to be observed also, that our Lord's miracles were not disputed by the early opponents of Christianity. Their attempts to account for them amount to an admission of their reality. Julian, the apostate, does not deny the fact of the five thousand being fed, apparently, by five loaves and two fishes, but he accounts for it by ascribing it to the power of magic, or to some illusion wrought on their imagination. They who can swallow this need not bogle at any miracle, for we can conceive nothing more miraculous than that five thousand hungry men should be satisfied with an imaginary feast.

It was reserved for modern unbelievers to dispute facts which remained uncontroverted by the only persons who had it in their power to give an effectual refutation, by an unequivocal denial of the statements, had they known them to be false. Yet this was never done: unreasonable as the first adversaries of Christianity were, they did not dare to show the extent of their prejudice and animosity, by denying what thousands could attest on the evidence of their own senses. And on the same principle the evangelists boldly state, and publish to the world what they knew the most inveterate of their enemies would not dare to contradict. They make no parade in the statement of these miracles: to them they were not wonderful; for they knew that nothing was impossible to him who performed them: they show no anxiety to conciliate belief; it never entered into their mind to suppose that there could be any doubt on the subject: they therefore state them as simple historical facts, for the information of those who were not eye-witnesses of them; and the time and circumstances in which they were published may be considered as equivalent to a challenge to the whole nation of the Jews, to contradict, if they could, any one of their statements.

Take any one of the miracles which our Lord is said to have performed, and think how impossible were the means of imposition. Would any persons, in possession of their senses, have affirmed in the face of thousands who could have refuted them, had they deviated from the truth, that Christ fed five thousand persons in the wilderness with five loaves and two fishes, and that twelve baskets of fragments remained after the feast; that he raised Lazarus from the dead, after he had been four days in the grave, in the presence of a great number of persons who had gone from Jerusalem to condole with his sisters; that great multitudes went out to meet Jesus on his approach to Jerusalem, and that one great motive was that they might see Lazarus who had been raised from the dead? Would any one have ventured to affirm that the sun was covered with darkness during the space of three hours, when our Lord was on the cross, had not this been a fact notorious to the whole land of Judea? The most barefaced impostors that ever lived never dared to vent such falsehoods as these, in the face of thousands, who had the evidence of their own senses, or the testimony of numberless eye-witnesses to contradict their assertions. And had the evangelists been guilty of such extravagance, they must not have been impostors but madmen; and the history of their phrenzy never would have survived to excite the astonishment of the world: or if it should be affirmed that they were really mad, then the world must be concluded to have been as mad as they, to have believed their account, or to have allowed their extravagant assertions to pass uncontradicted, when the impression which they made became obvious. and in considerably less than forty years, undermined the foundations of all the religious systems in the world. We shall soon see that the Apostles were possessed of sound and candid minds, and that they only who resisted the conclusions resulting from their statements deserved the name of madmen.

We only propose to examine minutely the evidence for one of the miracles recorded in Scripture; but it is one of principal importance; for if it be false, none of the rest can be true; or if they be true, they are of no avail. We allude to the miracle of our Lord's resurrection, on which he stakes the credit of his pretensions and the truth of his religion. The Scribes and Pharisees said to him, "Master, we would see a sign from thee." But he answered and said unto them, "an evil and adulterous generation seeketh after a sign; and there shall no sign be given to it, but the sign of the prophet Jonas; for as Jonas was three days and three nights in the whale's belly, so shall the Son of man be three days and three nights in the heart of the earth." Mat. vii. 38, 39. On another occasion, the Jews said to him, "What sign showest thou unto us, seeing that thou dost these things?" Jesus answered and said unto them, "destroy this temple, and in three days I will raise it up." John ii. 18, 19. And to show what importance the apostle assigns to this miracle, he says, "If Christ be not risen, then is our preaching vain, and your faith is also vain." 1 Cor. xv. 14. If this miracle, then, be well ascertained, it renders all the rest credible, and may, indeed, be considered as the crowning evidence by which the truth of the gospel miracles and the gospel doctrines is attested.

There is reason to doubt if the best accredited facts in the history of the world be attested by such full and satisfactory evidence as the miracle of Christ's resurrection. It is seldom that we have the concurring testimony of four contemporary historians respecting any one event, of which they declare themselves eye-witnesses. The history of the world is not written in general by eye-witnesses, but by persons who have derived their information from various and uncertain sources; sometimes taken up from common report, or from documents which cannot be authenticated, and generally tinctured in its course by the imagination or prejudices of the writers and reporters. On these accounts a great degree of scepticism is allowable with regard to the commonly received history of the world. But should we meet with four ancient historians who declare that they had all been present during a war or a campaign, and who write accounts of the transactions agreeing in all essential particulars, and not positively contradicting each other in any, we would not hesitate for a moment to yield implicit credit to the general facts which they have recorded. But, if we except the account of the resurrection, and of the other occurrences in the life of our Lord, there is no event of ancient history which comes down to us thus attested.

We receive, with implicit confidence, Sallust's account of Cataline's conspiracy, because he was a contemporary, though not particularly engaged either on the one side or the other; we never entertain a doubt as to the events which occurred in the expedition of Cyrus, and the retreat of the ten thousand, because they are recorded by Xenophon who was present, and who conducted the retreat. We have no doubt whatever as to the exploits of Cæsar, because he himself recorded them; we scarcely allow ourselves to entertain the very natural suspicion that his statements may be distorted a little by self-partiality. We believe the short account which Eutropius gives of Julian's expedition against the Parthians and Persians, because he tells us that he himself served in that campaign. But in all these cases there is only one competent witness, on whose evidence we depend; and, generally speaking, we are sufficiently liberal in allowing its due weight to human testimony. We only ask the same candour to be extended to the history of the resurrection. This event is recorded by the four evangelists who saw and conversed with Jesus after his resurrection. Some have supposed that Luke ought to be excepted. But this is not certain; and his own words seem to imply the contrary: for he says he "had perfect understanding of all things from the very first." Here, then, are four authors writing separate and independent accounts of a wonderful event, of which they declare themselves to have been eye-witnesses; their statements as to time and circumstances agree in all material points; with such shades of difference, however, as prevent all suspicion of collusion or preconcerted design. Nobody can doubt that they were amply qualified as witnesses, from the opportunities of observation which they enjoyed; and there can be no possible reason for rejecting their evidence, unless some suspicion can be cast on their motives.

There are only two grounds on which suspicion can rest; it may be said either that they wished to deceive others, or that they themselves were deceived. Before we fix upon them a charge of desiring to impose upon the world, it will be but fair to show some reason for their entertaining such a design. That they had no such design must be apparent to every one who candidly examines their account. They all agree in declaring that Christ's resurrection was an event which they did not expect, and that they all doubted its reality after it was first announced to them. This is very unlike the language of impostors; it shows that they did not believe, or did not understand, the repeated intimations which their master had given respecting his resurrection. Had they been impostors and fabricated the accounts, the best way would certainly have been to set a bold face to the business at once, and to have declared that the resurrection of their master was an event which they had, from the first, confidently expected. But their declaration that they did not expect it corresponds exactly with the idea which they had formed of Christ's character and kingdom. They never allowed themselves to believe that he was to die, and, of course, they could not possibly understand the hints which he had given respecting his resurrection.

But it may be said that the disciples had motives of self-interest which induced them to frame and propagate the doctrine of Christ's resurrection. If this can be shown it must excite suspicion, if it does not amount to a valid objection. For it is not uncommon to see men advancing and obstinately maintaining the greatest absurdities and falsehoods, when they have an interest in doing so. Truth is then sacrificed to some supposed advantage. But amidst all the inconsistencies of human conduct we doubt if any man ever continued for any length of time to assert a falsehood, when it not only brought him no advantage but every possible inconvenience. A man who has told a lie once may persist in it for a while, for the sake of consistency, and to avoid the humiliation of confessing himself a liar. But let his interest lie on the other side; let his falsehood bring misery and contempt along with it, and he will soon be brought to his senses, and renounce an imposition so injurious to his own comfort.

Let us see whether this reasoning does not apply in its full force to the circumstances of the apostles and all the first witnesses of Christ's resurrection. What possible object could they have in persisting in an account so very improbable, had they not known that it was a truth of the most momentous importance which they were bound to promulgate to the world? They soon found that it had no tendency to promote their reputation, but rather to make them be laughed at as fools, as happened in the case of the apostle Paul when he preached the doctrine of Christ's resurrection to the philosophers at Athens. People, however, can bear to be laughed at when they gain any thing by it. But what were the disciples to gain by proclaiming the resurrection of their master? Not wealth and pleasures, surely; for they preached up abstinence and mortification: nor yet power and honours, for they knew, to use an expression employed by the most eminent among them, that they were counted "the off-scouring of all things." Here, then, we may justly say, is a marvellous thing, that so many men should persist in propagating a known falsehood without object or end—without interest or motive, and that they should daily expose themselves to insult, to persecution, and to death, solely for the purpose of propagating an unprofitable lie. Could we suppose all this possible, no parallel could be found to it in the annals of human folly, which are sufficiently pregnant with absurd materials. Yet scarcely will we find one man, much less great numbers of men, who will choose to be gratuitously wicked, and persist in a known falsehood, when it not only brings them no profit, but, on the contrary, subjects them to every conceivable disadvantage.

But we must be prepared for the other alternative, viz. that the first disciples were weak and enthusiastic men, and that they were themselves deceived, and became the dupes of their own delusions. And here, we will readily grant, that when once the mind is infected by any false doctrine or erroneous opinion, it is not easy to say to what lengths it may go in extravagance and folly. Hence we have seen men suffering for opinions which all the world but themselves knew to be false or pernicious. This is conceding as much as the adversaries of Christianity can require. But it will be of no avail to them. For it must be observed that all the great points on which our religion rests, and particularly the doctrine of Christ's resurrection, are not matters of *opinion:* they are *facts*, with regard to which even an enthusiast could not be mistaken. No stretch of imagination could make twelve men, nay, five hundred men (for by this number was our Lord seen after his resurrection), no stretch of imagination could make such a number believe that they saw Jesus alive, after he had been crucified, that he conversed with them familiarly for forty days, and then ascended into heaven in presence of them all. That there might be no room to suspect even the possibility of a mistake, he appeared to them on various occasions, and for a length of time, so as completely to satisfy the most scrupulous and incredulous among them, of the reality of an event so pleasing, but so unexpected. They do not disguise the pleasure and surprise which they felt on receiving the first authentic intelligence of the resurrection. "They believed not, for joy;" an expression struck from the mint of truth, and incapable of coming from the lips of a deceiver. They thought it was too good news to be true; and they felt that mixed sensation of joy, wonder, and incredulity, which overwhelms a depressed or wounded spirit, on the announcement of great and unexpected good fortune.

The apostle Paul enumerates several, though not all, of the occasions on which Christ appeared after his resurrection. He says that he was first "seen of Cephas, then of the twelve; after that he was seen of above five hundred brethren at once, of whom the greater part remain unto this present; but some are fallen asleep; after that he was seen of James, then of all the apostles; and last of all he was seen of me also, as of one born out of due time." 1 Cor. xv. 5—8. Now, were we even to admit the supposition of the infidel, that the first witnesses of the resurrection were enthusiasts, this admission would only tend to strengthen the evidence for the extraordinary fact; for an enthusiast is always an honest man; he may be deceived in a matter of opinion, but he has no wish to deceive others; and therefore when he attests, not the reveries of his fancy, but the objects which have come under the cognizance of his senses, he may be implicitly believed.

The amount of the argument, then, in so far as regards the motives of the first witnesses of Christ's resurrection, may be thus stated: if they had been impostors they would have had more sense, and more regard to their own interest, than to publish and persist in such an improbable and unprofitable doctrine: and if they had been enthusiasts, they would have had more honesty than to affirm as truth what they knew to be false; for a man cannot be an enthusiast, and at the same time a wilful deceiver.

But let us look for a moment to the features of the fact, as stated by the sacred historians, and not denied by the enemies of Christianity. The Jewish rulers were fully aware that our Lord had declared that he would rise again on the third day after his death.

We have already shown that the disciples could not understand this, because they could not allow themselves to think that the Messiah was to die. But the Jews, who had all along been bent on his death, had no such prejudices to obscure their conceptions. Judas, too, who had become their agent, and who had none of the views and feelings of the other apostles to prevent him from understanding the distinct intimations which our Lord gave of his resurrection, would doubtless put his employers in full possession of all these particulars; and they were not lost upon them; for they took the most judicious precautions to prevent an event which, if accomplished, they foresaw would render abortive all that they had done. The chief priests and Pharisees, therefore, went to Pilate, and said, "Sir, we remember that this deceiver said while he was yet alive, after three days I will rise again: command therefore that the sepulchre be made sure until the third day, lest his disciples come by night and steal him away, and say unto the people he is risen from the dead: so the last error shall be worse than the first." Pilate readily assented to their proposal; "so they went and made the sepulchre sure, sealing the stone and setting a watch."

Yet notwithstanding of all these precautions, the body of Christ did disappear on the third day, as the Jews themselves confess, and no infidel has been hardy enough to deny it. And how do they account for the circumstance? The only account they have ever attempted to give is, that the disciples came and stole away the body whilst the guard was asleep. If they could possibly have invented any other feasible story, or if falsehood could ever find a secure asylum, they never would have published an account so full of improbabilities and contradictions. For, in the first place, it is in the highest degree improbable that so many men as composed the guard (the number we do not exactly know, but we may be sure it was such as was deemed sufficient to defeat all attempts on the part of the disciples to carry off the body either by stratagem or force) should have all been so fast asleep as not to be awakened by the noise of persons rolling a large stone from the mouth of the sepulchre, and carrying a dead body through the midst of them. And, in the next place, consider who they are who give the account? The soldiers themselves were the only persons qualified to give any account of the business; but had the report which they circulated been true, they would have been the last persons in the world to confess a delinquency which they must have expiated by their lives. Besides, their account, like most falsehoods, contains in its bosom its own refutation; for if they were actually asleep, how could they know whether the disciples carried off the body or not? This could only be an inference; and, in the circumstances of the case, a very improbable one. For they who had universally forsaken their master when they foresaw his destruction, were not likely to risk much for him after he was actually dead. The evidence, then, stands thus, even on the admission of Jews and unbelievers; the resurrection of Christ is attested by hundreds who declare that they saw him frequently after that event, and with their eyes open, and all their senses in exercise; whilst the contrary statement, that the disciples stole away his body, is only attested by sleeping witnesses, who, in such circumstances, were certainly incapable of bearing testimony to any thing but their own dreams.

It may indeed be said, that the statement we have given rests on the authority of the apostles and evangelists. It does so; but it has never been contradicted, and it carries with it internal evidence of its truth. The Evangelist Matthew gives a most natural account of the whole transaction. He tells us that some of the guard ran instantly to the chief priests and told them all they had seen; upon this a council was held, and it was thought best not to make a show of punishing the soldiers for their supposed neglect, because they knew they would die declaring the truth. The council therefore agreed to bribe the soldiers; and they gave them, we are told, a large sum to induce them to propagate the unlikely story which we have been examining; and as they knew that the soldiers must do this at the peril of their lives, they said to them, "If this come to the governor's ears, we will persuade him and secure you," which they knew it would not be difficult to do, as Pilate could not be supposed to have any partiality for Christianity, though he was perfectly convinced of the innocence of its author. "So," the evangelist adds, "they took the money and did as they were taught; and this saying is commonly reported among the Jews till this day." That is, it was commonly said among the Jews at the time when Matthew's account was published, that our Lord's disciples took away his body when the guard was asleep. Thus the author, at the time he publishes his history, which was within thirty years of the time when the event happened, appeals to the whole country of Judea where his work was circulated, for the truth of what he stated as to the Jewish account of the resurrection. No author in his senses would have made such an appeal, had not this been the current edition of the story among the Jews; for every man living could have contradicted him, and such a palpable mis-statement would have offended the friends, and given every possible advantage to the enemies of Christianity. But the statement is not denied; it is the common account among unbelievers down to the present day; and we have endeavoured to show that it carries in its face falsehood and contradiction.

The grounds, then, on which we are authorized, or we may almost say compelled, to believe the doctrine of Christ's resurrection are these: it is attested by persons who had every opportunity of knowing the truth, and who had no inducement to tell a falsehood; and it is attested even by the enemies of Christianity, who, from the account which they have given of this transaction, show to the perfect satisfaction of every one capaple of distinguishing between truth and falsehood, that their account is fabulous, and that Christ is indeed "risen from the dead according to the Scriptures."

This doctrine, thus satisfactorily established, accounts completely for the zeal and for the success of the apostles and first preachers of Christianity, which, on any other view, must appear altogether inexplicable. We need not be surprised to see them devoting their whole lives, and sacrificing every consideration of ease and temporal convenience, in propagating the religion of him who was so visibly demonstrated to them to be the Lord's life, and the only hope of salvation; nor need we wonder that the doctrines of the cross, so different from any thing that had hitherto been known among men, should increase and flourish in the immediate hands of him who had preached it, for "healing to the nations." A candid examination of the success which attended the labours of the apostles cannot fail to make us recognise more clearly the power and wisdom of God in rendering such feeble instruments effectual in promoting such momentous consequences.

They tell us that they wrought miracles in the name of Christ, and that it was in consequence of the signs and wonders which God wrought by their hands that the Gentiles were turned to the knowledge of the truth. These were high pretensions; and it would have required more infatuation or effrontery than ever falls to the lot of any person of sound mind, to advance such claims in the very face of persons capaple of producing instant refutation, had they been unfounded. In the second epistle to the Corinthians, xii. 12, St. Paul says, "Truly the signs of an apostle were wrought among you in all patience, in signs and wonders, and mighty deeds." It is not in the power of human credulity to suppose that such a declaration would have been made, had it not been supported by truth. We can easily conceive that a man may boast, in one place, of fictitious exploits alleged to have been done in another. But was ever any braggart so senseless as to make the very people whom he wished to deceive, the judges of his impudence and lying vanity? No; such a supposition is belied by every feature of human nature; and therefore we may rest assured that the apostle appeals to events which no man could contradict.

But we dwell not any longer on a detail of evidence for the authenticity of the apostolic miracles; generally speaking, they rest on the same foundation with those performed by our Lord. We would only request attention to a few facts in the history of the Apostles which never have been, and never can be, disputed, viz. to the fact of unlearned fishermen converting the world, subduing the pride of philosophy, and resisting the efforts of power, till the princes of the earth were compelled to bend the knee before the cross of Christ; to the fact of such persons publishing doctrines which the ingenuity of learning never had been able to discover, and inculcating precepts for the regulation of life, far exceeding any thing that the wisest moralists or politicians had ever devised; to the facts of their blameless lives, of their disinterested labours, of their unwearied benevolence: grant but these facts, and you need no higher miracle, and no stronger confirmation that they were commissioned and taught of God; and these are facts which infidels themselves will not venture to dispute.

Such were the persons employed, and such the extraordinary result of their labours. Let us see whether we can discover the secret of their success in the nature of the means which they used. Did they owe their success to a more approved method of teaching than had usually been practised, to superior eloquence or more elaborate reasoning? Quite the reverse; they themselves boast that they did not attempt to inveigle converts by the enticing words of man's wisdom. 1 Cor. i. 17. Their doctrine was indeed pre-eminently distinguished by its importance, and its majestic simplicity: but these are not qualities with which the world is readily captivated, when separated from the accessaries of high birth, or eloquence, or fashionable opinion. The apostles had none of these advantages to recommend their doctrines. They derived no influence from their rank in society; none from the reputation of their learning; none from the obsequiousness and pliancy of their manners. They were stern moralists, inflexible advocates of truth, justice, and purity; intrepid reprovers of every deviation from integrity and virtue. Though in things indifferent they had sufficient liberality to "become all things to all men;" yet they were entirely unaccommodating and unbending with regard to every thing that had even the appearance of evil.

In all these respects the apostles were as opposite as can possibly be conceived to the character and conduct of those who seek pleasure or private advantage from the doctrine which they teach; for the doctrines of the gospel are not accommodated to a single failing, to a single prejudice, or to a single sinful propensity in human nature. They are addressed to the highest feelings, the sublimest conceptions, and the loftiest and purest hopes which the mind can entertain; and they never can be relished but by a heart emancipated from vulgar prejudices, and purified from mean and grovelling affections. They had to contend with the prepossessions of the Jews, which were the more inveterate from their being founded on mistaken interpretataions of the word of God; and with the learned pride of the Greeks, who had imposed their literature on the masters of the world, and scorned, of course, to be tutored by the despised nation of the Jews. In short, the general prejudices of human nature, and the local and natural prepossessions of every tribe and district, were all up in arms against the new and unwelcome doctrine, and against its unlearned and uncourtly teachers. Yet with all these disadvantages, the doctrine of the cross prevailed more and more, till the heathen temples were deserted, and the heathen rulers began to fear that the Christians might form a combination to overturn their power.

Now, although we had never heard of the apostles having wrought a single miracle, yet the plain facts which have been stated, and which have never been controverted, sufficiently demonstrate that the gospel was miraculously propagated, or that it stood by the power of God, which is all the miracle that we require.

Unbelievers have attempted to assign various secondary causes to account for the rapid progress of Christianity, without the necessity of a divine interference. Among other things, it has been alleged that the doctrine of the soul's immortality was taught so clearly by the first preachers, and is in itself so soothing and consolatory, that it excited immediate attention, and secured a ready reception to a religion in which it formed such a prominent feature. This very concession on the part of unbelievers furnishes an unanswerable argument against their system; for it admits that this important doctrine, which ought to form the basis of all religion, was very imperfectly understood before. How then did the uneducated teachers of the gospel obtain such clear views on a subject so important, and so remote from the ordinary conceptions of men? The most that the learned heathens could say on the subject was, that it was a comfortable creed, and that even though it were false, yet the belief of it was pleasant in the meantime, and could be attended with no disagreeable after consequences. Certainly our Lord and his disciples took up a very different ground. They made the doctrine of a future state the *primum mobile* of life, and taught mankind to consider every thing as subservient to this great end. But before this doctrine can be regarded as an attractive one, we must consider what is implied in it, as enforced by the preaching Christ and his apostles. According to their statement, it is a doctrine that can be consolatory only to the righteous; that is, to those who receive the faith of the gospel and exhibit its fruits in their lives; but it is the most terrible doctrine that ever was preached to the wicked and disobedient; for it declares that they "shall be punished with everlasting destruction from the presence of the Lord, and the glory of his power." Unless it could be shown that the gospel holds out the blessings of eternal life indiscriminately to all, it could have no attractions to the wicked, who always form the majority; and could it be shown to have such a tendency, the righteous would have reason to reject it as derogatory to the nature of God and subversive of his government.

It is indeed said in our translation that "Jesus Christ brought life and immortality to light." The word here translated immortality (αφθαρσιαν) should be translated "incorruption," as is done 1 Cor. xv. 53, and elsewhere; and then it must be understood as relating to that spiritual incorruptible life which can be enjoyed only by "the pure in spirit" in the kingdom of heaven. In fact, the doctrine of "eternal life," taught in the gospel applies solely to the principles of the spiritual and divine life, which are planted in the soul in the present world, and which being perfected by the varied discipline of life and dispensations of providence, is at last ripened into complete holiness and bliss in the kingdom of God.

This was a doctrine which formed no article in the creed of the heathens. Their idea of immortality merely implied the continuance of existence, and the enjoyment of the same pleasures and pursuits in which they had been engaged in the present world. Their Elysium was much the same as the Mahometan paradise. But the "eternal life" of Scripture is entirely the reverse of all this, so far as regards sensual enjoyments. In the Christian heaven there is no hunger nor thirst, no marrying nor giving in marriage, none of those relative ties which constitute the duties and happiness of society in the present world, and no feeling can be admitted there except those spiritual and divine habits which have been engrafted in the soul from the admiration and imitation of the divine perfections.

Another misrepresentation has been advanced with a view to exclude divine influence from the propagation of the gospel, and to account for its success from common and secondary causes. It is alleged that it takes responsibility from man; and relieves him of much trouble, by teaching him to depend on the merits of another; and that a religion characterized by such features, could not but be acceptable to the indolence of human nature.

This is either ignorant or malicious misrepresentation. All that the gospel inculcates respecting the necessity of divine influence, and the aids of the Holy Spirit, is intended to stimulate, not to relax our exertions. "Work out your salvation with fear and trembling; for it is God which worketh in you both to will and to do of his good pleasure." Philip. ii. 12, 13. Here the operation of the Spirit of God, who works in us to will and to do of his good pleasure, is stated as an inducement to work out our salvation with fear and trembling: and it certainly is a powerful argument for exertion when we reflect that every virtuous emotion proceeds from the Spirit of God, who promises his assistance, and calls us to be labourers together with him in the great work of salvation. At the same time this consideration may well inspire us with fear, lest we should have received so much of the grace of God in vain, and lest we be found wanting in the due improvement of the ample means and assistance with which he has furnished us. All the exhortations of the gospel correspond with this representation; hence we are called on to watch and to pray, and to be active and diligent in the use of those means which God has appointed and promised to bless for our edification.

And with regard to the other objection that the gospel found a ready reception, because it pointed out an easy method of salvation by teaching men to rely on the merits of another, we may safely say that human nature must be greatly changed from what it was, if this view of Christianity proved a recommendation to it. It is not commonly found that any thing which tends to sink human merit will meet with a ready reception among men; and we believe that the greatest object to the gospel has always arisen from the low estimate which it forms of human virtue; and from its representing the best services of men as unprofitable in the sight of God. There is nothing that men will not do sooner than believe this. They will give their bodies to be burnt, or to be torn in pieces by every conceivable torment, if any person can persuade them that heaven may be won by such sacrifices. And it is not difficult to produce such a conviction: it is a deep rooted prejudice of the human heart: it is a wrong conclusion drawn from just and natural premises; it is founded on the feeling of responsibility, on the consciousness of guilt, and on the persuasion that some extraordinary sacrifice is necessary to procure expiation. But along with these feelings and convictions, which might naturally enough lead to humiliation, there is a principle of pride no less firmly rooted in the mind of man, which teaches him to believe that the expiation may be made by his own efforts, and that his personal sufferings and privations will have merit to atone for any sin.

This notion lies at the foundation of all the superstitions of polytheism; and the bodily sufferings and voluntary inflictions which were so profusely exhibited, were the result of pride rather than of humility. The infatuated visionary was attempting to take heaven by force, and to establish his claim to salvation, as a debt and not as a favour. The doctrines of Christianity are the reverse of all this in every point of view, and, therefore, it must have been an objection to them that they opposed such inveterate prejudices of the human mind. So much was the Church of Rome aware of this, that to remove all objections to its external sovereignty, the only object which, as a church, it ever had in view, it laid hold of those very prejudices which Christianity had exploded, and revived the claims of human merit by prescribing certain penances and bodily services as available to salvation.

From these facts, any one may judge how far the gospel owes its success to the conformity of its doctrines with the common notions and prevailing feelings of the human mind. It is, indeed, one of the singularities attending its dissemination, that it forced its way in the world, in spite of the most formidable obstacles arising from the sins which custom had licensed, and from the prejudices which superstition had consecrated in the human mind. This is in itself sufficient evidence that "God gave *visible* testimony to the word of his grace" when he enabled the first preachers of the gospel to triumph over obstacles, which, in modern times, resist all the powers of learning, of eloquence, and of argument. And should any one feel disposed to regret that the same signal success does not attend the labours of modern missionaries, who are much better qualified, in point of literary attainments, than the apostles were, we would remind them that this very circumstance is one of the most decided proofs of the divine origin of our religion. Were it immediately received, we might be apt to suspect that there was nothing peculiar in it; and were the labours of modern missionaries, who do not pretend to miracles, as successful as those of the apostles, there could be no reason for bringing in the visible power of God in behalf of the first preachers of Christianity. The many remarkable failures which we have witnessed, are proofs that the rapid success of the apostles was chiefly owing to visible interpositions of divine power; and that the want of this extraordinary aid is the cause of the slow progress of Christianity in modern times. But these failures, instead of discouraging, should animate our efforts; as they afford a demonstration that God himself originally established that religion which he commanded his servants to carry to the remotest corners of the earth; and we need never despair of a blessing on a work which God himself has countenanced, and which he has hitherto distinguished by his special support against all the attacks of unbelievers.

But there is another species of evidence adduced in favour of Christianity, which, as contra-distingished from the evidence of testimony and facts, has been denominated *internal*, and is founded chiefly on the adaptation of the gospel to the wants and circumstances of men; on its excellence as a rule of practice, as a source of knowledge, and as a ground of hope and of consolation; and it is argued that a religion which has so many marked characteristics of benevolence and wisdom can have no other than a divine origin. We are disposed to consider the arguments connected with this view of the subject, as, of all others, the most conclusive. Indeed there is, properly speaking, no Christianity, till those convictions of its power and efficacy are produced in the mind; they constitute the sum and substance of practical Christianity, and therefore they are to be considered as results, rather than as evidences: as consummations of Christian faith, rather than as steps in the arguments which lead to it. A man's conviction is already complete by the time he feels that the gospel has enlightened his mind, reformed his practice, confirmed his hopes, and removed his fears. He has then, as it is expressed in Scripture, "the witness in himself," 1 John, v. 10, his conscience, feelings, and all his faculties yielding a ready assent to the value and importance of the Christian revelation.

But it would be needless for a Christian to tell an unbeliever what he feels on these subjects. One man's feelings can be no argument to another: and the unbeliever will take his stand exactly on the same ground, and will say, that he rejects the gospel, because it is revolting to his feelings, and because he is persuaded that the adoption of it would mar his happiness. Here then, we shall suppose, is the point with regard to which the two parties are at issue, the one maintaining that the gospel promotes human happiness, the other that it destroys it. Are there no *data*, then, by which this controversy can be decided? Is there no standard to which we can refer on a point so deeply interesting to human nature? To maintain that there is not, would be to confound reason with prejudice, to renounce as fallacious every intimation of conscience, and to dismiss as insufficient every principle which enables us to judge of the consequences of actions.

Is the gospel, then, or is it not, friendly to human happiness? If a verdict shall be returned in its favour, it will be entitled to the support of all who hold that happiness is "our being's end and aim." At the first view, its aspect is not alluring: but it will be an argument in its favour, if it can be shown to be friendly in its intentions. Its doctrines and its precepts stand as antagonists to all those propensities which are nourished by excess, and by inordinate love of the world: but this will not operate to its disadvantage, if it can be shown that nothing less than the self-denial which it enjoins can prevent us from being suicides of our own happiness; and that unrestrained indulgence is the sure road to disgrace and misery. It is quite common to hear it said, how can a religion which professes to come from heaven, be so opposite to the propensities of human nature? Can the same God give opposite intimations, and, at the same instant, impel to gratification and forbid it? This apparent anomaly does not originate in the gospel: it has its foundation in the nature of man, which supplies, at the same time, both a stimulus and a check to gratification. On the one hand, we feel a decided love of pleasure, whilst on the other, conscience interferes to prevent the unlawful indulgence of it; and the ardour of gratification is checked by the failing powers of nature, and by the languor or disease which excess produces.

It is obvious, then, that there are very contradictory principles in our nature; we are prone to excess, and reluctant of restraint, yet we are compelled to attend to the voice of conscience which points out the boundaries which we ought to respect, and warns us of the danger which attends transgression. It is farther obvious, even without the light of Christianity, that man rises in the scale of moral excellence, of public usefulness and private happiness, in proportion as he resists the undue indulgence of the mere animal propensities, and obeys the moral feelings of his nature: whilst the man who degrades himself by brute enjoyments, necessarily forfeits rational happiness, the esteem of his fellow creatures, and the hopes of a better world. These are axioms recognised by all nations whose names have not sunk into oblivion, by neglecting the conduct which results from them. Is it not, then, highly in favour of Christianity, that it takes a decided part with these better principles of our nature, that it labours to strengthen conscience, to promote justice, to banish selfishness, to increase universal benevolence? And if it can be shown that the gospel promotes all these objects infinitely better than any other system, and supplies motives and inducements far beyond what any man, or set of men, ever devised, we shall have, in that case, a strong presumptive evidence of its divine origin; and this presumption must amount to certainty, when we consider the men by whom it was first announced, and the circumstances in which it was first propagated.

But let us view the subject a little more narrowly in its general complexion and structure, and see whether we cannot discern the symptoms of an origin infinitely more exalted than any other system of morals or religion can justly claim. And here let it be observed, that all the ancient systems of morality and religion laid claim to a divine origin, and we have the names recorded of the gods, or inspired legislators, who established them. It is long since the world has been satisfied of the futility of these pretensions, and the systems founded upon them have been abandoned as inconsistent with the light of reason and with some of the best interests of man. They either permitted what was hurtful, or forbade what was innocent; and the consequence was, that they exhibited the contradictory extremes of profligacy and licentiousness on the one hand, and of the most revolting violations of nature, and of nature's feelings on the other.

All religions, but that of Christ, are chargeable with these defects and improprieties. It prescribes no self-denial, except with regard to sinful lusts; no mortification except of evil affections; it gives full scope to every feeling that contributes to the real enjoyment of life, whilst it guards, by the most awful sanctions, every duty, the observance of which is necessary for our present and future happiness. It extends our views far beyond the limits of this world; it confirms those anxious anticipations and eager desires of immortality which the mind has, at all times, so fondly cherished; and these being established, and the future life of man being shown to depend on his present conduct, as mankind have always believed, the gospel, in conformity to this leading doctrine, tells us, that every action of our lives should have a reference to immortality, and that it will profit a man nothing to gain the whole world and lose his soul. This is the necessary conclusion arising from a universally received doctrine; and it is here that the excellence of the gospel is particularly manifest, for it does not tell us that earth and heaven are absolutely opposed to each other, or that we cannot discharge a conscientious duty to both, or that we must be miserable here in order to be happy hereafter. It warns us, indeed, of the danger of undue attachment to the world, as tending to check every spiritual aspiration, and to make us unmindful of our best hopes; but whilst it prescribes rules which have for their ultimate, and apparently their only object, the eternal interests of the human soul, it is found that the observance of these rules promotes our present happiness more effectually than if we had nothing else in view; and we learn from experience, that "godliness is profitable unto all things, having the promise both of the life that now is and of that which is to come."

An unbeliever will perhaps be inclined to dispute this statement, and in particular to deny the influence of Christianity in promoting present happiness. We appeal to the bar of reason and conscience, and promise to abide by their decision, even with regard to the most obnoxious precepts of the gospel. Take *humility*, that characteristic feature of Christianity, for an example. The author of our religion says, "Learn of me, for I am meek and lowly, and ye shall find rest to your souls." With regard to this injunction, which the unchristian mind must necessarily dislike, the question simply is, whether a man is most likely to find rest to his soul, by humbling himself, or by endeavouring to humble others; in the latter attempt he will never be completely successful; he will always find some to resist his claims, or dispute his pretensions: and he will always suffer under the feelings of wounded pride and disappointed ambition. It will be alleged that humility is only the property of a low, unmanly spirit, and that it must destroy the dignity and energy of the human character. No one will think so who remembers that this humility arises solely out of the relation in which the Christian feels himself to stand with regard to God, and not from any fear or great reverence which he entertains for man. He who thinks humbly of himself from a consideration of the divine majesty, will be in no danger of thinking too highly of others; he will form a just estimate of them, and will perceive that he ought to regard them with feelings of charity and brotherly love, rather than with fear or idolatrous veneration.

We have seen how nobly this quality was exemplified in the conduct of the apostles. They were distinguished by patience, meekness, and humility; but they were distinguished no less by undaunted fortitude and unparalleled intrepidity. Though born and brought up in the humblest stations of life, they were not confounded when they were called before princes and rulers. Paul had the boldness to arraign the very vices for which Felix was notorious, and the profligate governor trembled in the presence of the man who was brought as a prisoner before his tribunal.

Here, then, is one singular quality enjoined by Christianity, to which the natural mind feels a repugnance, but which reason can demonstrate to be perfectly consistent with the dignity and happiness of man, and to be, in fact the best means of promoting both. And it is one of those moral qualities, more, perhaps, than any other peculiar to the gospel. There is no word in the classical languages of Greece and Rome to denote the virtue of humility. It is a quality, however, which results so naturally out of the relation in which man stands to his Maker, that the religion which so forcibly enjoins it may be said to have a sign from heaven, that it proceeds from God; whilst those which encourage opposite qualities betray themselves to be of earthly origin and of human invention.

Take another quality, the forgiveness of injuries, which, if not absolutely peculiar to the gospel, is at least enforced by it with a clearness, and with a strength of motive not to be found in any other system of religion or morals. "Forgive thine enemies," says a heathen, "for by returning their injuries thou art only equal with them, by forgiving them thou art superior." This is very fair reasoning; but we may justly doubt whether it would produce any very decided effect. The precept of the gospel, however, goes much farther, and is enforced by much more powerful motives. "Love your enemies, bless them that curse you, do good to them that hate you, and pray for them that despitefully use you and persecute you." This is stretching the precept, it may be thought, to the very verge of human endurance; yet it is nothing more than the fair result and legitimate conclusion of the principle by which our Lord recommends it, which is, "That ye may be the children of your father who is in heaven, for he maketh his sun to rise on the evil and on the good, and sendeth rain on the just and on the unjust." Mat. v. 44, 45. Was any such motive ever suggested by any other teacher? Was man ever authorized to contemplate such an exalted origin, or called upon to imitate such a spotless pattern? Nothing like it is to be found in the records of human wisdom. We see ourselves placed in the most intimate union with God, and, as his children, we are called upon to imitate his perfections, the most conspicuous of which are mercy and forgiveness.

Let us now see, then, whether we discover in the gospel such marks and characters as must necessarily belong to a religion which comes from heaven. Such a religion must explain and exalt the divine perfections; must make us better acquainted with the nature and government of God, whose being is universally admitted, but whose character is, in general, very imperfectly understood; must be distinguished by wisdom and benevolence; must tend to promote the best interests of man for time and for eternity; and all these marks are to be found in the gospel of Christ, or they are to be found nowhere. It has, at least, annihilated the claims of every other religion, and if any one should entertain a suspicion that it may still mislead us, we can only say, that if it does, there can henceforth be no confidence in human reason, no dependence on human testimony, and no trust even in miraculous appearances: for in all these respects every thing that the mind can require to satisfy its doubts has been most amply supplied; and we do not think it possible for the present faculties of man to receive any fuller demonstration of the truth of Christianity than is set before us in the authentic facts on which it rests, and the intrinsic excellence by which it is distinguished.

It may appear matter of astonishment that a religion so attested, and so obviously calculated to promote the best interests of man, should nevertheless be so obstinately resisted. This, which might appear singular, is resolved into a prominent feature of human nature by our Lord's words, "Whoso doeth evil hateth the light, neither cometh to the light, lest his deeds be reproved." If the view which has been given of human nature be correct, if it be earthly and sensual in its original tendencies, averse to restraint, and prone to excessive gratification, in these circumstances opposition to the gospel is exactly what we may expect, and is an additional internal evidence of its divine origin. A religion perfectly accommodated to the natural feelings, or falling in with the prevailing propensities of human nature, would need no other evidence to prove that it could not be divine. For who can doubt that the prominent features of the human character, before it is refined and exalted by moral culture and religious principle, are pride and ambition, selfishness and sensuality, qualities which can never be countenanced by a divine religion, and which must be subdued before such a religion can be relished by the human mind.

It is common enough to hear it said by professed friends of Christianity, that it is congenial to human nature; and so it is when once the heart adopts its precepts; its yoke is then felt to be easy and its burden light. But there must be many a struggle and many a sacrifice before this surrender of the heart is made; and whilst we would recommend the gospel as in the highest degree calculated to promote the happiness of man, we would wish it, at the same time, to be remembered, that it is only accommodated to our real wants, but not to our misjudging wishes; that it promotes our real dignity, whilst it lays prostrate in the dust our imaginary consequence; and that it advances our best interests for time and for eternity, by opposing many of our decided inclinations.

It is a proof, then, that the gospel is heavenly, when we see it so obstinately resisted by the sinful feelings of men; and in every instance where it has ultimately been rejected, the reason may be found in some depraved affection, or some sinful bias of the human heart. It is the intimate and indissoluble union between the doctrines and the practical precepts of the gospel—the inseparable connexion between faith and holiness, that appears so formidable to the indolence and inveterate prejudices of men. It is not the abstract creed of Christianity that gives offence. Men are by no means nice as to their creed; there is no absurdity too monstrous for them to swallow; and Christianity, when degraded to the rank of a superstition, and disjoined from its influence on life and morals, is as popular as any other, and will as readily obtain proselytes. This was proved by the success of the Romish missionaries, one* of whom tells us that his arms were completely tired with baptizing the immense

* St. Francis Xavier.

multitudes of heathens who flocked to conversion in one day. If the gospel were satisfied with such converts, we do not believe there would be any difficulty of christianizing in a short time the whole world. For no religion can come forward with such pretensions as Christianity; and were it not so intimately connected with the heart and the conduct, it would soon become the dominant religion throughout the world.

It is not the fault of Christianity, then, that it is not more readily and more extensively received. It has a work to accomplish on the mind of every individual, which is in direct opposition to confirmed habits and preconceived opinions; and the transformation of character which it effects cannot be brought about without resistance on the part of our natural feelings. One great design of the gospel is to "bring the whole man into subjection to the obedience of Christ," that is, to emancipate the mind from the dominion of ignorance, prejudice, and sin, and to substitute in its place the sovereignty of reason, knowledge, and virtue, as embodied in the law of God. Who can doubt that such a change is desirable, and that it should be the object of a divine religion to attempt to accomplish it? And who is so ignorant of human nature as to suppose that this change can be effected without a struggle? The gospel, then, bears in its face one distinct feature of divinity, in being opposed to all the sinful, and degrading, and mischief-working propensities of human nature.

It will probably be alleged that, according to this reasoning, there are insuperable obstacles to the general reception of the gospel, in the very principles of human nature. To this we would answer, that the observations which have been made apply chiefly to ripened sinners, to those whose natural propensities have not been checked by early culture, and who have been allowed to grow up in antichristian habits and feelings. Even with regard to these, though their conversion be difficult, it is not impossible. They are in the situation in which all heathen nations have been when the gospel was first announced to them, and their prejudices, however strong, are not invincible. But we can easily conceive a situation in which these unfavourable symptoms may, in a great measure, disappear; and that situation will occur, when Christian discipline, judicious education, and good example, are all brought to operate on the youthful mind, and are employed to train it from the very first evolution of its feelings, to Christian habits and sound knowledge. The visible opposition to the gospel will then vanish, because the principles on which that opposition is founded, have been crushed before they acquired ungovernable strength, and because the mind has been made familiar with the enlightened doctrines and useful tendency of Christianity.

The internal evidence for the divine origin of Christianity which has hitherto been adduced, is founded on the wisdom and utility of its instructions as connected with the history and the hopes of man. And, in fact, every argument produced to show the reasonableness of any of the doctrines of Christianity, is to be considered in the light of an internal evidence in its behalf. But there is an extensive class of arguments of this description arising neither from the doctrines nor from the precepts of Christianity, but from circumstances connected with its history. The low and suffering condition of Christ, for instance, is in perfect consistency with what is stated to be the great end of his mission, viz. to lay down his life a ransom for many. Had he appeared in the splendour of regal dignity, and maintained throughout a state corresponding to it, the great consummation of his death could not have happened. The same circumstances would have disqualified him for a teacher, and for an example to suffering mortals. As nothing is of so much consequence to us as to be taught to endure the ills of life with patience, fortitude, and hope, so we find that he who is set forth as the hope of Israel, and of all nations, was placed in exactly such circumstances as best qualified him for giving us useful lessons of faith, fortitude, and resignation. Had he lived respected, and died renowned, he could not have shown us the efficacy of Christian faith, in supporting the heart amidst the severest trials, and in realizing to us the hope of a better world. His doctrine was, "fear not them who can kill the body;" or in other words, hold fast integrity and a good conscience, though at the expense of life itself: and he illustrated the precept by his example. No degree of suffering could make him swerve from his purpose, or relinquish his feelings of benevolence and love to the human race. Since, then, man is born to sorrow, is it not a proof of wisdom and goodness on the part of God that "the Captain of our salvation was made perfect through suffering?" It was this condition alone that perfected him as a teacher, as an example, and as a propitiation.

Here, then, all the parts of this extraordinary scheme hang rightly together; and we may add its perfect consistency as a farther recommendation to our acceptance of it, as a plan devised by God.

Some have alleged that we know so little of the nature of God, that it is presumptuous in us to say what kind of revelation he might be expected to give, and of course all arguments founded on *internal evidence*, which go, in effect, to measure the ways of God by our conceptions of fitness, must be precarious or fallacious. We do not assent to this conclusion. We do not say what kind of revelation God *might* have given; we only presume to judge of that which he *has* given. It appears that some of the wiser heathens were led to expect, or, at least, to desire a revelation. They judged it necessary on account of the hopeless ignorance of men. Had they speculated on the nature of that revelation, we may be perfectly certain that they never would have anticipated that which was actually given. It rested on deeper principles than the light of nature could discover. But this does not prevent us from passing a judgment respecting it, now that it is known; and the beauty and excellence of the Christian revelation is this, that it has not fettered but improved our faculties, and made them capable of passing a decision on its adaptation to the wants and circumstances of men.

There is not one precept, and scarcely one doctrine of the gospel, that does not rest on other grounds than mere authority. As the Almighty requires of us a reasonable service, he suggests reasonable motives for the performance of it, and has made us capable of discerning that his demands are not founded in wanton despotism, but in the tenderest regard to the happiness and improvement of his creatures. Admit but this, and who can doubt the competency of human reason to pronounce on the nature and tendency of a scheme professing to come from God? It may be said that the miracles performed are sufficient to command our assent to the doctrines which they were wrought to inculcate, although we should be totally unable to understand them. But how few doctrines are there of this kind in the Christian revelation? We believe there are none but the divinity of Christ, and his appointment to redeem mankind. These points could not be established by reasoning; they lie beyond the sphere of its natural operations. But these points being established by the power which the Saviour possessed, they become proper subjects of reasoning; and we are entitled to inquire whether there is any thing in them contradictory to the general analogy of nature, to the known character of God, as manifested in his works, or to the ordinary course of his providence. And if we shall find that there is here no contradiction, but, on the contrary, a beautiful harmony and additional illustrations of the divine nature and government, extending, connecting, and methodizing our knowledge, we have then *internal* proofs that the doctrine is from God. Here, as in every other instance, the revelation itself supplies the means of judging of its nature and character; and we have so much the greater reason to conclude it to be from God, when it furnishes the most important information in a way that the mind of man would not have devised.

We are far from presuming to say that the mysteries of heaven must be made obvious to our apprehension. These mysteries we are bound to believe when established by unequivocal miracles. But a miracle never was displayed to establish a mystery unconnected with the life and hopes of a Christian. The most mysterious parts of the Christian creed have a direct bearing on faith and practice. The Trinity, for instance, forms an essential article of belief; for without it we could have no idea of the Father who sends, of the Son who saves, and of the Holy Ghost who sanctifies. In short, no mystery is revealed in Scripture but what is intended to have an influence on the faith, and consequently on the duties and the hopes of men. On these latter points we can judge; and if a doctrine were announced, as enjoined by heaven, but which is found to contradict the first principles of reason, and to militate directly against human happiness, we might justly hesitate about admitting its truth, even though miracles were wrought to support it. What we mean to affirm is this; that even a miracle could not establish a general principle at open variance with those clear intimations arising from the light of conscience and reason, and from the visible ordinations of providence. The evidence could not be stronger on the one side than on the other; and the result could only be an entire suspension of our faith on the point in question; as the means of determining would be utterly destroyed by the contradictory intimations of our senses and our reason.

It is clear, then, that we are compelled to judge of every doctrine by its general tendency, as much as by the authority with which it is enforced. A miracle shows the power of the legislator; but we judge of his wisdom or his goodness by the nature of his enactments: and the beauty and excellence of the Christian dispensation consist in this, that its most peculiar doctrines are such as our reason is compelled to approve, though it would never have been able to discover them. We have thus a double security for our faith; for on the one hand we see it enforced by a power which no man can with safety resist: whilst on the other it is recommended by such distinct features of beneficence and wisdom as must secure both the love and approbation of every reasonable mind. Were miracles wrought to enforce maxims hurtful to human happiness, it would be a mere tyrannical display of power, at which the heart would revolt. But when we see that power is manifested to secure obedience to laws framed for our own good, we admire both the wisdom and condescension of the lawgiver, and we then love and revere a power which is exercised only to secure our own happiness.

Some of the friends of Christianity seem to have conceived a prejudice against the *internal* evidence for its divine origin, chiefly, we believe, because this is the point which infidels have principally contested, and on which they profess to build their opposition. The evidence of miracles remained almost unquestioned till it was assailed by the flimsy sophism of Hume, which would long ere now have been forgotten, had it not been preserved from oblivion, by being embodied in the beautiful refutation of Campbell. The evidence of prophecy, too, has been in a great measure unmolested; the only relevant objection that unbelievers have urged being, that the prophecies were written after the events which they pretend to predict; an objection so shallow and untenable, that to mention it is a sufficient refutation. But unbelievers have adopted a mode of warfare which has often been successfully practised by a skilful enemy; they have left the strong holds unmolested, and have directed all their efforts against the troops who keep the field, being well assured that when these are completely routed, and unable to appear, the strong places must quickly fall. In other words, they have attacked the substantial doctrines and distinguishing precepts of Christianity, under the impression, which we believe to be well founded, that if they can get the better of these, the external evidence will soon go for nothing.

And shall we decline to meet them on this field? Shall we post ourselves behind our bulwarks, contenting ourselves with bidding defiance to our enemies, whilst they are allowed to ravage the country, and harass its population? Such conduct would be cowardly, and unworthy of the high cause which we profess to advocate. Whilst, then, we should avoid the presumption of demanding that the mysteries of God should be brought down to the level of our understanding, a demand which reason itself must pronounce to be unreasonable, and impossible to be complied with; yet we may confidently affirm, that no doctrine is revealed in Scripture inconsistent with the dictates of enlightened reason: on the contrary, they are all recommended by their obvious congruity with some principles which reason recognises as ultimate and incontrovertible.

Hitherto we have applied this mode of illustration only to the precepts and moral instructions of the gospel, and have endeavoured to show that even when they oppose our feelings, they promote our happiness, and are approved by our reason. These precepts are not so much distinguished by the novelty of the qualities which they enjoin, (for they are, in general, founded on the broad basis of human nature,) as by the novelty of the sanctions by which they are enforced, and by the strong unqualified terms in which they are delivered.

This is a striking peculiarity in our Lord's manner as a moral teacher. He does not attempt to win assent by slow and cautious advances on our prejudices; he assails them at once, and rouses their utmost opposition by the decided and unqualified nature of his attack. When he wishes to discourage vindictive feelings, and prevent men from taking into their own hands the adjustment of their own wrongs, he does not proceed on the principles of political morality, to show that such practices would be injurious to the state; but he says in language alike calculated to astonish and offend, "Whoever shall smite thee on thy right cheek turn to him the other also." Mat. v. 30. His object was to arouse the attention to a momentous truth; and he clogs the precept with no deduction or qualification, knowing that men would soon be ingenious enough to discover these for themselves. To show the dangerous tendency of riches, he does not stop to point out the temptations to which they lead, or to warn mankind against their gradual influence in deteriorating the character, but he says in language, which no man, whether rich or poor, can ever forget, "It is easier for a camel to go through the eye of a needle, than for a rich man to enter the kingdom of heaven." Such a declaration, proceeding from an authoritative teacher, must have roused the most languid attention: even his disciples, we are told, "were exceedingly amazed;" this was what was intended; it would excite discussion among those who heard it; and, on due examination, it would be found to be the converse of that salutary proposition, that none but the "poor in spirit," shall inherit the kingdom of God; and that they who are only rich as to this world, shall never taste the blessedness of heaven.

This peculiarity is not to be found in other moral teachers, who are compelled to employ every artifice to seduce men into their conclusions. But Christ "taught with authority," inasmuch as he laid down the rule, without stating the reasons on which it was founded, which no other teacher had ventured to dispense with; and which even he would not have neglected had he not possessed other means of securing attention; and had he not seen that the reasonableness of his precepts would ultimately sustain them.

The want, then, of the usual processes of reasoning in bringing out moral deductions, is a proof that our Lord had other means of giving them efficacy; whilst the excellence of the maxims, which must be obvious when they are subjected to candid examination, shows how little despotism there is in divine enactments, and that they are addressed to our reason, our conscience, and our best interests.

In this article we have endeavoured to give a comprehensive view of the foundation on which true theology rests; and we have gone so far beyond the outworks, as to adduce many of the peculiar doctrines and precepts contained in the Scriptures, as illustrative of the divine origin of the record in which they are contained, and proclaiming, at the same time, their own high authority and the reverence which is due to them. We had intended to give a view of *polemical* Theology, and a catalogue of the books most useful for the Theological student; but the limits prescribed to this article prevent us from entering on the wide and thorny field of polemical Divinity; and it would have been necessary to append so many qualifications to every book that we recommended, that this undertaking would itself have formed a volume. We, therefore, only recommend, as of unquestionable utility, the earnest study of the sacred Scriptures, in the original languages; and perhaps the best commentaries on them will be found in the various translations which different Christian churches and communities have given of the original Scriptures.

THEOPHRASTUS, a celebrated Greek philosopher, and the pupil of Aristotle, was born at Eresium in Lesbos B.C. 371. He died B.C. 276, at the age of 85. His principal works are his *Characters*, and his *History of Plants*. Among the best editions of the first are those of Isaac Casaubon, of Needham, with the notes of Duport, Cantab. 1712, and of Fischer, Coburg, 1763. The most complete edition of his History of Plants, is that of Budæus, in Greek and Latin, Amstelod. fol. 1644. The last edition of his whole works is that of Heinsius, Greek and Latin, folio, Lugd. Bat. 1613.

THERMO-ELECTRICITY.

THERMO-ELECTRICITY is a term introduced a few years ago into natural philosophy, to signify the electrical current, excited in a circuit of conductors, when the equilibrium of its heat is disturbed in such a manner as to cause therein a circulation of caloric.

Thermo-electricity being a particular branch of *Electromagnetism*, which has been discovered since the publication of the volume of this work in which it ought to have been treated, it will be necessary to comprehend the whole doctrine of electromagnetism in the present article.

HISTORY.

In the earliest period of the history of magnetism and electricity, the minds of philosophers were more struck by the resemblances of these two agencies than by their disparities. The first philosopher who undertook a regular series of comparative experiments upon magnetism and electricity, was the celebrated Dr. William Gilbert, who first published his inquiries in the year 1600. He was aware of so many disparities between them, that he declared their resemblance to be merely accidental. He had indeed strong reasons to think so at that time, for the magnetical polarity was well known to him, and principally by his own experiments, but the discovery of the electrical polarity was reserved for a philosopher of the following century (du Fay). This discovery, and particularly the fundamental law of electrical polarity, brought forward by Franklin, again countenanced the opinion of the resemblance of electrical and magnetical powers; and the sagacity of *Æpinus* gave great credit to it. But immediately after this acknowledgment of their resemblance, another excellent philosopher, *Van Swinden*, was struck with the disparities which remained still unexplained, and his ingenious inquiries obtained much approbation. The discoveries of *Galvani* and *Volta*, by which the electrical powers were exhibited in forms very different from those formerly known, gave the opinions upon this subject a new turn. The German philosopher, *Joh. Will. Ritter*, was thought during some time to have produced magnetical effects by the Voltaic pile, but his experiment having been repeated without success, the subject remained as it was. Thus the balance inclined alternately sometimes to the one, and sometimes to the other side; but at no time have either of these opinions met with general reception. A certain turn of mind has here, as in most other controversial doctrines, exercised a considerable influence. One class of natural philosophers have always a tendency to combine the phenomena and to discover their analogies; another class, on the contrary, employ all their efforts in showing the disparities of things. Both tendencies are necessary for the perfection of science, the one for its progress, the other for its correctness. The philosophers of the first of these classes are guided by the sense of unity throughout nature; the philosophers of the second have their minds more directed towards the certainty of our knowledge. The one are absorbed in search of principles, and neglect often the peculiarities, and not seldom the strictness of demonstrations; the other considers the science only as the investigation of facts, but in their laudable zeal they often lose sight of the harmony of the whole, which is the character of truth. Those who look for the stamp of divinity on every thing around them, consider the opposite pursuits as ignoble and even as irreligious; while those who are engaged in the search after truth, look upon the other as unphilosophical enthusiasts, and perhaps as phantastical contemners of truth. Happily these two tendencies are in most natural philosophers so well tempered with good sense, that their controversies seldom exhibit any of the exaggerations which have disgraced so many theological and metaphysical controversies; but they always exercise their influence, which is generally a salutary one, in forming an opposition of sentiment in the republic of letters by which stagnation is prevented. This conflict of opinions keeps science alive, and promotes it by an oscillatory progress, though it seems to the common eye a mere fluctuation, without any definite purpose.

The reasons for and against an essential resemblance between magnetism and electricity might, before the discovery of electromagnetism seem to be nearly balanced. The most striking analogies were, that each of them consists of two powers, or directions of powers, of an opposite nature, submitted to the same laws of attraction and repulsion; that the magnetical action on bodies, fit to receive it, has much analogy with the electrical action; that the distribution of the powers in a body, which has an electrical charge, and still more a series of bodies charged by cascade, differs very little from the distribution of the powers in a magnet; if we imagine a Voltaic pile, and principally the modification denominated after Zamboni, composed of minute and molecular elements, it would have the most perfect analogy with a magnet; and lastly, that the tourmaline differs but little from such an electrical magnet.

We shall not here consider that most of these analogies are overturned by the discovery of electromagnetism; but still confining ourselves to the period before this discovery, it may be objected that the magnetical and electrical powers do not act on each other, which should be the case, if they were of the same nature; that all bodies transmit with ease the magnetical action, but not the electrical; that neither the tourmaline nor any system of charged glass-plates, or of galvanical arrangements, has the effects of the magnet. Although it might be answered that the galvanical circuit, in its first period, seemed no less different from any electrical apparatus than the Voltaic pile from a magnet, these objections did not cease to have considerable weight, but we have hitherto deliberately omitted one of the arguments, viz. the observation of magnetism in bodies struck by lightning, and the experiments made to imitate this effect. It had often been observed, that the magnetical needles in a ship struck by lightning have suffered a change in their polarity.

A very remarkable case of this kind, mentioned in the Philosophical Transactions, Vol. xi. No. 127, p. 647, seems to be the earliest on record. It is there related that a vessel, whose mast was struck by lightning, had the poles of the needles in all its compasses inverted, yet the compasses themselves were not struck. Some other observations of a similar nature are recorded in Domsdorph's *Treatise upon Electricity, Magnetism, Fire, and Ether*, (uber Electricitat, Magnetismus, Feuer und Ether, 1783.) An accident of this kind, which happened in the year 1751, caused Franklin to try the effect of artificial electricity upon needles of steel. The result was, that when the needles were in a position in which the earth could produce in them some magnetism, this effect was much increased by any electrical stroke; but when the position gave no such advantage, he found that the extremity of the needle, in which the electricity entered (which received the positive electricity) was directed towards the north, when the needle was conveniently suspended. *Wilcke*, who repeated these experiments, obtained the same results, only with the difference, that in the case when the direction of the electrical stroke seemed to decide the polarity, this was the inverse of that observed by Franklin. (Transactions of the Royal Academy at Stockholm, 1766.) The experiments made in the year 1785, upon the same subject by *van Marum* and van Swinden have been considered as decisive against the magnetical effects of electricity, nevertheless the ninth of their experiments was precisely an electromagnetical one, for they led the electrical discharge transversely through a steel needle, and obtained a strong magnetical polarity in a direction perpendicular to the magnetical meridian; but they considered this as a singularity not to be explained, and hence it has been out of the sight of philosophers from the year 1785 until 1820, when electromagnetism was discovered. (See *Van Marum, description d'une très grande machine électrique.*)

One of the earlier experiments, which probably belongs to electromagnetism, is that of *Cavallo*, by which he proved that iron has more efficacy on the magnetical needle, when an acid, particularly diluted sulphuric acid, acts upon it.

Joh. Will. Ritter, already mentioned, pursued a great number of researches upon the analogy of magnetism and electricity. He had in the year 1801 made a series of very delicate experiments upon the galvanical difference between the two magnetical poles of a steel needle. The result deduced from his experiments was, that the southern extremity of the needle was more oxidable than the northern, and that the galvanical effect of two magnetical needles upon a frog was such, that the south pole acted as the more oxidable, the north pole as the less oxidable metal. It is now acknowledged, that he has been led into error by the difference which a small disparity in the polish of the metal can produce, and which he employed insufficient means to avoid. The same philosopher stated likewise erroneously, that a platina wire, which has been employed to make a liquid communicate with a powerful galvanic circuit, assumes some magnetical direction, and that a needle, of which one half is zinc and the other silver, takes, when conveniently suspended, the same direction as the magnetical needle. The precipitation with which Ritter published these and some other erroneous statements, has thrown a shade over the name of this unhappy but ingenious philosopher, who has enriched science with several discoveries of great importance, and whose profound yet obscure ideas in many cases have anticipated the discoveries of future times. We are far from patronizing a vain exhibition of new ideas, by which it is possible for a very ordinary mind to make pretensions to every new discovery; but when works are marked with the true stamp of genius, it is but justice to acknowledge the merits of their speculations. Some writers have thought that this act of justice would deprive experimental philosophers of a part of the honour due to their exertions; but this honour is quite unimpaired, if the author, who has anticipated their discoveries, has only had a vague and obscure notion of them; while it must be avowed, that when the author has clearly announced the discovery, has derived it from good data and conceived its connections with other truths, the merit of the experimental philosopher is only that of having confirmed it by experiment, which still in many cases can be a work of no smaller claim to glory than the primitive conception itself.

Among the electromagnetical experiments which preceded the discovery of electromagnetism, ought to be mentioned an experiment of Professor Mojon at Genoa, who found that a steel needle having been 22 days in communication with a galvanical apparatus of 100 elements, had become magnetical,—an experiment which would have been of no historical interest, if its author had not founded upon it, 18 years later, a pretension to the discovery of electromagnetism. He seems not to have been aware that his pretended discovery, were it true, should be considered as new even now; for the magnetical effect, hitherto proved by experiments, is not in the direction of the electrical current, but perpendicular to it. The experiment of Mojon is described in *Aldini's Essai Théorique et Expérimental sur le Galvanisme.* Paris, 1804, tom. i. pag. 339 and 340. *Aldini* mentions, at the same place, that a certain Mr. *Romanesi* at Trent had confirmed the experiment of *Mojon*, and at the same time observed that galvanism makes the magnetical needle deviate. Professor *Aldini*, whose work upon galvanism comprehends two volumes, does not say a word more upon this subject.

It is, therefore, not surprising, that neither the French institute, nor the other learned societies, nor the numerous natural philosophers, to which the work was presented in the year 1804, took any notice of this observation, which would have accelerated the discovery of electromagnetism by sixteen years. *Romanesi* seems likewise to have forgot his observation, until electromagnetism was discovered.

Two or three years before the discovery of electromagnetism, Professor Maschmann at Christiania, in Norway, observed that the silver tree, formed in a solution of nitrate of silver, when put in contact with mercury, (the *arbor Dianæ*,) takes a direction towards the north; and the celebrated Professor *Hansteen* found that this direction can likewise be determined by a great magnet. As the metallic precipitation is also of galvanical nature, this observation may be considered as one of the precursors of electromagnetism.

Electromagnetism itself was discovered in the year 1820, by Professor *Hans Christian Oersted*, of the university of Copenhagen. Throughout his literary career, he adhered to the opinion, that the magnetical effects are produced by the same powers as the electrical. He was not so much led to this, by the reasons commonly alleged for this opinion, as by the philosophical principle, that all phenomena are produced by the same original power. In a treatise upon the chemical law of nature, published in Germany in 1812, under the title *Ansichten der chemischen Naturgesetze*, and translated into French, under the title of *Recherches sur l'identite des forces èlectriques et chymiques*, 1813, he endeavoured to establish a general chemical theory, in harmony with this principle. In this work, he proved that not only chemical affinities, but also heat and light are produced by the same two powers, which probably might be only two different forms of one primordial power. He stated also, that the magnetical effects were produced by the same powers; but he was well aware, that nothing in the whole work was less satisfactory, than the reasons he alleged for this. His researches upon this subject were still fruitless, until the year 1820. In the winter of 1819–20, he delivered a course of lectures upon electricity, galvanism, and magnetism, before an audience that had been previously acquainted with the principles of natural philosophy. In composing the lecture, in which he was to treat of the analogy between magnetism and electricity, he conjectured, that if it were possible to produce any magnetical effect by electricity, this could not be in the direction of the current, since this had been so often tried in vain, but that it must be produced by a lateral action. This was strictly connected with his other ideas; for he did not consider the transmission of electricity through a conductor as an uniform stream, but as a succession of interruptions and re-establishments of equilibrium, in such a manner that the electrical powers in the current were not in quiet equilibrium, but in a state of continual conflict. As the luminous and heating effect of the electrical current goes out in all directions from a conductor, which transmits a great quantity of electricity; so he thought it possible that the magnetical effect could likewise eradiate. The observations above recorded, of magnetical effects produced by lightning, in steel-needles not immediately struck, confirmed him in his opinion. He was nevertheless far from expecting a great magnetical effect of the galvanical pile; and still he supposed that a power, sufficient to make the conducting wire glowing, might be required. The plan of the first experiment was, to make the current of a little galvanic trough apparatus, commonly used in his lectures, pass through a very thin platina wire, which was placed over a compass covered with glass. The preparations for the experiments were made, but some accident having hindered him from trying it before the lecture, he intended to defer it to another opportunity; yet during the lecture, the probability of its success appeared stronger, so that he made the first experiment in the presence of the audience. The magnetical needle, though included in a box, was disturbed; but as the effect was very feeble, and must, before its law was discovered, seem very irregular, the experiment made no strong impression on the audience. It may appear strange, that the discoverer made no further experiments upon the subject during three months; he himself finds it difficult enough to conceive it; but the extreme feebleness and seeming confusion of the phenomena in the first experiment, the remembrance of the numerous errors committed upon this subject by earlier philosophers, and particularly by his friend *Ritter*, the claim such a matter has to be treated with earnest attention, may have determined him to delay his researches to a more convenient time. In the month of July 1820, he again resumed the experiment, making use of a much more considerable galvanical apparatus. The success was now evident, yet the effects were still feeble in the first repetitions of the experiment, because he employed only very thin wires, supposing that the magnetical effect would not take place, when heat and light were not produced by the galvanical current; but he soon found that conductors of a greater diameter give much more effect; and he then discovered, by continued experiments during a few days, the fundamental law of electromagnetism, viz. *that the magnetical effect of the electrical current has a circular motion round it.*

When he had discovered this fundamental law, he thought it proper to publish the discovery, in order that it might be as soon as possible perfected by the co-operation of other philosophers. Apprehending that others might lay claim to this discovery, he sent a short Latin description of his experiments to the most distinguished philosophers and learned bodies; and though, by this means, he has not avoided the pretensions which have been made to his discovery by others, still he has rendered them ineffectual. It deserves, perhaps, to be noticed, that the above-mentioned Latin description, consisting of four pages in 4to., of which the first gives the introduction and the description of the apparatus, the last the conclusions, contains upon the two intermediate pages, the results of more than 60 distinct experiments. From this brevity, it has happened, that some philosophers have thought that he had treated his subject in a superficial manner.

As the details of this discovery, and of all those which have originated from it, will be exhibited in this article, we shall in the remainder of this historical sketch, in order to avoid repetitions, confine ourselves to the most striking and leading facts, and insert the other historical notices in the doctrinal part.

The first discovery to which that of Professor Oersted gave occasion, was that of *Mr. Ampere*, member of the French institute. He found that a conductor, conveniently suspended, is attracted by another, when both are transmitting an electrical current in the same direction; but that they repel each other, when the two currents have opposite directions. Professor *Schweigger* at Halle, invented at the same time, an electromagnetical multiplicator, which is of very extensive use. *Mr. Arago* found that steel can be magnetized by the electrical current. *Mr. Gay Lussac* at Paris, and Professor *Ermann* at Berlin, discovered, that when the current has passed perpendicularly through the plane of a steel ring, or through a steel plate, it shows no magnetical effect, before the circumference was interrupted.

The most remarkable of all the discoveries, to which that of *Oersted* has given occasion, is no doubt the thermo-electricity, discovered in 1822 by *Dr. Seebeck*, member of the Royal Academy at Berlin.

In the same year, the rotation of a magnetical needle around an electrical current, and of a body, which transmits an electrical current around a magnet, first imagined by *Dr. Wollaston*, was exhibited in a series of ingenious experiments by *Mr. Faraday*.

Effect of the Electrical Current upon the Magnetic Needle.

The galvanic battery was the first apparatus, by which the magnetic effects of electricity were demonstrated. In order to make it give its magnetic action, its two poles must be joined by a conductor, commonly a metallic wire, which, for brevity's sake, we shall call the *uniting conductor*, or the *uniting wire*.

When not closed, the galvanic circle produces no effect upon the needle of a compass.

When the uniting wire is approached, and placed parallel, or nearly so, to a properly suspended magnetical needle, it is caused to deviate from its ordinary direction.

The magnetical effect of the electrical current is not interrupted by the interposition of other bodies. Already the first experiment showed that it passes like the magnetism of a loadstone through metals, glass, resin, wood, stoneware, water, &c.; even when the magnetical needle was placed in water, it was affected by the electrical current.

When the conducting wire is placed parallel to a conveniently suspended magnetical needle, the direction of the needle is changed.

1. If the needle is above the wire, and the positive electricity passes from the right to the left hand of the observer, the north end of the needle will go from the observer.

2. When the needle is below the wire, the direction of the needle is changed in the opposite way; its north end approaches to the observer. It is not necessary, in this and the preceding experiment, that the needle is in the same perpendicular plane as the conducting wire; it is only required that the needle shall be sufficiently near the wire, and in the first experiment, in a plane above, in the last in a plane below it.

3. When the needle is in the same horizontal plane as the wire, and is placed between the observer and the wire, the north end is elevated.

4. If the needle is upon the opposite side, the north end is forced down. In these two experiments, the needle must be very near to the wire.

From these facts, Professor *Oersted* concludes, *that the magnetical action of the electrical current describes circles round the conductor.* It will perhaps not be out of place to quote here his own words, which have been overlooked by several authors, who have written the history of this discovery.

In the original publication he says, "ex observatis colligere licet, hunc conflictum (the electrical current,) gyros peragere; nam hoc esse videtur conditio, sine qua fieri nequit, ut eadem pars fili conjungentis (conducting wire,) quæ infra polum magneticum posita cum orientem versus ferat, supra posita eandem occidentum versus agat." For the sake of brevity we shall, in the following pages, denominate the direction of the current after the system of Franklin; or, to speak according to the system of two electricities, after the direction of the positive electricity in the current. If we now suppose that the electricity of the current enters the conductor at the right hand of the observer, the austral magnetism (the same which predominates in the north-end of the needle,) will, upon the superior surface of the conductor go off from the observer; on the side most distant from the observer, the austral magnetism goes downward; on the inferior surface it goes towards the observer; on the side nearest the observer it goes upwards. This is represented in Plate DXXII. Fig. 1. where B A is the conductor in which the direction of the current is A B, the circle *c d e f* represents a plane perpendicular to the conductor, in which the magnetical circulation takes place. This plane is here and in the other figures represented as if it were material and opaque. The little arrows show the direction of the austral magnetism. We can make the application of this law to experiments, in a very commodious manner. For this purpose take a piece of paper (Fig. 2,) upon which the arrows and letters, there represented, are drawn. This piece of paper is to be wrapt around a cylindrical body, for instance a pencil, in such a way that the arrows lie in a plane perpendicular to the axis of the cylinder. We have thus an electromagnetical index, which, put in the place of any part of the conductor, shows the direction of the magnetical powers in it. The sharp ends of the arrows indicate the direction in which the austral magnetism (and consequently the north-end of the needle,) is repelled, and the contrary attracted; the opposite ends of the arrows indicate also the direction in which the boreal magnetism (and consequently the south end of the needle) is repelled, and the contrary attracted. The reader may understand without trouble the most complex facts we are here to explain, if he has at hand two such cylinders, during the experiment. The same thing may be expressed in different ways. Mr. Hill, lecturer of mathematics at the University of Lund, in Sweden, has proposed one of the best. Let us imagine, says he, that the observer swims upon the electrical current, with his face turned outwards, (with his back turned towards the axis of the current,) and his head towards the origin of the current, the direction of the austral magnetism of the current will always proceed from his left to his right hand.

This law was confirmed by several other experiments.

When the uniting wire is placed in the same horizontal plane as the needle, but perpendicular to its direction, and near one of its poles, this pole will be elevated, if the current comes from the east, but depressed if it comes from the west. This will easily be understood by the inspection of Plate DXXII. Fig. 3. B A represents here the conductor, N S and N′ S′ two needles. All the parts of the drawing have the same signification as in Fig. 1, only that the dotted lines denote the inferior parts of the magnetical circles, but the uninterrupted lines the superior parts. It is evident that N (the north end of one of the needles) is here driven upwards by the repelling action from below and the attracting one above it. In the same manner, S′ (the south end of the other needle) is both drawn and pushed upwards.

The effect is on both sides the same, because not only the magnetical poles, but likewise the opposite sides have contrary effects. If one of the needles were turned by means of a magnet, so that each side of the wire could act upon a pole of the same kind, one of them would be elevated, when the other was depressed.

When the uniting wire is perpendicular, and the current enters its superior part, a needle, of which one of the poles is very near to the wire, will be thrown westwards; but if the wire is placed over against a point of the needle, situated between one of the poles and the middle, the needle will be turned eastwards. By opposite currents the results are likewise opposite. Fig. 4 will make this easier understood. A B is the uniting wire, the notations the same as in the former figures. It is evident, by the inspection of the figure, that the north end of the needle *a*, having predominant austral magnetism, must be repelled by the similar magnetism of the conductor; and be turned towards the west. The attraction of the opposite magetism in the conductor tends to give the needle the same direction; but as this coincidence of motions, produced by opposite powers, is constant in electromagnetism, we shall always confine ourselves to mention but one of them. The south end of *e*, having predominant boreal magnetism, is also repelled by the similar magnetism of the current, which here has the same direction as the austral on the opposite side of the conductor. Thus the north end of the needle is on one side of the conductor turned the same way as the south end on the other side. The north end of *c* receives the strongest impulses from the west, and must, therefore, be pushed eastward; while the south end of *d* receives the strongest impulses from the east, and must move towards the west, and in consequence of this its north end must also turn eastward like that of *c*. Were the wire placed exactly over against the middle of the needle, this would be solicited equally in opposite directions, and therefore rest at its place.

When the uniting wire is bent in such a manner, that the parts on each side of the flexture are parallel, the exterior surfaces of the two branches are similar, and also the interior ones. In Fig. 5, A C D B represents such a wire. As the current enters the superior branch at C, and in the inferior at B, it is obvious that the directions of the powers in the magnetical circles are the same at *e* and *f*, at *g* and *h*. Suppose that the two branches are in one perpendicular plane, and the north end of the needle is placed in a plane, below the superior and above the inferior branch, the north end will be repelled, when placed on the west side, and attracted, when placed on the north side of the wire. Above the superior branch, or below the inferior branch the effects are in the opposite direction. All the other cases, belonging to the effects of bent connecting wires upon magnetical needles, may be easily explained in a similar manner.

These are the principal experiments, by which Professor Oersted endeavoured to establish the fundamental law of electromagnetism. As they all belong to one class, it has been practicable for us here to maintain in our account the historical order, without impairing the systematical one. In order to have a short term, we shall call the magnetical action of the electrical current, the *revolving magnetism.*

The discoverer remarks, in his Latin publication, that the magnetical action of the current being necessarily propagated and not instantaneous, the association of a progressive and revolving motion must give origin to a spiral motion; still, he adds, this seems not to be required for the explanation of the electromagnetical facts hitherto discovered. His words are, "Præterea motus per gyros cum motu progressivo, juxta longitudinem conductoris conjunctus, cochleam vel lineam spiralem formare videtur, quod tamen, nisi fallor, ad phænomena hucusque observata explicanda nihil confert." Several writers upon the continent have considered it as an essential point in Oersted's theory, that the magnetical motions in the current should be of a spiral form; but it is evident that he has well distinguished this theoretical but still necessary consequence from the fundamental law, deduced from the facts. Supposing here spirals in the place of parallel circles, their windings must be so near to parallelism, that the deviations from it must be imperceptible. Thus the question belonging to the spirals may be left for farther research, in which, perhaps, the whole doctrine of vibrations might be considered.

In an appendix published two months later, (in Schweigger's Journal,) Professor Oersted explained the apparent difference observed between the effect of the galvanical battery, and that of a simple galvanical circuit. In the battery, which is a compound galvanical circuit, as well as in the simple one, the electrical current goes from the more oxidable metal (zinc), through the liquid conductor, to the less oxidable (copper): and when the water is taken away in one of the elements of the battery, and a wire put in its place, the direction of the current remains of course the same; but when we make use of a simple circuit, the water remains at its place, and the uniting wire connects the two pieces of metal in a place, where the direction of the current is the opposite to that of the water. Fig. 6 will make this more perspicuous; Z represents here the zinc, C the copper, W the water, U the uniting wire; the arrows marked with $+ e$ and $- e$ indicate the direction of the electrical current. It is visible that when in W the current goes from zinc through the water to the copper, it must in U go from the copper to the zinc.

In this appendix it is remarked that the magnetical efficacy of the electrical current depends not on its intensity, but on its quantity of electricity, and that the simple galvanical circuit is preferable for electromagnetical experiments. Some time after the discovery of electromagnetism, the great Swedish chemical philosopher *Berzelius* was of opinion that all the effects of the uniting wire could be explained in assuming four magnetical poles in its circumference. Plate DXXII. Fig. 7, where A indicates the austral, B the boreal poles, represents such a distribution. As the appearances in the first electromagnetical experiments may, until a certain degree, be represented by this scheme, it had many adherents, even since Berzelius had abandoned it. In order to decide the question upon this subject, Professor Oersted made a direct experiment which will be understood by Fig. 8. AB is a wooden pillar more than twelve feet high; C is a magnetical needle, protected with glass against motions in the air; DE a wire of brass; K a galvanical apparatus; HGF and OJL brass wire; M and N small cups with mercury. The whole movable part of this arrangement was supported by a wooden frame, not here represented. It appears that the apparatus K with its conductors, whose extremities are plunged in the mercury, can turn around nearly through the whole circle, without an interruption of the continuity of the conductors; thus the same point of the perpendicular wire, though immovable itself, changes every moment its relative place in the circuit, when the movable part FGIL is turned round. The experiment shows that the deviation remains the same, whatever the position of the movable part may be, and that of consequence the polarity must be the same in all points of the circumference of the conductor. The great distance of the other parts of the circuit is the reason that DE is the only one which can have a sensible effect upon the direction of the needle.

A most useful application of electromagnetism is the *electromagnetic multiplier*, invented by Professor Schweigger at Halle, and improved by several other philosophers. We have already seen that when the uniting wire is bent so as to form two parallel branches, each of them acts in the same direction upon one of the poles of a magnetical needle placed between them (Fig. 5.). On proceeding upon this principle it is clearly shown that when the uniting wire is bent several times, as ABCDE, Fig. 9, and a magnetic needle is suspended in the space, inclosed by the windings of the wire, each of its horizontal parts must produce upon the needle an equal effect; thus in the figure the effect is quadrupled. It is to be remarked, that the windings should be as near each other as possible, in order to keep them all very near to the needle. At the same time the windings must be isolated from each other, which is effected by covering the wire with silk. As the windings can be repeated a great number of times, the multiplication of the effect may go very far. It should be nearly without limits, were it not that the conducting power decreases when the length of the wire increases. In order to give the instrument the solidity necessary, the wire is wound upon a frame. As it is required that the needle should be as movable as possible, it is suspended by a fibre of silk, such as is found in the cod of the silk-worm. The instrument may be made much more sensible by means of another magnet placed so as to diminish the directive power of the needle. Mr. Nobili has made a new improvement in this apparatus. In the place of one needle he introduces a compound index, consisting of two needles, NS and S′N′, Fig. 10, in opposite directions, and joined by a piece of wood or of stout wire, GH. When these two needles are of equal strength, the directive power of the index is reduced to nothing; so that the most feeble impulse will move it. But even when one of them has some preponderance, the force required for making the index deviate is still inconsiderable. At the same time this arrangement has the advantage, that both needles receive an impulsion, the needle NS from the inferior side of the conductor, and S′N′ from the superior. The needles being in opposite situations, one will receive the same direction by the superior, as the other by the inferior side of the wire. When the needles approach as much to equality as is required for some nice experiments, the index is too easily moved in some others. In order to make the instrument proper for experiments with various degrees of force, though all of the feebler kind, Professor Oersted added a bent magnet, IKL, which can be placed so as to repel the nearest end of the index, or so as to attract it. The first of these positions is represented in Plate CXXII. Fig. 10. The magnet can also be approached to the index or removed from it. Fig. 11 represents the whole instrument of half its dimensions. AB is a stand of wood, having a screw on each corner for levelling it. CCC, CCC are two supporters likewise of wood, bearing the frame *defg*, upon which the multiplying wire is wound. This wire may be conveniently 50 to 60 feet long, and make 100 or more windings. From the windings each end of the wire passes through a little ring h, (the other is not to be seen in the figure,) at ii the ends of the wire passes also through rings, which are here covered by the other parts of the figure; KK, KKK, are two small pillars of ivory or wood, supporting the transverse piece ll, through which passes the cylindrical piece mp, having a head at m, and being movable upwards and downwards. At the centre r of the inferior extremity, p is a little hole, communicating with a transverse hole, which here is represented as shut with a pin, seen immediately under the ring o. Through the hole at r is introduced one end of the silk rx, which is drawn out through one of the openings of the transverse hole, and fastened by means of the pin abovementioned. By the silk rx is suspended the index, consisting of the superior magnetic needle ns, and the inferior one, of which the extremity n is here visible, the other being covered by other parts of the figure. The boreal pole of one of these needles is turned in the same way as the austral of the other, and both connected with a piece of wire. The circle at whose divisions the index points, is made of glass, preferable to brass, which often is magnetic. At q is a slit to receive the needle and keep it; when the instrument shall be transported, a similar one is on the other side of the instrument. The index is cleared from the slits when the instrument is to be employed. Having been thus cleared, it is still at rest until the piece mp is drawn upwards, the ring o stops it, so that it shall not be elevated too much. The index is sheltered from the air by means of a case of glass which covers the whole frame including the index, and has in the upper part a hole through which the head m of the piece mp passes; tt is a pile movable in the slit yy, which has a scale, showing the distance from a point in the same plane, perpendicular below the centre of the index; uv is a bent magnet, which has two points, one of which is visible at w, the other is placed in a hole in the pile tt. This magnet can be taken out, and the point w introduced in the pillar, in order to augment or diminish the directive power of the index, as the purpose may require. When this instrument is to be used, the index must, as already mentioned, be taken out of the slits, and the piece mp be elevated, so that the index can move freely.

When it is made to oscillate too much it may be brought to rest by lowering the piece mp a moment. If the two needles of the index have exactly the same power, it will have the highest mobility; but if this is not obtained, the bent magnet uv is to be so placed upon the pillar tt that the two nearest poles of the index are repelled. By approaching or retiring the pillar, the magnet may be brought into such a position that the directive power of the index is scarcely sensible. When the instrument is in this state it can make sensible the difference between two pieces of metal, of which one differs only from the other by $\frac{1}{100}$ alloys, when a powerful liquid is applied. When a more considerable effect is to be tried, the bent magnet is put in such a position that it attracts the nearest poles of the index. When the magnet is near the index, and the current makes the index deviate very little, the deviation increases as the magnet is removed. The distance of the magnet being measured by the scale, this arrangement may contribute much to the determination of the powers. As the needles submitted to the effect of the current can never rest at an angle greater than 90°, the needle is prevented from going farther by means of two small pins here marked with the Greek letter φ.

The use of the electromagnetical multiplier is very extensive. Before the invention of this instrument, a prepared frog was considered as the nicest test for galvanism; the multiplier surpasses it by far. Mr. *Poggendorff* has made a very extensive trial upon the galvanic series of metals and other conductors, by means of this instrument. Professor Oersted has made use of it, for confirming the discovery earlier made by *Zamboni*, upon electrical currents which two pieces of one metal makes with a liquid. He has also discovered, by means of this instrument, that two equal pieces of metal give galvanical effects, when one of the pieces is earlier introduced in the fluid than the other, a fact which Sir Humphry Davy has confirmed, as it appears, without knowing Oersted's experiments. Professor Oersted has also made use of this instrument for trying silver. With a powerful liquid conductor, solution of potash and muriatic acid for instance, silver pieces, whose alloy differs less than a hundredth, give a deviation of several degrees. As silver containing brass gives more effect than silver containing an equal quantity of copper, when muriatic acid is employed, but less when solution of potash is the liquid conductor, the presence of brass in silver is easily discovered by this instrument. It need scarcely be mentioned that gold and other metals may be tried in the same manner. Dr. Seebeck, at Berlin, has investigated, with much care, all the circumstances belonging to the construction of the multiplier. These researches are given in an excellent paper, read at the Royal Academy of Berlin, on the 14th December 1820, and the 8th February 1821, containing a valuable detail of experiments upon several points of electromagnetism. Dr. Seebeck has proved, by experiment, what might be presumed in theory, that the increase of the effects of the multiplier, with the number of the turns, is limited by the resistance against the transmission increasing with the length. The effects of the multiplier increase also with the breadth of the conductor, which he made of a long and thin lamina, in the place of a wire; still the advantage of broad conductors is only confined to experiments with considerable powers: in feeble currents the effects of broad and narrow conductors are equal.

Several philosophers have given themselves much trouble to produce upon the needle, by means of common electricity, the same effects as those produced by galvanism. A simple electric spark transmitted through a conductor passes too speedily to move the needle. A current produced by the electrical machine does not seem to contain a sufficient quantity of electricity for acting upon the needle without the aid of the multiplier. Even by this instrument it was tried often, without decided success, until of late Mr. Colladon, at Geneva, repeated the experiment with a multiplier, in which the wire was covered with three folds of silk, and thus well isolated. When he approached the two ends of the wire of this instrument to the two conductors of an electric battery of 4000 square inches, so as to make the discharge go a little distance through the air, before it enters in the wire. In this manner a current sufficiently strong, and of some duration, is produced, whereby a considerable deviation is effected. The current produced by an electric machine caused also a deviation of several degrees in this instrument.

Professor Oersted proposed, in a paper printed in Schweigger's Chemical Journal, 1821, to make use of magnetical needles, suspended in various directions for investigating the electrical currents in the atmosphere; but he has published nothing since that time. Mr. Colladon has, with full success, employed the multiplier, to prove the presence of electromagnetism in a thunder storm.

The idea of magnetical revolutions around the uniting wire experienced much opposition at its first publication. Professor Schweigger objected to it, that when such revolutions did exist, it would be possible to make a magnet circulate round the uniting wire. Dr. Wollaston drew the same conclusion, but with the contrary meaning; finding this result probable, he invented an instrument to prove it. The experiment having been stopped by an accident, Mr. Faraday took it up, and made an extensive series of experiments on the subject, conducted with the same skill which he has displayed in so many other investigations. He found that not only the magnet may be made to turn round the conductor, but that likewise a movable conductor, may be made to turn round the magnet. We shall have an opportunity to return to this subject; here we can only give an account of the experiments by which the motion was communicated to the magnet. Plate DXXII. Fig. 12, represents an apparatus proper for the experiment; CCCC represents a cup of glass, or some other non-conductor, through the bottom of which passes the conductor EFG. The cup is filled with mercury, in which a small magnet AB floats, being kept in a vertical position by a piece of platinum, fixed at its inferior extremity. It can also be kept in this position by fixing the inferior extremity to the bottom by means of a short thread of silk. *D* is a conductor whose lower end dips in the mercury. When a strong electrical current is now caused to pass through this arrangement, the magnet revolves about the conductor D. The directions of the rotations are in all cases such as the fundamental law of electromagnetism indicates that they should be. A magnet can also be made to turn round its own axis by an electrical current. Let CCCC, Fig. 13, be a cup of glass or wood, nearly filled with mercury; AB a magnet, having at its lower extremity a steel point, introduced into the agate H. JK is a slip of brass or ivory, having a hole through which the magnet passes freely, and by means of which it is kept perpendicular at the superior extremity; A, is a cavity for receiving mercury; EF is a wire, at whose extremity is also a cup for mercury; and at D is placed a similar one, from which proceeds a wire amalgamated on its lower extremity, in order to favour the electrical communication. When the electrical current is established by conductors plunged in the mercury at D and F, the magnet will turn with great rapidity.

On the power of the Electrical Current in developing Magnetism in other Bodies.

In a paper read before the French Institute, the 25th September 1820, Mr. Arago showed that the electrical current possesses, in a very high degree, the power of developing magnetism in iron and steel. Sir Humphry Davy stated the same facts in a letter to Dr. Wollaston on the 12th November 1820. Dr. Seebeck communicated to the Royal Academy at Berlin, the 14th December, an excellent series of experiments upon the same subject. Thus treated in the space of three months by three so highly distinguished philosophers, the subject was nearly exhausted in the same year that the discovery was made. The uniting wire of a powerful galvanic apparatus attracts iron-filings often with such a power as to form a coating around the wire ten or twelve times bigger than itself. Mr. Arago found that this attraction did not take its origin from any previous magnetism in the iron-filings, which could touch iron without adhering to it; nor was the attraction to be considered as a common electrical one, since brass and copper filings were not attracted. He found also that the iron-filings began to move before they came in contact with the uniting wire. Hence it must be admitted that this attraction is operated by converting each little piece of iron into a temporary magnet. Greater pieces of soft iron were also converted into temporary magnets, and small steel-needles into permanent magnets. Sir Humphry Davy had, in his researches, obtained the same results, before he had got notice of the experiments of the French philosopher. Dr. Seebeck seems to have been in the same case, when he made his experiments; but he had received notice of Arago's experiments when he published his own. The direction of the magnetism produced is always according to the fundamental law. Let the circle in Fig. 14 represent a horizontal section of a perpendicular conductor, in which the current comes from above; let the little arrows indicate the direction of the revolving magnetism, and BA, BA, BA, BA, some steel needles; then these needles will obtain austral magnetism at A, and boreal magnetism at B.

Dr. Seebeck found that a steel needle was strongly magnetized when it was drawn around the conductor. The direction of the magnetism was the same as it should be, if the needle had been laid closely around the conductor, and afterwards removed. He laid also an armour of soft iron on both sides of the conductor, which hereby was made able to bear a considerable weight of iron.

Mr. Arago and Mr. Ampère, employed in the development of magnetism the principle of the multiplier, without having notice of the discovery of Schweigger. A steel needle AB covered with paper, was surrounded by a winding of the uniting wire EE, as represented in Plate CXXII. Fig. 15. The steel-needle may also be included in a glass tube. The great galvanic apparatus of the London Institution is now found to develope magnetism in such an eminently high degree, that a little steel bar, by falling through a glass tube, around which the windings of the uniting wire passed, was magnetized to saturation.

The electricity produced by friction, when employed in sufficient quantity, developes likewise magnetism in steel. The discharge of an electric battery, and even of a single bottle, magnetises a steel needle. All these magnetical effects are submitted to the same law as those of the galvano-electrical current, and hence they are also increased upon the principle of the multiplier. When the discharge passes through the air across the steel-needle, the magnetism developed is feebler than it is when the electricity passes across it through a metallic conductor.

Mr. Savary, at Paris, has of late discovered that steel-needles placed at different, yet small distances from a wire, through which passes an electric discharge, do not all obtain magnetism in the same direction. In one of his experiments he caused to pass the discharge of a battery having twenty-two feet surface through a platina-wire of about three feet in length and one-hundredth of an inch in diameter. The needles in contact with the wire became magnetised in the direction commonly observed, which he calls the positive direction, but a needle placed at the distance of 1.1 millimetre, about $\frac{1}{24}$ inch, becomes magnetic in the opposite direction, which he calls the negative. At the distance of 2 millimetres a needle was not made magnetic by the discharge. At the distance of 3 to 8 millimetres the needles become magnetic in the positive direction, but most at the distance of 5.5 millimetres. From 8.6, to 21.4 millimetres, the magnetic direction was negative, with increasing intensity from 8.6, to 14.6, and with decreasing from this point until 21.4, where it was nearly at zero. From 23 millimetres distance the magnetic direction became again positive. As for different conducting wires, he found, that within certain limits the maximum of effect is the more distant from the wire, and the numbers of alternating directions the greater, in the same degree that the wire is shorter in comparison to its length. In a helix of narrow windings, needles placed parallel to its axis obtain all the same kind of magnetism, but by varying the electrical power, from that of one bottle of Leyden, to that of a battery of twenty-two feet surface, he obtained, in one experiment, six alternations, viz. three positive and three negative. When the needles are included in a metal coating, for instance, wrapt in a lamina of tin, the effect is changed. If the coating is thick, the effect is nothing, but by a coat sufficiently thin the effect may be increased. When the conducting wire is straight, a plate interposed between the wire and the needle, if thin, augments the effect, if thick, diminishes it; a certain thickness may also be found by which the plate is without effect. The needle is in all these experiments in contact with the plate. When the plate is not interposed, but the wire placed upon the plate, the effect of a very feeble discharge is increased by the plate, and still more the thicker it is. At a certain degree of discharge a thin plate diminishes the effect, a thick plate augments it. The effect of very considerable discharges is always reduced to nothing, or inverted by thick plates. By the galvanic arrangement the same effect is not produced, when the current is uninterrupted, but analogous effects to those mentioned may be produced by an apparatus which has intensity enough to give sparks at the moment of closing the circuit. The current must, for this purpose, only be established for a moment; a constant current destroys the alternations.

The analogy of these effects, with those alternations, which may be produced in bad conductors by common electric experiments, is obvious.

Mr Hill, at Lund in Sweden, has found that when the discharge passes along a magnetical needle, exactly through its axis, all its magnetism is destroyed. He even considers this as the best means to take away the magnetism of a needle. At the same time he remarks that when the electric charge does not go through the axis, a feeble magnetism is developed on both sides of the line of passage, which probably has led preceding philosophers into an error respecting the magnetical effects of electricity. (Schweigger's Journal for the year 1822, No. 3.)

Professor Ermann at Berlin found that when the electrical discharge passes perpendicularly through the centre of a round plate of steel, it reveals no magnetism, but when a split is afterwards made in the plate, or a sector cut out of it, the opposite side of the gap shows the opposite magnetism. The celebrated Gay Lussac and Mr. Welther, without knowing the experiment of the Prussian philosopher, discovered the same fact in a steel ring. This experiment is very illustrative; it shows that the steel disc or steel ring, whose circumference has been in the same state as that of the uniting conductor, preserves after the cessation of the current a latent magnetism, resembling that of a magnetic circle, composed of small magnets, connected by their opposite poles. Such a circle is ineffectual when the circumference is closed, but becomes a magnet when opened. This magnetism was, however, effectual during the time that the ring or disc was comprehended in the current, wherein its magnetism at every moment received a new impulse. Hence we may conclude that the circumference of the uniting conductor is not to be compared with a magnetic circle, wherein the powers are at rest, which is the theory brought forwards by *Mr. Prechtel*, director of the polytechnic school at Vienna; but our experiment confirms the original idea of the magnetical effect of the current as produced by a revolving magnetism.

This view of the subject, that the magnetism of the electrical current is a magnetism in motion, has been overlooked by a great number of authors who have written upon electromagnetism: while it has been adopted by two highly distinguished philosophers, Dr. Wollaston and Mr. Biot. The difference between magnetism in motion and at rest being until our time unexemplified, this view appeared to many philosophers as a mere postulate, which they tried to avoid, by adopting some other theory, particularly the elaborate theory of Ampere, of which we shall afterwards speak. Now the theory of revolving magnetism has obtained a considerable support by the discovery of Mr. Arago, who, in his researches on the effect of metals upon the oscillations of the magnetic needle, found that it was much affected by a metallic plate, for instance a copperplate, when either the needle or the plate was put in motion. There is certainly but few philosophers who have not repeated Arago's remarkable experiment by which a rotatory plate of copper or some other metal puts a magnetic needle conveniently suspended, into a revolving motion. We must pass in silence the numerous and skilfully conducted experiments of Mr. Barlow and Dr. Seebeck, and only quote for our purpose those of Messrs. Herschel and Babbage, by which it is proved that a rotating magnet causes a conveniently suspended metallic plate to turn round. Mr. Poisson has read before the French Institute an elaborate mathematical treatise upon the theory of moved magnetism. Thus the theory of revolving magnetism has obtained the only confirmation which could still be desired.

Effects of the Magnet upon the Uniting Wire.

Professor Oersted, in the prosecution of his experiments, was well aware that a movable part of the electric circuit must be attracted and repelled by a magnet after the same laws by which the uniting wire acts upon the magnet. He published, two months after his first electromagnetical paper, another paper, in which he gives an account of an experiment he made; he found that a little galvanical circuit, suspended by a thin metallic wire, was put in motion by a magnet. He complains himself in this paper, that he had not succeeded hitherto in getting an apparatus sufficiently movable to be directed by the magnetism of the earth (Schweigger's Journal.) Professor Schweigger at Halle, and professor Erman at Berlin, both invented, without knowing Oersted's experiment, apparatuses fit for the same purpose. It would be tedious to give an account of all the experiments made upon this subject; a short description of those which are considered as the best will be sufficient. Plate DXXII. Fig. 16 represents, with some slight modifications, an apparatus invented by Mr. Ampere. A B C D E F G H is a bent wire, of which the two ascending parts at B and G are isolated from each other by some non-conductor and tied together. At A, and also at H, is soldered a steel point, which reposes on the bottom of a small iron cup filled with mercury, at K and M. J K and L M are brass wires, N O a piece of wood, in which they are inserted, and by means of which they can be fixed at a convenient place. It appears that when the current enters at the end of one of these wires, for instance at J, it is obliged to pass through the whole movable conductor A B C D E F G H, and go out at the other end L. This conductor is put in motion with much promptitude by means of the magnet. In comparing this arrangement with Fig. 5, it is obvious that the part D E F G of the movable conductor, in which the current enters at D, is quite analogous with B D C A, Fig. 5, and that therefore the austral magnetism on the interior side of both is turned toward a spectator placed over against the place represented by the figure. It is also evident that the magnetical direction is the same in the part B C D, which turns the same side to the space included by the movable conductor. Thus a magnet whose austral pole is directed against this space will repel the conductor, but placed near to a point of the exterior side it will attract it. On the opposite side of the plane B C D E F G, all the effects are opposite to those here mentioned.

The magnetism of the earth is likewise able to give a direction to the suspended wire. This direction must, in the northern hemisphere, be the same which is produced by a magnet placed below the wire with its austral pole above, and its magnetical axis put in the direction of the dipping needle; which direction is the same as that which a magnetical needle should tend to give the wire if it were fixed below it, in the same position which the current gives it. Thus the plane C D E F must be directed perpendicularly to the magnetical direction; when the current enters at A, the perpendicular part F E will be placed towards the west, but towards the east, if the current enters at H.

The same reasoning may be employed in all other cases where a movable uniting wire is exposed to the influence of terrestrial magnetism; for instance, when the wire is suspended in such a way as to permit the particles to move only in vertical planes. Plate DXXII. Fig. 17, represents an arrangement of this kind. A B C D is a wire, whose two extremities are wrapt round the ends of a thin axis of some non-conductor, and are terminated by two steel points, *a* and *d*, destined to be placed in two steel cups filled with mercury, and communicating with a galvanic apparatus. In order to give it the mobility necessary, it is nearly balanced by a counterweight at E. When the axis is placed perpendicularly to the direction of the magnetic needle, and the current enters at *a*, that is in the west, the plane A B C D will be driven out of its perpendicular position, and deviate towards north: but if the current enters at *d*, the deviation will be austral. If the axis A D is placed in the direction of the magnetic needle, the deviation will, in the first case, be towards the west, in the last towards the east. The boreal pole of a magnet, placed below B C produces the same phenomena; the deviation goes always to the left of the current.

The principle of the multiplier has also been applied to the movable uniting wire. Fig. 18 represents one of these contrivances invented by Mr. Ampere, and somewhat modified by Professor Van de Ross. On the extremity A of the wire is a steel point, resting in a cup with mercury: B is a part of the wire, which forms spirals, fixed on a circular piece of pasteboard, through whose centre it passes at the last, and is prolonged to C, which dips in a cup of mercury. Another apparatus, likewise invented by Mr. Ampère, is represented in plate DXXIII. Fig. 1. The wire passes through a glass tube, from A to B, it is then wrapt around it, and being returned to the extremity A, passes also around C D, and being arrived at D is drawn through the tube, and descends finally to the inferior cup.

Another apparatus of Mr. Ampère, improved by Mr. Marsh, destined to show the magnetical effect of the earth upon the uniting wire, is represented Fig. 2; A B is a cup of glass nearly filled with a convenient liquid, containing a galvanical arrangement, and kept swimming upon a liquid by a piece of cork; the uniting wire is like that of Fig. 1.

In the same manner as a magnet can be made to revolve round the uniting wire, so can a movable uniting wire be made to revolve round a magnet. Fig. 3 shows the principal parts of an apparatus for this experiment; C C C C is a glass cup having a hole through its foot, into which is inserted a copper tube, soldered to a copper disc, cemented to the foot of the glass. The wire E F is also soldered to another copper disc upon which the glass rests; *n s* is a magnet inserted in the copper tube. The cup is filled with mercury. At *a* there is a sort of ball and socket joint, by means of which a wire *a b* is put in communication with the arm D H of a brass pillar: both the socket and the ball are amalgamated, and a piece of silk fixed to the ball or head of the wire, passes through a hole drilled in the arm D H, and by which the wire *a b* is suspended, thereby preserving the contact, and leaving to the latter a perfect freedom of motion. When the current is established, the wire *a b* will revolve about the magnet. The directions of the rotations are such as the theory indicates.

We have seen that a magnet can be made to turn round its axis. An apparatus has likewise been contrived for producing the same phenomena in a movable uniting wire. For shortness sake we shall here omit the description of it, while we give the description of a very simple turning apparatus invented by Mr. Ampere, and whereof a perpendicular section is exhibited in Fig. 4. A B C D and *a b c d* are two cylinders of copper, soldered to a bottom of copper, in such a manner that the space between the two cylinders is able to contain a liquid, but the interior cylinder is left open at both its ends. To *a* and *b* is soldered a bent copper wire, having a cavity at F. *z z* is a light cylinder of zinc, to which is also soldered a bent wire, in the middle E of which is a steel point resting in the cavity F, and consequently the cylinder *z z* will move upon its point of suspension. When the space between the two cylinders is filled with a convenient fluid conductor, an electrical current is established. Now, if a magnet N S is introduced into the cylindrical space of *a b c d*, the cylinder *z z* will begin to turn. When the north end (the austral pole) is upwards, the motion is from left to right of the observer, and the contrary with the magnet reversed; all as it could be predicted from the fundamental law of electromagnetism.

Another ingenious contrivance, invented by Mr. Barlow, is represented in Fig. 5, where A B is a rectangular piece of hard wood, C D a wooden pillar, D E F a piece of stout brass or copper wire, *ab* a somewhat smaller bent wire, soldered to it at F, through the legs of which passes the axis of a wheel W, of thin copper, *h f* is a small reservoir for mercury, and *g i* a narrow channel running into it. H is a strong horse shoe magnet. Mercury being now poured into the reservoir *h f* till the tips of the wheel are slightly immersed in it, and the surface covered with weak dilute nitric acid, let the connexion with the battery be made at *i* and *D*, and the wheel will immediately begin to rotate. If the current or the magnet be inverted, the motion of the wheel will also be reversed. In order to understand this experiment, it must be remarked, that each radius of the wheel which touches the mercury, is a part of the uniting conductor, of which one side is repelled by the austral, the other by the boreal pole of the magnet; thus it must either tend to raise or depress each of these radii.

Sir H. Davy has exhibited the rotation of a conductor by means of mercury. When in a shallow non-conducting vessel containing mercury, the conductors of a powerful galvanical arrangement are plunged at some distance from the sides, and one of the poles of a strong magnet is brought from below to the bottom of the vessel, near one of the conductors, the mercury round this conductor will form a vortex about it. The directions of the motions are always according to the poles and conductors in action, such as the fundamental law indicates.

When a movable part of the uniting wire is placed in the direction of the dipping needle, it cannot be put in motion by the magnetism of the earth: but when it is placed in another plane, though under the same inclination, it is put in motion. Professor Pohl at Berlin, has invented an apparatus, represented in Plate DXXIII. Fig. 6, exhibiting this phenomenon. AB is a piece of board, supported by screws, by means of which it can be levelled. *CD* is a wooden pillar, whose superior part is immovable, and has on its top an agate, which serves to support a steel-point, whereupon rests a wire EF, balanced by a counter-weight G. At E is a cavity containing a drop of mercury, by means of which one of the conductors, whereof only a part, H, here is represented, may be made to communicate with the movable wire. JKL is a circular channel containing mercury, which can be put in communication with the galvanic apparatus through a conductor at M. When a powerful electric current is transmitted through the apparatus, EF can only rest in the position of the dipping needle; in all others, it moves until it arrives at that position, which it nevertheless will leave by the motion already obtained. Hence it must still continue to turn, when it is not stopped, to the position in which it is possible for it to rest.

Mutual Action of Electrical Currents.

Mr. Ampère found, soon after the discovery of electro-magnetism, that *two conductors attract each other, when they are transmitting electrical currents of the same direction, but that they repel each other when the currents have opposite directions.*

The movable conductor, represented in Plate DXXII. Fig. 16, and already described, may be employed to prove this by experiment. As the current which passes through the movable wire ABCDEFGH, has in CD the opposite direction of that in FE, the same uniting wire, which attracts one of these, will repel the other. This experiment may be exhibited in various shapes; but it does not appear that any experiment which could not be made by this simple apparatus is necessary for confirming the law above mentioned.

This law may easily be deduced from the fundamental law of electro-magnetism, as may be seen by Plate CXXIII. Fig. 7, which represents two parallel currents of equal direction, and expressed by the same signs of which we have made use in the preceding pages of this article. It is here evident, that the boreal magnetism at *b* meets with the austral at *a*, and that the austral at α meets with the boreal at β, thus the effect must be attraction. In Fig. 8, two currents of opposite directions are represented, where the boreal magnetism at *b* meets with that at β, and the austral magnetism at α with the similar at *a:* which must produce repulsion.

When the currents are not parallel, but form an angle, they attract each other when both are directed either towards the apex or in the contrary way, but they repel each other when one of the two currents is directed towards the apex at the same time that the other goes off from it. Fig. 9. represents two currents which go from the apex. The boreal magnetism being in one of these directed from *a* to *b;* the austral magnetism in the other from β to α, the result must be an attraction by which the conductors, if one of them is movable, are brought to parallelism. The figure represents only one side of the conductors; but the opposite sides, having both their magnetical directions reversed, will likewise be attractive. It is also easily understood, that the opposite magnetical poles are directed against each other, and produce attraction when the current in both conductors goes towards the apex of the angle. Fig. 10. represents two currents having opposite directions with respect to the apex of the angle. Here the similar poles in the magnetical rotations are directed against each other, and therefore produce repulsion, such as to place both conductors in the opposite ends of one straight line, if one of them is movable.

This may be confirmed by means of the apparatus represented in Plate CXXIII. Fig. 11, consisting of two parts, viz. a movable conductor, A C B, and a multiplying wire D E F G. The movable wire is terminated by two steel points at A and B, which are to be placed in two small steel cups filled with mercury, and communicating with a galvanic apparatus. The multiplying wire is preferred to a straight one, in order to increase the effect. The upper part D E, of the multiplying wire is placed at the same height as the branch B C of the movable conductor; but in such a position that both conductors prolonged would form an angle. The extremities F and G of the multiplying wire are to be put in communication with a galvanic apparatus.

Mr. Ampère, to whom we are indebted for the discovery of the mutual attractions and repulsions of the electrical currents, considers the law of this action as a fundamental one, at least so far as our present knowledge extends. He thus admits no rotative action in the electrical current, but he transports it to the magnet, in which he supposes electrical currents, revolving in planes perpendicular or nearly perpendicular to the axis of the magnet. At first he supposed that all the currents had their centres in the axis, and were situated in planes perpendicular to this axis, but as he soon found that this would not represent the phenomena, he supposed that each atom of the magnet was surrounded by electrical currents, still revolving in planes perpendicular to the axis of the magnet. When Mr. Poisson, however, showed, that in consequence of this view the greatest effect of a magnetical bar would be placed in its extremity, contrary to experiment, he changed this supposition, and at present he is of opinion that the currents are situated in a plane somewhat inclined to the axis of the magnet.

By these suppositions, and a considerable exertion of mathematical skill, he is enabled to make this view represent well enough the phenomena, though his theory is very complicated. It is not necessary here to enter into a discussion on all the points of this theory, as simple consideration of the fact upon which it is founded will be sufficient to decide the question.

Let us suppose that electromagnetism had not been discovered before the discovery of the mutual action of electrical currents, the application of the common philosophical rules should enable us to discover therein the rotative character of the action. The fact is, as above mentioned, that parallel currents attract each other when they have the same direction, and repel each other when they have opposite directions. Now it is to be remarked, that two parallel things of the same direction have their opposite sides placed against each other: the left of the one is nearest the right of the other: but two parallel things of contrary directions have their similar sides turned against each other: right against right, or left against left. Thus the fact reduced to the simplest philosophical expression is that *two points of electrical currents repel each other by their similar sides, and attract each other by their opposite sides.* The most direct enunciation of the experimental result cannot here be considered as at the same time the expression of the philosophical one; for it is evident that two parallel things cannot act upon each other immediately, but only by some transverse action, which here shows itself as consisting of attractions and repulsions in opposite directions, or in other terms, as having polarity. But such contrary powers forming a circle, should keep themselves in equilibrium, and produce no effect without their limits, were they not in motion. Thus the very experiment of Mr. Ampère should, in the absence of all other evidence, be sufficient to prove, *that the electric current contains a revolving action, exhibiting every appearance of polarity.* We do not mean to ascertain the nature of these attractions and repulsions; but it has been our object only to point out the more immediate consequences of the facts.

Electromagnetical Currents produced by Heat.

Dr. Seebeck, in his researches upon electromagnetism, extended at the same time his investigations to the laws of galvanic action, and among these to the influence of heat in galvanic arrangements. Some phenomena here occurred to him which led him to think that two metals, forming a circuit, might produce magnetism when the equilibrium of heat in it was disturbed. Experiment confirmed this opinion. Plate DXXIII. Fig. 12. represents such a circuit; let ABC be a piece of bismuth, and ADC a piece of copper, and let one of the junctions, *A* for instance, be heated, an electrical current will be established, which here can only betray its existence by the magnetical needle; this indicates all the magnetical properties of an electrical current, and, in the instance here mentioned, the current goes into the heated junction from the bismuth to the copper. Dr. Seebeck is not inclined to consider the effect thus produced as a true electrical current, but an effect *sui generis:* and indeed we have not hitherto been able to discover in this circuit either any chemical effect, nor heat or light; still we can represent all the phenomena of Dr. Seebeck's circuit by the same terms as those of the common electrical current: and in the explanation of all the facts, it will appear highly probable that this current is truly a particular kind of electrical one. Professor Oersted has proposed to call the current discovered by Dr. Seebeck the *thermo-electrical* current, and in consequence of this to distinguish the action hitherto called Galvanism by the name of the *Hydro-electrical current.* Hence we have now the names *thermo-electricity* and *hydro-electricity,* to which we could add the name *tribo-electricity* for the electricity produced by friction. Dr. Seebeck has made a very considerable number of experiments upon the thermo-electricity produced by the metals and other perfect conductors. In a circuit containing bismuth, together with one of the other metals, he finds that, in the heated junction, the current goes always from the bismuth to the other metal; of course the bismuth loses, at that point, positive electricity. This we shall, for shortness sake, express thus: bismuth becomes negative with all other metals in the thermo-electrical circuit. In the same sense tellurium may be said to become positive with all other metals. It appears already by these two examples, that the thermo-electrical order of the metals is not the same as the hydro-electrical; and indeed the experiments of Dr. Seebeck have proved that these two orders are discrepant throughout.

The order of the metals, beginning with that which becomes negative with all others, is,

1. *Bismuth.*
2. *Nickel.*
3. *Cobalt.*
4. *Palladium.*
5. *Platinum.* Several pieces of this metal gave very different results, even those which came from the same workshop. Three pieces from Jeannetty's platina manufacture were placed in the order of their effects very far from each other. The pieces which kept this place here between palladium and uranium were prepared by Dr. Wollaston, Mr. Bergemann, chemist at Berlin, Mr. Trick, chemist, appointed to the manufacture of china at Berlin, and Mr. Jeannetty at Paris. As one of these pieces was prepared by Dr. Wollaston, and the two Berlin chemists being men of much chemical skill, we may consider this place as that of the pure platinum, if Mr. Becquerel had not found that two parts of the same platinum wire give a considerable thermo-electric action, when one of them was drawn out so as to become much thinner. Hence it appears that the density of the platinum has a considerable influence upon its thermo-electrical effect. This might perhaps also be the case with other metals.
6. Uranium.
7. Copper, reduced from the oxide by means of black flux, Comp. No. 12.
8. Manganum.
9. Titanium.
10. Brass, some specimens. (Comp. No. 13.)
11. Gold, of Hungarian ducat containing $\frac{1}{90}$ alloy of silver and copper.
12. Copper, occurring in the trade, and containing no silver, iron, lead, or sulphur. (Comp. 21.)
13. Brass, some specimens. (Comp. No. 10.)
14. Platinum, a piece of unknown origin. (Comp. No. 5, 18, 29.)
15. Mercury, the purest occurring in trade.
16. Lead, specimens occurring in trade, and pure lead.
17. Tin, English and Bohemian.
18. Platinum, A bar from Jeannetty's manufacture.
19. Chromium.
20. Molybdænum.
21. Copper, occurring in trade, and containing neither silver, iron, lead or sulphur. (Comp. 12.)
22. Rhodium.
23. Iridium.
24. Gold, *a,* purified by antimonium, *b,* reduced from the oxide.

25. Silver, *a*, purified by cupellation, *b*, reduced from the chloride of silver.
26. Zinc, *a*, occurring in trade, *b*, pure zinc.
27. Copper, reduced from sulphate of copper, *a*, by iron, *b*, by zinc. (Comp. 12. and 21.)
28. Wolfram.
29. Platina, some specimens, (Comp. 5, 14, 18.)
30. Cadmium.
31. Steel.
32. Iron, *a*, occurring in trade, *b*, pure iron.
33. Arsenic.
34. Antimony, *a*, occurring in trade, *b*, pure.
35. Tellurium.

In this series, Dr. Seebeck found that though most of the metals placed here near each other give only a feeble effect, and the more distant a stronger effect, this rule is not constant; tellurium, for instance, gives with bismuth less effect than antimony. With most of the metals in the series tellurium produces a feebler effect than antimony; with silver it produces more effect than with most of the metals placed above it. Antimony produces more effect with cadmium than with mercury. Iron produces only a feeble effect with most of the other metals, and particularly with nickel and cobalt. Of such exceptions Dr. Seebeck has found a great many.

Dr. Seebeck also examined the thermo-electrical powers of several other bodies. Sulphuret of lead becomes negative even in contact with bismuth. Some other sulphurets, as sulphuret of iron, of arsenic, of cobalt and arsenic, of copper, all with a maximum of sulphur, stand in the thermo-electrical series very near to the bismuth. On the contrary, the sulphurets with a minimum of sulphur stand very near to antimony; that of copper stands even under antimony.

Dr. Seebeck found also that concentrated nitric and sulphuric acids are to be placed above the bismuth, but that a concentrated solution of potash or of soda, obtains a place below antimony and tellurium.

Dr. Seebeck constructed also circuits of two pieces of one metal; heating or melting one of the pieces, and putting one extremity of the other piece, which must be bent, in durable contact, while the opposite extremity was in temporary contact with the heated piece. A bent silver wire was, for instance, plunged first with one of its extremities and afterwards with the other in melted silver; the magnetic needle indicated that the current was directed from the melted metal to that extremity which had been the longest time in contact. The same effect, though feebler, was observed when the silver had ceased to be liquid. When a platina wire is tried with a heated piece of platina the direction of the current is opposite. The general result of Seebeck's experiments is, that in the metals of the superior part of the thermo-electric series the direction of the current is as in the platina going from the heated metal to that extremity of the bent piece, which is latest put in contact with it; but in the inferior part of this series the current goes, as in the silver, from the heated metal to that extremity of the other metal, which has been longer in contact with it.

As soon as the thermo-electrical current was discovered, it was obvious that a compound thermo-electrical circuit might be formed in analogy with Volta's complex hydro-electrical circuit. This consequence did not escape Dr. Seebeck, but discovering some opposing circumstances, which we shall soon mention, he bestowed little labour upon this subject, to which he perhaps proposed to return another time. Baron Fourier and Professor Oersted undertook, without knowing this observation of Dr. Seebeck's, a similar research. Their first complex thermo-electrical circuit was a hexagon formed of three pieces of bismuth and three of antimony soldered together. One of the sides was put in the magnetic direction, and a compass placed below it, when first one of the junctions was heated, then two, not adjacent junctions, were heated, at last three, still leaving between two heated junctions one which was not heated. The compass needle changed its direction some degrees by the heating of one of the junctions, still more by the heating of two, and most when all the three junctions were heated. By cooling the three junctions by means of ice, and leaving the three others to the temperature of the atmosphere, similar and even more comparable effects were produced. By heating three alternating junctions, and cooling the other with ice, the effect rose to 60° of the compass used in the experiment. In another series of experiments a rectangular circuit of 22 bars of antimony and 22 of bismuth soldered together was employed. Here likewise as in the preceding experiment, the combined effect of heating and cooling was employed. Now the circuit was opened by dissolving one of the junctions, and, in order to establish the circuit, when required, a little cup of brass destined to contain mercury, was soldered to each of the two bars, whose conjunction was interrupted. A copper wire of about 4 inches in length, and $\frac{1}{25}$ inch in diameter re-established nearly the current; and by two parallel pieces of this wire the current was brought to the full effect. A wire of the same diameter, but a little more than three feet long, was found a tolerably good conductor, while a platina wire of $\frac{1}{50}$th inch and about 16 inches long scarcely transmitted a fortieth of the effect. Liquid acids and solutions of alkalies or other metallic oxides, which prove excellent conductors in the hydroelectrical current, were found quite isolating in the thermo-electrical circuit. Two discs of silver, separated only by a lamina of the thinnest blotting paper, moistened with sulphate of copper, isolated likewise the whole effect of the thermo-electrical current.

The thermo-electrical current, even the most intense that was tried, produced no visible chemical effect; nor was it capable of producing heat in thin metallic wires, probably because they are too feeble conductors of thermo-electricity.

The thermo-electrical circuit also produces no effect upon the electrical condensation.

It is very remarkable that, notwithstanding all that has been mentioned, the thermo-electric circuit makes a prepared frog palpitate, like the hydro-electrical circuit. The communication between the extremities of the circuit and the nerves of the frog were made by means of platina wire, in order to guard against the influence of unequally oxidated surfaces.

Among circuits differing only by their length, the shortest has the greatest effect. A circuit of double length has not much more than half the effect. Complex circuits do not seem, therefore, at first sight, more efficacious than simple ones; the length being as much increased by the increased number of elements, as the effect should be heightened by the greater number of acting junctions; but comparing circuits of equal length whereof one has only two junctions, the other more, we see the true influence of the increase of acting junctions. Plate DXXIII. Fig. 13 represents a simple circuit of antimony *aa*, and bismuth *bb*, where only one of the junctions is to be heated or cooled. Fig. 14 represents a complex circuit of the same length, formed of two pieces *aa* of antimony, and two pieces *bb* of bismuth. Two of the junctions of the latter arrangement, situated on the extremities of one diagonal are here heated or cooled. Under the same changes of temperature, where the circuit, Fig. 13, made the needle to deviate about 22 degrees, that of Fig. 14, made it to deviate about 30 degrees. Fig. 15 and 16 represent two circuits of double the extent of the former, one simple, one having three alternations. By the same differences of temperature, by which the arrangement, Fig. 15, gave from 13 to 15 degrees, that of Fig. 16 gave nearly 32 degrees.

In several complex circuits, it is found that the heating or cooling of one junction only produces twice the angular deviations of that added by the addition of each active junction more. The effect of one active junction, when the others are at rest, is by experiment found to be twice the effect of all the arrangements, divided by the sum of the elements + one. The effect of each addition of a new active junction is only half this quantity, and seems even to be in a decreasing ratio, when the number of junctions is great.

The effect of thermo-electricity upon the multiplier is very instructive. Fig. 17 represents an arrangement formed by two pieces *b*, *b*, of bismuth, and one piece *a* of antimony. When the two free extremities of *b*, *b*, are put in communication with the extremities of the wire of the multiplier, and one of the junctions between *a* and *b* is heated or cooled, the needle of the multiplier is deviated, but very little; when one of the junctions is only cooled with ice, the effect is not so great as that of a disc of copper with one of silver, having common water as the liquid conductor. But when the extremities of *b*, *b*, are put in communication by means of a short piece of metal, the effect on the compass needle is considerable, whereas the effect of the hydro-electrical current of silver and copper, and even of silver and zinc, with common water as the liquid conductor, is scarcely sensible upon the same compass needle. This is a strong additional proof of the difficult transmission of thermo-electricity.

From all these observations we must conclude that the thermo-electric current produces an enormous quantity of electricity, but in a state of exceedingly small intensity. In order to conceive this well, it is to be remarked that the *intensity* of electricity is measured by the attractions and repulsions, whose force is in the inverse ratio of the squares of the distances, and that the *quantity* of electricity is measured by the number of equal surfaces which can be electrified by it to a certain degree of attraction and repulsion indicated by the electrometer. In the voltaic pile the intensity increases with the number of dics, the quantity with the surface of each of the discs. The greater the intensity the greater is the power of surmounting obstacles, or of penetrating through imperfect conductors; on the contrary, the greater the quantity the more perfect conductor is required to transmit it. The electricity produced by some thousand pairs of discs is able to penetrate a little lamina of air; that of some hundred pairs can at least penetrate through a considerable length of water; that of two pairs cannot easily be transmitted but by the solid conductors and some of the powerful liquid conductors.

The thermo-electrical current has a prodigious quantity of electricity in comparison with the hydro-electrical of silver, zinc, and water, but the intensity of the electricity is much greater in the latter; the electricity of the former is impaired by the resistance of the long multiplying wire, the electricity of the latter surmounting this resistance is on the contrary increased by the multiplying wire.

The complex thermo-electric circuit produces much more effect upon the multiplier, not only when the increased number of elements heightens the effect upon the compass needle, but still also when this increase does not augment the direct effect upon the needle. We must therefore conclude that the intensity increases with the number of the elements in the thermo-electrical as well as in the hydro-electrical current. It must therefore be possible to attain an intensity of the thermo-electrical current great enough for penetrating the liquid conductors, and producing the most considerable chemical effects. Still the construction of a thermo-electrical circuit of a great number of elements is very difficult, because the elements must be as short as possible in order to preserve the conducting faculty; but even the smallness of the distance between the heated and cooled parts must give way to a very speedy re-establishment of equilibrium. The best way seems to be, to produce the heating and cooling of the junctions by some continual current of hot and cold liquids.

A very easy manner of constructing thermo-electric batteries deserves to be mentioned. Fig. 18 represents it. The parts indicated by the odd numbers 1, 3, 5, represent copper slips, and those indicated by the even numbers 2, 4, 6, small bars of bismuth. All the junctions situated on one side of the dotted line *cd*, are to be heated, those on the other side are to be cooled. The extremities *a* and *b* are to be connected by a conductor. The number of elements may here be tolerably great.

That the intensity of the electro-magnetic current must increase with the temperature was to be presumed; but this is not a general law. Dr. Seebeck had already found some exceptions, and also Professor Cumming at Cambridge, who made his experiments without knowing those of Dr. Seebeck upon this subject. We shall not stop here to detail these experiments, as another philosopher, Mr. Becquerel, availing himself of the imposed instruments of research, and making a very ingenious application of them, has given us exact measures of the quantities here occurring.

It was supposed that the declination of the needle, produced by the electrical current is in the ratio of the sine of the angle of deviation. Though this is a consequence of the resolution of powers, he thought that, in a matter so little known as the magnetical effects of the electrical current, it might be advisable to examine the law of this measure by experiment, particularly with regard to the multiplier, where the current makes so many windings round the needle. In order to execute this plan, he formed his multiplier with four parallel and equal wires, covered with silk, and each making an equally great number of windings. Thus he had four multiplying windings about one frame. To the ends of each multiplying wire he soldered the ends of an iron wire, so that four thermo-electrical circuits, consisting of the copper wires of the multiplier and the iron wires were formed. When he wished to put one of these currents in activity, he cooled one of the junctions with ice, and heated the other in mercury. The junction was included in a thin bent glass tube, in order to guard it against the dissolving power of mercury. The mercury was heated by means of a lamp, somewhat above the temperature required, and when heated the lamp was taken away; thus the temperature remains for a short time stationary. In this manner he tried first the effect of one, then of two, three, or four of the multiplying circuits, and noted down the deviations produced, one of the junctions still being kept at the freezing point. Thus he found that one of the circuits gave, by 5° Centigrade or 9° Fahr. above the freezing point (41° Fahr.) a magnetic deviation of 0.65° French division, or 0,585° of common division of the arc. Two circuits gave by the same temperature twice 0.585°; three gave thrice, and four gave four times this quantity; whence he concluded, that when one circuit produces 4°.585 it has four times the power of that producing only 0°.585. It is easily understood that the greater angles of deviation could not be in the same ratio as the action; but this does not hinder us from drawing analogous conclusions. Thus by a difference of 180° Fah. one circuit gave the deviation 10,71° of the circle; but two circuits gave nearly the same (10°.575) by a difference of 90° Fah. But it is not in all temperatures that this proportion of the effect and temperature takes place; in very high degrees of heat he found that the effect of circuits of copper and iron did not increase so fast as the temperature. From the freezing point (32° Fah.) up to 284° Fah. the magnetical effect increases with the temperature. From this degree to 572° the magnetic power, though increasing with the temperature, still proceeds in a decreasing progression; and exposed to the immediate action of a lamp, the current is inverted. When none of the junctions is at the freezing point, the effect of the circuit is equal to the difference of the effect, which each of the two temperatures applied to one of the junctions, the other being at the freezing point, should give; thus, for instance, a circuit of iron and copper, when one junction is heated to 392° F., the other being at 32° F. has an intensity expressed by 37; but when the heat is only at 212°, the intensity is expressed by 22. The difference of these two numbers is 15, which is found by experiment to be the effect of the circuit, in which one junction is heated to 392° and the other to 212°. He found that a complex circuit of copper and iron produced an effect proportional to the number of elements, which is not the case, when the whole power of the circuit can be exerted, but is only so, when a very small part of the whole effect can be transmitted through a conductor, of such a length or feeble conducting faculty; that it requires much intensity of electricity, for being penetrated. Thus the observation of *Mr. Becquerel* proves, what had already been shown by less perfect experiments, *that the intensity of thermo-electricity increases as the number of the elements.*

Circuits of iron, with gold or silver, have likewise, as well as those which it forms with copper, a *minimum* of effect, by a certain elevated temperature, and in a still higher one their current changes its direction. In circuits of platina with gold, silver, lead, zinc, copper, and palladium, the differences of the intensities form an increasing arithmetical series.

Mr. Becquerel found that two pieces of platina form an active thermo-electrical current, when they are not of a perfectly equal nature. He cut through a piece of platina wire, and had one of the pieces drawn thinner; these two formed a thermo-electrical circuit. He maintains that the circuit is not efficacious unless a piece of some other metal is soldered to the one end of the wire, upon which statement we cannot but entertain some doubt, though Mr. Becquerel's authority is of no little weight. As Mr. Becquerel had found that the increments of the magnetic effect preserve the more their proportion to the increments of temperature, the more difficult the metal is in being melted, he considers a circuit of two unequal pieces of platina as a pyrometer. By means of this, he has tried the temperature of the different parts of a spirit-flame, and estimated the temperature of the blue flame bordering the white, at 1350° Centigr., or 2462° Fahr.; in the white part he estimated it to be 1080° Cent. or 1976° Fahr., and in the darker part of the flame to be 780° Cent. or 1426° Fahr. The last he considers as too high, because the other parts of the flame contributed to heat the junction.

Terrestrial Electro-Magnetism.

We cannot pass by this subject entirely, though we must treat it very briefly. Mr. Ampère, who thinks that magnetism consists only in transverse electrical currents, must, in consequence of his hypothesis, suppose an electrical current round the earth, from east to west. He thinks that the numerous strata, of which our globe is composed, may form considerable galvanic arrangements; still he supposes that the rotation of the earth cannot but have an effect on the electric currents around it. Mr. Ampère, in consequence of his system, admits no other magnetism of the earth than these currents. The opinion, that the earth is surrounded by electrical currents, though not strictly proved, is very probable. As for the galvanic arrangements which the earth is supposed to contain, there can be no doubt that the strata of the earth may form such combinations; but it is not at all proved that they produce a current from east to west. As far as the different currents formed by the strata, do not destroy the effect of each other, it is probable that their resultant effect lies nearly in the perpendicular; for the most general situation of the strata, is that one is placed above the other, generally with some inclination; but as this inclination may have all possible directions, the effects of the galvanic arrangements, (in so far as their action should have a horizontal direction, and thus be founded upon the inclinations,) must destroy each other, even if the inclination towards one side should be somewhat predominant; for galvanic arrangements combined in variable directions of their currents, produce a total effect much feebler than the difference of their positive and negative effects. The most efficacious excitation of electricity upon the earth appears to be produced by the sun. Its light passes round the globe from sunrise to sunrise, and produces evaporation, deoxidation and heat. Evaporation in contact with oxidable matters, produces electricity, as has already been asserted, but first exactly elucidated by the ingenious experiments of Mr. Pouillet. That the deoxidation which the sun produces during the day not only of the surface of plants, but also upon the surface of many other bodies, particularly when moistened, excites electric currents, is a well known galvanic fact. That the heat produced by the sunbeams, and also circulating from east to west, must produce an electrical current can scarcely be doubted; for though the surface of the earth be not composed of perfect conductors, and this resistance should make a common current insensible, the celerity of the circulation may, on the other hand, augment the effect to a degree sufficient for producing some effect upon the magnetic needle. Now, if it be admitted that the sun produces an electric current round the earth, this current must form a zone of considerable breadth, whose most intense part is situated in the plane of the circle, in which the sun seems to make its daily motion. Thus the situation of the most intense part of the zone varies with every day of the year. If we suppose that the earth had no other magnetism than that of this zone, a steel needle made magnetic by an artificial current, and then freely suspended, should take a direction towards the north and the south. Even a steel needle laid across the great natural current should be made magnetic, and suspended, take its direction accordingly. But the great current must also produce magnetism in the body of the earth itself; and as the magnetic effects of the inferior side of the current are opposite to those of the superior one, the magnetic poles of the earth become the opposite to those of the needle directed by the current, and should, therefore, if we for a moment suppose the electric zone destroyed, still give it the same direction. Thus the earth seems to have a constant magnetic polarity, produced, in the course of time, by the electrical currents which surround it, and a variable magnetism produced immediately by the same current. As the sun does not produce an equal effect upon water as upon solid bodies, the intensity of the current cannot be equal in all parts of a parallel circle, and therefore the direction of the needle cannot be perpendicular to the equator, nor can it form everywhere the same angle with the equator, for the lines of equal electromagnetic intensity must be twice bent by the influence of the two great masses of continent. The yearly and daily change of the electromagnetic zone, must occasion yearly and daily variations. As to the variations comprehended in greater periods, we might perhaps attribute them to a motion of the coolest points in each continent, which it appears cannot remain the same for ever, because the currents of warmer air must principally be directed towards such points; but we shall leave this research to future times, which may discover causes concealed from us, for explaining the great and secret revolution, which is continually performing in our globe.

It would be to offend against a love of truth, if we proposed these views as ascertained facts. Our researches upon the magnetism of the earth have been, during too short a time, directed by the electromagnetic discoveries, to enable us to give a complete theory of this subject. The great series of profound mathematical and philosophical investigations by which Professor Hansteen, at Christiana, has confirmed and improved the theory established by Dr. Halley, shows how many difficulties are to be surmouted. The accordance of this theory with observation, seems even to exclude the possibility of a new theory; but it must be remarked that this theory is only a mathematical representation of the phenomena, and does not pretend to be a physical one. In the same way as the mathematical laws of the celestial motions were discovered by Kepler, long time before their physical laws were superficially guessed by Hooke, or profoundly recognised and demonstrated by Newton, so the physical laws of the magnetism of the earth may now, perhaps, be fairly conjectured, and in a future age be brought to the requisite degree of perfection. Still we hope that these views will recommend themselves to farther investigation, as they would, if proved, have the great advantage of showing an intimate connexion between an extensive series of phenomena upon the earth and those of the universe.

Some Theoretical Considerations.

The question has during late years been often proposed, *whether or not magnetism and electricity* *are identical.* There has been a good deal of misunderstanding in the discussions on this subject. Mr. Ampère pretends that the discoverer of electromagnetism, though he had earlier admitted the identity of these effects, has, in his first paper upon electromagnetism, denied it. We must here remark, that the words have two acceptations; in one of these Professor Oersted is perhaps the most earnest supporter of this identity, in the other he is a no less decided opponent of it. His opinion is, that all effects are produced by one fundamental power, operating in different forms of action. These different forms constitute all the dissimilarities. Thus, for instance, pressure upon the mercury of the barometer, wind and sound, are only different forms of action of the same powers. It is easy to see that this fundamental identity extends to all mechanical effects. All pressures are produced by the same powers as that of air; all communications of motion, and likewise all vibrations, owe their origin to the same expansive and attractive powers, by which each body fills its space, and has its parts confined within this space. This fundamental and universal identity of mechanical powers has for a long time been more or less clearly acknowledged; but the effects which have hitherto not been reduced to mechanical principles, seemed to be derived from powers so different, that the one could scarcely be deduced from the other. The discoveries which began with galvanism, and which have principally illustrated our century, led us to see the common principles in all these actions. Two or three years before the beginning of the century, Ritter had, by means of the simple galvanic arrangement, pointed out and distinctly stated the principle of the electro-chemical theory; still his ideas were not generally admitted before the discovery of the Voltaic pile had struck the mind of the experimental philosophers with more palpable facts. That heat and light are produced by the union of the opposite electrical powers, had been acknowledged by the Swedish philosopher Wilcke, a cotemporary of Black, but this view was far from being generally admitted. Winterl brought it forward in 1800, and was supported by Ritter and Oersted. The last investigated the subject farther, and developed some of the principal laws of the generation of heat by the electrical and chemical powers.* He proved that the electrical powers are present in all cases where heat and light are generated. That magnetical effects can be produced by the same powers need not here be mentioned. As the chemical powers give rise to expansion and contraction, it appears that their nature is not different. Thus acknowledging the fundamental and universal identity of powers, effects must be considered as different, when their form of action differs, and therefore magnetism, in this acceptation of the term, is far from being identical with electricity. It would likewise be erroneous to pretend that all chemical effects are produced by electricity; but the truth seems to be, that the chemical effects are produced by the same powers which, in another form of action, produce electricity. The name of *electro-chemical* theory, given to the modern chemical system, seems, therefore, less admissible than the denomination of *dynamico-chemical* theory, proposed by Oersted so early as 1805. It is still true, that the common electro-chemical theory deserves its name, as it does not go out of the limits of an electrical view of the subject. This theory stops throughout in generalities, and gives no account of the disparities of the effects. We will not pretend that a sufficient dynamico-chemical theory has hitherto been pointed out; we must even admit that our knowledge is not ripe enough for this purpose; but we think that some laws, accounting for the disparities, have been pointed out in the work above quoted, upon the identity of electrical and chemical powers (viz. fundamental powers), and that the ideas therein explained deserved attentive examination. The dynamico-chemical theory must still remain very imperfect, until it is decided if the powers acting in magnetism, electricity, heat, light, and chemical affinities are to be ascribed to vibratory, circulating, and other internal motions or not. That these effects do not pass without the most remarkable internal motions, appears from the experiments upon light and upon electro-magnetism. The electrical current is a system of rotative motions, upon whose directions, perhaps, all the disparity of positive and negative electricity depends. It is not improbable that even magnetism involves some rotations, and thus the opinion of Mr. Ampère comes to agree with ours, at least in this point. When the transmission of the electrical current through liquid bodies is accompanied with a chemical decomposition, it seems necessary to admit that the substances styled electro-positives and electro-negatives, must rotate in opposite directions, and we may suppose that their neutralizing powers are connected with the propensities to those opposite rotations. The new discoveries, in short, reveal to us the world of secret motions, whose laws are probably analogous to those of the universe, and which deserve to be the subject of our most earnest meditations.

* *Recherches sur l'identite des forces electriques et chimiques*, p. 193—233.

APPENDIX.

AMERICAN SILK.

IT is now well ascertained that the white mulberry, considered as the best food for silk worms, will grow and thrive in every part of the United States, and it is even believed by many, that the red mulberry (*morus rubra*) indigenous to this country, might supply its place. Experiments, however, have not sufficiently shown to what extent this is to be admitted. It appears that the worm feeds with equal avidity on the one as on the other, and that he does not show any preference to either when both are presented to him at the same time. But some say that there is a difference in the silk produced by that insect when fed on the leaves of the red mulberry; that it contains more gum, and consequently is harder and more difficult to reel than the cocoons of worms fed on the leaves of the white mulberry. We must leave it to time and experience to decide this question. In the meantime, we are happy to state, that the plantation of the white Italian mulberry is rapidly extending itself through almost every state in this Union, and that, from its abundance, it will probably before long supersede every other tree for the feeding of silk worms.

It is also an admitted fact, that the climate of this country, from north to south, is favourable to the raising of silk worms. Experiments have been made even in Vermont and Maine, and they have succeeded. It is well known, that for the space of seventy years, silk worms have been raised in great quantities in the state of Connecticut, particularly in the counties of Windham and Tolland, which abound in white mulberry trees. The farmers of those parts extract the silk from the cocoons, and manufacture it into sewing silk, which they dispose of in the circumjacent country by way of barter, and it even serves them as a circulating medium, the legislature of that state having provided wise regulations to prevent fraud and imposition. That silk, however, is not merchantable in our sea port towns, as it is neither equal to imported silk, nor can it be afforded at the same price. Such as it is, however, it serves the purposes of the country people, which is truly astonishing, when we consider that it is made without any other machinery than the common spinning wheel, and by persons unskilled in the arts of reeling and throwing or twisting the material, which in Europe constitute different professions, requiring long practice and a regular apprenticeship. Too much praise cannot be given to the industry and ingenuity of the Connecticut women, by whom this labour is exclusively performed. That state is destined to become rich by the silk culture and manufacture, when better methods and the proper instruments shall have been introduced among them. At present it cannot be said that this branch of industry is to them a source of riches; it has been remarked, on the contrary, that the silk districts are comparatively poor.

The culture of silk was in the view of the British government from the earliest period of the colonization of this country. King James I. who hated tobacco, the staple commodity of Virginia, gave orders to the governor of that colony to take measures to introduce the culture of silk, in hopes that it might supersede what he called the nauseous weed. Silk worms' eggs, white mulberry trees, and printed instructions were sent over and distributed. In 1623, the Colonial Assembly directed the planting of mulberry trees, and a fine was afterwards imposed on every planter who should not plant, at least, ten such trees for every hundred acres of land that he possessed, while a premium was offered of ten thousand pounds of tobacco to those who should export two hundred pounds worth of raw silk. It does not appear that any was ever exported, or even that any measures were taken to instruct the people in the art of spinning or reeling the silk from the cocoons, so as to make it merchantable; nevertheless, mulberry trees were generally planted, and it is said that they now abound in the eastern part of that state.

South Carolina, in early times, made some efforts to introduce the culture of silk, but those efforts were partial, and were not attended with much success. Some patriotic ladies sent raw silk of their own raising to England, where it was manufactured into stuffs. But the quantity was small, 251 lbs. of it only having been entered at the custom house in the course of six years. The thing did not proceed farther. The silk being of course very imperfectly reeled, its waste must have been considerable, and the proceeds of it not being equal to the labour and expense that it occasioned, discouragement necessarily followed.

The colony of Georgia proceeded in a more cautious manner, and their success was proportionate. Upon its first settlement in 1732, the culture of silk was contemplated as a principal object of attention, and lands were granted to settlers upon condition that they planted one hundred white mulberry trees upon every ten acres when cleared, and ten years were allowed for their cultivation. All this was excellent; but what was better still, is that a native of Piedmont was engaged to instruct the people in the art of rearing the worms and *winding the silk*. The colonial trustees undertook the management of the business, and they succeeded so well that before the year 1750, large quantities of raw silk had been exported from Georgia into England. In that year a public filature was erected by order of these trustees, and the exports of silk from the year 1750 to 1754 inclusive amounted to $8,880. In the year, 1050 lbs. of raw silk were produced at the filature, which supposes the reeling of at least 8000 lbs. of unstifled cocoons. In the year 1758, that building was consumed by fire with a quantity of silk, and 7040 lbs. of cocoons. M'Call, the historian of Georgia, relates, that in the year 1759, this colony exported upwards of 10,000 lbs. of raw silk, which sold for two or three shillings per pound higher than that of any other country. But this fact may well be doubted, as it is in direct contradiction to authentic records which will be presently mentioned.

One would naturally suppose that the production of raw silk as an article of exportation had been established in Georgia on a solid and lasting foundation. Yet it began to decline, for what reason we know not, many years previous to our revolution. We are informed by an official statement of William Brown, comptroller of the customs at Savannah, that between the years 1755 and 1772, a period of seventeen years, including the year 1759, no more than 8829 lbs. of raw silk were exported from that port, something less than had been before exported in five years. This branch of industry, however, lingered until some time after the peace with Great Britain. The last we hear of silk in Georgia is in the year 1790, when upwards of 200 lbs. weight of the raw article were purchased for exportation at 18*s.* and 26*s.* per pound, we presume of the currency of the country, (4*s.* 8*d.* to a dollar), which makes those prices equal to about $4 and $5,50 per pound, a very high price even at this day, when it is known that the current prices of Italian raw silks in the London market are from 9*s.* to 22*s.* sterling.

We are at a loss to conceive how a branch of industry which appeared then to be in so flourishing a state, can have suddenly disappeared from a state where it had been introduced in a manner so well calculated to ensure its permanency. We have been told that it was owing to the rage for the culture of cotton, which began about that time to take possession of the minds of the inhabitants of the southern states. This is the most rational way of accounting for an event which Georgia may long have reason to lament. We must add, also, that before the revolution, the business was monopolized by the trustees who had the management of the colony, in which there was but one filature of silk, which probably, after the war, fell into the hands of those who had neither the means nor the capacity to turn it to advantage. If the art of reeling silk had been generally disseminated through the state, it would, no doubt, have been preserved, whereas it appears to be entirely lost.

In the year 1770, on the recommendation of Dr. Franklin, who was then in England, the American Philosophical Society undertook to promote the culture of silk in Pennsylvania. Money was raised by subscription and a filature established at Philadelphia, to which an end was put by the revolutionary contest. Unfortunately, we have no details respecting this filature, its establishment, its progress, or its end. It is said by some that a person skilled in the art of reeling silk from the cocoons, was obtained from France and placed at the head of it, as director. But this fact is not sufficiently ascertained. It does not appear that any raw silk was exported from the port of Philadelphia.

During the revolutionary war, of course, (except, perhaps in Connecticut and for a while in Georgia,) no attention was paid to the culture of silk. After the peace, other objects engrossed the attention of the public. About the year 1790, Mr. Aspinwall of Connecticut, made fruitless efforts to introduce this branch of industry in Pennsylvania and New Jersey; he succeeded no farther than the planting in those states some thousand of mulberry trees. It does not appear that he was aware of the importance of the art of reeling; indeed, few persons, if any, in the country, seem at that time and long afterwards to have carried their views farther than the converting the raw material into sewing silk, as was done in Connecticut. The variety of arts, whose concurrence is required for the manufacture of silk stuffs, was far from being generally or correctly understood.

From time to time, however, some patriotic writers endeavoured, through the newspapers, to draw the attention of the public towards the culture of silk; but those publications produced little effect. It was recommended to the citizens to plant mulbury trees and raise silk worms; but nobody told them what they should do with the cocoons that those silk worms should produce. The example of Connecticut was sometimes set before them; but that was not very encouraging. A few pounds of domestic sewing silk were hardly worth the labour which the cultivation of the raw material would require, and indeed, it might have been observed that the counties of Tolland and Windham, where the greatest quantity of silk was raised, instead of being the richest in the state, were, as we have said, comparatively poor.

Still, there were reflecting minds, who, casting their eyes over the southern parts of the continent of Europe, particularly Italy and the south of France, and paying attention to the immense riches which they derived from the silk culture and manufactures, and the great profits which England obtained from the latter alone, felt an ardent desire that the United States should participate in these blessings, for which they were so well fitted by their climate, and the industry and activity of their citizens. But the difficulty was how to go to work to produce the desired effect.

At last an enlightened and patriotic citizen of Pennsylvania, Charles Miner, Esq. of West Chester, who for several years had been actively engaged in promoting the culture of silk in his immediate district, and who was then a member of the House of Representatives of the United States, had the happy idea of submitting the subject to the consideration of the national legislature, who he thought might devise effectual measures to attain the object he had in view. On the 29th of December 1825, the house on his motion resolved: "that their committee on agriculture be instructed to inquire whether the cultivation of the mulberry tree and the breeding of silk worms, for the purpose of producing silk, be a subject worthy of legislative attention, and should they think it to be so, that they obtain such information as may be in their power respecting the kind of mulberry tree most preferred, the best soil, climate and mode of cultivation, the probable value of the culture, taking into view the capital employed, the labour and the product; together with such facts and opinions as they might think useful and proper—and further, that the same committee inquire whether any legislative provisions are necessary or proper to promote the production of silk."

We have already observed that at that time the people were not generally aware of the difficulty of the art of spinning or reeling the silk from the cocoons, as is practised in Europe; the most that was thought requisite by the best informed, was the importation of a few machines to facilitate the labour; as to the skill, it was thought that it would be as easily acquired as was done in the article of cotton, which our people had easily learned to prepare for exportation and to employ in manufactures. Indeed, many believed that the women of Connecticut, who could make sewing silk, were sufficiently possessed of that art, and that instruction from abroad was not required, or if it were, it could easily be obtained from the books that had been written on the subject in France and elsewhere.

Under these impressions, the committee met and acted. On the 2d of May 1826, they made a full report, in which they gave a luminous view of the importance of the culture of silk to the United States. They showed that in five years, 1821—1825, we imported upwards of 35 millions of dollars worth of silk goods, of which we exported not quite 8 millions, leaving 27 millions to be paid by our citizens, and that in the last of those years we had imported ten millions worth of silks and exported only five millions of bread stuffs. After this strong exposition, and stating a variety of facts relative to the then existing state of the culture of silk in the United States, they recommended the following resolution, which the house adopted without debate: "*Resolved*, That the secretary of the treasury cause to be prepared a well digested manual, containing the best practical information that can be collected on the growth and *manufacture* of silk, adapted to the different parts of the Union, containing such facts and observations in relation to the growth and manufacture of silk in other countries as may be useful, and that the same be laid before congress at their next session."

The secretary of the treasury at that time was the Hon. Richard Rush, of Pennsylvania. It is to be regretted that he was not instructed personally to inquire and obtain information from those parts of Europe where the culture of silk most flourishes, and where the manufactures from that material have attained their highest perfection; he would have been told that the spinning of the raw silk, whether it was intended to be exported abroad or manufactured at home, was the first thing to be attended to, as it would promote the silk culture, by opening a market for the cocoons; he would have been told also, that it was a difficult art, that required instruction and experience, and he would no doubt have proposed to congress the best means to introduce that art among us; but as he was only ordered to cause a manual to be prepared, he performed that duty by committing the work to Dr. James Mease of Philadelphia, a member of the American Philosophical Society, who was known to have paid much attention to the general subjeet.

The manual was in consequence compiled by that gentleman, and on the 11th of February 1828, it was reported by the Secretary to the House of Representatives, who ordered 6000 copies of it to be printed for the use of the members. The Senate also ordered a number of copies to be printed, so that the work was disseminated far and wide. It contained full instructions for the planting of mulberry trees and the raising of silk worms, the latter chiefly extracted from the great work of Count Dandolo, whose method, though perhaps well suited to the meridian of Italy and France, is much too troublesome for that of this country. Experience indeed has shown, that silk worms may be raised among us without the aid of artificial heat, which Count Dandolo, and after him the author of the manual, recommends as indispensable. Our farmers would never submit to the numerous minute observances which that work requires to bring the cocoons to perfection.

All these proceedings, emanating from the highest authority in the nation, gave a strong impulse to the silk culture in the United States. Mulberry trees were planted in various places, nurseries were formed in the neighbourhood of our large towns; foreign works were translated, extracted from and abridged; in short, a considerable zeal was excited throughout the Union. A society was formed in the city of Philadelphia, in the year 1828, "for promoting the culture of the mulberry tree and the raising of silk worms." Although there were among them many rich individuals, their joint funds were not considerable; they therefore very properly confined themselves at first to the granting of premiums.

Their views, however, soon extended beyond what appears to have been their original plan, and desirous of adding example to precept, and to introduce into Pennsylvania the making of sewing silk, as practised in Connecticut, they endeavoured to obtain from that state a woman qualified to instruct other females in that branch of industry, in which having failed, they turned their thoughts to Europe, and wrote to a correspondent at Marseilles to procure for them and send over a person sufficiently qualified to reel the silk from the cocoons and convert it into sewing silk. This order was not easy to be executed, as the reeling of silk is performed by women, under the direction of an overseer, called a director of a filature, and the making of sewing silk from the raw material after it is reeled, belongs to a class of mechanics called silk-throwsters, who employ a great deal of expensive machinery. Of course a person competent to both could not easily be obtained. After, however, many fruitless inquiries, the agent found a young man, who, on examination, proved to be adequate to the task required. This young man, named John D'Homergue, was the son of an eminent silk manufacturer at Nismes, who had brought him up to the various branches of his profession, in hopes that he should succeed him in his establishment. The young man, however, when he came to the age of manhood, chose to follow the profession of a lawyer, and at the time that we speak of, was the editor of a newspaper in the city of Marseilles. The agent engaged him to come over to this country, telling him, as was really the truth, that the company which had sent for him consisted of some of the richest and most respectable men in the city of Philadelphia. He had, indeed, no instructions to make a specific bargain with him, but there was no doubt that on his arrival every thing would be done to his satisfaction. Mr. D'Homergue in consequence embarked, and arrived in the city of Philadelphia in the month of May 1829.

It is very clear that Mr. D'Homergue had no idea of our numerous associations for the *promotion* of various things connected with the general welfare of the country. He thought of a mercantile company, associated for the purpose of carrying on together some lucrative branch of industry, and provided with means adequate to their object. He found, on the contrary, excellent patriots, but poor manufacturers. He found no preparation made for a silk establishment, no place provided for carrying on the operations, no machinery, except one single Piedmont reel, which had been imported by one of the members. In short, he met with the most complete disappointment.

This society, however, by being the means of inducing Mr. D'Homergue to come to the United States, rendered an important service to their country, the happy consequences of which will be long felt, whatever may become of the individual hereafter. He has contributed much to enlighten the public mind on the subject of the culture and manufacture of silk, which he published in the year 1829, and which have drawn the attention of the national legislature. There is now a bill before the House of Representatives of the United States, reported by their committee on agriculture on the 12th of March 1830, the object of which is to establish, at Philadelphia, a normal school, in which Mr. D'Homergue is to be employed in instructing sixty young men, from the different states of the Union, in the art of reeling silk from the cocoons, an art which requires practical instruction and experience, and without which the culture and manufacture of silk can never be effectually carried on in this country. The pressure of other business has hitherto prevented that bill from being taken into consideration; but its plan seems to be generally approved, and there is great reason to hope that it will finally receive the legislative sanction. This is the more probable, that Mr. D'Homergue, during the two years that have elapsed, has been unceasing in his exertions to promote his favourite object. A filature has been established under his direction in the city of Philadelphia, in which more than twenty women have been more or less instructed in the art of reeling silk from the cocoons. Several parcels of raw silk from that filature have already been exported to Europe, where they have been pronounced to be a fair beginning, and to give great hopes for the future. Of that silk, Mr. D'Homergue has wove two flags, bearing the colours of the United States, each twelve feet long and six feet broad, one of which has been presented to the House of Representatives of the United States, and the other to the Legislature of Pennsylvania, who have both condescended to give to those specimens of American industry, a conspicuous place in the halls of their sittings.

In the meantime, correct information on the subject of the various arts connected with the culture and manufacture of silk, has been widely disseminated by a great number of writings throughout the United States, and artists of various descriptions (but no reelers or spinners of silk from the cocoons) have migrated from Europe to our shores. There are now several throwsting mills in operation in various parts of our country, that work on foreign raw silk, which is now imported in great abundance. It is hoped that, if the plan before congress shall be adopted, it will not be long before our manufacturers shall be supplied with the domestic material, and that silk will thus become one of the principal sources of our national riches and prosperity.

DUPONCEAU.

GENERAL EXPLANATION

OF THE

PLATES BELONGING TO VOLUME SEVENTEENTH

OF THE

AMERICAN EDITION

OF THE

NEW EDINBURGH ENCYCLOPÆDIA.

PLATE CCCCLXXXVII. No. I.

Fig. 1, 2. Represents Dr. Wollaston's Dip Sector.
Fig. 3, 4, 6. Are Diagrams explanatory of the principle of Hadley's Sextant.
Fig. 5. Is a representation of this Sextant.
Fig. 8. Is a Diagram explanatory of the principle of Amici's Sextant. See Fig. 10, Plate CCCCLXXXVII, No. II.
Fig. 9. Is a drawing of this Sextant.

PLATE CCCCLXXXVII. No. II.

Fig. 7. Shows the method of using Hadley's Sextant.
Fig. 10. Is a Diagram illustrative of Amici's Sextant.
Fig. 11. Represents Troughton's artificial Horizon.
Fig. 12. Represents Dollond's artificial Horizon.
Fig. 13. Shows the method of using the artificial Horizon.
Fig. 14. Is the cover of the artificial Horizon.
Fig. 15. Represents Serson's Nautical Top.
Fig. 16, 17. Represents Troughton's Level Sextant.
Fig. 18, 19. Represent Mr. Adam's Nautical Eye Top.
Fig. 20, 21. Represent Dr. Brewster's improvement upon it.

PLATES CCCCLXXXVIII to CCCCXCV.

Are Diagrams illustrative of the principles of Ship-building.

PLATE CCCCXCVI.

Fig. 1—4. Contain a comparative view of the construction of square and circular sterns.

PLATE CCCCXCVII.

Fig. 1—9. Show the advantage of circular over square sterns.

PLATE CCCCXCVIII.

The principal figure is the disposition of the frame of an 84 Gun ship, according to the improved construction of Sir R. Seppings.
Fig. 1—7. Are a perspective view, plan, &c. of a longitudinal section of a 74 Gun ship.

PLATE CCCCXCIX.

Fig. 1, 2. Is a Draught for Building a Ship of 84 Guns.

PLATE D.

Fig. 1—5. Represent Sir R. Seppings's improvements on Ships in the Mercantile Navy.

PLATE DI.

Fig. 1, 2. Show the old principle of framing the stern with transoms.

Fig. 3—6. Are Diagrams illustrative of the theory of the paddle wheels of Steam Boats.

PLATE DII.

Fig. 1. Represents Mr. Morton's Portable Slip, or apparatus for hauling vessels out of water to be repaired.

PLATE DIII.

Fig. 1—96. Are Representations of the particles of Snow seen through a Microscope according to the Observations of Mr. Scoresby.

PLATE DIV.

Fig. 1—3. Show Dr. Ure's apparatus for measuring the elasticity of Steam.

Fig. 4, 5, 6. Represent the first Steam Engine invented by the Marquis of Worcester, according to the idea of Mr. Scott of Ormiston.

Fig. 7. Represents Dr. Papin's first Steam Engine.

Fig. 8, 9, 10. Contain a representation of Savery's Steam Engine.

Fig. 11. Represents Dr. Papin's second Steam Engine.

PLATE DV.

Fig. 1, 2. Represent Dr. Desagulier's improvement on Savery's Engine.

Fig. 3. Shows Mr. Kier of Birmingham's improvement on Savery's Steam Engine.

Fig. 4, 5. Contain a view of Newcomen's Atmospheric Engine.

PLATE DVI.

Fig. 1, 2. (marked Fig. 6, 7 of Plate DV). Represent Beighton's Steam Engine.

Fig. 3. (marked Fig. 1 in text). Is a view of Leupold's High Pressure Engine.

Fig. 4. (marked Fig. 2 in text) Shows Blakey's improvement on the Steam Boiler.

Fig. 5. (marked Fig. 3 in text) Shows Mr. Watt's mechanism for opening and shutting the Nozle Valves.

PLATE DVII.

Represents Mr. Watt's Reciprocating Engine of 1788. In p. 368 margin, read Plate DVII, in place of DVIII.

PLATE DVIII.

Fig. 1. Represents the Albion Mill Steam Engine erected by Messrs. Boulton and Watt.

Fig. 2. Shows the Regulator Box.

Fig. 3. Is a Diagram explaining the principle of the parallel motion.

Fig. 4. Shows the construction of the Throttle Valve.

PLATE DIX.

Fig. 1. Represents Mr. Hornblower's Double Cylinder Engine.

Fig. 2, 3. Show Hornblower's Skeleton Valve.

Fig. 4. Represents Trevithick's High Pressure Engine.

Fig. 5. Shows Trevithick's Boiler.

Fig. 6, 7. Show the principle of the Steam Engine proposed by Mr. Perkins.

Fig. 8—13. Represent a Steam Engine without a Boiler, the invention of Mr. Scott of Ormiston.

Fig. 14—18. Show Mr. Gurney's Tube Boiler.

Fig. 19, 20. Show Mr. Gurney's Condenser.

Fig. 21. Represents Mr. Murray's Sliding Valve.

Fig. 22. Represents Mr. Sim's Valve.

Fig. 23. Represents Cartwright's Piston.

Fig. 24. Represents Jessop's Piston.

PLATE DX.

Fig. 1, 2. Are drawings of Jonathan Hull's Steam Boat, invented in 1735.

Fig. 3. Is an enlarged view of the mechanism of Hull's reciprocating motion.

Fig. 4. Is an external view of a Steam Vessel.

Fig. 5. Represents the Engine erected by Mr. Gutzmer for the Royal George Steam Boat.

Fig. 6, 7. Are an Isometrical view and section of the Steam Boat Engine.

Fig. 8. Represents Gurney's Steam Boat Engine.

Fig. 9, 10. Show the revolving Paddles of Mr. Oldham, compared with the common Paddles.

PLATE DX. No. II.

Fig. 1. Represents the Steam Boat invented by John Fitch.

Fig. 2. Represents the Bridge over the Delaware River near Trenton.

Fig. 3. Represents Oliver Evans's Columbia Steam Engine.

PLATE DXI.

Fig. 1—4. Represent Messrs. Losh and Stephenson's Rail Road and Steam Carriage.
Fig. 5, 6. Are drawings of a Steam Carriage Engine.
Fig. 7—10. Represent Mr. James Watt's original apparatus for Drying by Steam.

PLATES DXII, DXIII, DXIII, No. II.

Are illustrative of the principles of Stenography.

PLATE DXIV.

Fig. 1—5. Represent Professor Barlow's apparatus for measuring the Strength of Materials.

PLATES DXV, DXVI, DXVII.

Are illustrative of the article Surgery, and are minutely described in pages 597, 598 of this volume.

PLATES DXVIII, DXIX, DXX.

Are illustrative of the article Tactics, *Naval*, in this volume.

PLATE DXXI.

Fig. 1. Shows Dr. Hooke's Telegraph.
Fig. 2. Represents M. Chappe's Semaphore.
Fig. 3. Mr. Edgeworth's second Telegraph.
Fig. 4. Rev. Mr. Gamble's Shutter Telegraph.
Fig. 5. Rev. Mr. Gamble's radiated Telegraph.
Fig. 6. Dr. Garnet's Telegraph.
Fig. 7. Lord George Murray's Telegraph.
Fig. 8. French Semaphore Telegraph.
Fig. 9. Mr. Edgeworth's one-armed Telegraph.
Fig. 10. French Coast Telegraph.
Fig. 11. Colonel Pasley's polygrammatic Telegraph.
Fig. 12. Colonel Pasley's improved Telegraph.
Fig. 13. Colonel Macdonald's Shutter Telegraph.
Fig. 14. Sir Home Popham's Semaphore.
Fig. 15. Colonel Macdonald's Ball and Shutter Telegraph.
Fig. 16. Colonel Macdonald's 6 ball and 3 figure Telegraph.
Fig. 17. Colonel Pasley's Universal Telegraph.
Fig. 18. Do. Do. for nocturnal signals.
Fig. 19, 20. Show the construction of the above Telegraph.
Fig. 21. Shows the Telegraphic signs for this Telegraph.

PLATE DXXII.

Fig. 1—6. Illustrate the Electro-magnetic discoveries of Professor Oersted.
Fig. 7. Shows Berzelius's idea of four magnetic Poles in the uniting wire.
Fig. 8. Shows Professor Oersted's apparatus for deciding this question.
Fig. 9. Professor Schweigger's Multiplier.
Fig. 10. M. Nobili's improved Multiplier.
Fig. 11. Professor Oersted's Multiplier.
Fig. 12. Is Mr. Faraday's apparatus for causing a Magnet to revolve round an electrical Conductor.
Fig. 13. Is Mr. Faraday's apparatus for causing a Magnet to revolve round its own axis by means of an electrical current.
Fig. 14. Illustrates the development of magnetism in other bodies by the electrical current.
Fig. 15. Method used by MM. Arago and Ampere.
Fig. 16. Shows the apparatus used in M. Ampere's experiments on the effects of the magnet on the uniting wire.
Fig. 17. Is an apparatus in which the earth's magnetism gives a direction to the uniting wire.
Fig. 18. Shows M. Ampere's application of the principle of the multiplier to move the uniting wire, as somewhat modified by Professor Van de Roos.

PLATE DXXIII.

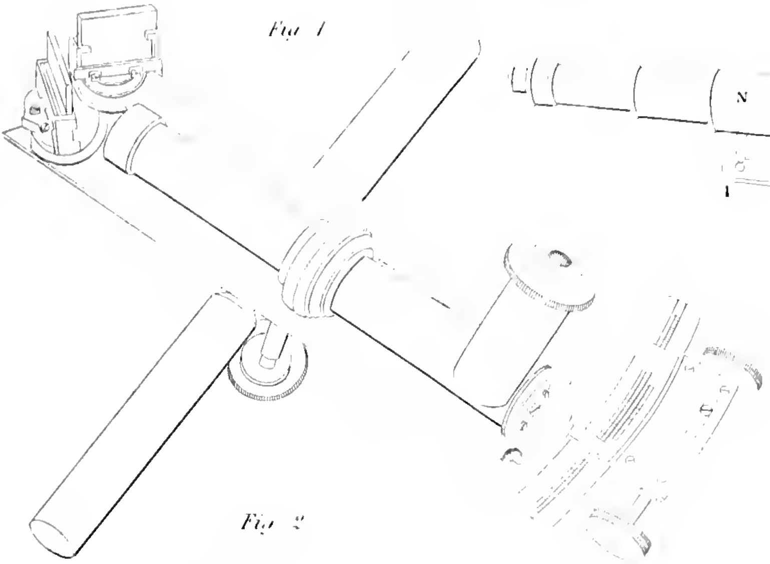
Fig. 1. Is another apparatus invented by M. Ampere for the same purpose.
Fig. 2. Is M. Ampere's apparatus improved by Mr. Marsh for showing the magnetical effect of the earth on the uniting wire.
Fig. 3. Is an apparatus for causing a movable uniting wire to revolve round a magnet.
Fig. 4. Is Ampere's revolving apparatus.
Fig. 5. Is Professor Barlow's revolving apparatus.
Fig. 6. Is Professor Pohl's revolving apparatus.
Fig. 7—10. Illustrate M. Ampere's discoveries respecting the mutual action of electrical currents.
Fig. 11. Is an apparatus for illustrating M. Ampere's doctrines.
Fig. 12—17. Are illustrative of Dr. Seebeck's discovery of electro-magnetic currents produced by heat.
Fig. 18. Shows the method of constructing Thermo-electric batteries.

END OF VOLUME SEVENTEENTH.

ERRATA.

Page 670, first column, 23d line from bottom, for *Hagersville* read *Rogersville*.
Page 671, first column, 2d line, for *remains* read *remain*.
Same column, 5th line, for *Atchabalaya* read *Atchufalaya*.
Same column, article Tequendama, for *Stanblack* read *Stauback*.
Same article, for *Catskill* read *Caterkill*.

SECTOR, SEXTANT, *PLATE CCCCLXXXVII.N°1.*



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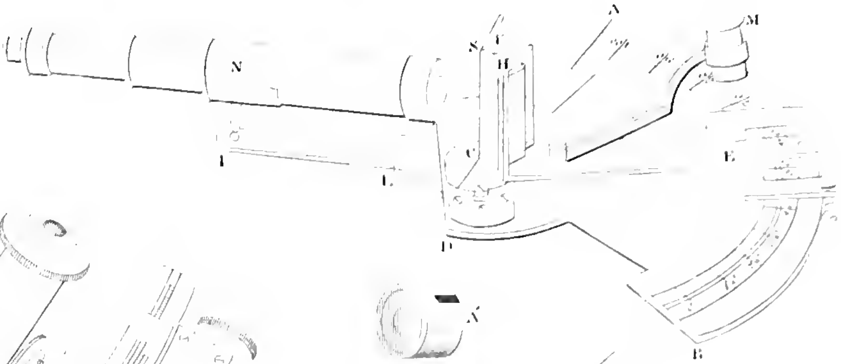

Fig. 9

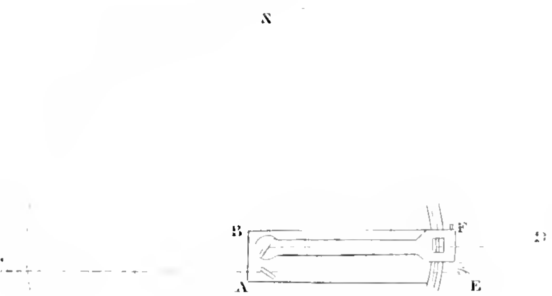

Fig. 2

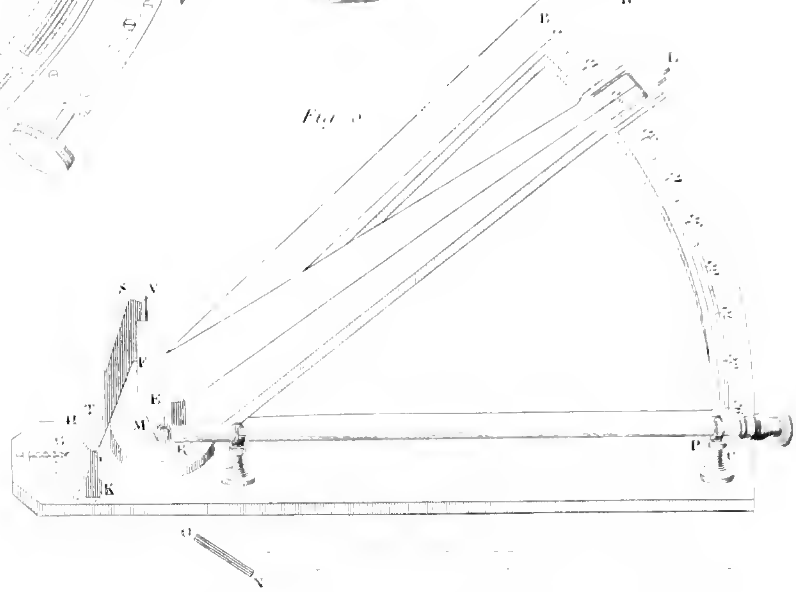

Fig. 5

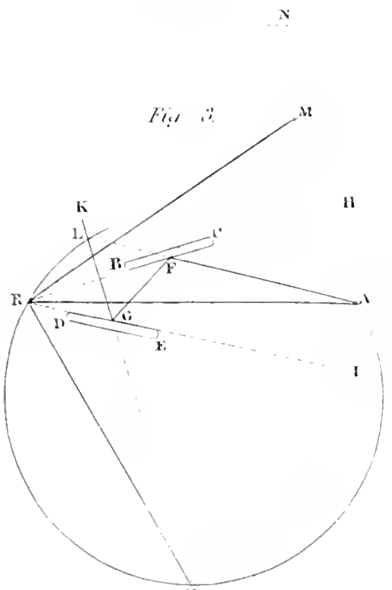

Fig. 3

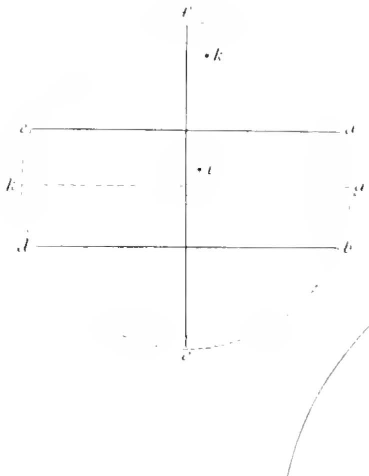

Fig. 6

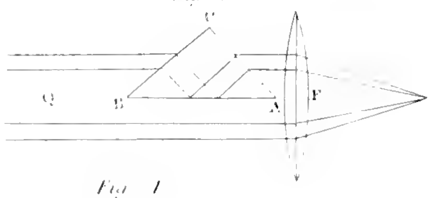

Fig. 8

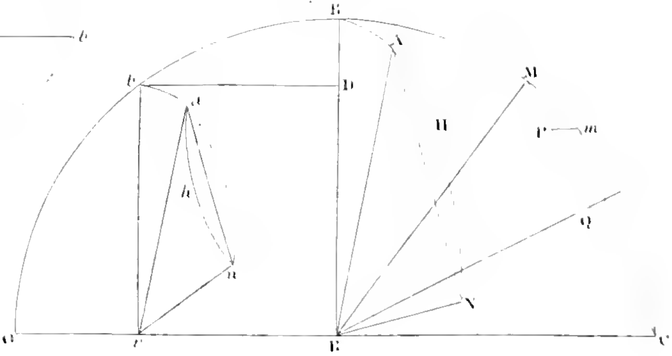

Fig. 7

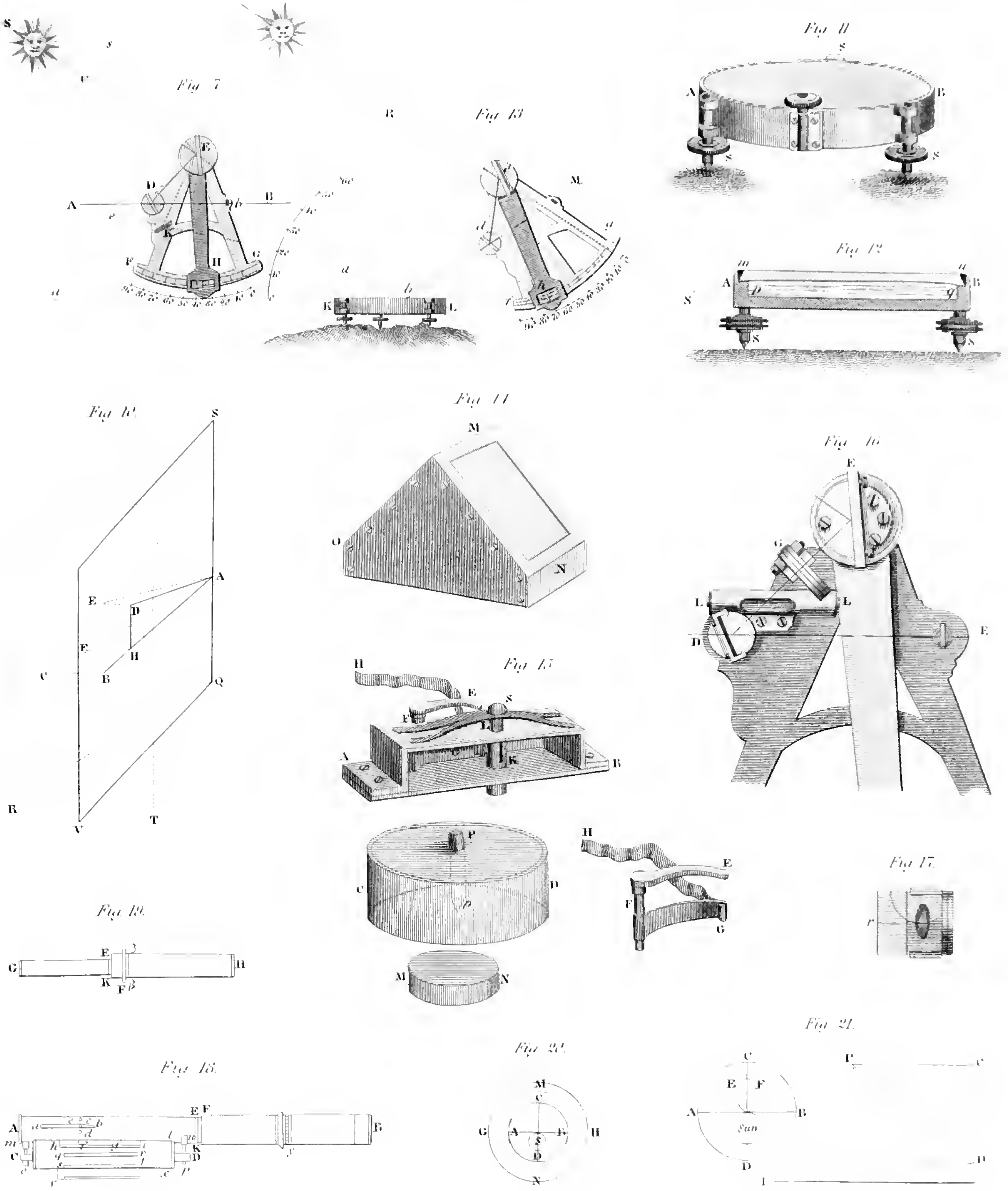
Fig. 7
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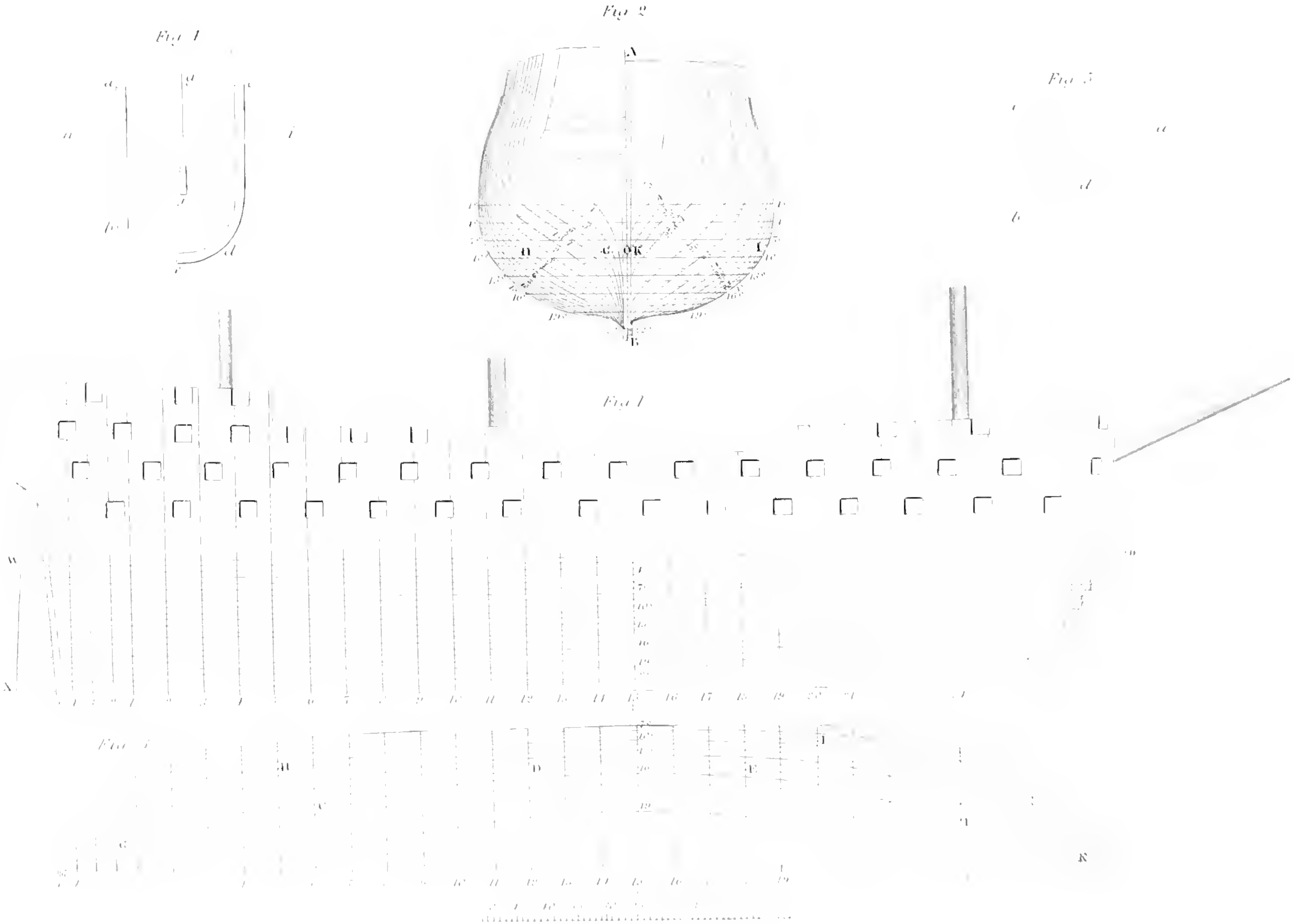
Fig. 20
Fig. 21



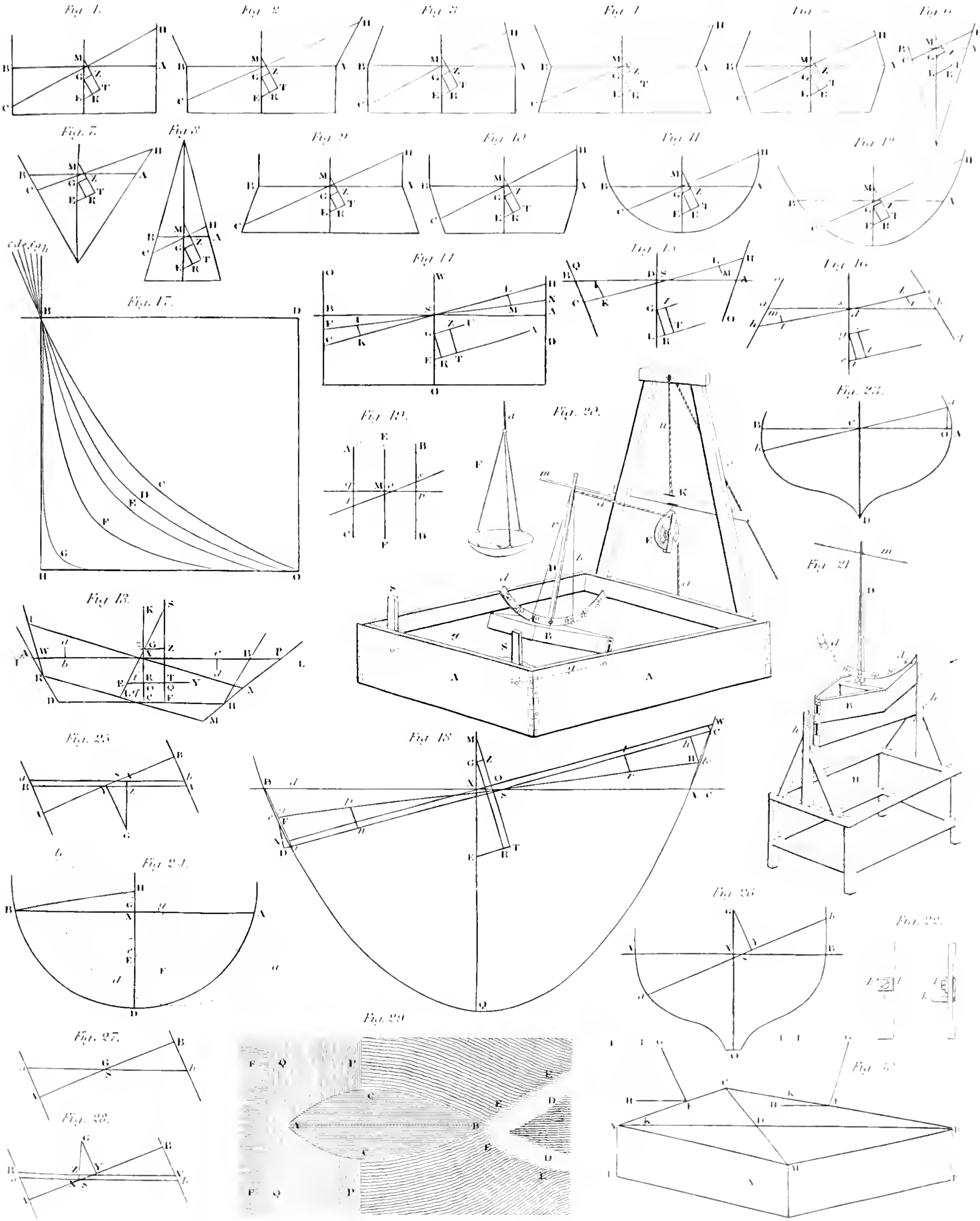


Fig. 1.
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Fig. 3
Fig. 7.
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Fig. 10
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Fig. 17.
Fig. 19.
Fig. 20.
Fig. 23.
Fig. 21
Fig. 13.
Fig. 25
Fig. 18
Fig. 24.
Fig. 26
Fig. 27.
Fig. 28.
Fig. 29

SHIP BUILDING.

PLATE CCCCXCI.

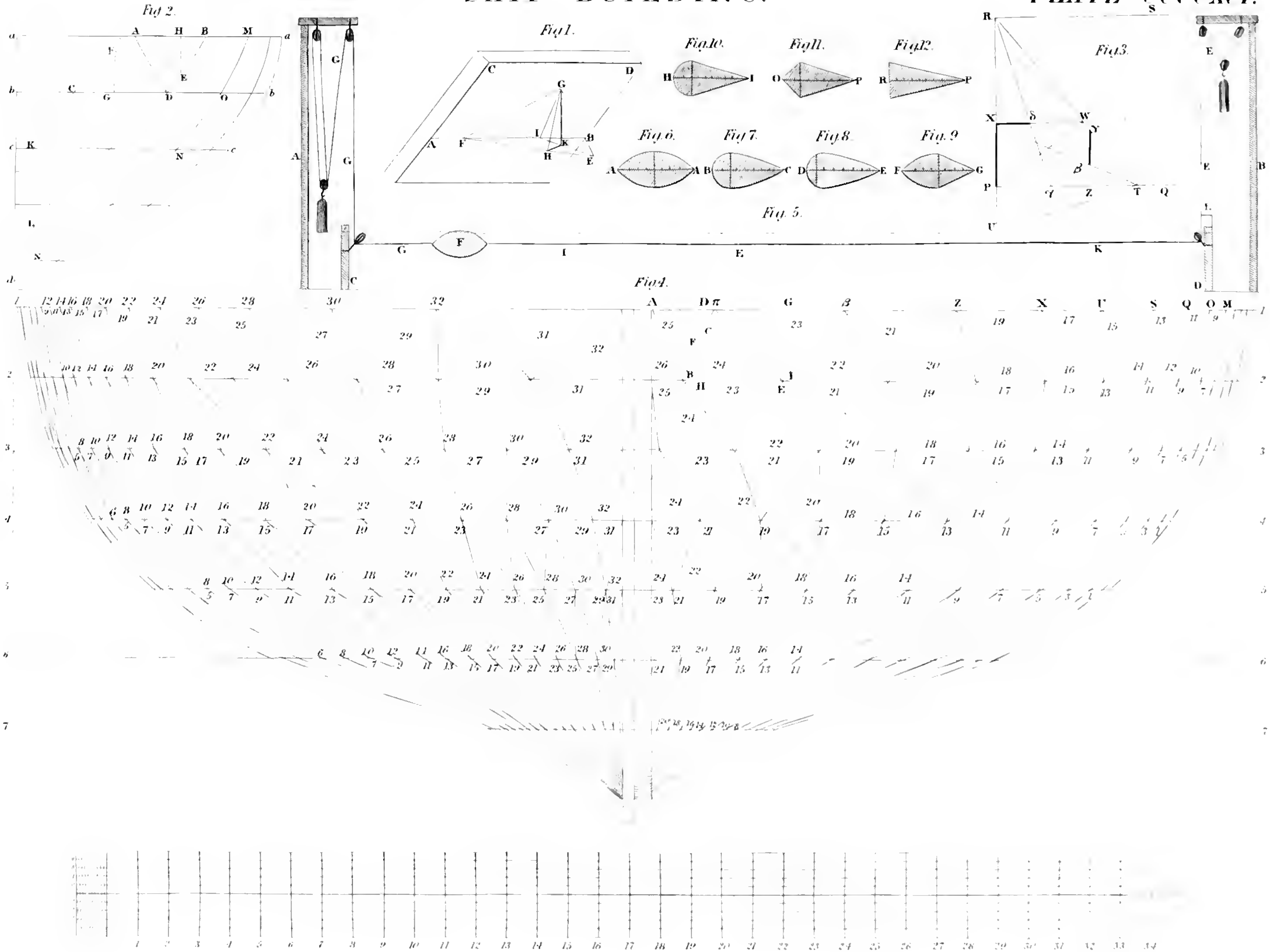
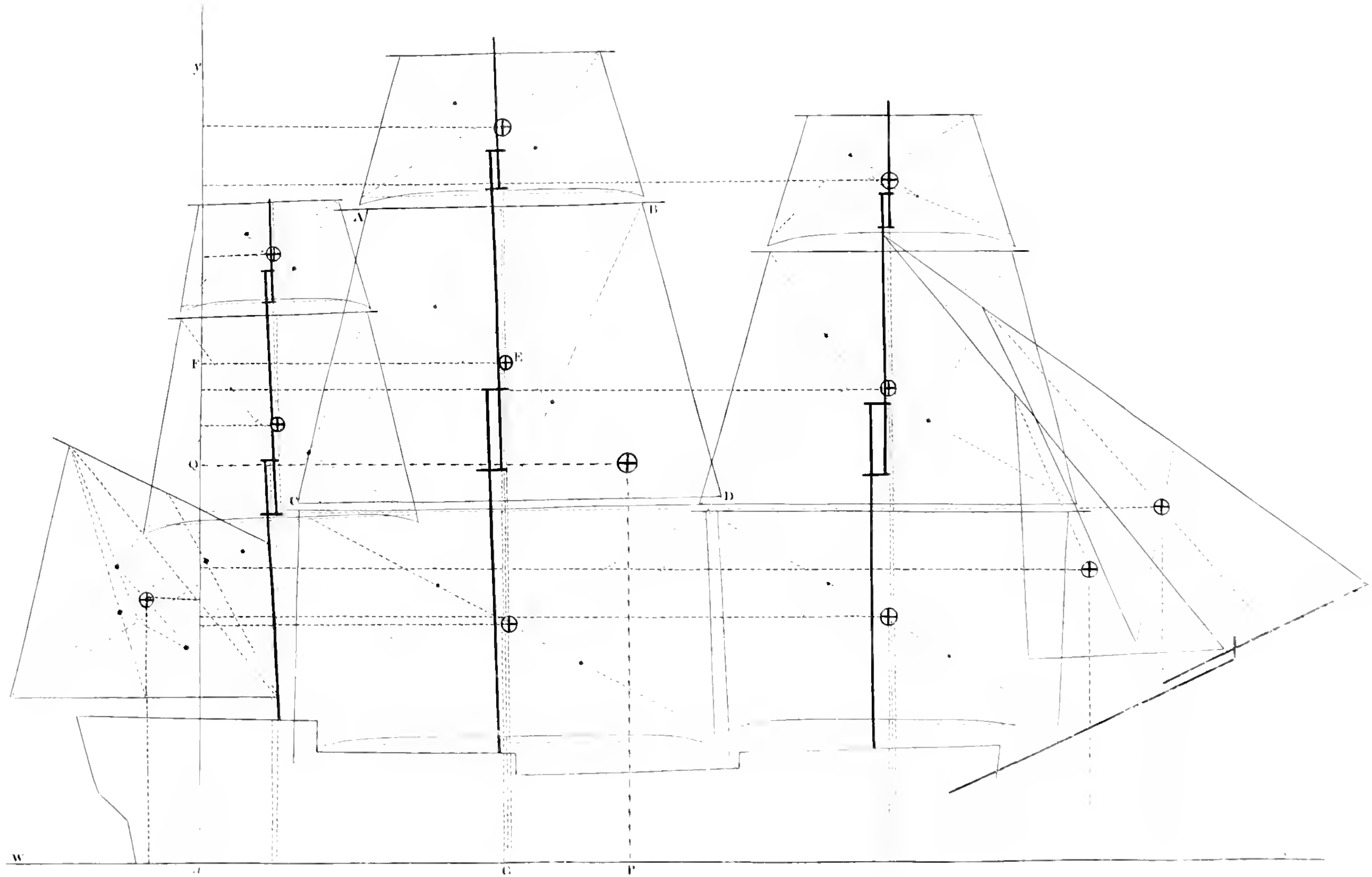


PLATE CCCCXCIII



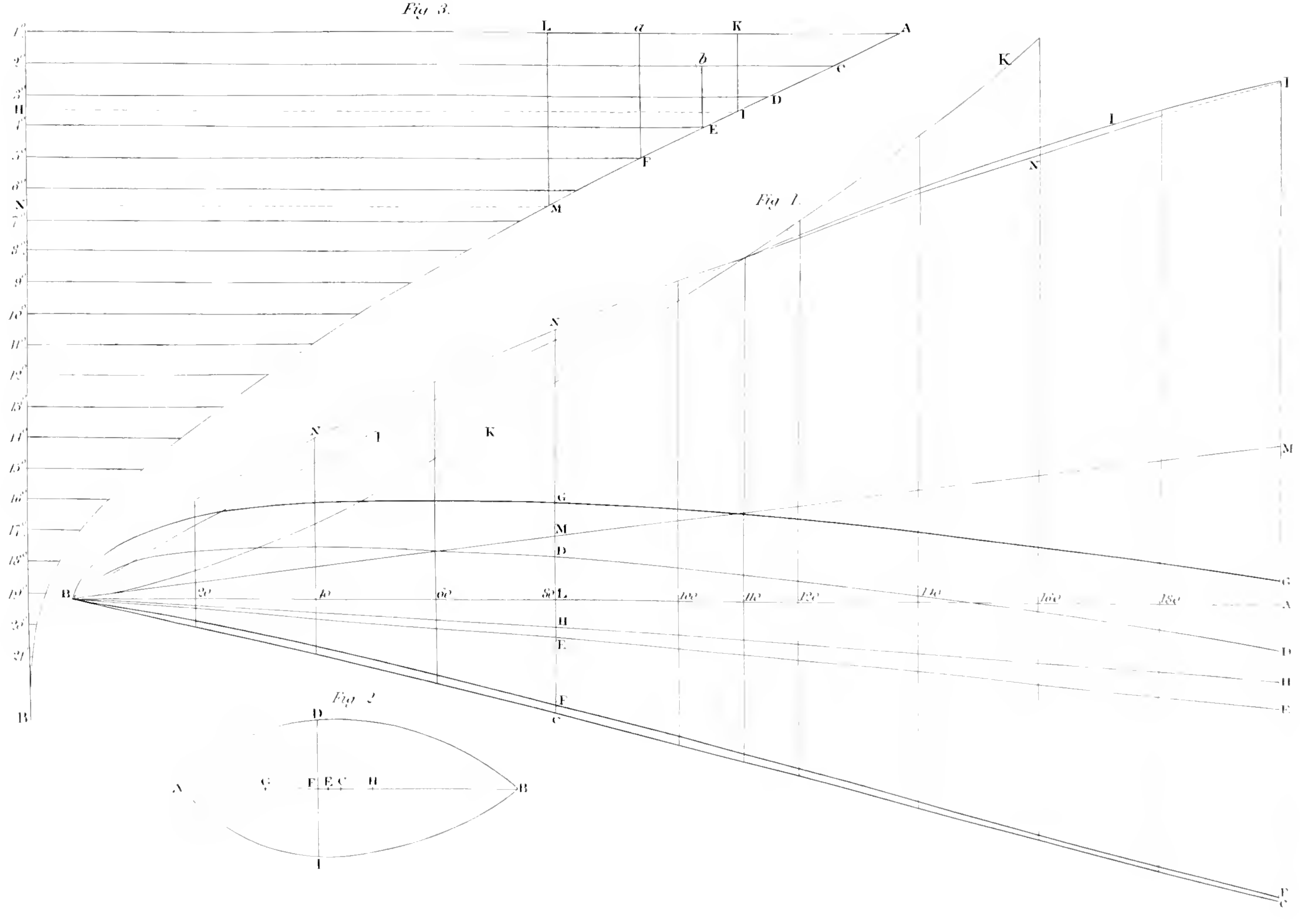


Fig. 3.
Fig. 1.
Fig. 2.

Fig. 2

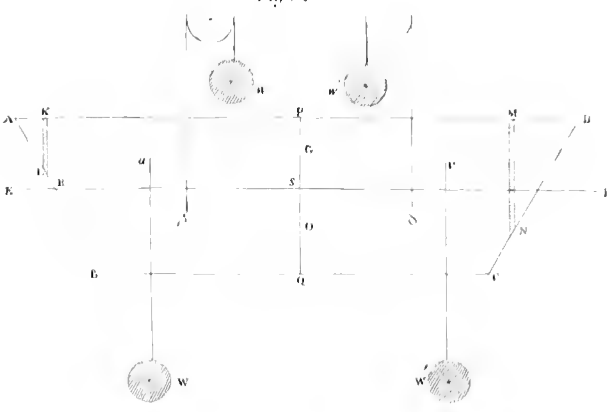


Fig. 1

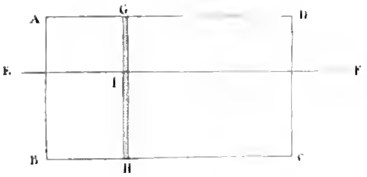


Fig. 6

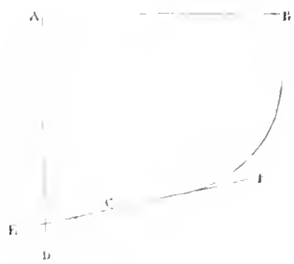


Fig. 3

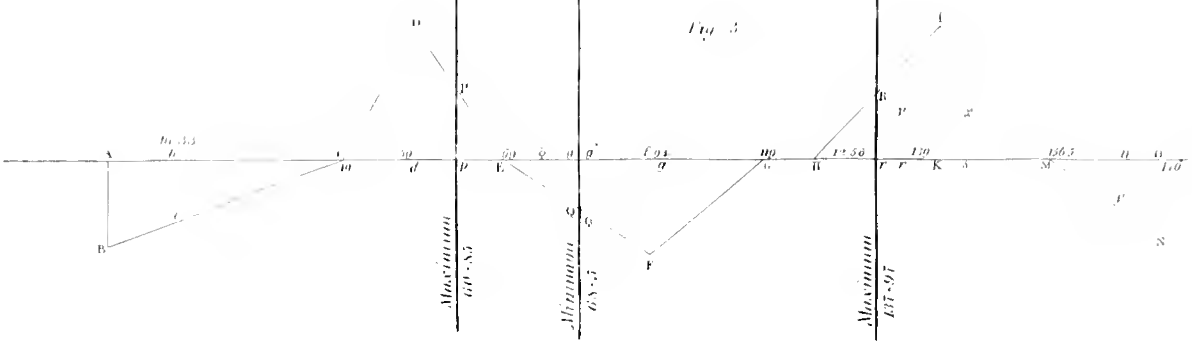


Fig. 4

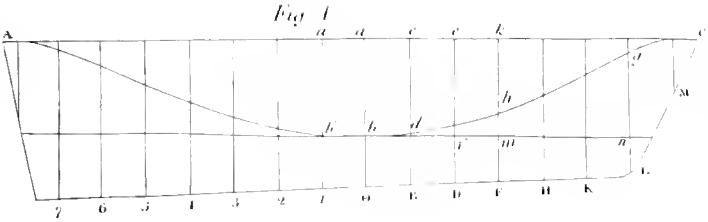


Fig. 5

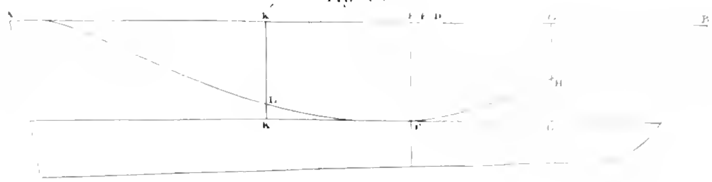


Fig. 7

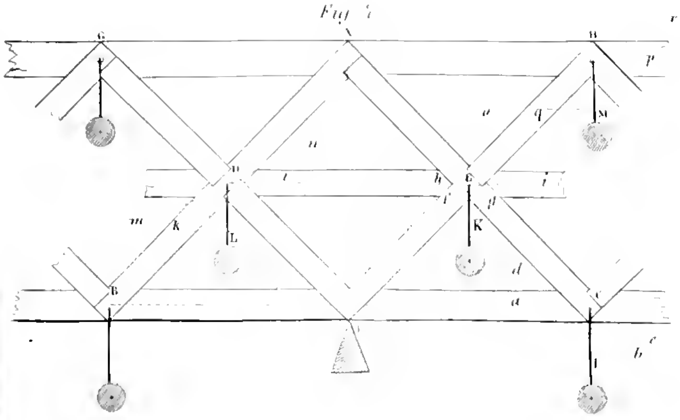
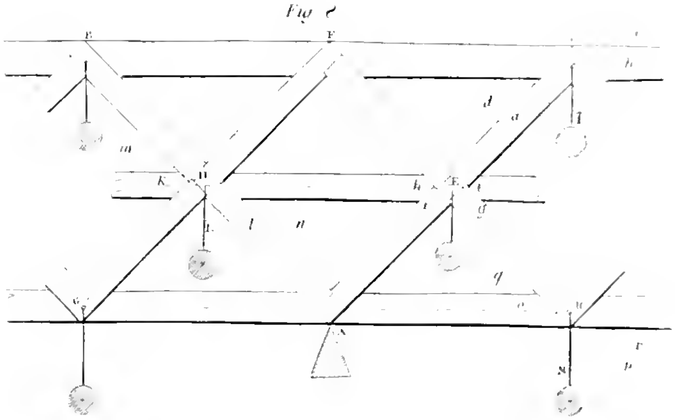


Fig. 8



Drawn by G. Harvey

Fig. 1

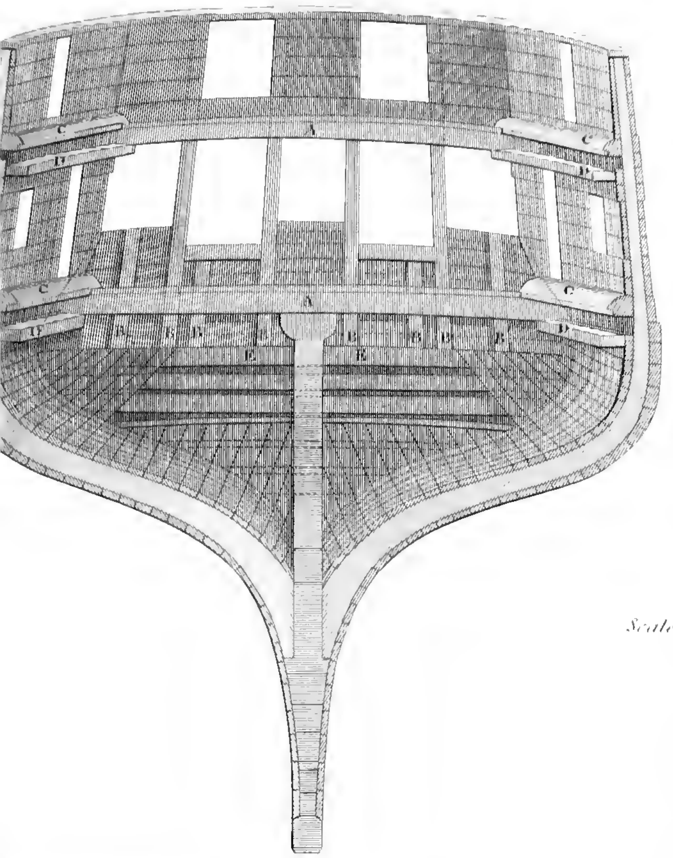
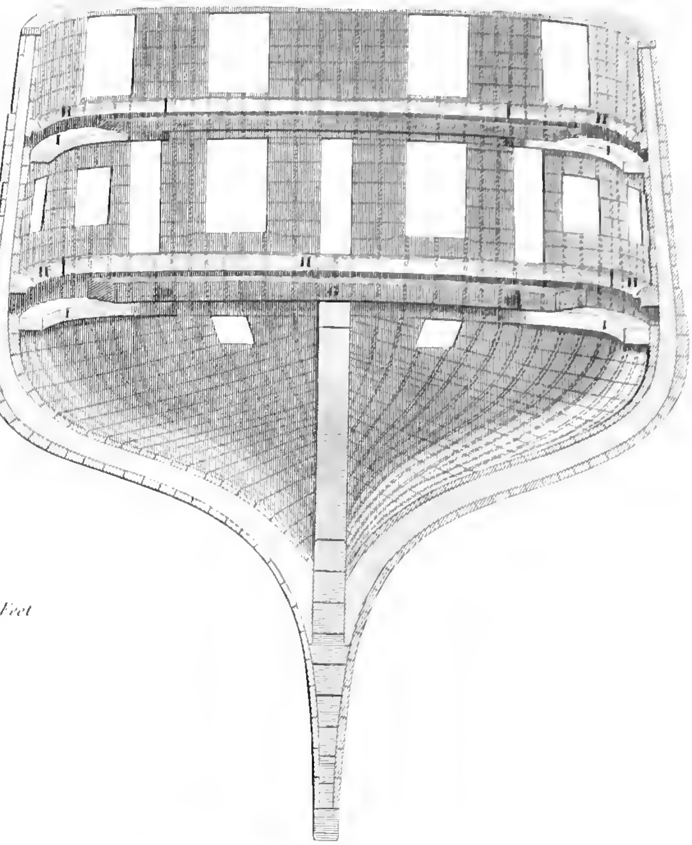


Fig. 2



Scale of Feet

Fig. 3

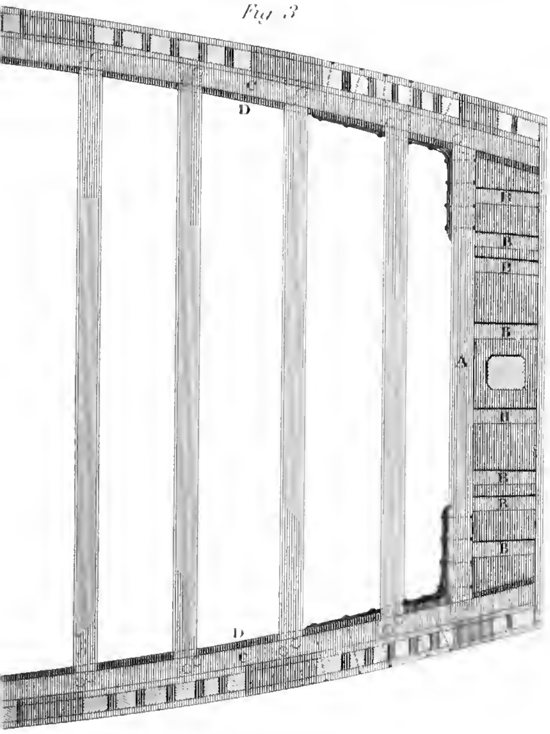
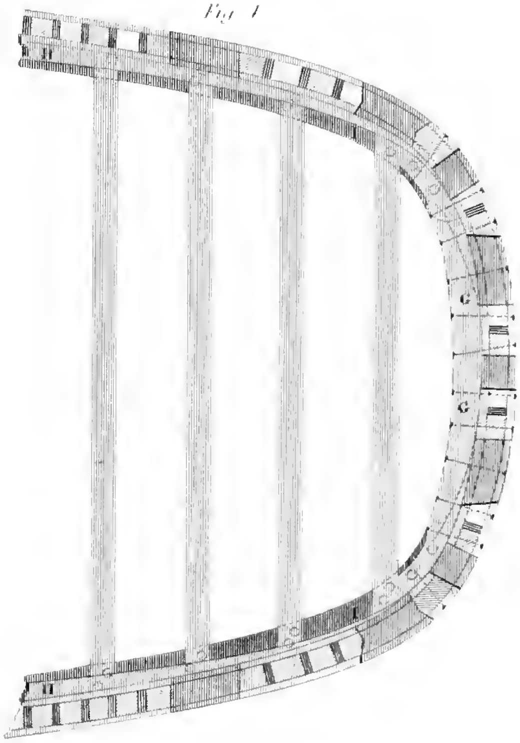
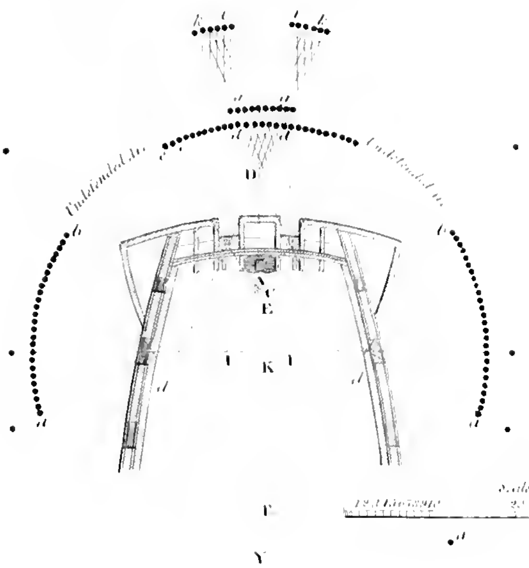


Fig. 4



Plan of the Square Stern of the Boadicea Frigate with the different bearings determined for the Guns

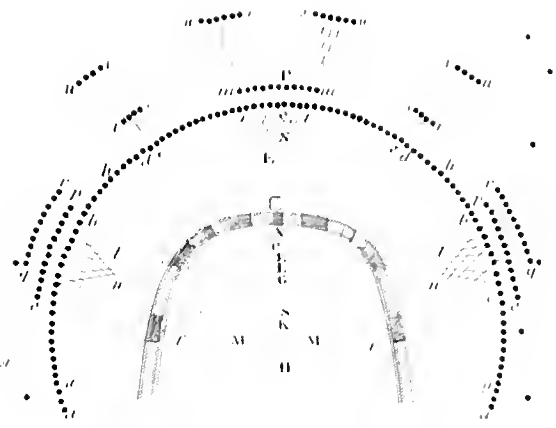
Fig. No 1.



Scale for Fig. 1 & 2

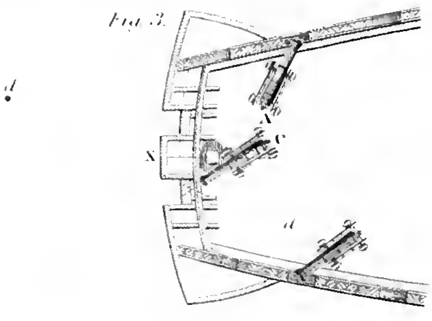
Plan of the circular Stern of the Hamadryad Frigate with the different bearings determined for the Guns

Fig. 2.



Plan of the Upper Deck of the Boadicea Frigate, with the After broadside and Stern Guns, trained at their greatest angles

Fig. 3.



Plan of the Upper Deck of the Hamadryad Frigate, with the Guns at the after broadside port and at the adjacent quarter and Stern ports bearing on the same point, at a distance less than twelve fathoms of the quarter

Fig. 4.

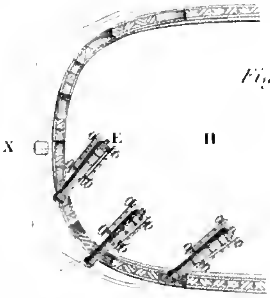
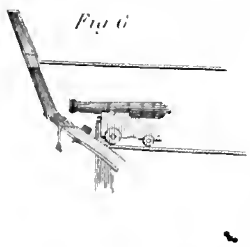


Fig. 5.

Plan of the Upper Deck of the Hamadryad Frigate with the Guns at the after broadside port and at the adjacent quarter port trained to their greatest angles before the beam, when fought at the same time

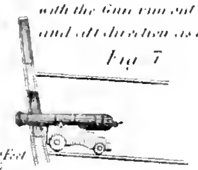
Thwartship view of the Stern of the Boadicea Frigate with the Gun run out in a fore and aft direction as far as possible

Fig. 6.



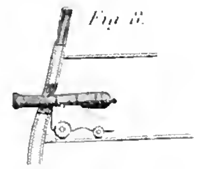
Thwartship view of the Stern of the Hamadryad Frigate, with the Gun run out in a fore and aft direction as far as possible

Fig. 7.



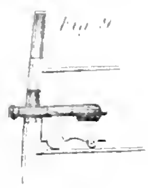
Fore and aft view of the after broadside Guns of the Boadicea and Hamadryad Frigates

Fig. 8.

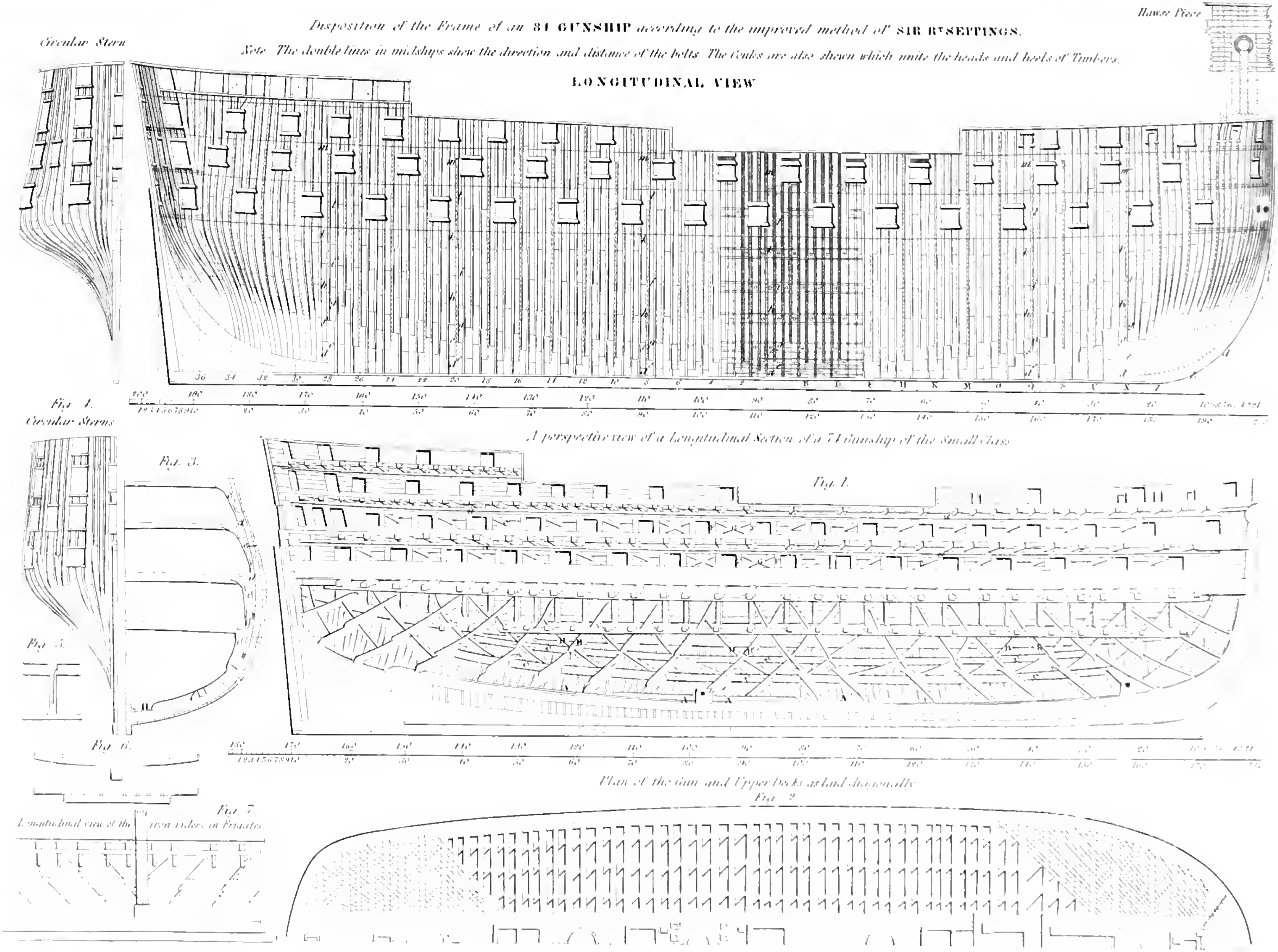


View of the quarter port of the Hamadryad the projection being square from the curve of the side and the Gun run out as far as possible

Fig. 9.



Scale for Figs. 3 4 5 &c.


Disposition of the Frame of an 84 GUNSHIP according to the improved method of Sir Rt. Seppings.
Note The double lines in midships shew the direction and distance of the belts. The Coaks are also shewn which unite the heads and heels of Timbers.
LONGITUDINAL VIEW
Hawse Piece
Circular Stern
Fig. 4.
Circular Sterns
A perspective view of a Longitudinal Section of a 74 Gunship of the Small Class
Fig. 1.
Fig. 3.
Fig. 5.
Fig. 6.
Fig. 7
Longitudinal view of the iron riders in Frigates
Plan of the Gun and Upper Decks as laid diagonally
Fig. 2

A DRAUGHT
For Building a Ship of
84 GUNS.

DIMENSIONS

	Ft	Ins
Length on the Gundeck	196	$1\frac{1}{8}$
—— *of the Keel for Tonnage*	161	$11\frac{1}{8}$
Breadth Extreme	51	$5\frac{1}{4}$
—— *Moulded*	50	$8\frac{1}{4}$
Depth in Hold	22	6
Burthen in Tons	N° $2279\frac{22}{94}$	

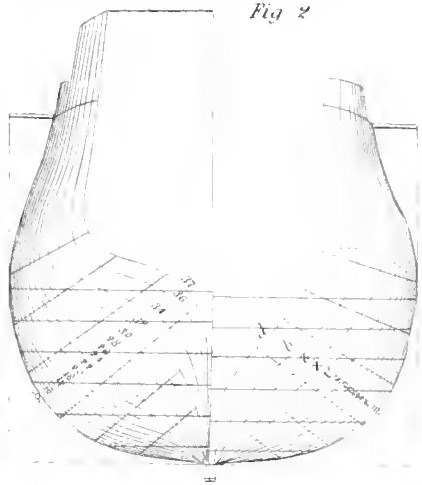


Fig 2

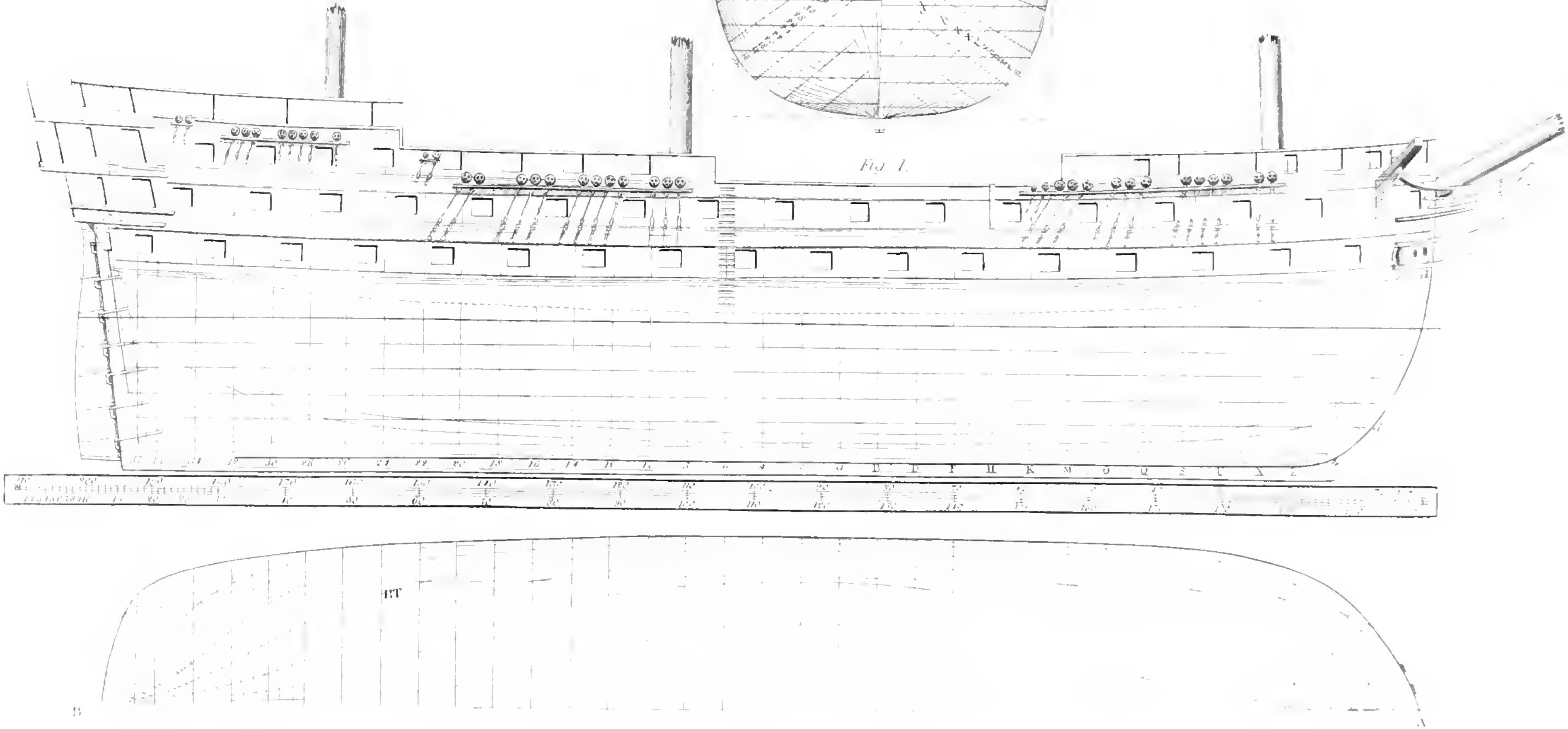


Fig 1.

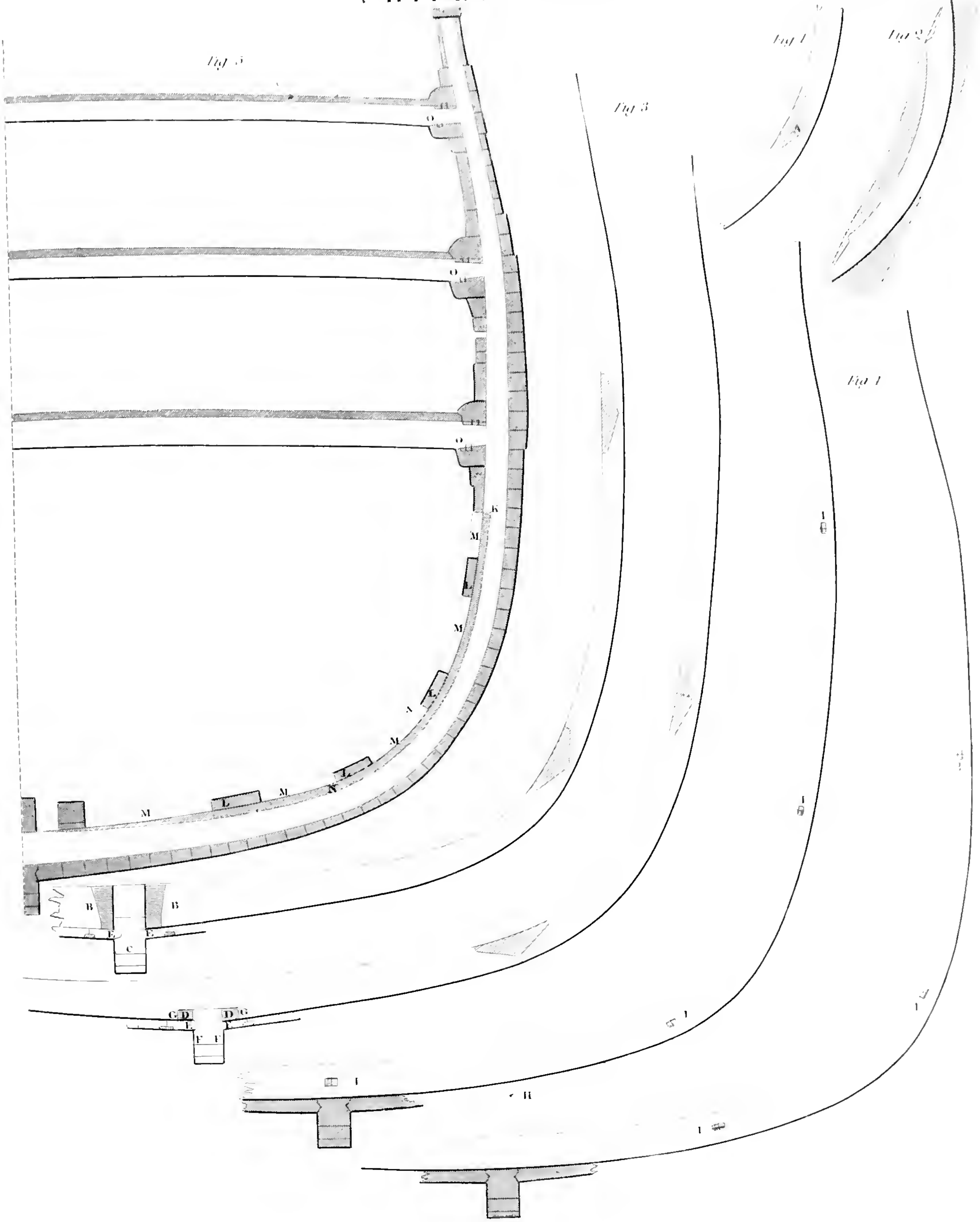


Fig. 5
Fig. 3
Fig. 1
Fig. 2
Fig. 4
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Fig. 1.

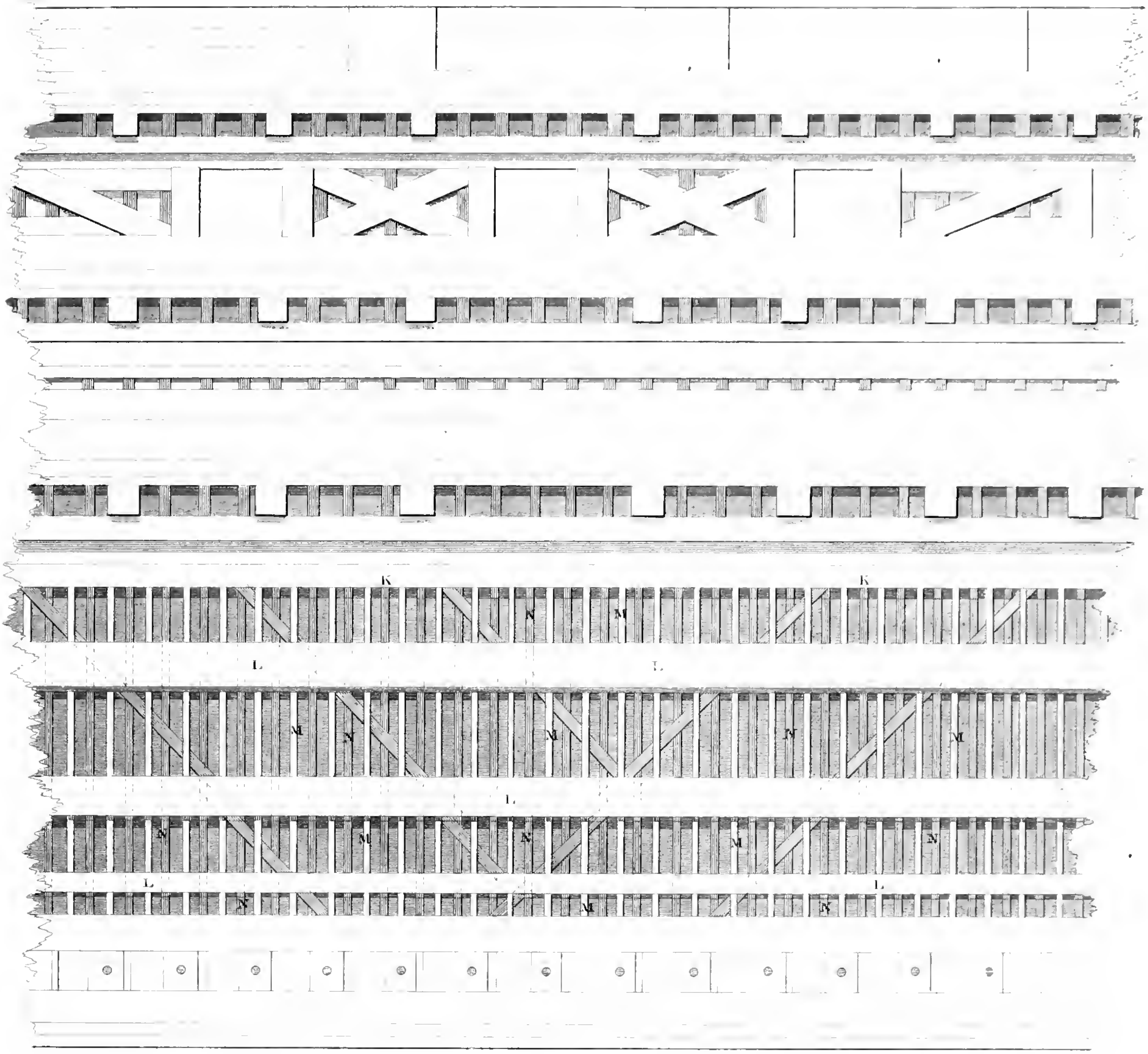


Fig. 2.

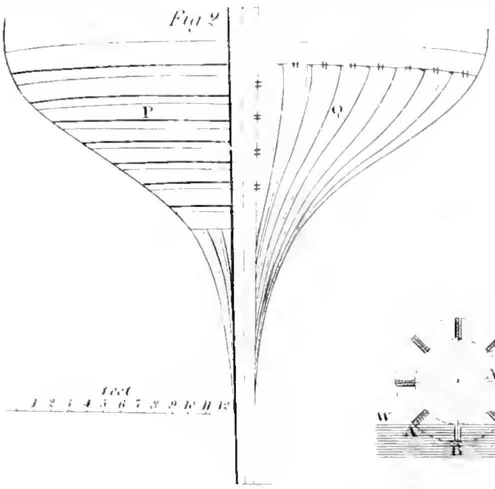


Fig. 4.

Fig. 5.

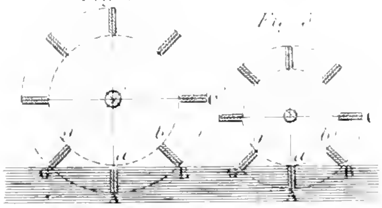


Fig. 3.

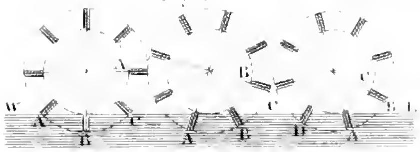
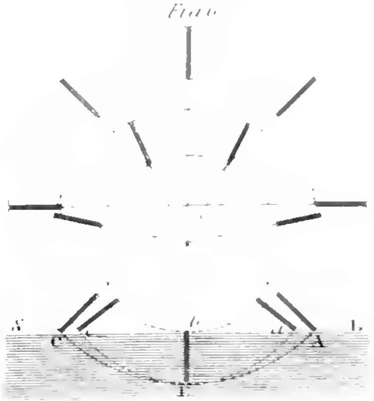


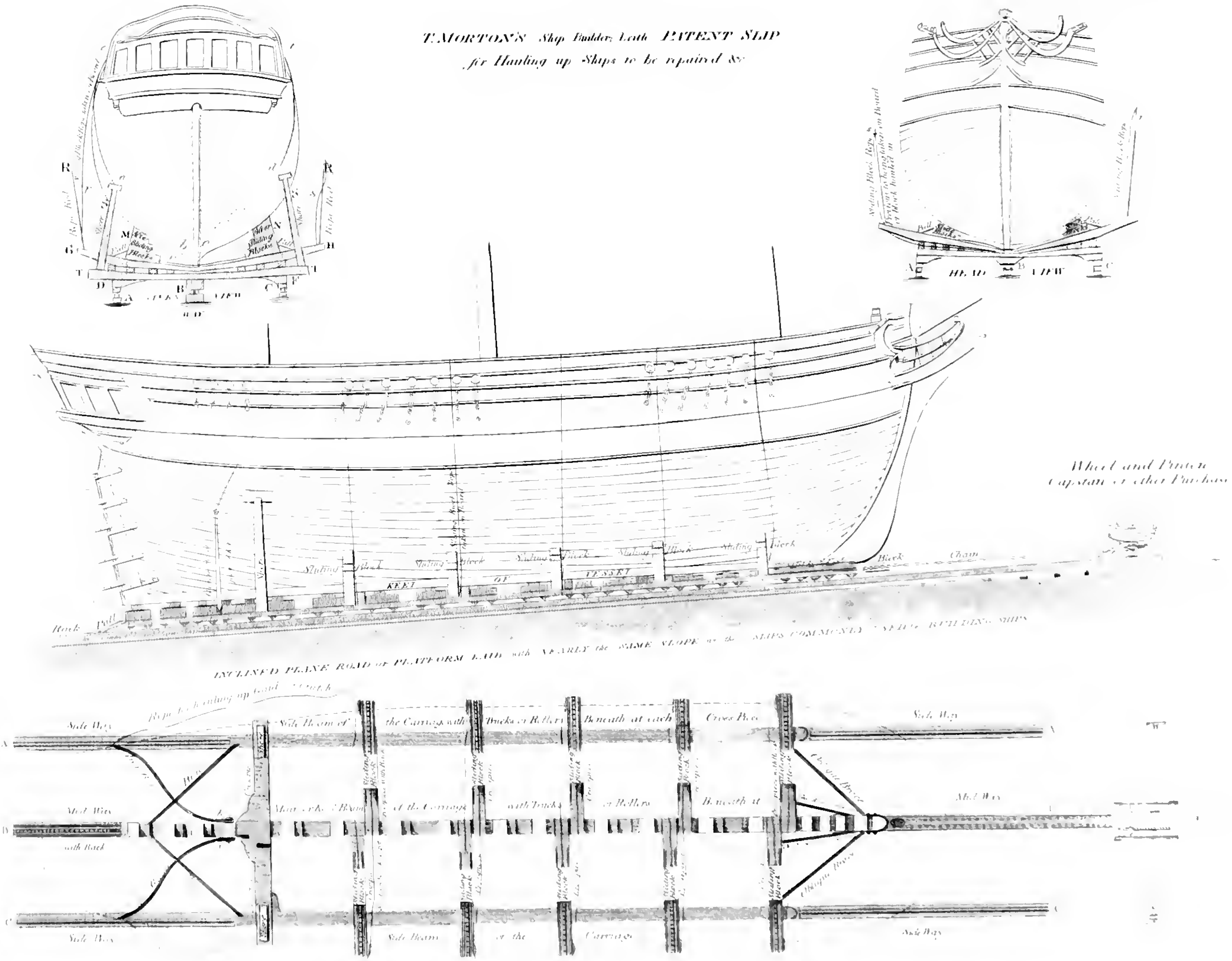
Fig. 6.



SLIP.

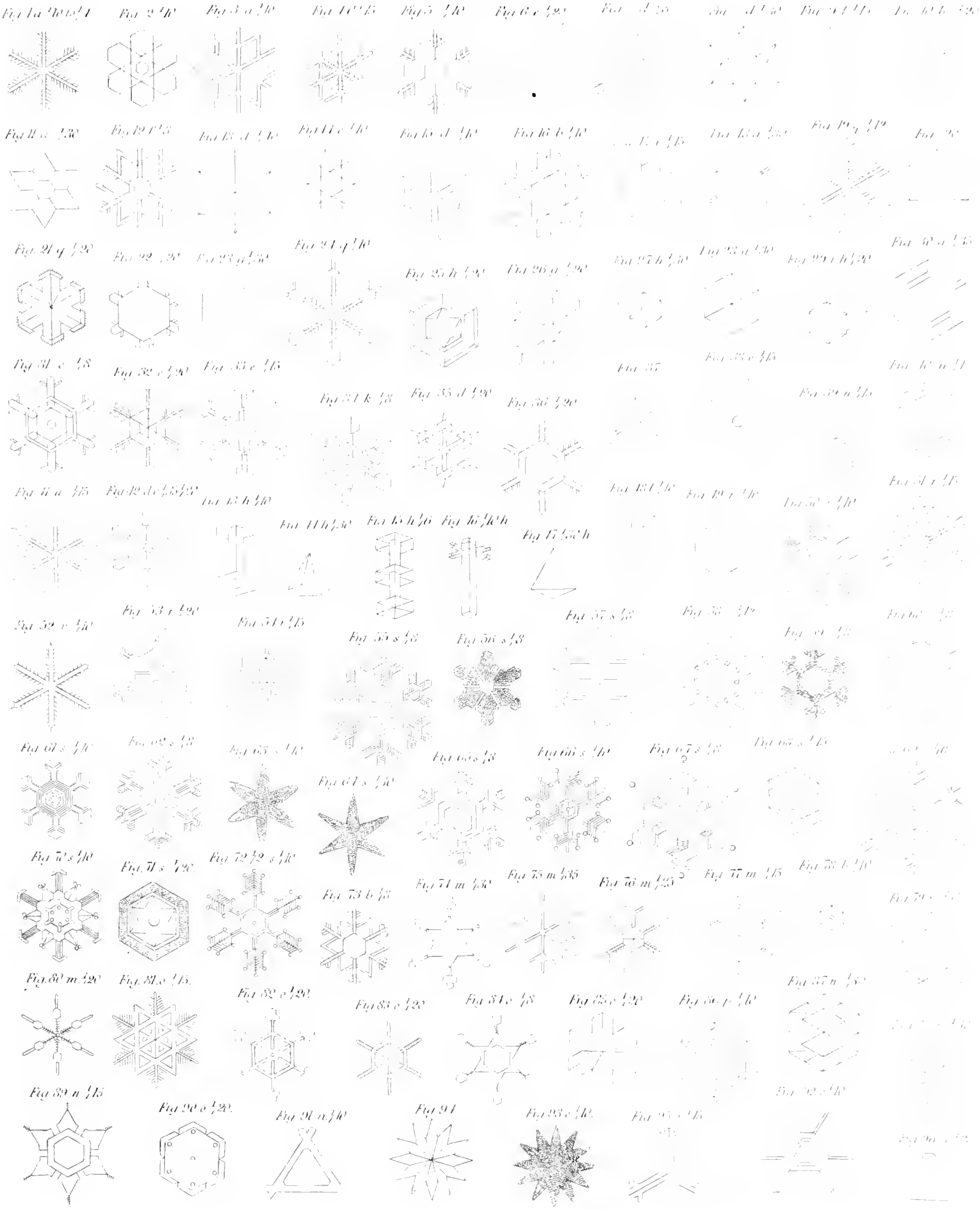
PLATE DII

T. MORTON'S Ship Builder, Leith PATENT SLIP
for Hauling up Ships to be repaired &c.



SNOW.

PLATE DIII.



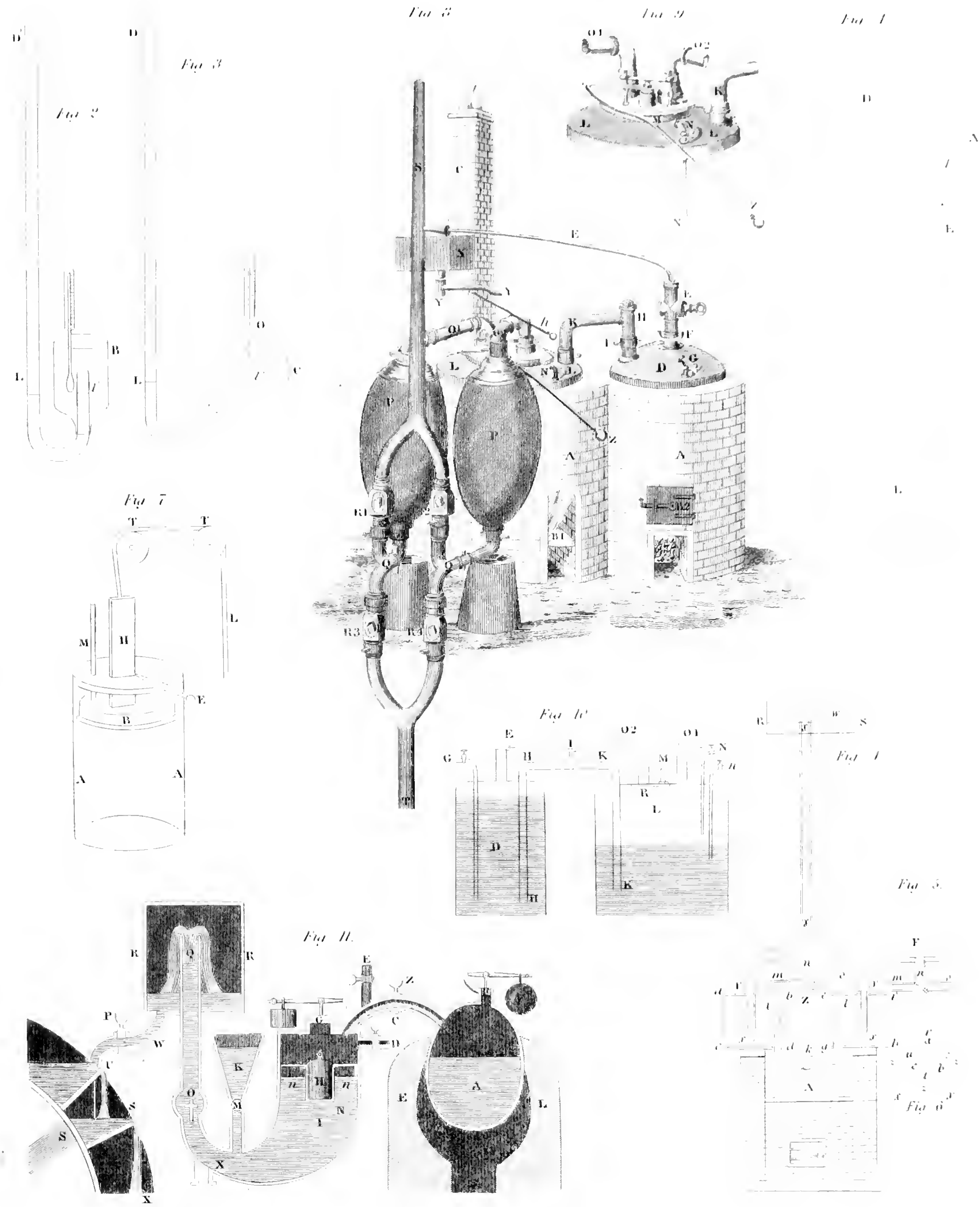


Fig. 2
Fig. 3
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 5
Fig. 6

Fig. 1

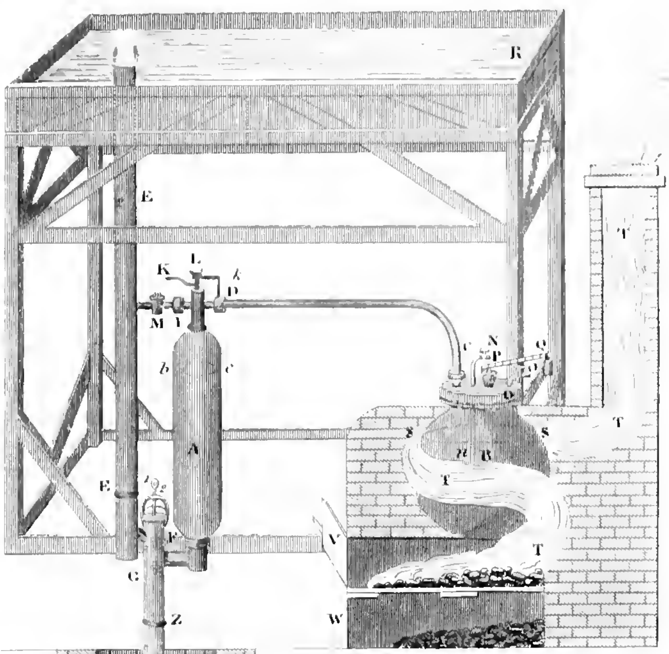
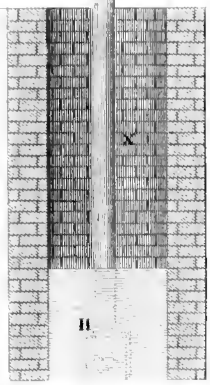



Fig. 3

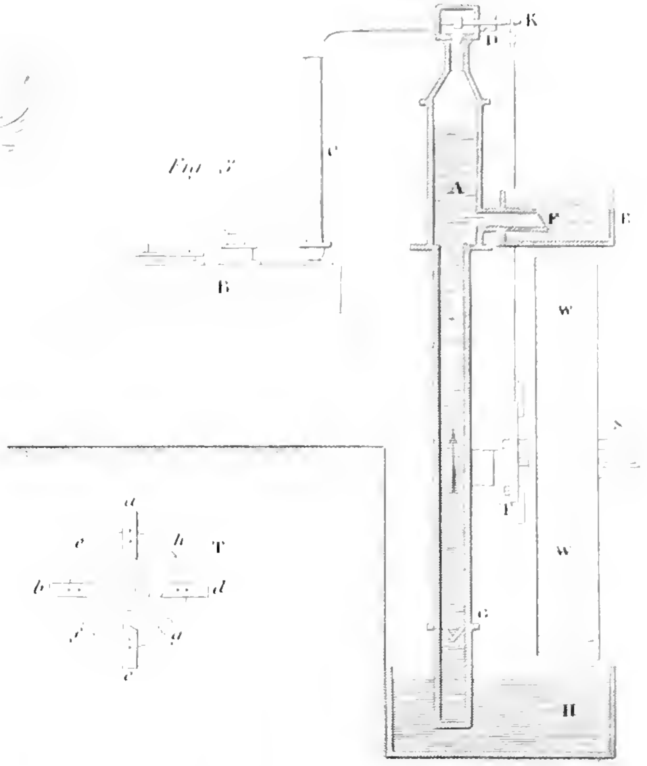


Fig. 2

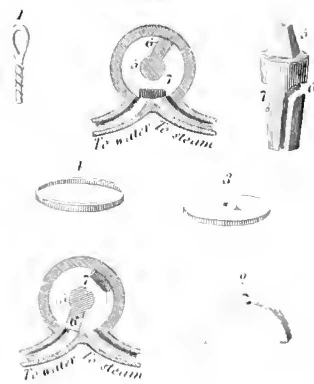


Fig. 4

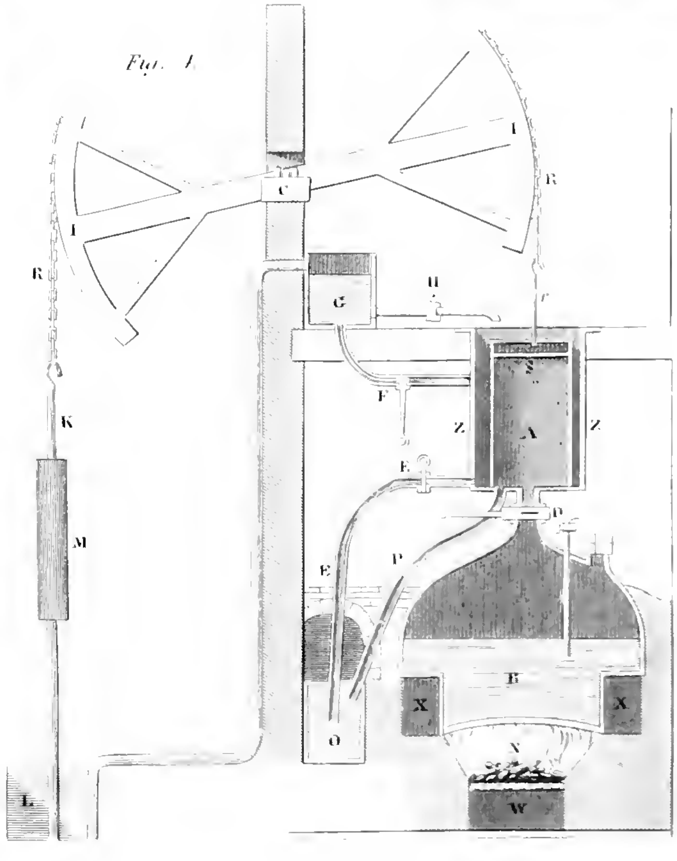
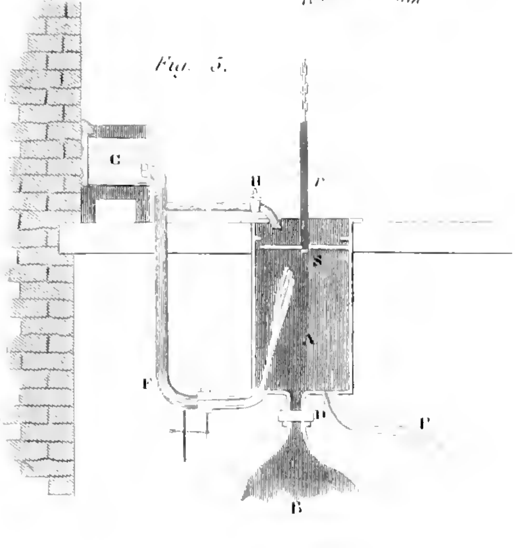


Fig. 5



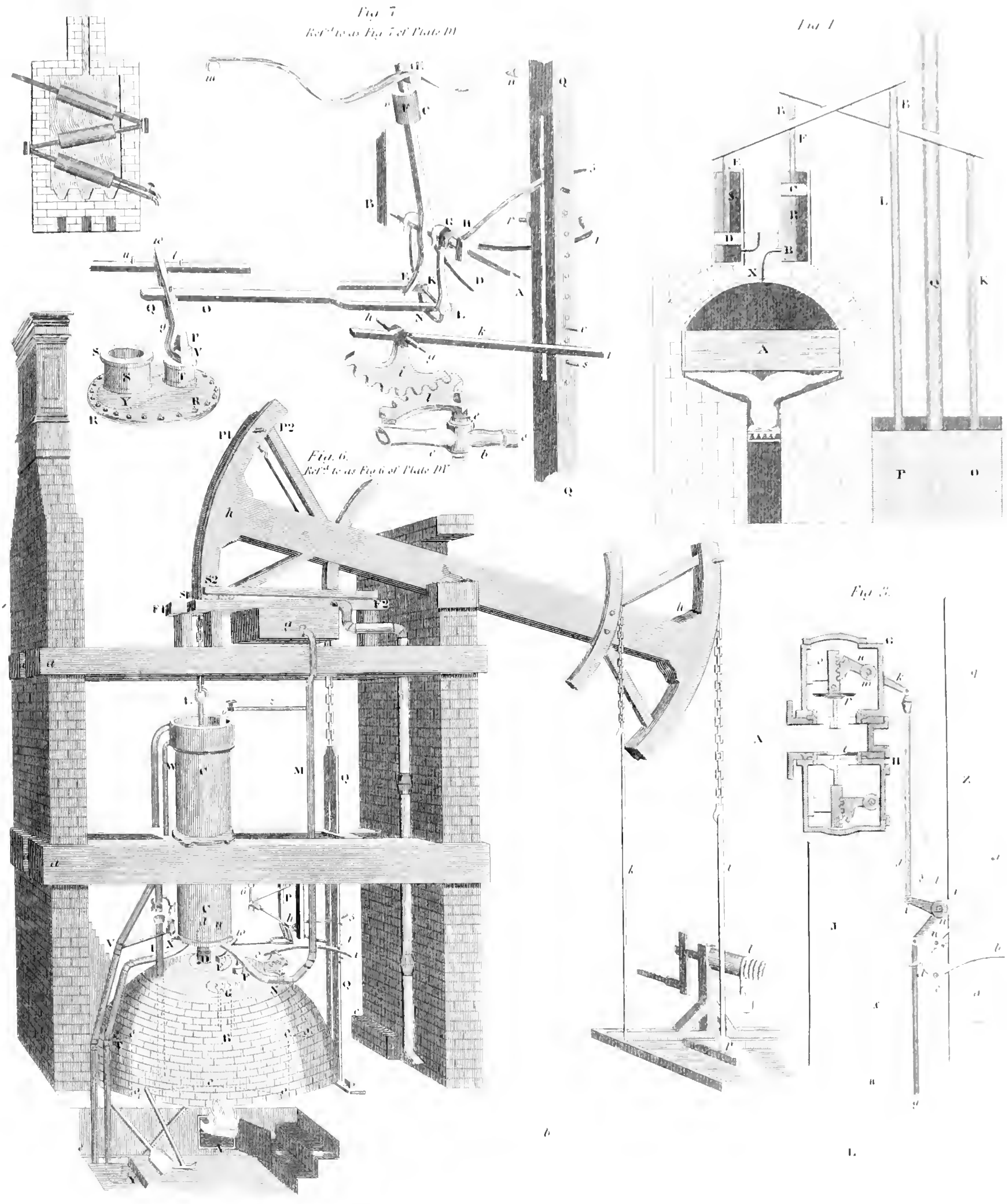
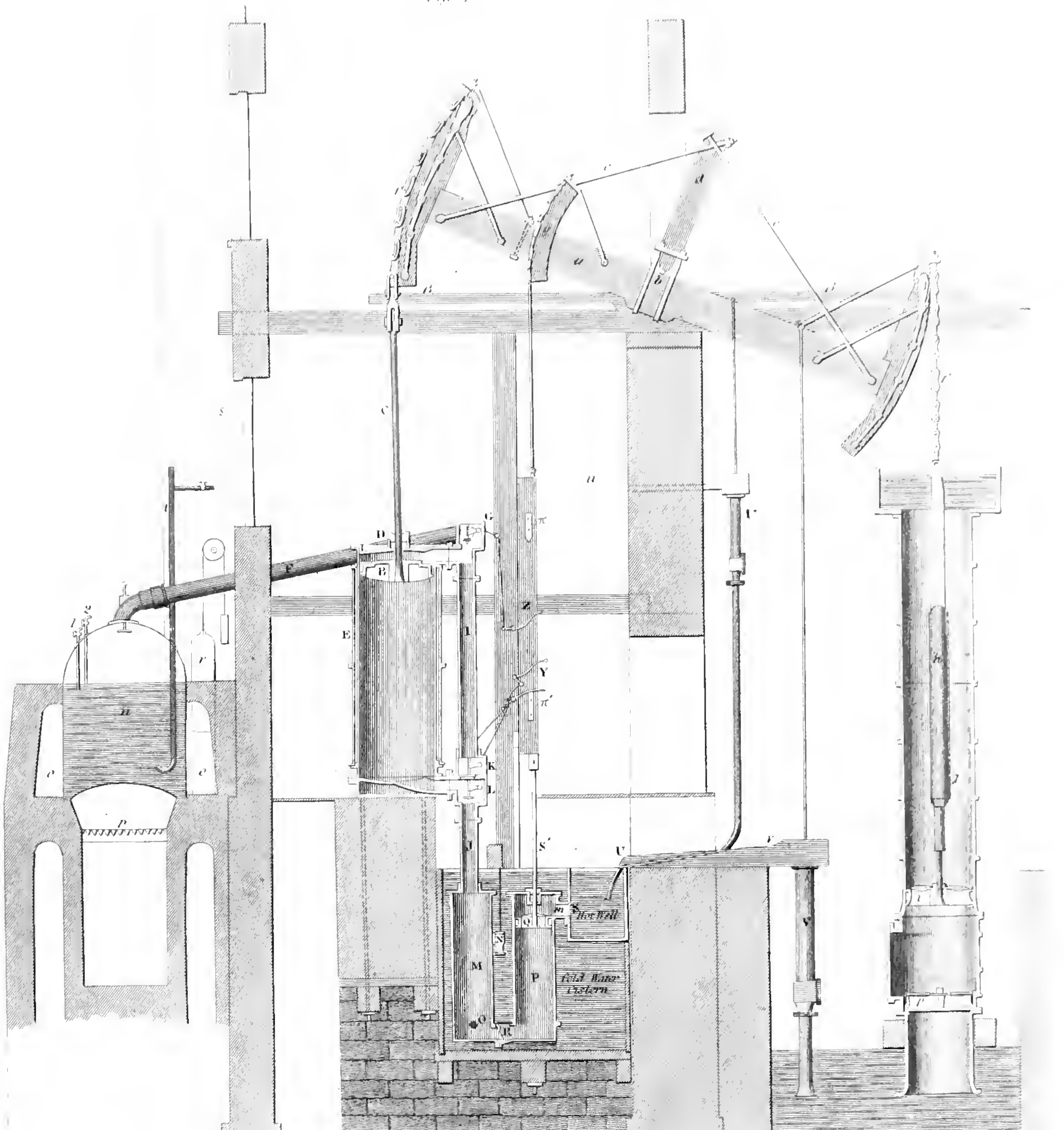


Fig 7
Ref to as Fig 7 of Plate DV
Fig 1
Fig. 6.
Ref to as Fig 6 of Plate DV
Fig 3.

STEAM ENGINE   *PLATE DVII*

Mr Watts Single Reciprocating Engine as Constructed 1788

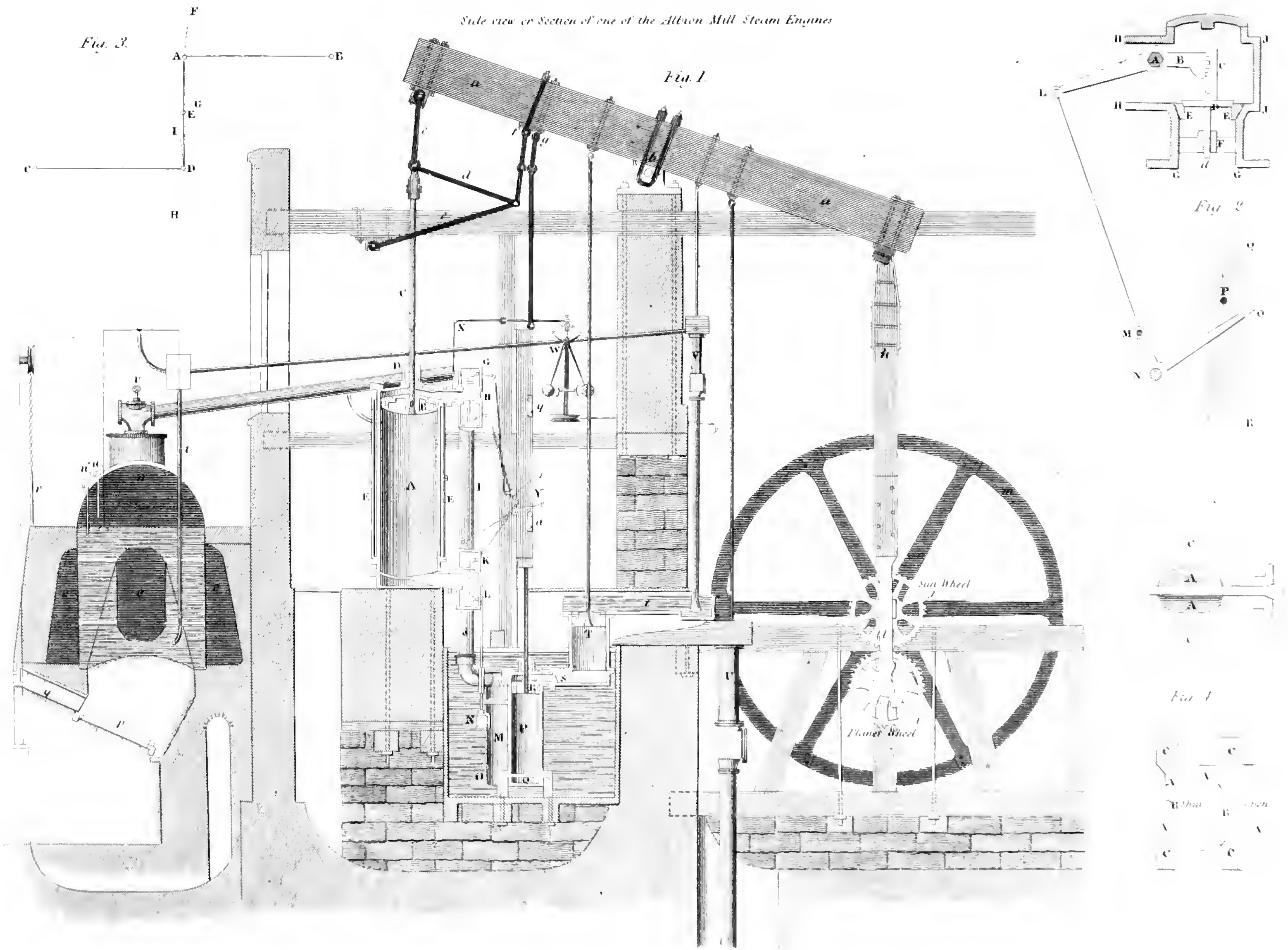
Fig. 1



STEAM ENGINE

PLATE DVIII

Side view or Section of one of the Albion Mill Steam Engines



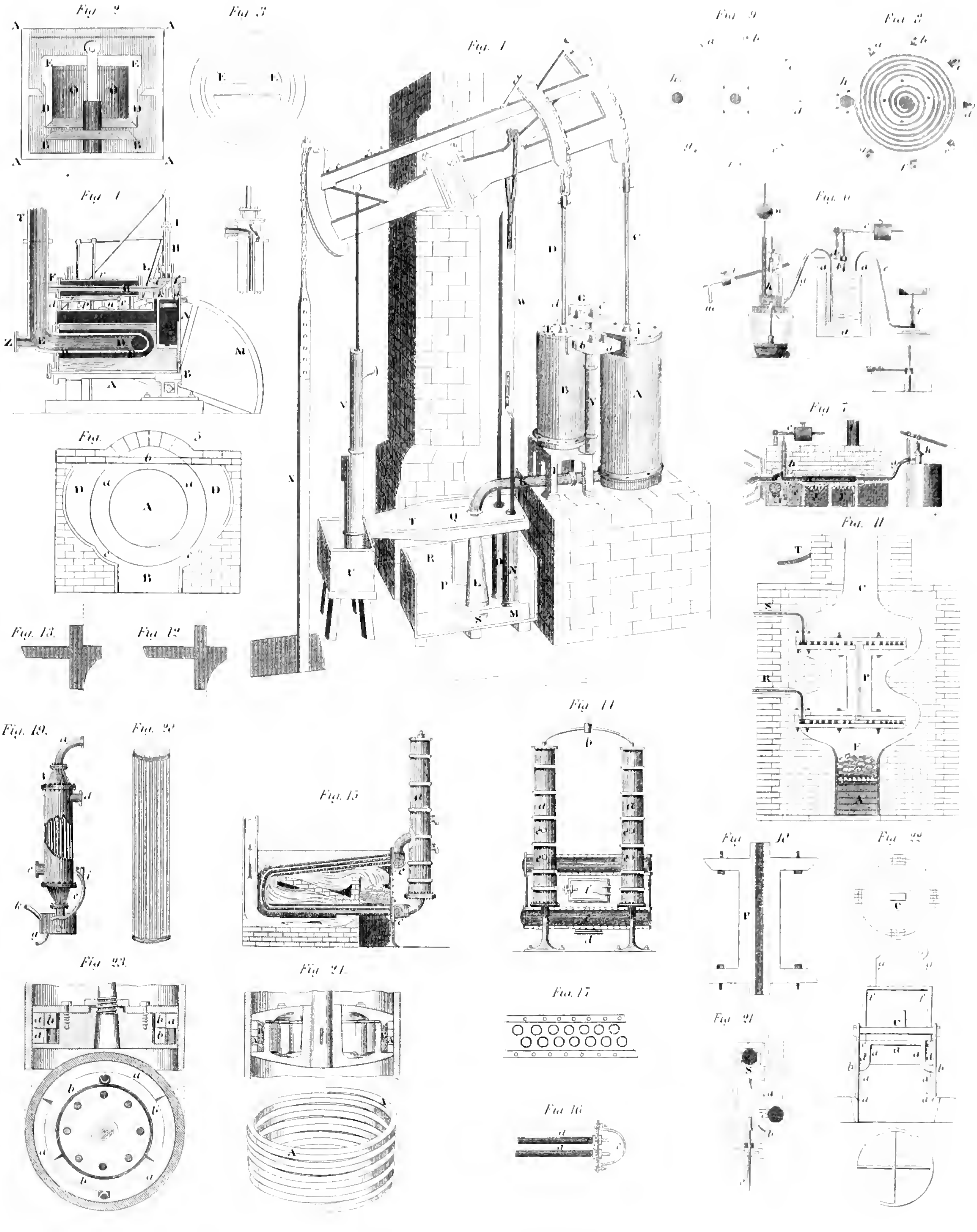


Fig. 2
Fig. 3
Fig. 1
Fig. 5
Fig. 7
Fig. 13
Fig. 12
Fig. 19
Fig. 20
Fig. 15
Fig. 23
Fig. 17
Fig. 16

STEAM BOAT.

PLATE DX

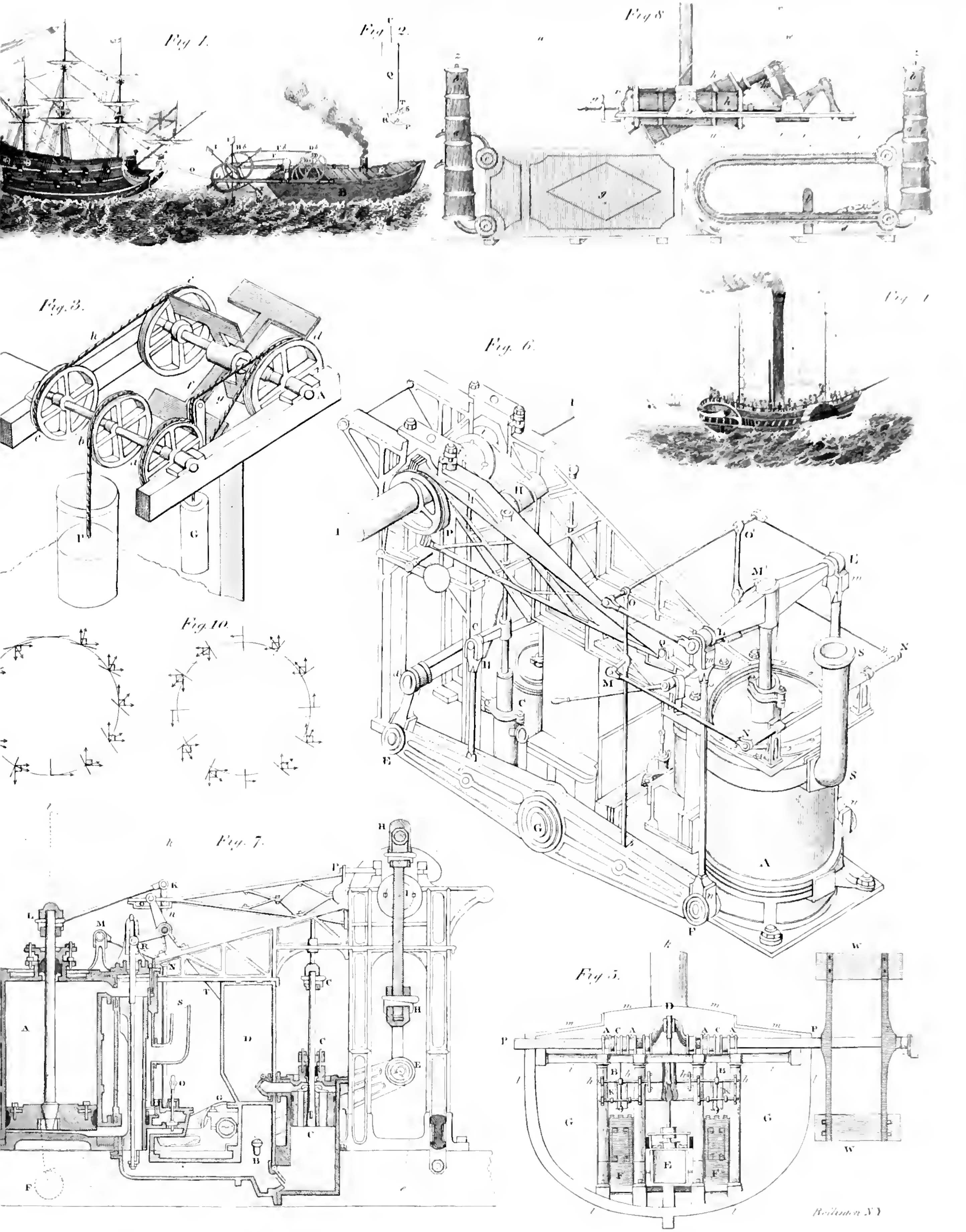


Fig. 1
Steam Boat invented by John Fitch

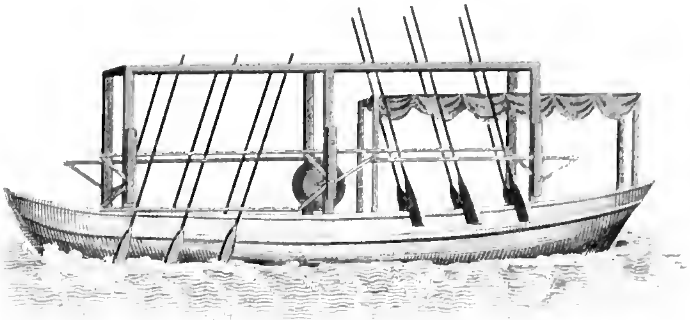
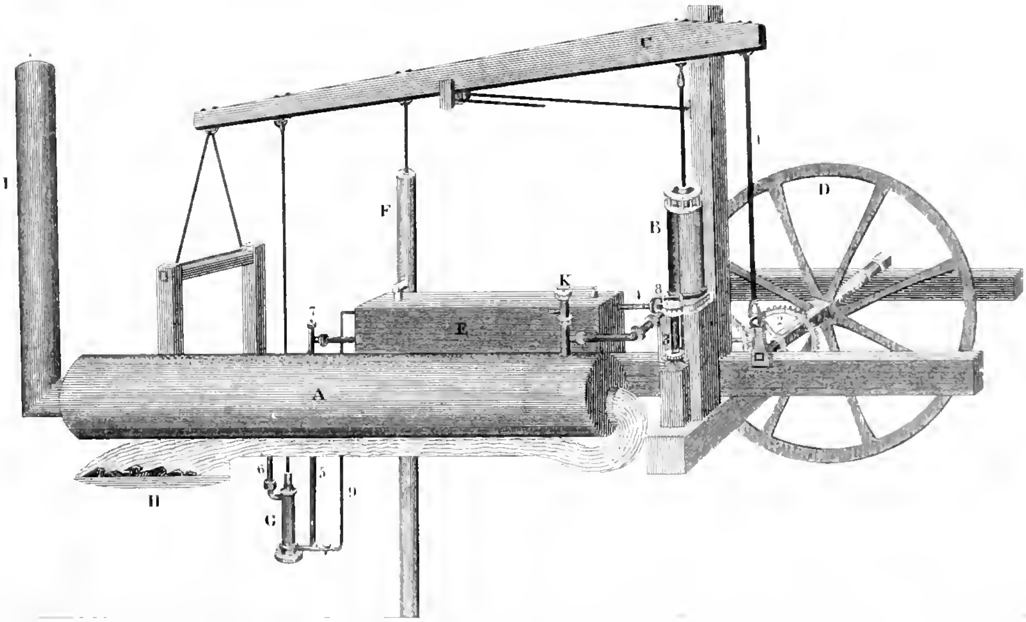


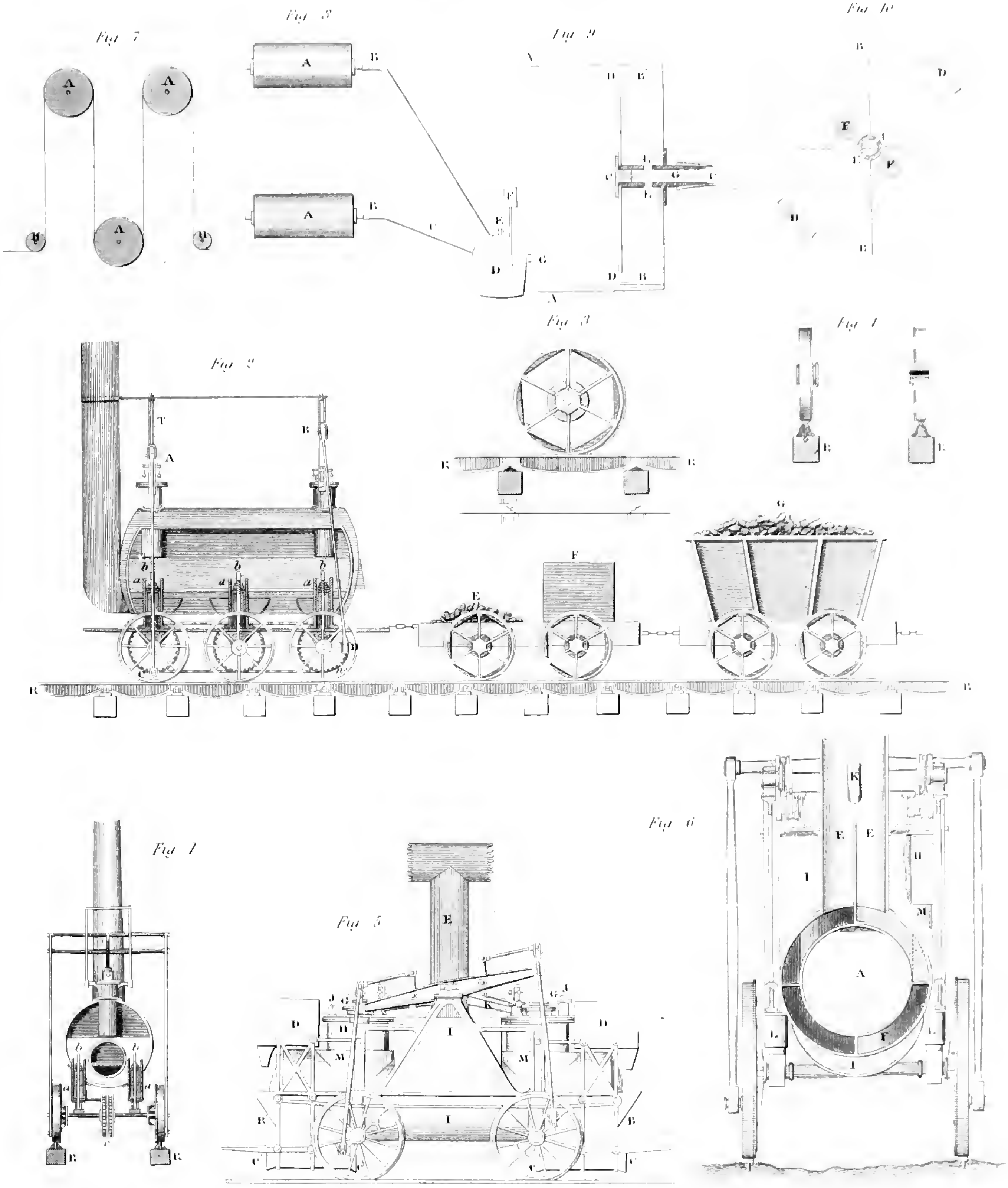
Fig. 2
Bridge over the Delaware near Trenton.

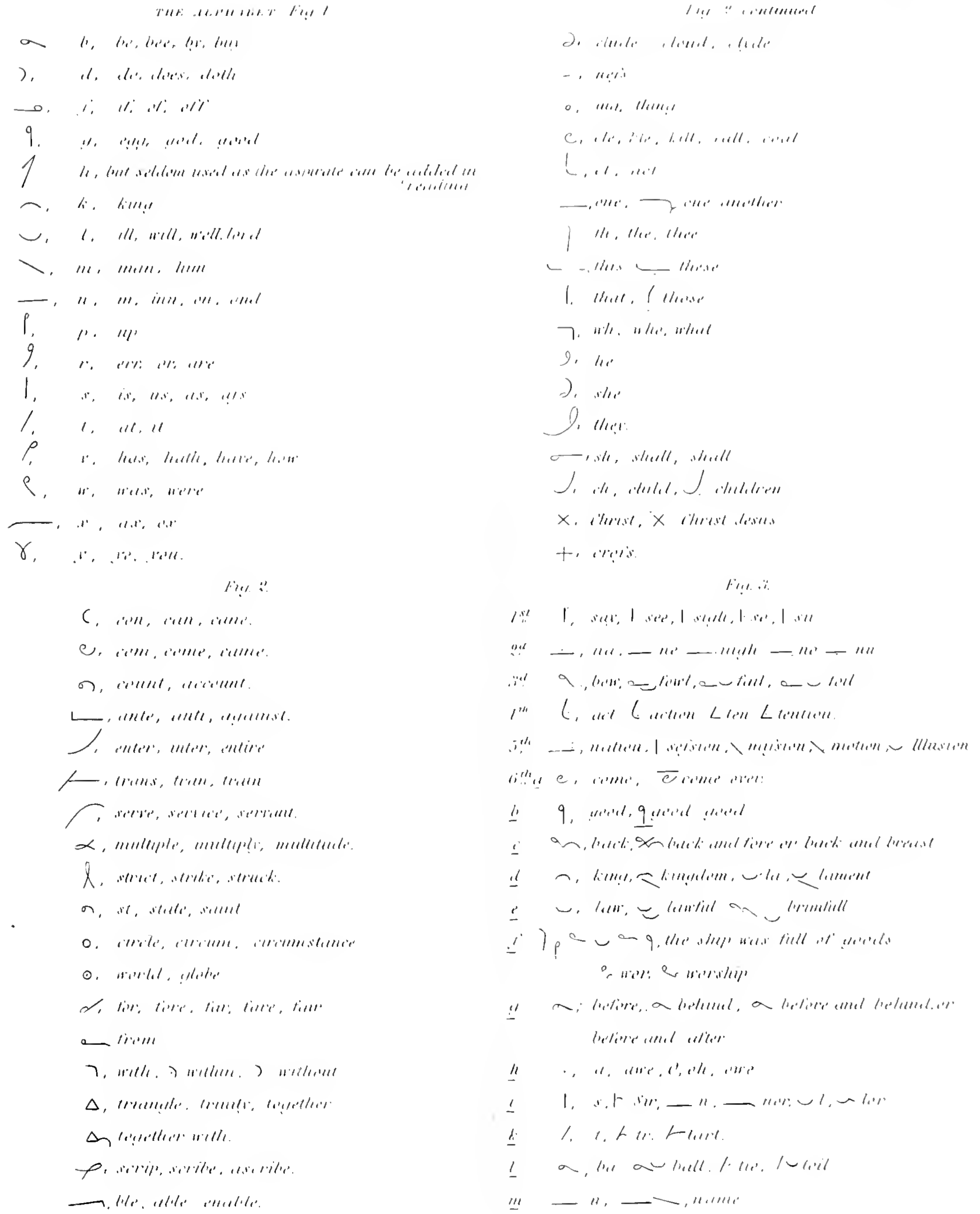
Fig. 3
The Columbian Steam Engine



STEAM CARRIAGE.   PLATE DXI.

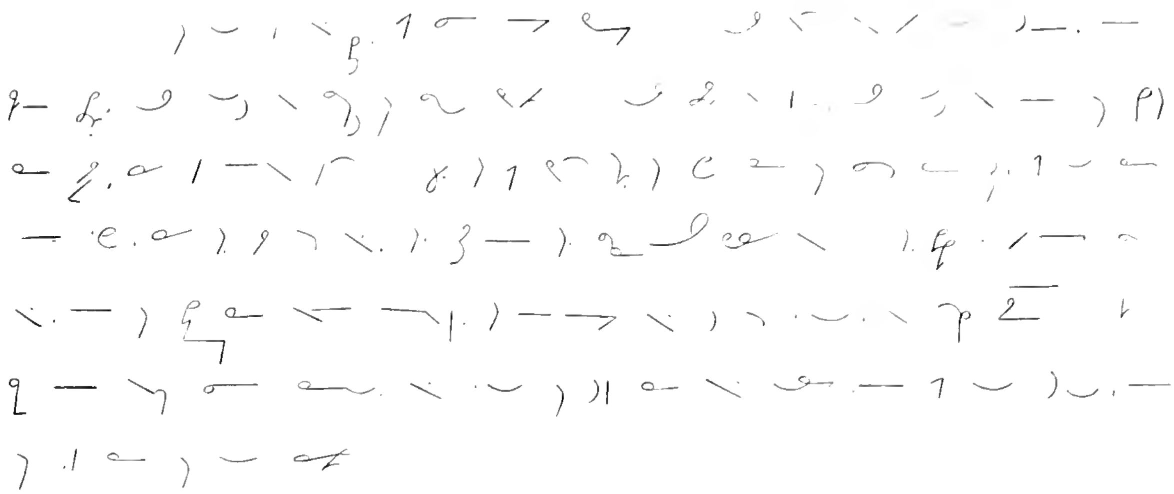
STEAM DRYING MACHINE.



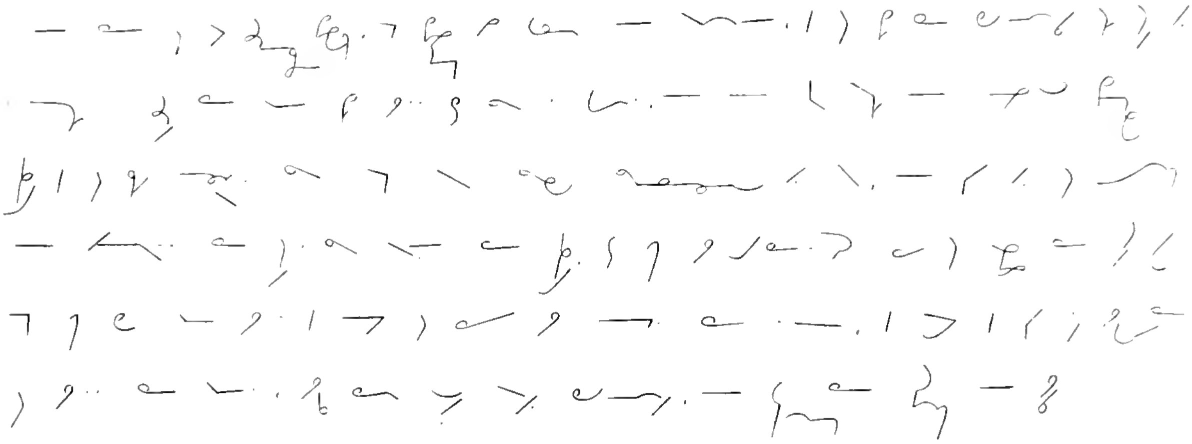

THE ALPHABET Fig 1
b, be, bee, by, buy
d, do, does, doth
f, if, of, off
g, egg, god, good
h, but seldom used as the aspirate can be added in reading
k, king
l, ill, will, well, lord
m, man, him
n, in, inn, on, and
p, up
r, err, or, are
s, is, us, as, ass
t, at, it
v, has, hath, have, how
w, was, were
x, ax, ox
y, ye, you
Fig. 2
con, can, came.
com, come, came.
count, account.
ante, anti, against.
enter, inter, entire
trans, tran, train
serve, service, servant.
multiple, multiply, multitude.
struct, strike, struck.
st, state, saint
circle, circum, circumstance
world, globe
for, fore, far, fare, fair
from
with, within, without
triangle, trinity, together
together with.
scrip, scribe, ascribe.
ble, able, enable.
Fig 2 continued
clude, cloud, clude
ness
ing, thing
cle, ple, kill, call, coal
ct, act
one, one another
th, the, thee
this, these
that, those
wh, who, what
he
she
they.
sh, shall, shell
ch, child, children
Christ, Christ Jesus
cross.
Fig. 3.
1st say, see, sigh, so, su
2d na, ne, nigh, no, nu
3d bow, fowl, fail, toil
4th act, action, ten, tention.
5th nation, session, mission, motion, illusion
6th a come, come over.
b good, good, good
c back, back and fore or back and breast
d king, kingdom, la, lament
e law, lawful, brimfull
f the ship was full of goods
wor, worship
g before, behind, before and behind, or before and after
h a, awe, O, oh, owe
i s, Sir, n, nor, l, ler
k t, tr, tart.
l ba, ball, tie, toil
m n, name

EXAMPLES

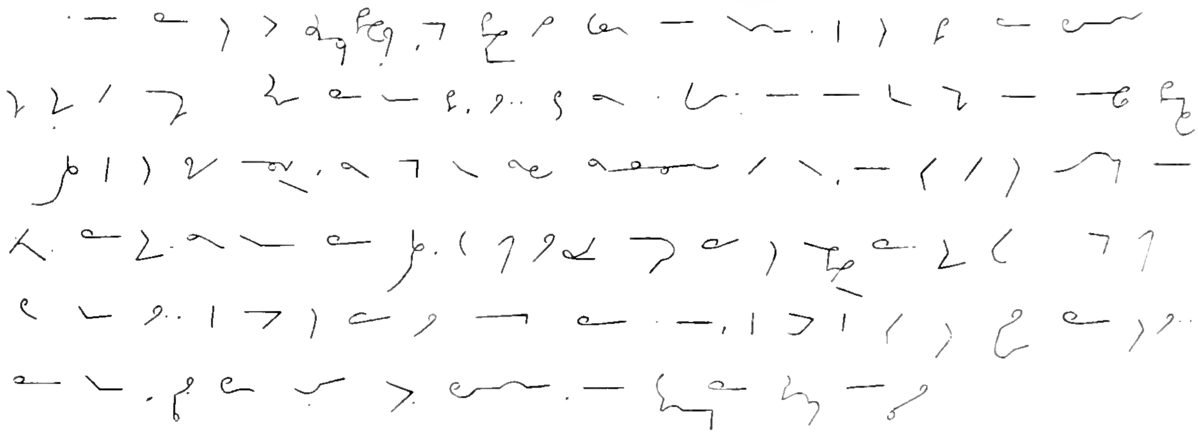
The 23rd Psalm



From Doctor Blair's Rhetoric

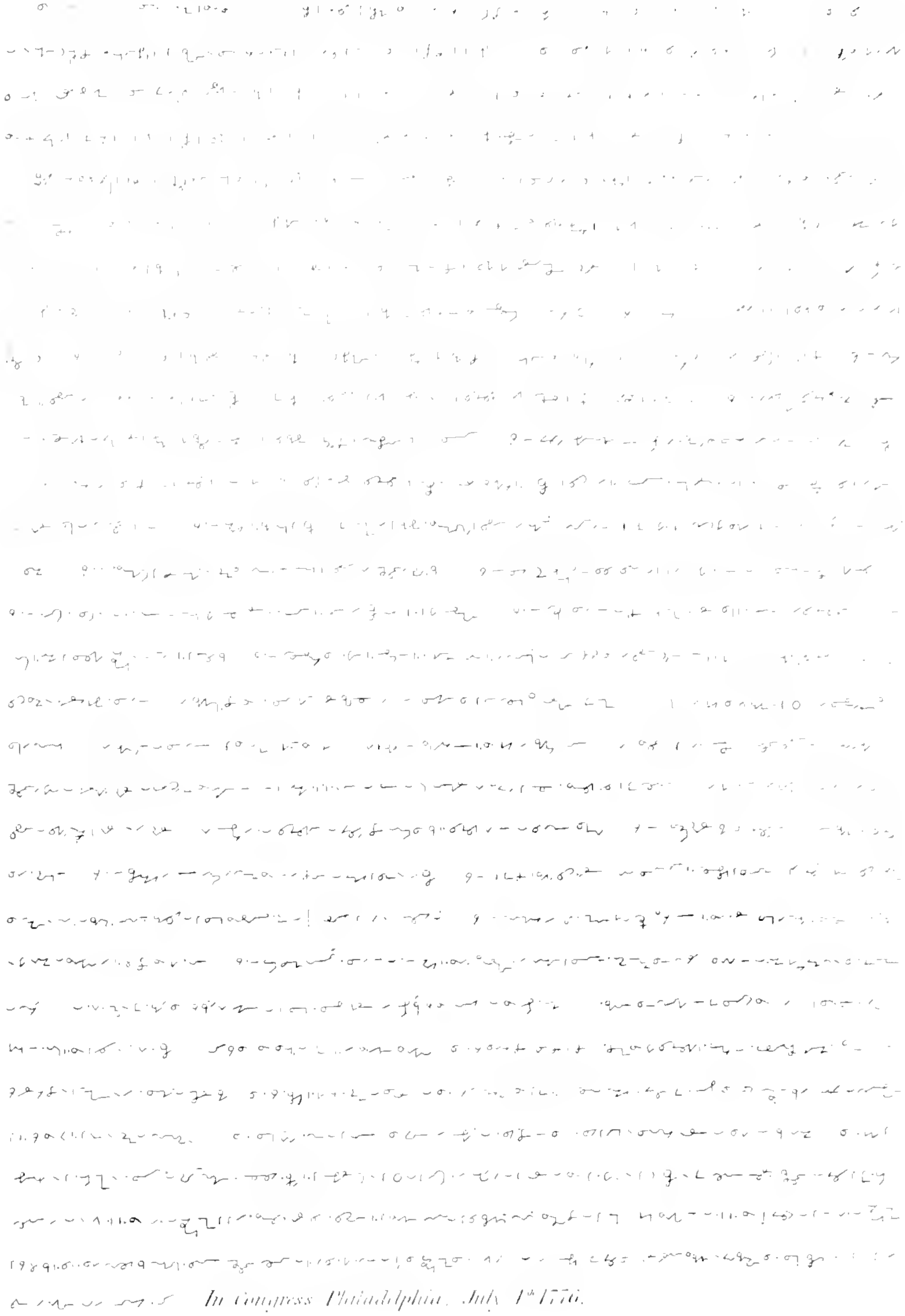


The succeeding passage is a form for following a Speaker more easily by using a few vowel points and not lifting the pen till a word is finished



DECLARATION OF AMERICAN INDEPENDENCE.

The following is a Fac Simile from the hand of M.T.C. Gould



In Congress Philadelphia, July 4th 1776.

John Hancock.

STRENGTH OF MATERIALS. *PLATE DXIV.*

Fig. 3.

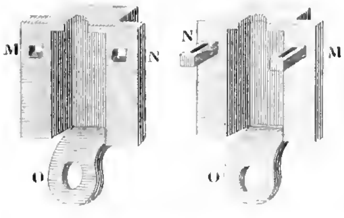


Fig. 2.

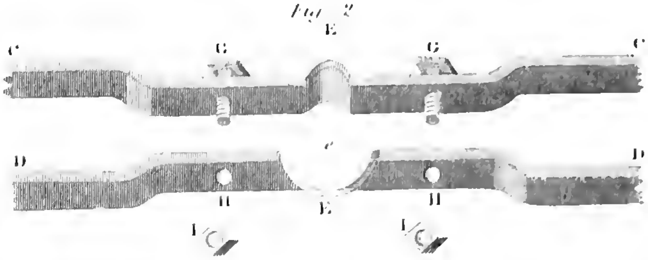


Fig. 1.

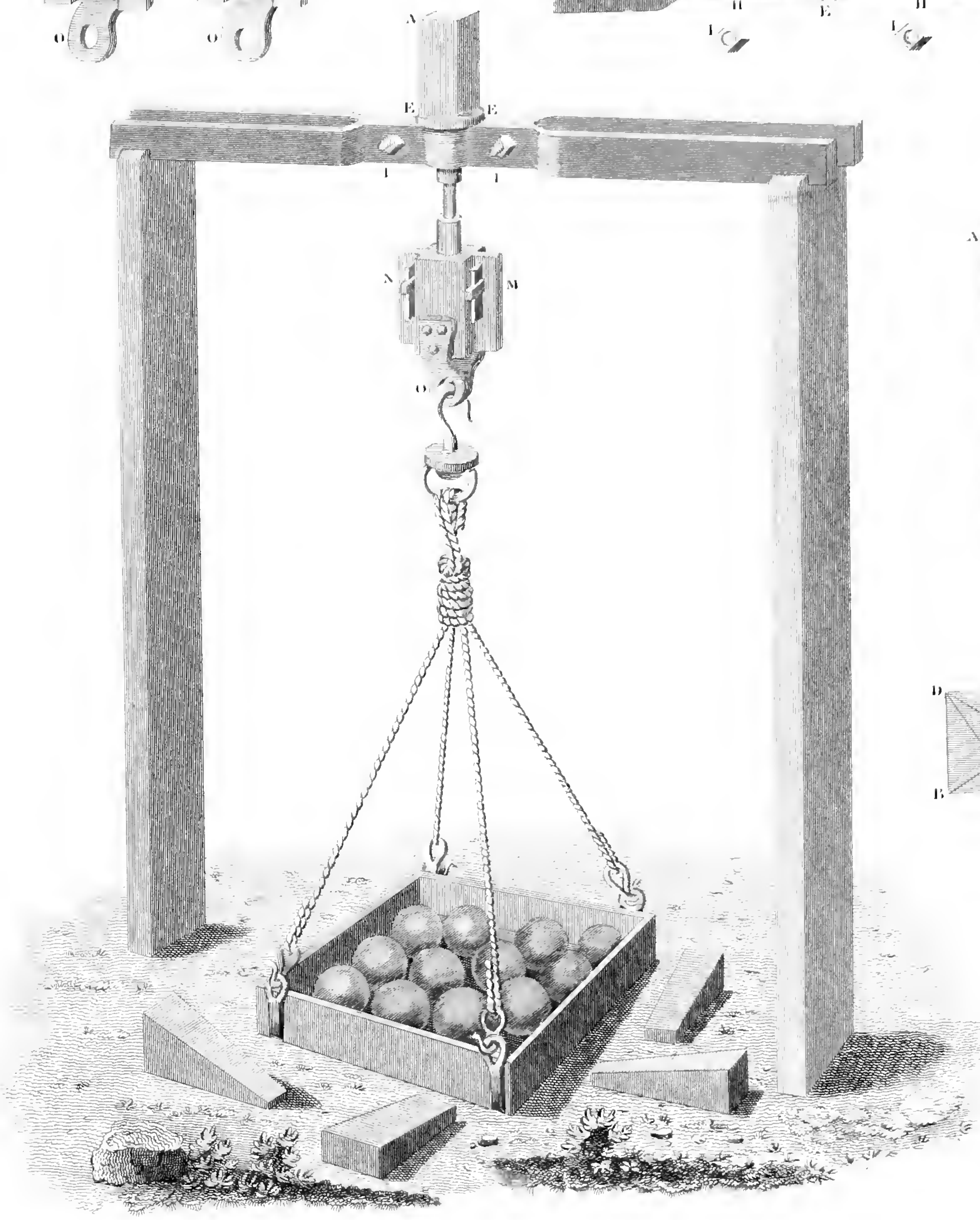


Fig. 4.

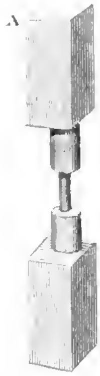


Fig. 5.

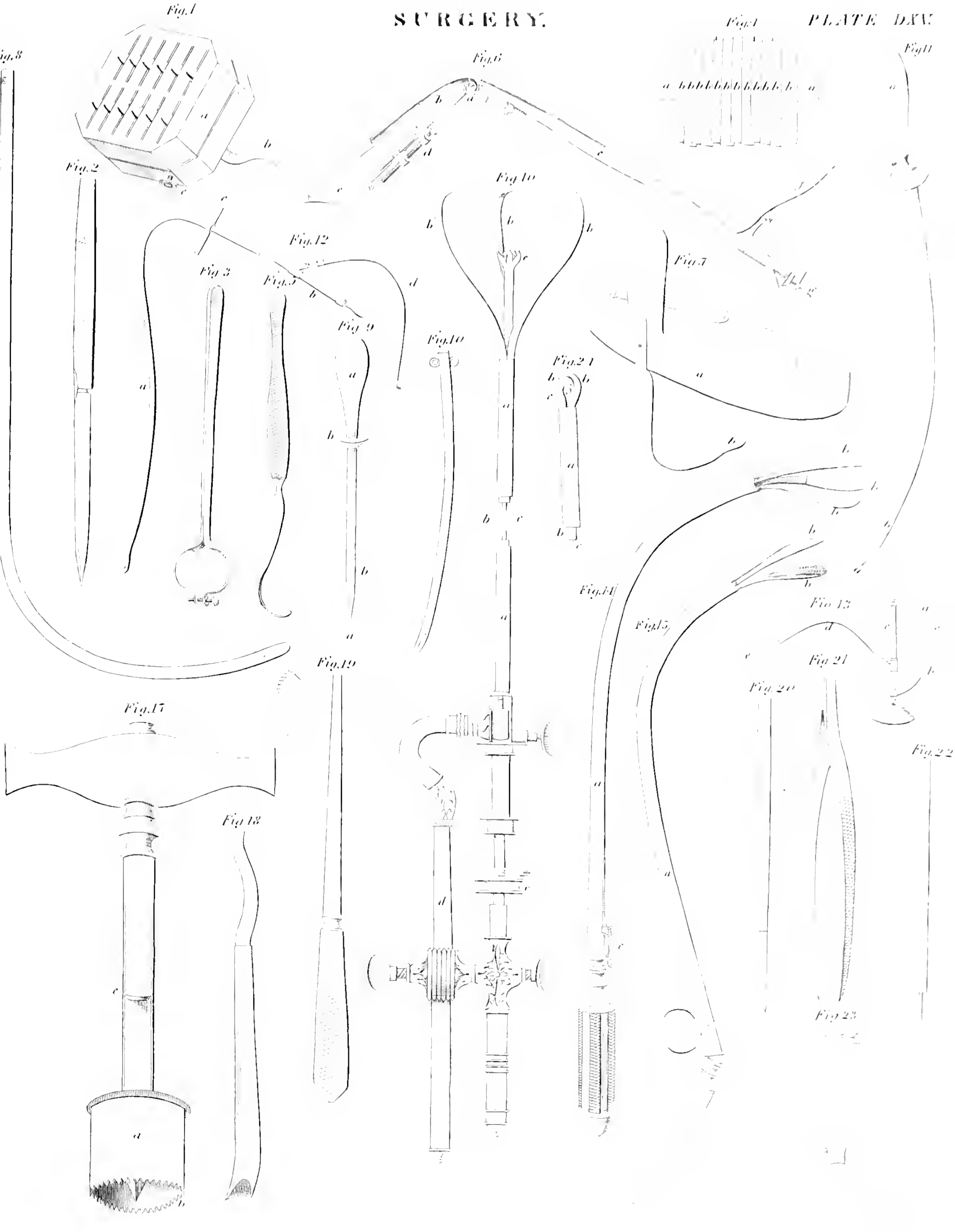


Fig.1
Fig.2
Fig.3
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Fig.18
Fig.19
Fig.20
Fig.21
Fig.22
Fig.23
Fig.24


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 11
Fig. 6.
Fig. 7
Fig. 8
Fig. 12
Fig. 9.
Fig. 10.
Fig. 5

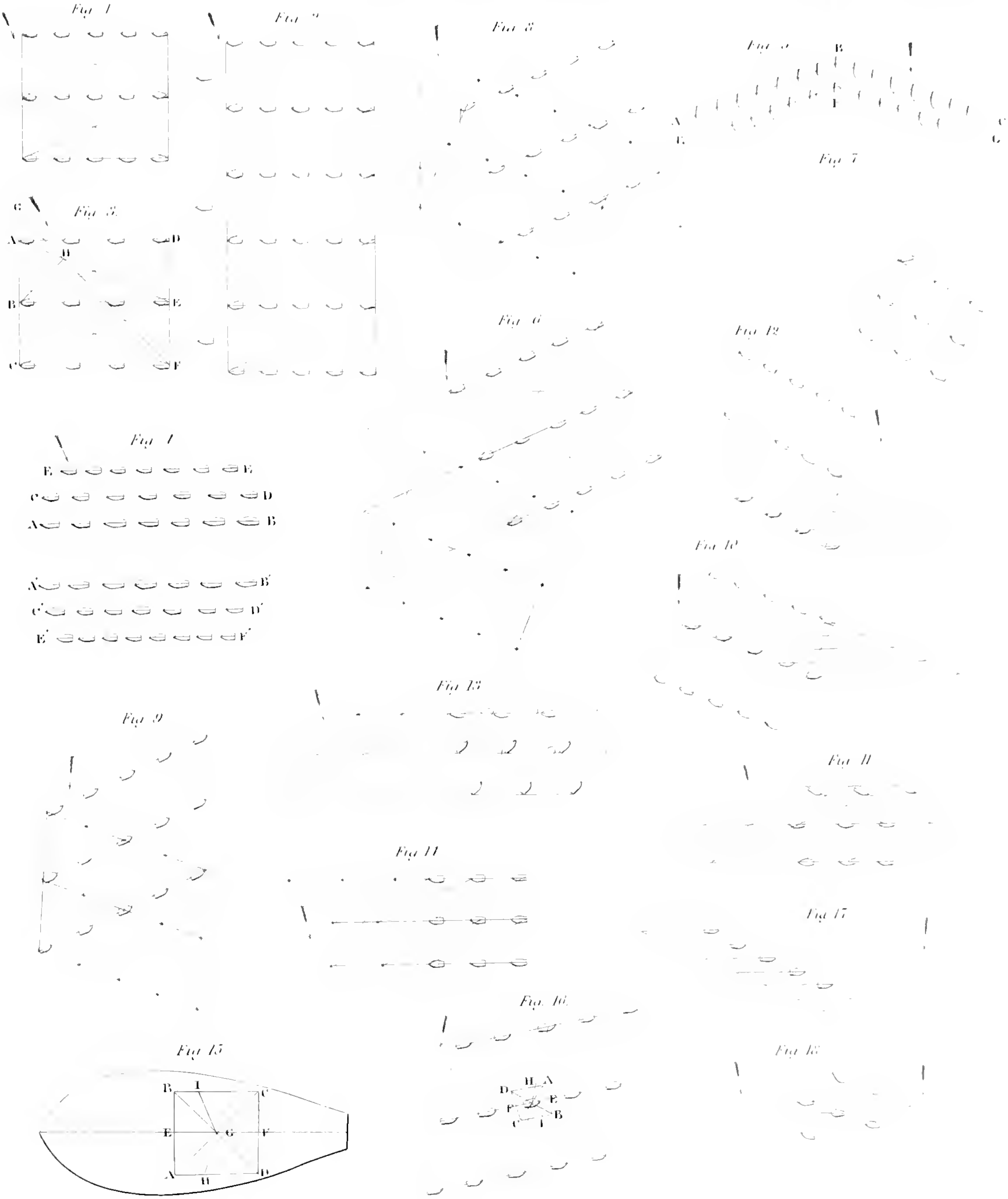
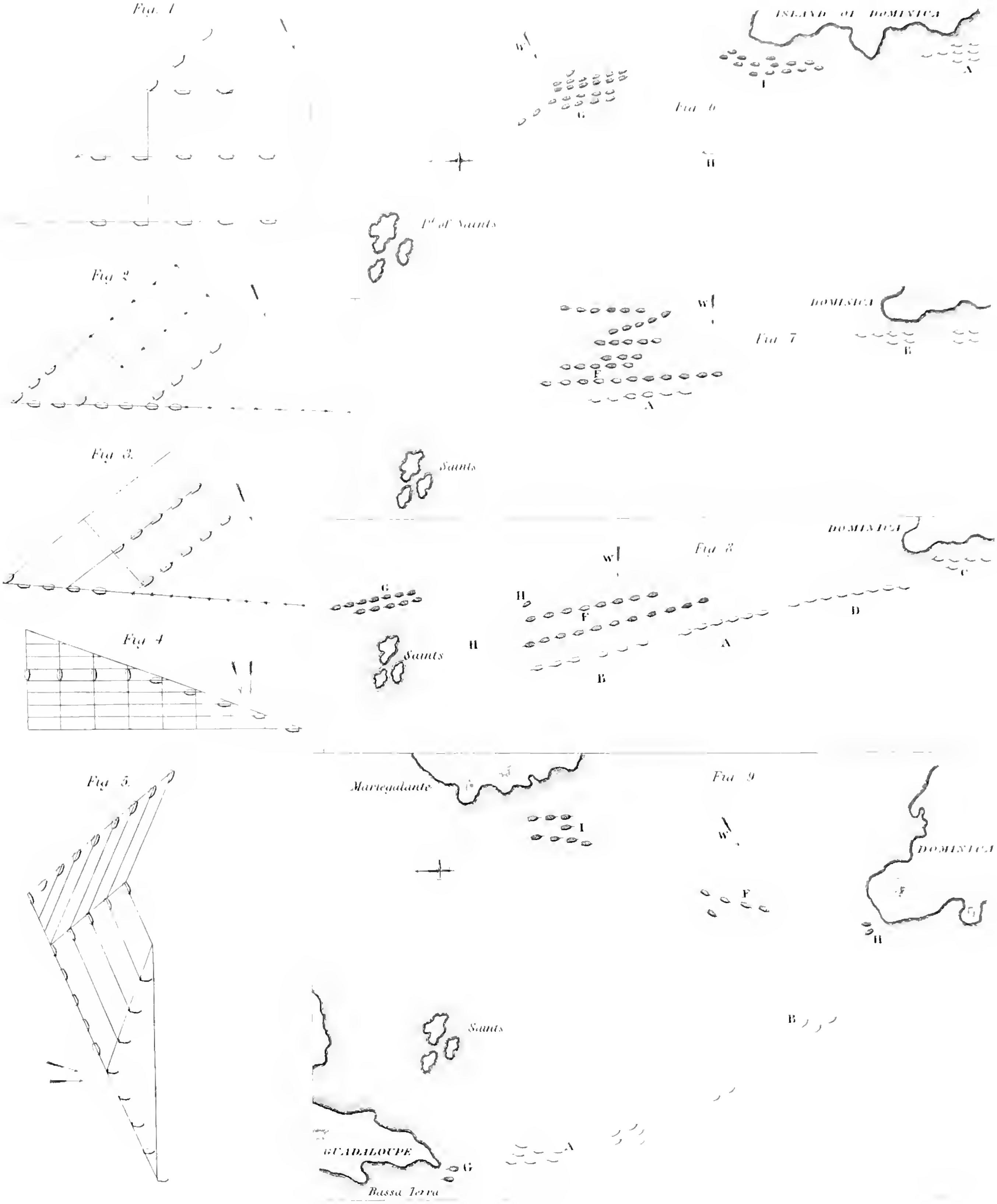


Fig. 1
Fig. 3.
Fig. 4
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 12
Fig. 13
Fig. 14
Fig. 15
Fig. 16.
Fig. 17
Fig. 18

TACTICS NAVAL. *PLATE DXIX.*



TACTICS NAVAL.

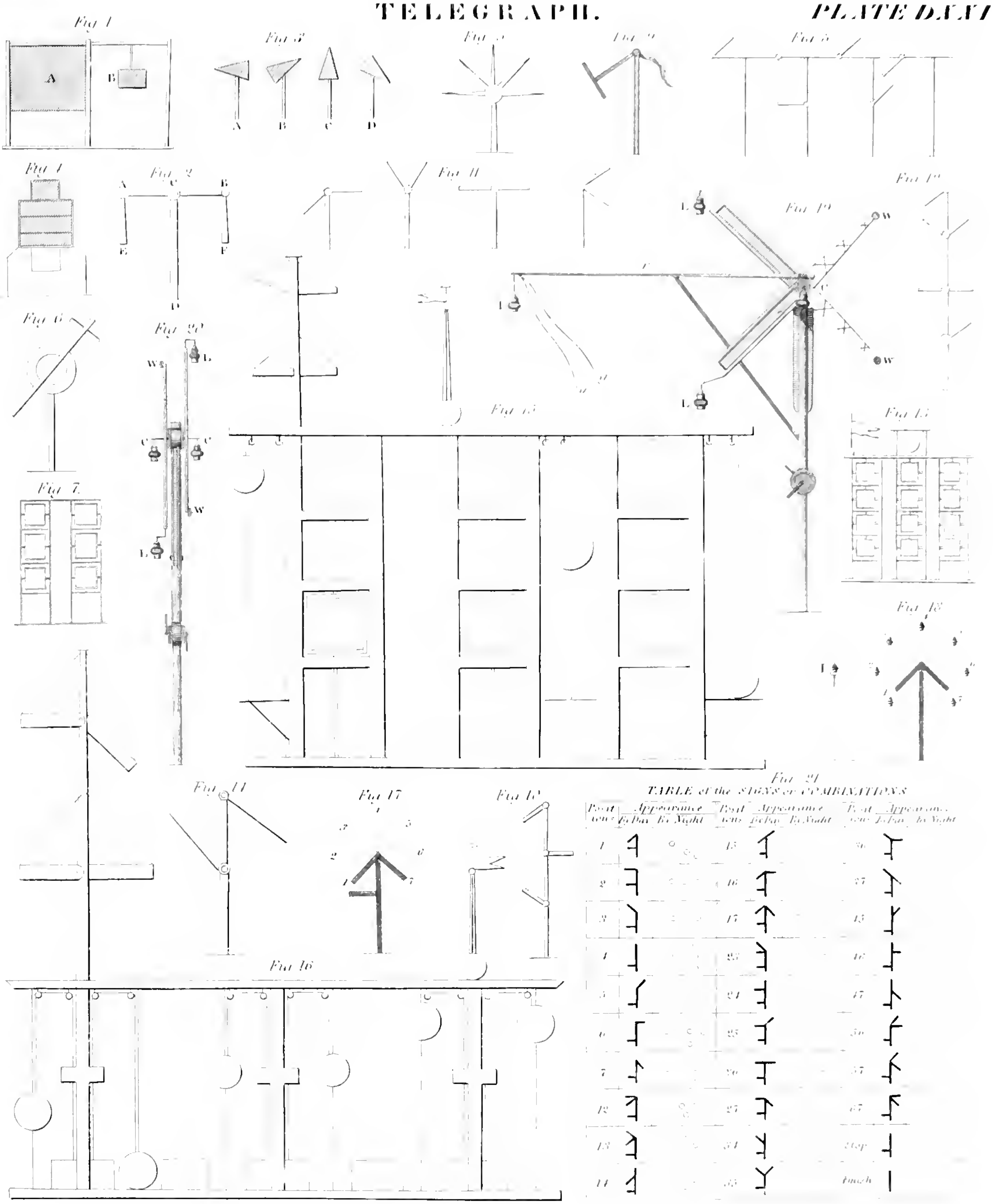
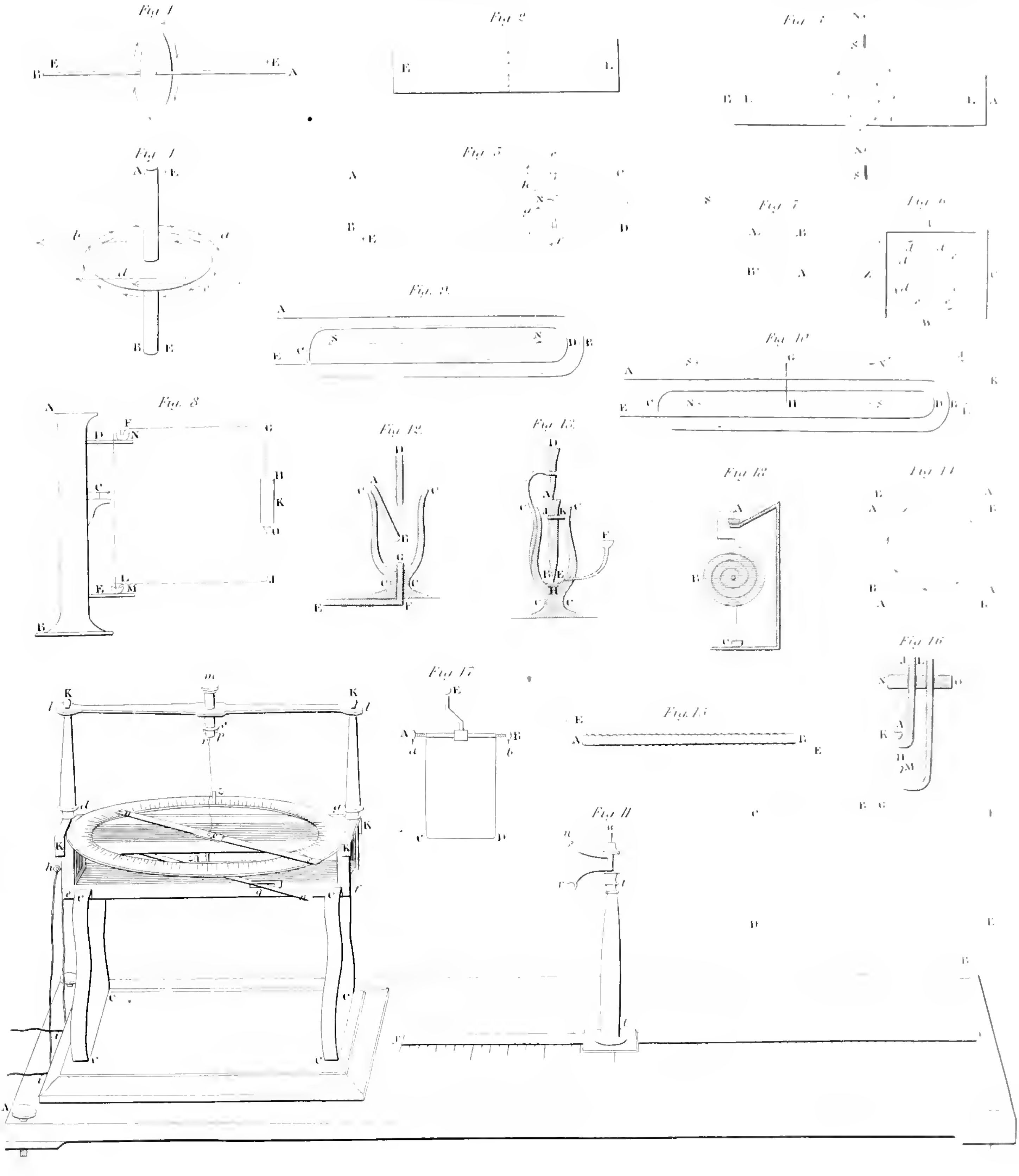


Fig 1
A
B
Fig 2
A
C
B
E
F
D
Fig 6
Fig 7
Fig 20
W
L
C
Fig 19
L
W
Fig 13
Fig 18
Fig 14
Fig 17
1
2
3
4
5
6
7
Fig 16
Fig 21
TABLE of the SIGNS or COMBINATIONS
Position
Appearance
By Day
By Night
1
2
3
4
5
6
7
12
13
14
15
16
17
23
24
25
26
27
34
35
Stop
Finish

THERMOELECTRICITY.

PLATE DXXII.



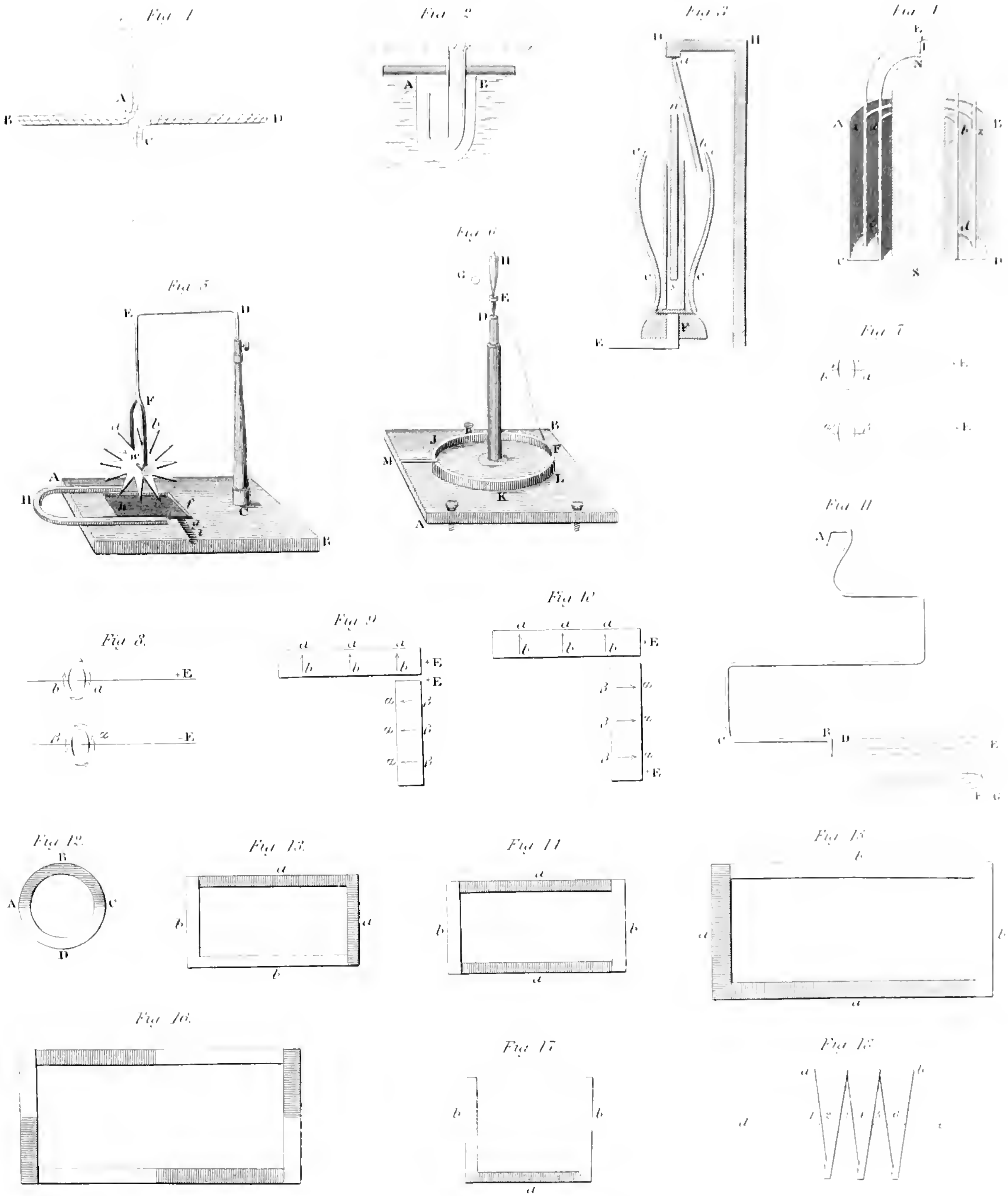


Fig 1
Fig 2
Fig 3
Fig 4
Fig 5
Fig 6
Fig 7
Fig 8
Fig 9
Fig 10
Fig 11
Fig 12
Fig 13
Fig 14
Fig 15
Fig 16
Fig 17
Fig 18