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# JOURNAL OF SCIENCE,

EXHIBITING

A VIEW OF THE PROGRESS OF DISCOVERY

IN NATURAL PHILOSOPHY, CHEMISTRY, MINERALOGY, GEOLOGY, BOTANY, ZOOLOGY, COMPARATIVE ANATOMY, PRACTICAL MECHANICS, GEOGRAPHY, NAVIGATION, STATISTICS, ANTIQUITIES, AND THE FINE AND USEFUL ARTS.

CONDUCTED BY

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OF THE

# EDINBURGH JOURNAL OF SCIENCE.

## No. XIX.

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## NOTICES TO CORRESPONDENTS.

It will give us great pleasure to receive Dr HEINEKEN's Abstract of his Meteorological Journal for 1828.

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OF THE

# EDINBURGH JOURNAL OF SCIENCE.

## No. XX.

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## NOTICES TO CORRESPONDENTS.

Our Correspondent in *Mexico*, who has been so kind as to transmit to us two papers in this Number, is requested to favour us with the continuance of his correspondence through the same Channel.

We shall be happy to receive Mr TREGASKIS's paper on the bursting of Steam Boilers.

We have been disappointed in not receiving Dr HARTMANN's promised Communication.

When Dr HIBBERT returns from the Continent, he will no doubt enable us to answer M's. inquiries respecting Auvergne.

Mr SANKEY's valuable paper entitled, " Theory of the action of Caloric in producing the expansion of fluids and solids, with a formula for the modulus of gravity," came too late for insertion in this Number, but will appear in No. I. of our New Series.

We have not seen the new Instrument called the *Contremorfil*, invented by ROMER of Paris; but we may inform our Correspondent, that one of the agents for its sale is Mr FRODSHAM of Grace-Church Street, well known as one of our ablest chronometer makers.

Mr SMITH's highly interesting Communication will appear in No. I. of our New Series.

In the arrangements for next Number, we shall follow X's advice as much as possible.

THE

# EDINBURGH

# JOURNAL OF SCIENCE.

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ART. I.—*Biographical Account of* ALEXANDER WILSON, *M.D. late Professor of Practical Astronomy in Glasgow.* By the late PATRICK WILSON, A. M. Professor of Practical Astronomy in the University of Glasgow. *

ALEXANDER WILSON, M. D. late Professor of Practical Astronomy in Glasgow College, was a younger son of Patrick Wilson, town-clerk of St Andrews, and was born there in 1714. He was very young when his father died, and was afterwards brought up by the care of his mother, Clara Fairfoul, a person much respected for her prudence, virtue, and piety.

Having received the usual education at the different schools, he entered to the College of St Andrews, where he made great proficiency in literature and the sciences, and, after completing a regular course of studies, was admitted to the degree of Master of Arts in his nineteenth year.

Before the expiration of his academical course, his inclination led him to prefer the study of natural philosophy, and particularly those branches of it which relate to optics and astronomy. From his earliest years he discovered a strong propensity to several ingenious arts, among which may be men-

* This Memoir of Dr Wilson, after being read at the Royal Society of Edinburgh on the 2d February 1789, was withdrawn by its author, for the purpose of making some alterations upon it; and was never returned for publication. It was found, however, among the papers of Mr Patrick Wilson, and is now printed with the consent of his family. Its connection with the history of science, and of the progress of the useful arts in Scotland, gives it a very high degree of interest, and induces us to reprint it from the *Edin. Trans.* vol. x.—ED.

tioned drawing, modelling of figures, and engraving upon copperplate. Even when a boy, he often devoted his leisure to such employments, and though in all of them he was almost entirely self-directed and self-taught, yet, from time to time, he produced specimens of ingenuity which drew upon him a general attention, and which, by real judges, were considered as indications of uncommon natural talents.

Upon his leaving the college, he was put as an apprentice to a surgeon and apothecary in his native city, with a view of following that profession. At this period he became more particularly known to Dr Thomas Simson, professor of medicine in the university, who ever after treated him with much kindness and friendship. About the same time he had also the good fortune to find a patron in Dr George Martine, a physician in the town. In those days the construction and graduation of thermometers was little attended to or understood in Britain, and Dr Martine, from a just conception of the importance of this instrument in many philosophical pursuits, was then employed in composing those essays on the subject of heat which have rendered his name so justly celebrated. The author, besides illustrating so well the theory of the thermometer, was farther very desirous of bringing accurate thermometers into general use; and, with this view, he turned the attention of his friend Mr Wilson to the art of working in glass. Though this was to him entirely a new attempt, depending upon many trials, and much mechanical address, yet he very soon acquired an admirable dexterity in forming the different parts of the instrument by the lamp and blowpipe, and in constructing and graduating the scales with accuracy and elegance; an employment which, for a long time, Mr Wilson continued to be fond of at convenient seasons, and in which it is well known he greatly excelled.

Possessing naturally much activity of mind, and employing most of his leisure in some ingenious attempt or other, it was about this time that, in making certain optical experiments, he discovered the principles of the solar microscope, so far as to exhibit to several of his friends in a dark chamber the images of small objects enormously magnified, by the sun's rays entering at a hole in the window-shutter, and after several refractions falling upon a white ground within. But Mr Wilson as yet was too far separated from the great world, and had too little experience for bringing forward to the notice of the public any novelty of this kind ; and soon after, a similar combination of glasses, with additional improvements, occurred to Mr Lieberkuhn, and was at length received as a very curious enlargement of the optical apparatus.

It was also, whilst employing himself in such researches, that Mr Wilson proposed to many of his philosophical friends the idea of burning at a great distance by means of plain mirrors, so situated as to throw the rays of the sun upon the same area, without the smallest knowledge of such a thing ever having been imagined by any person before him. But, wanting the means of providing himself with any costly apparatus, the matter was pursued no farther ; and it is well known that M. de Buffon, some years afterwards, when equally uninformed of what Kircher had thought of, hit upon the same conception. In 1747, by a magnificent construction far beyond the reach of Mr Wilson's finances, the French philosopher showed what might be done in this way, and with such effect as to render the famous secret imputed to Archimedes, of setting on fire the Roman galleys, much less apocryphal than it had ever been considered before his time.

In 1737 Mr Wilson departed from St Andrews, and by the advice of his friends went to London, in order to seek for employment as a young person who had been bred to the medical profession. Soon after his arrival there, he engaged himself with a French refugee, a surgeon and apothecary of good character, who received him into his family, giving him the charge of his shop, and of some of his patients, with a small annual salary. About twelve months after he had been fixed in this new situation, Mr David Gregory, professor of mathematics at St Andrews, coming to London, introduced him to Dr Charles Stewart, physician to Archibald Duke of Argyle, then Lord Isla. Dr Stewart received him with great kindness, and not long after made him known to Lord Isla, who very soon was pleased to bestow upon him marks of his attention and favour. In his interviews with this nobleman, Mr Wilson had his curiosity much gratified by some valuable astronomical and physical apparatus which his Lordship had got constructed for himself, and had placed in his library. On the other hand, Mr Wilson was happy in being able to contribute in some degree to the amusement of his patron, by constructing thermometers of different kinds for him and his friends, with more perfection and elegance than had been hitherto done at London.

Near eighteen months elapsed in this way, during which time he conciliated the good-will and esteem of his master, by a faithful and regular discharge of whatever business was committed to his care; and, in return, he found himself now and then indulged in opportunities of keeping up his connections with persons of a philosophical cast, when his attendance upon the shop or patients could be conveniently dispensed with. Mr Wilson has been often heard to speak of the satisfaction he enjoyed even at this period, and of his perfect contentment with every thing which had then fallen to his lot. But a serenity of temper, and a felicity of disposition, were qualities which eminently distinguished him throughout his whole life.

While he thus passed his time in what he considered as a comfortable settlement at his first entering upon the world, a circumstance of a very accidental nature occurred, which gave a new direction to his genius, and which in the end led him to an entire change of his profession. This was a transient visit which he happened one day to make to a letter-foundery, along with a friend who wanted to purchase some printing-types. In the course of seeing the common operations of the workmen usually shown to strangers, he was much captivated with the curious contrivances made use of in that business. Some short while afterwards, when reflecting upon what had been shown in the letter-foundery, he was led to imagine that a certain great improvement of the art might possibly be effected, and of a kind, too, that, if successfully accomplished, promised to reward the inventor with considerable emolument. His ideas upon that subject he presently imparted to a friend a little older than himself, who had also come from St Andrews, and who was possessed of a considerable share of ingenuity, constancy, and enterprise. The consequence of this was, a resolution on the part of both these young adventurers to relinquish, as soon as it could be done with propriety, all other pursuits, and unite their exertions in prosecuting the business of letter-founding upon an improved plan.

It was not long ere they were enabled to carry into effect this resolution, and they first established a small type-foundery at St Andrews, and one on a larger scale, two years afterwards, at Camlachie, a village near Glasgow.

In this situation, Mr Wilson had contracted habits of intimacy and friendship with several persons of the most respectable character, particularly with the Professors belonging to the University of Glasgow, and with Messrs Robert and Andrew Foulis, university printers. The growing reputation of the university press, conducted by these gentlemen, gave additional scope to Mr Wilson to exert his abilities in constructing their types, and being now left entirely to follow his own judgment and taste, his talents as an artist became every year more conspicuous. When the design was formed by the gentleman of the university, together with Messrs Foulis, to print splendid editions of the Greek classics, he, with great alacrity, undertook to execute new types upon a model highly improved. This he accomplished at an expence of time and labour which could not be recompensed by any profits arising from the sale of the types themselves. Such disinterested zeal for the honour of the university press was, however, upon this occasion so well understood, as to induce the university, in the preface to the folio Homer, to mention Mr Wilson in terms as honourable to him as they were just.

Though he thus continued to prosecute letter-founding as his chief business, yet, from his great temperance, domestic habits, and activity, he was enabled now and then to command intervals of leisure, which he never failed to fill up by some useful or ingenious employment. One of these, in which he took great delight, was the constructing of reflecting telescopes; an art which he cultivated with unwearied attention, and in the end with much success.

Among the more advanced students, who, in the years 1748 and 1749, attended the lectures on divinity in the university, was Mr Thomas Melvill, so well known by his mathematical talents, and by those fine specimens of genius which are to be found in his posthumous papers, published in the second volume of the *Edinburgh Essays, Physical and Literary.* With this young person Mr Wilson then lived in the closest intimacy. Of several philosophical schemes which occurred to them in their social hours, Mr Wilson proposed one, which was to explore the temperature of the atmosphere in the higher regions, by raising a number of paper kites, one above another, upon the same line, with thermometers appended to those that were to be most elevated. Though they expected, in general, that kites thus connected might be raised to an unusual height, still they were somewhat uncertain how far the thing might succeed upon trial. But the thought being quite new to them, and the purpose to be gained of some importance, they began to prepare for the experiment in the spring of 1749. *

Mr Wilson's house at Camlachie was the scene of all the little bustle which now became necessary; and both Mr Melvill and he, alike dexterous in the use of their hands, found much amusement in going through the preliminary work, till at last they finished half-a-dozen large paper-kites, from four to seven feet in height, upon the strongest, and at the same time, upon the slightest construction the materials would admit of. They had also been careful, in giving orders early, for a very considerable quantity of line, to be spun of such different sizes and strength as they judged would best answer their purpose; so that one fine day, about the middle of July, when favoured by a gentle steady breeze, they brought out their whole apparatus into an adjoining field, amidst a numerous company, consisting of their friends and others, whom the rumour of this new and ingenious project had drawn from the town.

They began with raising the smallest kite, which, being exactly balanced, soon mounted steadily to its utmost limit, carrying up a line very slender, but of a strength sufficient to command it. In the meantime, the second kite was made ready. Two assistants supported it between them in a sloping direction, with its breast to the wind, and with its tail laid

* As no public notice has hitherto been taken of this matter, though Mr Wilson had always some thoughts of doing so, it is hoped the following detail will not prove unacceptable or tedious to the reader.

out evenly upon the ground behind, whilst a third person, holding part of its line tight in his hand, stood at a good distance directly in front. Things being so ordered, the extremity of the line belonging to the kite already in the air was hooked to a loop at the back of the second, which being now let go, mounted very superbly, and in a little time also took up as much line as could be supported with advantage, thereby allowing its companion to soar to an elevation proportionally higher.

Upon launching these kites according to the method which had been projected, and affording them abundance of proper line, the uppermost one ascended to an amazing height, disappearing at times among the white summer clouds, whilst all the rest, in a series, formed with it in the air below, such a lofty scale, and that too affected by such regular and conspiring motions, as at once changed a boyish pastime into a spectacle which greatly interested every beholder. The pressure of the breeze upon so many surfaces communicating with one another, was found too powerful for a single person to withstand, when contending with the undermost strong line, and it became therefore necessary to keep the mastery over the kites by other means.

This species of aërial machinery answering so well, Mr Wilson and Mr Melvill employed it several times during that and the following summer, in pursuing those atmospherical experiments for which the kites had been originally intended. To obtain the information they wanted, they contrived that thermometers properly secured, and having bushy tossels of paper tied to them, should be let fall at stated periods from some of the higher kites; which was accomplished by the gradual singeing of a match-line.

When engaged in these experiments, though now and then they communicated immediately with the clouds, yet as this happened always in fine dry weather, no symptoms whatever of an electrical nature came under their observation. The sublime analysis of the thunder-bolt, and of the electricity of the atmosphere, lay yet entirely undiscovered, and was reserved two years longer for the sagacity of the celebrated Dr Franklin. In a letter from Mr Melvill to Mr Wilson, dated at Geneva, 21st April 1753, we find among several other particulars, his curiosity highly excited by the fame of the Philadelphian experiment; and a great ardour expressed for prosecuting such researches by the advantage of their combined kites. But, in the December following, this beloved companion of Mr Wilson was removed by death,—to the vast loss of science, and to the unspeakable regret of all who knew him.

In the year 1752, Mr Wilson, who had married Jean Sharp, daughter of William Sharp, a reputable merchant at St Andrews, brought his family to Glasgow. About five years afterwards, he invented the hydrostatical glass-bubbles, for determining the strength of spirituous liquors of all kinds, which long experience, especially among the distillers and merchants in the West Indies, has now shown to be more accurate and more commodious than the instruments formerly used. From the minutes of a Philosophical and Literary Society, composed of the professors and some of their friends, whose meetings were held weekly within the college, it appears that these hydrostatical bubbles made the subject of a discourse delivered by Mr Wilson in the winter of 1757. At this time he also showed how a single glass-bubble may serve for estimating very small differences of specific gravity of fluids of the same kind, such as water taken from different springs, or the like. This he did by varying the temperature of such fluids, till the same bubble, when immersed, became stationary at every trial, and then expressing the differences of their specific gravity, by degrees of the thermometer, the value of which can be computed and stated in the usual manner.

In the year 1758 he read another discourse to the same society upon the motion of pendulums. On this occasion he exhibited a spring-clock of a small compass, which beat seconds by means of a new pendulum he had contrived, upon the principle of the balance, whose centres of oscillation and motion were very near to one another. At one of the trials it performed so well as not to vary more than a second in about forty hours, when compared with a very exact astronomical clock near to which it was placed. It was some view of rendering much more simple and cheap the machinery of ordinary movements, by the slow vibrations of such a pendulum, which induced Mr Wilson to prosecute these experiments.

Not long after this, he also put in execution a remarkable improvement of the thermometer, which consists in having the capillary bore drawn very much of an elliptical form, instead of being round. By this means the thread of quicksilver upon the scale presents itself broad, and much more visible than it does in a cylindrical bore of the same capacity. The difficulty of constructing thermometers of this kind had nearly hindered him from completing his invention, as the thread of quicksilver was found extremely liable to disunite when descending suddenly in so strait a channel. But, by his long experience, joined to farther investigation and more trials, he at last discovered a method of blowing and filling thermometers with flattened bores, which freed them entirely from this defect.

About the same time, also, he conceived the design of converting a thermometer graduated for the heat of boiling-water, into a marine barometer, in consequence of the well-known difference of temperature which water, when boiling, acquires under the variable pressure of the atmosphere. This he effected, by making a boiling-water thermometer, about a foot in length, with a pretty large ball, and having a thread of quicksilver as broad and visible as was consistent with a very perceptible run upon small alterations of temperature. The stem of this thermometer he fortified, by inclosing it in a cylindrical case of white iron, having soldered to it, at its lower end, a socket of brass for receiving half of the ball, which afterwards became entirely defended, by screwing to the socket a hemispherical cap. At the other end of the case which environed the stem, there was soldered a tube of brass, wide enough to admit a scale of proper dimensions, before which there was an opening in the tube, defended by glass.

The utmost range of the scale he determined by the points, where the thermometer was found to be stationary when the ball, and a certain part of the stem were immersed in water, boiling under the greatest variations of pressure which the climate afforded. The interval so found, he subdivided by other observations into degrees, which corresponded to *inches* of the barometer, and which were so denominated upon the scale.

In the year 1756, the college of Glasgow, upon the death of Dr Alexander Macfarlane of Jamaica, a great lover of, and proficient in the sciences, received a legacy of a valuable collection of astronomical instruments, which that gentleman had got constructed at London by the best artists, and had carried out with him to Jamaica, with a view of cultivating astronomy in that island. The college, upon this, soon built an observatory for their reception, which, by medals placed under the foundation, was called by the name of their generous benefactor; and Mr Wilson was immediately thought of by the members of the faculty, as a proper person for taking charge of it, and making the astronomical observations. At this juncture his Grace Archibald Duke of Argyle, who had all along continued his patronage to Mr Wilson, more especially since he had brought the art of letter-founding into Scotland, used his influence with government, and procured his Majesty's presentation, nominating and appointing him professor of practical astronomy and observer in the College, with an annual salary of fifty pounds, payable out of the Exchequer; and, accordingly, in 1760, he was admitted to this new office by the unanimous and most cordial welcome of all the members of the faculty.

His two eldest sons, who had by this time entered upon a course of liberal education, not long after took upon them the further enlargement and improvement of the letter foundery; and, before dismissing this topic, it deserves to be mentioned, that Mr Wilson lived to such an advanced age, as to enjoy in the most feeling manner the reward of his early diligence and excellent example, in seeing the business rising in their hands to the highest reputation, not only in these kingdoms, but in foreign countries.

In 1763, when upon a visit at St Andrews, an honorary degree in medicine was conferred upon him by his Alma Mater.

Among the objects which now occupied him in the Observatory, his former labours towards improving the reflecting telescope were resumed, and pursued for a considerable length of time, with a view of obtaining some certain method of giving the parabolic figure to the great speculum. These trials were made upon a variety of metals, comparatively of a small diameter, and focal distance; but he regarded them only as preliminary ones, and had always in contemplation to engage with apertures of much greater dimensions. He was often heard to regret, that no crowned head, or wealthy association, ever thought of patronizing an attempt to construct some vast telescope, to be employed in making discoveries in the moon or planets, or in exploring the heavens; and, it is more than probable, that if his own means had been less circumscribed, he would of himself have attempted something of this kind. The more recent labours, and brilliant success of the excellent Dr Herschel, have fully shown that such suggestions were by no means romantic; and the writer of this account, who has had the happiness of being well acquainted with both these men, has often remarked a striking resemblance in their character and turn of mind.

In 1769, Dr Wilson made that discovery concerning the solar spots, of which he has treated in the *Philosophical Transactions of London* for 1774. Not long after he entered upon this new field, the nature of the solar spots was announced by the Royal Society of Copenhagen as the subject of a prize essay. This induced him to transmit thither a paper written in the Latin language, containing an account of his observations, and of the conclusions drawn from them. In return, he obtained the honourable distinction of a gold medal of near sixteen guineas intrinsic value, having, on its reverse, the figure of Truth pendent in the air, holding a wreath in one hand, and in the other a perspective glass, and the motto, *Veritati luciferæ.*

As an astronomical observer, he was remarkable for a sharp and clear eye, devoid of all blemish, and which, too, without being liable to fatigue, had long been inured to examine and to judge of small objects in their nicest proportions; a circumstance which must have proved of great advantage to him when employing his sight upon celestial appearances by means of the telescope; and it required only to know him, to have the fullest assurance of his fidelity in rendering an account of his observations.

His discovery in regard to the solar spots, though it be gaining ground more and more among those most conversant in astronomy, yet, like many other new discoveries, has not escaped its share of opposition. This gave him occasion to publish, in the *Philosophical Transactions of London* for 1783, the second paper upon that subject, after a silence of near ten years, wherein, upon the authority of many more observations made in that interval, he obviates objections, and maintains the reality of his discovery with an entire conviction. The amount of it is, "That the spots are *cavities* or *depressions* in that immensely resplendent substance which invests the body of the sun to a certain depth; that the dark nucleus of the spot is at the bottom of this excavation, which commonly extends downwards to a space equal to the semidiameter of our globe; that the shady or dusky zone which surrounds the nucleus, is nothing but the sloping sides of the excavation reaching from the sun's general surface downward to the nucleus or bottom." All this he has demonstrated by a strict induction drawn from the following phases of the spots, as they traverse the sun's disk.

When a large well-formed spot, consisting of a dark nucleus, and its surrounding umbra or dusky zone, is seen upon the middle of the sun's disk, the zone is generally equally broad all around; but when the same spot verges near to the limb, that side of the dusky zone which lies next to the centre of the disk, begins much sooner than the side diametrically opposite to turn narrower, and at last disappears, while the other still remains dilated and visible. And, in like manner, when a spot enters the disk by the sun's rotation, we see first the nucleus, and the upper and under sides of the shady zone or umbra, together with that side of it nearest to the limb, whilst the side opposite is still wholly invisible. But as the spot advances farther upon the disk, that side of its dusky zone which lately was invisible now shows itself, and continues to enlarge more and more till it becomes as broad as any other part surrounding the nucleus.

These phases, which he found so very palpable when observing carefully the great solar spot in November 1769, and so very frequent, though less obvious, in numberless other spots of a smaller size, which for several years afterwards he examined, prove in the clearest manner that the spots themselves are depressions in the luminous matter of the sun, and lead to many new and interesting ideas concerning the nature and constitution of that stupendous body.

But though he was the first astronomer to whose lot it fell to remark these phenomena of the solar spots which have been just now described, and to draw such important conclusions from them, it appears that the celebrated Mr Flamstead, so far back as the year 1676, had very nearly anticipated this discovery. For, one day when observing a spot of considerable size near the sun's limb, he actually beheld this appearance of the dusky zone which belongs to the nucleus, finding it almost wholly deficient on that side which respected the centre of the disk; and this, too, when the distance of the spot from the limb corresponded very nearly with that which Dr Wilson found to be so constant in his observations. Mr Flamstead was then, indeed, viewing his spot in peculiar circumstances, and the most favourable of all to perfect vision of the sun, as, by the intervention of a mist, he was enabled to use his telescope without the help of tinged glass put before his eye. The following is his account of this remarkable observation, in which, by the word *macula*, Mr Flamstead evidently means the nucleus of the spot, and by *nubecula* the dusky zone which surrounds it.

"1676, Nov. 9. Deinde densi adeò vapores excepere solem, ut per ipsos licuit illum nudis oculis intueri. Adhibito tum longiore tubo absque vitro rubro, (quo oculum adversus ejus splendorem munire soleo) maculum contemplatus sum: distincta valdè videbatur, ejusque figuræ quæ in schemate adpingitur: 'Nubecula ipsi circumducta elliptica omninò; *sed, quod valdè miratus sum,* admodum dilatata à parte limbum respiciente; ab altera vero versus centrum, maculæ fere cohærere videbatur.'"

"Observavi dein maculæ a limbo proximo distantium 1′ 13′."—*Hist. Cœlest. Flamsteedii*, vol. prim. p. 363.

When Dr Wilson saw the great spot on the 23d November 1769, it had nearly the same situation upon the disk, and the same aspect as the one here described. But, at that time, like Mr Flamstead, he had no conception of what was signified by such an appearance. It was not till next day, after remarking certain striking alterations of the form both of the nucleus and umbra, that the suggestion first arose in his mind of the spot being an *excavation* or *depression* on the luminous matter of the sun; which idea, the subsequent observations of the same spot most evidently confirmed.

Not long before his death, in turning over at more leisure the pages of this admirable astronomer, Dr Wilson for the first time met with the above passage, and was pleased at finding so remarkable a coincidence as to the leading fact upon which his discovery rests.

Among his papers there were found many letters he had received from Dr Maskelyne, upon whose correspondence Dr Wilson set a very high value. All his papers published in the *Philosophical Transactions of London* were communicated by that friend. Among these, we find a short one in the volume for 1774, wherein he proposes to diminish the diameter of the finest wires, used in the focus of the astronomical telescope, by flattening them according to a method there described; an idea which, though very simple, seems extremely worthy of attention.

In the month of January 1777, when conversing, as he often did in the evenings, with his son, who had now made some proficiency in the sciences, their attention was somehow turned to the following query, proposed by Sir Isaac Newton, among many others, at the end of his optics, namely, "What hinders the fixed stars from falling upon one another?"

In reflecting upon this matter, they readily came to be of opinion, that if a similar question had been put in respect of the component parts of the solar system, it would have admitted of a very easy solution, on account of *periodical motion* appearing to them as the great mean employed by nature for counteracting the power of gravity, and for maintaining the sun and the whole retinue of planets, primary as well as secondary, and of comets, at commodious distances from one another.

In like manner, Dr Wilson thought it not unreasonable to suppose, that the same principle might have assigned to it a dominion incomparably wider in extent, and that the order and stability, even of a *universe*, and of every individual system comprehended in it, might depend upon *periodical motion* round some grand centre of general gravitation. This conception, besides appearing to them warranted by every view they could take of the nature of gravity, seemed moreover to receive some support from the discoveries which, since the time of the great Halley, have been made of what has been called the "proper motions of the fixed stars," and particularly from the opinion entertained by that excellent astronomer, Dr Maskelyne, "that, probably, all the stars are continually changing their places by some slow and peculiar motions throughout the mundane space."

Soon after this view had arisen, out of the familiar conversation above-mentioned, it was published in a very short anonymous tract, entitled, "*Thoughts on general Gravitation, and Views thence arising as to the state of the Universe.*" The chief inducement to so early a publication was the hope of drawing immediate attention to so interesting a point, which might possibly lead to the discovery of some way by which the matter might be brought to the test of observation.

It is quite obvious, that the foregoing suggestions necessarily imply a motion of the solar system, as one of that immense host, which, for what we yet know, may be subjected to the laws of periodical revolution. Accordingly, it early occurred, that perhaps the most advantageous way of advancing in this investigation, might be to try to find out, if possible, symptoms of such a law as affecting that system to which we ourselves belong.

It sometimes struck him, when looking over the progress of philosophical discovery, that many things of high moment appear to have lain long wrapped up in embryo, by our not employing ourselves more frequently in what may be called a "*direct search*," and in filling up with more attention and boldness the list of desiderata. Between this last step, and the accomplishment of a profound discovery, he conceived that the transition might sometimes be made with no great effort of invention, by only sifting carefully such principles as are already known and familiar to us, and availing ourselves of them in their full extent.

It was by proceeding in this way, and when considering the manner by which the motion of light would be affected by reflecting and refracting media, themselves moving with great velocity, (a most interesting field in optics then wholly uncultivated,) that two principles came into view, either of which may possibly serve us in detecting a general motion belonging to the solar system, relatively to the surrounding fixed stars, or in proving a negative with regard to it. Of these, a very summary account has been given in the historical part of the *Edinburgh Philosophical Transactions*, vol. i. But, should they be successful in discovering such a concealed motion, the same principles cannot fail of determining the velocity and direction of it; and in process of time, whether such a translation of the whole system be in a straight line or a curve, and if in a curve, whether it be of a such a kind as may indicate a periodical revolution. And it needs scarce be mentioned, that if such a thing should actually be made out, besides enriching astronomy with that knowledge which depends upon measureable parallaxes in the sphere of the starry firmament; it would also bestow a very high authority upon Dr Wilson's suggestions, of what possibly may be the plan of nature in upholding the universe.

At the time of the last-mentioned publication, he was sixty-three years old, but still continued to enjoy the blessings of an uninterrupted state of good health. In the year 1784, at the recommendation of the university, his Majesty was graciously pleased to nominate and appoint Patrick Wilson, A. M. Dr Wilson's second son, to be assistant and successor to his father as professor of practical astronomy and observer; a circumstance which heightened the consolations he enjoyed during the evening of life.

In March and April 1786, when he had nearly completed his seventy-second year, it became apparent to his family and friends, that his constitution and strength were fast declining. After a gradual and easy decay, which lasted throughout the whole of that summer and autumn, and which he bore with the utmost composure and resignation, amidst the tender solicitudes of his surrounding family, he at last expired in their arms, on the 16th day of October.

The private character of Dr Wilson was amiable to an uncommon degree. From his early youth to venerable age, he was actuated by a rational and stedfast piety, enlivened by those gracious assurances which carry our hopes and prospects beyond the grave, and sweeten the lot of human life. The cast of his temper, though uniformly cheerful and serene, was yet meek and humble, and his affections flowed in the warmest current immediately from the heart. His looks, as well as his conversation and demeanour, constantly indicated a soul full of innocence and benignity, in harmony with itself, and aspiring to be so with all around it.

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ART. II.—*On the Mean Temperature of Bombay, deduced from Observations made in* 1827, *&c.* Communicated by ALEXANDER ADIE, Esq. F. R. S. E. &c.

THE observations from which the following results are deduced were made *before sunrise*, and at 11 o'clock A. M., 1 o'clock P. M., 4 o'clock P. M. and 9 o'clock P. M.

JANUARY 1827.

| | Temp. Fahr. |
|---|---|
| Before sunrise, - - - | 69°07 |
| 11 o'clock A. M. - - - | 76 58 |
| 1 P. M. - - - | 77 56 |
| 4 P. M. - - - | 78 55 |
| 9 P. M. - - - | 73 00 |
| Mean temperature for January, - | 74°95 |
| Highest, - - - - | 82 |
| Lowest, - - - - | 64 |

FEBRUARY 1827.

| | |
|---|---|
| Before sunrise, - - - | 72°91 |
| 11 o'clock A. M. - - - | 80 48 |
| 1 P. M. - - - | 81 53 |
| 4 P. M. - - - | 82 05 |
| 9 P. M. - - - | 77 87 |
| Mean temperature for February, - | 78 97 |
| Highest. - - - - | 85 |
| Lowest, - - - - | 69½ |

MARCH 1827.

| | |
|---|---|
| Before sunrise, - - - | 75°44 |
| 11 o'clock A. M. - - - | 81 22 |
| 1 P. M. - - - | 81 91 |
| 4 P. M. - - - | 82 30 |
| 9 P. M. - - - | 79 04 |
| Mean temperature for March, - | 79 98 |
| Highest, - - - - | 86 |
| Lowest, - - - - | $70\frac{3}{4}$ |

APRIL 1827.

| | |
|---|---|
| Before sunrise, - - - | 77°28 |
| 11 o'clock A. M. - - - | 85 25 |
| 1 P. M. - - - | 86 11 |
| 4 P. M. - - - | 86 33 |
| 9 P. M. - - - | 82 68 |
| Mean temperature for April, - | 83 53 |
| Highest, - - - - | 89 |
| Lowest, - - - - | $74\frac{1}{2}$ |

MAY 1827.

| | |
|---|---|
| Before sunrise, - - - | 82°95 |
| 11 o'clock A. M. - - - | 87 43 |
| 1 P. M. - - - | 88 14 |
| 4 P. M. - - - | 87 98 |
| 9 P. M. - - - | 85 02 |
| Mean temperature for May, - | 86 30 |
| Highest, - - - - | 91.00 |
| Lowest, - - - - | 80.00 |

JUNE 1827.

| | |
|---|---|
| Before sunrise, - - - | 81°58 |
| 11 o'clock A. M. - - - | 84 15 |
| 1 P. M. - - - | 84 43 |
| 4 P. M. - - - | 84 38 |
| 9 P. M. - - - | 82 23 |
| Mean temperature for June, - - | 83 35 |

Highest, 89
Lowest, 76½

JULY 1827.

Before sunrise, 80°58
11 o'clock A. M. 82 41
1 P. M. 87 64
4 P. M. 82 62
9 P. M. 81 05

Mean temperature for July, 82 86

Highest, 84½
Lowest, 79

AUGUST 1827.

Before sunrise, 79°06
11 o'clock A. M. 81 00
1 P. M. 81 16
4 P. M. 81 22
9 P. M 79 79

Mean temperature for August, 80 45

Highest, 83
Lowest, 77¼

SEPTEMBER 1827.

Before sunrise, 78°95
11 o'clock A. M. 81 51
1 P. M. 82 06
4 P. M. 82 03
9 P. M. 79 75

Mean temperature for September, 80 86

Highest, 83½
Lowest, 77

OCTOBER 1827.

Before sunrise, 79°14
11 o'clock A. M. 84 83
1 P. M. 85 59
4 P. M. 86 14
9 P. M. 81 96

Mean temperature for October, 83 53

| | |
|---|---|
| Highest, - - - - - | 88 |
| Lowest, - - - - - | 76¼ |

NOVEMBER 1827.

| | |
|---|---|
| Before sunrise, - - - | 76°49 |
| 11 o'clock A. M. - - - | 83 51 |
| 1 P. M. - - - | 84 26 |
| 4 P. M. - - - | 84 35 |
| 9 P. M. - - - | 80 30 |
| Mean temperature for November, - | 81 78 |
| Highest, - - - - - | 87 |
| Lowest, - - - - - | 67 |

DECEMBER 1827.

| | |
|---|---|
| Before sunrise, - - - | 68°70 |
| 11 o'clock A. M. - - - | 77 95 |
| 1 P. M. - - - | 78 70 |
| 4 P. M. - - - | 79 80 |
| 9 P. M. - - - | 71 03 |
| Mean temperature for January, - | 75 23 |
| Highest, - - - - - | 84.00 |
| Lowest, - - - - - | 59.00 |

Hence we have for the mean monthly temperatures,—

| | |
|---|---|
| January, - - - - | 74°95 |
| February, - - - - | 78 97 |
| March, - - - - | 79 98 |
| April, - - - - | 83 53 |
| May, - - - - | 86 30 |
| June, - - - - | 83 35 |
| July, - - - - | 82 86 |
| August, - - - - | 80 45 |
| September, - - - - | 80 86 |
| October, - - - - | 83 53 |
| November, - - - - | 81 78 |
| December, - - - - | 75 23 |

Mean annual temperature of Bombay for 1827, 80°98

The slightest examination of the preceding observations is sufficient to convince us that the mean temperature of Bombay for 1827 must be considerably less than 80°98, which is the mean of five ordinates of the daily curve. Three of the ordinates, viz. that of 11 A. M., 1h P. M., and 4h P. M. are taken during the warm part of the day. The ordinate of 9h P. M. is very little above the mean ordinate; so that in the preceding series of observations there is really only *one ordinate*, namely, that before sunrise, which is near the lowest part of the curve, and decidedly below the mean temperature. Two ordinates, therefore, or observations at 12 P. M. and about 3h A. M. are wanting to enable us to deduce from the series the accurate mean temperature of Bombay.

Taking the mean temperature before sunrise as the lowest during the day, we have by the Leith observations the following correction :— *

| | | Deviation from Mean Temp. |
|---|---|---|
| Before sunrise, | - | — 2°873 |
| 11 o'clock A. M. | - | + 1 683 |
| 1 P. M. | - | + 2 882 |
| 4 P. M. | - | + 2 972 |
| 9 P. M. | - | — 0 438 |
| Sum of deviations from the mean, | - | + 4°226 |

Hence we have

| | | |
|---|---|---|
| Observed mean temperature, | - | 80°98 |
| Correction, | - - - | — 4.226 |
| Corrected mean temperature, | | 76°764 |

If we now compute the mean temperature of Bombay in N. Lat. 18°58′ and east Long. 72°38′, by Dr Brewster's General Formula for the Eastern Hemisphere of the Globe we shall find :—

* See this *Journal*, vol. v. No. ix. p. 30.

| | | |
|---|---|---|
| Mean temperature by formula, | - | 72°58 |
| Corrected observed temperature, | - | 76 76 |
| Difference, | | 4°18 |

This difference, which is very considerable, may arise partly from the insular situation of Bombay, which is no doubt warmer than in the same latitude on the continent.

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ART. III.—*Table of the Variations of the Magnetic Needle at Boston, Falmouth, and Penobscot, in North America, during* 128 *years.** By S. DE WITT, Surveyor-General.

THE following interesting document, which was furnished me by the late General Schuyler, shows the changes in the variation needle at Boston, Falmouth, and Penobscot, from 1672 to 1800, embracing a period of 128 years. The difference of variation between the two epochs appears to be 5°.53′, giving a little more than $2\frac{3}{4}$′ths for the mean annual variation.

As long as I can remember, the surveyors in our country on retracing old lines have allowed at the rate of 3′ per year, and acquiesced in the correctness of that rule till 1805.

Since 1785, I occasionally observed the variation of the needle, and from these observations I found no reason for departing from the old rule till 1807, when, to my surprise, I found that a sudden change had taken place in the direction of the needle. In order to ascertain its extent, I examined a number of lines which had been surveyed in 1805, and which gave a difference of 45′ from July 30th, 1805, to September 4th, 1807.

I found the following to be the variation at Albany.

| | | | Variation. |
|---|---|---|---|
| 1817, October 3d, | - | - | 5° 44′ West. |
| 1818, August 1st, | - | - | 5 45 |
| 1825, April 24th, | - | - | 6 0 |

* Abridged from the *Transactions of the Albany Institute,* vol. i. No. i. p. 4, June 1828.

The following table exhibits the variation of the compass from actual observation from 1672 to 1800. It was drawn up by John Winthrop, Esq. Hollis Professor of Mathematics at Harvard College in Cambridge.

| | Boston. | Falmouth. | Penobscot. | Mean Ann. Diff. |
|---|---|---|---|---|
| 1672 | 11° 15′ | 12° ′ | 12° 8′ | 15′ |
| 1678 | 11 | 11 45 | 11 53 | 30 |
| 1689 | 10 30 | 11 15 | 11 23 | 30 |
| 1700 | 10 | 10 43 | 10 53 | 14⅓ |
| 1705 | 9 45 | 10 31 | 10 39 | 15⅓ |
| 1710 | 9 32 | 10 12 | 10 25 | 12⅓ |
| 1715 | 9 18 | 10 3 | 10 11 | |
| 1720 | 9 5 | 9 50 | 9 58 | 13 |
| 1725 | 8 57 | 9 36 | 9 44 | 12 |
| 1730 | 8 37 | 9 22 | 9 30 | 16 |
| 1735 | 8 23 | 9 8 | 9 30 | 14 |
| 1742 | 8 | 8 45 | 8 53 | 23 |
| 1745 | 7 56 | 8 41 | 8 49 | 4 |
| 1750 | 7 42 | 8 27 | 8 32 | 15 |
| 1757 | 7 20 | 8 5 | 8 13 | 21 |
| 1761 | 7 7 | 7 52 | 8 | 13 |
| 1763 | 7 | 7 45 | 7 53 | 7 |
| 1770 | 6 45 | 7 31 | 7 39 | 14⅕ |
| 1775 | 6 32 | 7 17 | 7 25 | 13⅗ |
| 1780 | 6 18 | 7 3 | 7 11 | 14 |
| 1785 | 6 4 | 6 49 | 6 57 | 14 |
| 1790 | 6 50 | 6 35 | 6 43 | 14 |
| 1795 | 5 35 | 6 21 | 6 29 | 14⅕ |
| 1800 | 5 22 | 6 7 | 6 15 | 15⅕ |
| 128 years Diff. | 5° 53′ | 5° 53′ | 5° 53′ | |

Mean Annual Difference, 2′ 45″ 28‴

NOTE BY THE EDITOR.

The preceding document, if correct, will be regarded as one of great value by the natural philosopher. When we consider, however, that the observations have been made at three different places, and by various observers in the same place, we cannot but view with suspicion the extraordinary coincidence in the number 5° 53′, which represents at three places the difference of variation for 128 years! The similarity between the differences of each period for the three different places is also exceedingly suspicious. For example, from 1735 to 1742, the difference of variation is exactly 23′ at each of the three places of observation; and in the following period, from 1742 to 1745, the difference of variation is 4′ at each of the three places. Such a strange coincidence in the observations is not likely to have taken place, even if the same observer and the same instrument had been the means of obtaining them.

It would be highly desirable, therefore, both for science and for the credit of those gentlemen whose respectable names are connected with this document, that its history should be diligently inquired into.

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## Art. IV.—*Account of the Quartz Crystals, and the Siliceous Paste found in the Marble of Carrara, as described by* M. Repetti. *

The cavities containing different fluids which occur in several species of crystals have only a few years ago attracted the attention of natural philosophers. We have already published on this subject several important memoirs by Sir Humphry Davy and Dr Brewster. In the present paper, I propose to give an account of the curious results contained in a work by M. Emmanuel Repetti, entitled *Sopre l'alpe apuana ed i marmi di Carrara.* I ought to inform those who are not much disposed to admit, without strong evidence, facts of which they do not understand the cause, that in Italy the knowledge and sincerity of M. Repetti are well known.

The rock crystals found in the marble quarries of Carrara

* This Analysis is translated from the *Annales de Chimie, &c.* Jan. 1828, p. 86. The extracts only are *from* M. Repetti. See the following article.

are generally remarkably clear. Spallanzani was satisfied from those in the museum of Pavia, where there is a great number of specimens, that they surpass in limpidity the purest crystals from Germany, Hungary, and Switzerland.

The largest and most perfect of these crystals are contained in irregular cavities of the calcareous mass in the *crystal ovens*, as the workmen call them, *(forni a cristalli,)* perfectly closed on all sides. Here the crystals are insulated, sometimes in groups, but always adhering to the marble. Most frequently they are found implanted perpendicularly to the sides of the cavities. Sometimes, however, their pyramidal extremities are free, and they touch the rock only by the faces or angles of the prism.

The small crystals which are encased in the substance of the marble have no transparency. Their colour is milk-white, and their exterior form is not regular. One might suppose, says M. Repetti, that want of room has also prevented them from assuming the geometrical forms of crystals contained in cavities.

Rock crystal is never found in the statuary Carrara marble. It occurs in the common white pearly marble of the grottos of *Colombara della Paiastra* and the *Fossa dell' Angelo*, situated near the foot of *Monte Sacro.*

The workmen employed in the Carrara quarries informed M. Repetti, during his first visits, that the cavities in the marble which contained quartz crystals generally contained a greater or less quantity of pure water, slightly acidulated; that they have often recourse to this fluid to quench their thirst; and that the crystals of calcareous spar encased in the substance of the marble, and which they call *luciche*, are almost a certain proof that a liquid cavity containing quartz crystals is not far distant. Hence the workmen have called these crystals spies *(la spia.)* M. Repetti has satisfied himself of the accuracy of these observations.

I proceed now to the extraordinary fact which forms the principal object of this paper.

" In the spring of 1819, M. Pontaleone del Nero, proprietor of a quarry in the *Fossa del Angelo*, having caused to be sawn in his own presence the shaft of a great column for the new church of St François at Naples, perceived a *lucica.* This led him to probe the marble with an iron, when in an instant, and to the great surprise of all those who assisted at the operation, there was seen a cavity larger than usual, every where lined with crystals, and *containing about a pound and a half of liquid.* With still greater astonishment *they saw at the bottom of the cavity a transparent protuberance as large as the fist, and which seemed to have all the characters of rock crystal.* Transported with the idea that he was about to possess himself of the purest specimen of hyaline quartz in the world, he instantly attempted to detach it from its matrix; but alas! he had scarcely withdrawn his hand from the cavity before he saw an elastic and pasty substance, which at first might have taken any shape, and received any sort of impression. It soon, however, became solid and opaque, when it had the aspect of calcedony, or of a fine porcelain biscuit. Disappointed by this unfortunate metamorphosis, and putting no value on a substance, the whole importance of which seemed to him to be gone, M. del Nero threw it in vexation among the debris of marble collected in the ravine."

Such is the account given in the very words of M. Repetti. This naturalist does not dissemble that it may be considered incredible; but, according to him, every person present gives the same account, and among these were several well worthy of credit. Besides, he adds, the fact quoted by M. del Nero is not unique, though examples of pasty crystals as large as his have not occurred.

When Spallanzani visited Carrara in 1783, the workmen told him that they sometimes found in the marble crystals which became hard after they were taken out. "But I have discovered," says Spallanzani, "that this opinion is not true. The quartz contained in the marble is as hard before its extraction as after it is exposed to the air, which is also perfectly conformable to the laws of crystallization." To this positive denial of the fact related by M. Nero, M. Repetti replies, that M. Spallanzani misunderstood the workmen, and that he mistook for a general law what was stated to him only as an exception.

Such was the state of the question when M. Repetti published his work in 1820. Since that time he has inserted in the *Anthologia* an observation which he made along with M. Pompeo Pironi, a naturalist of Milan, and which appeared to him to remove every doubt.

" In passing," says he, " to the west of the *Foce della Bruciana*, I observed accidentally a micaceous marly rock of a chestnut colour, and of the kind which the French call *molasse*, where, if I may use the expression, nature was caught in the fact.

" In a vertical section of the ground contiguous to the new road, I observed some veins or contorted fissures which traversed the mass of marl, and were covered with quartz and calcareous spar, and from which there issued, as if the water of infiltration pushed it from within outwards, a *substance transparent and viscid between the fingers, like the gum which exudes from trees.*

" I immediately recollected the fine experiments of Berzelius, by which he showed that one of the characteristic properties of *silex* was, that it precipitated itself from solution in a gelatinous form, and the phenomenon quoted in my work on a pasty mass found in 1819, in an anhydrous geode of Carrara marble. I was instantly satisfied that the fact which I had discovered afforded an irrefragable proof of the recent formation of quartz crystals in the cavities and fissures of calcareous rocks.

" My first care was to extract from the fissure a portion of the semifluid substance, and to wrap it up in a sheet of paper, with the view of submitting it to chemical analysis. I also thought of impressing upon it some figure which might prove, in the event of its becoming solid, that it had been originally fluid, but its extreme liquidity prevented me from doing this.

" In the evening of the very day on which I discovered it, *I found that the paste contained in my sheet of paper had become solid, opaque, friable, rough to the touch, and of a white tint.*"

In the remainder of his paper, M. Repetti relates a series of experiments made at Florence in concert with Professor Taddei, and from which it follows that the *pasty substance was* composed of

| | | | |
|---|---|---|---|
| Silex, | - | - | 5 parts. |
| Lime, | - | - | 1 |

for the author supposes from the details of his analysis that it was not a simple mixture.

The reader has, however, before him the elements of the question, and may judge for himself whether or not the observation of M. Repetti is sufficiently precise to *obtain* a place in science. Some may perhaps regret that this naturalist did not insist more on the circumstances relating to the transparency of the substance which he analyzed, and that of the large pasty mass extracted from the marble by M. Nero. With regard to the objection of Spallanzani it can have no weight, since the phenomena of polarisation have proved that the jellies of oranges and gooseberries are really crystallized, and that they even possess double refraction.

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Art. V.—*Facts and Observations relative to the recent formation of Quartz Crystals, &c. and of indurated Calcedony from Siliceous Solutions and Pastes.*

As we have not been able to procure the original work of M. Repetti, we are glad to have it in our power to lay before our readers the copious extracts from it given in the preceding article, although we had *six years* ago published in the *Ed. Phil. Journal* the simple facts which he had observed.

The English scientific reader will doubtless partake in the surprise with which we have read the observations of the learned French editor on the paper of M. Repetti. The facts are brought forward as something quite new and unique, as something which geologists have overlooked, and as bordering on the marvellous; and the reader is told that he must judge for himself whether or not the observation of M. Repetti is sufficiently precise to receive a place in science.

In England we have been long familiar with analogous and with similar facts, and even with facts far more puzzling than those of M. Repetti. Our mineralogists and geologists and natural philosophers never doubted the testimony upon which these were published; and, with the exception of some red-hot Plutonists, whose prejudices were opposed to the belief that many minerals have been, and are now, forming from aqueous deposition, we never met with any unprejudiced philosopher who did not admit the facts as implicitly as any other in physical science. For our part, we cannot see where the wonder lies. Among the extraordinary facts on which every science is founded, and many of which are every hour obvious to our senses, is it at all a matter of wonder, or is it even slightly marvellous, *that a soft transparent siliceous mass should be found in the cavity of a calcareous rock, and should harden into something like calcedony or porcelain*, or that *a calcareo-siliceous gelatinous mass should become solid, opaque, and friable?*

The following are a few of the facts which are impressed on our memory, and which it may be interesting to bring together.

1. *Spongy Amorphous mass of Carbonate of Lime formed by the evaporation of a Fluid in a Cavity.*—Count Bournon, *Mineralogy*, vol. ii. p. 33, informs us, that in the vicinity of Lyons there is a calcareous rock containing often very large geodes, having for their envelope silex mixed with lime, frequently alternating in concentric layers. Within these geodes beautiful crystals of carbonate of lime occur, mixed with those of quartz, which they rivalled both in transparency and perfection of form. Upon breaking numbers of these geodes, Count Bournon found *some of them full of water*, and on one occasion he obtained half of a geode with the water which it contained unspilt. Observing that the fluid moved with a massy heaviness like mercury, he concluded that it must be a very concentrated solution; and as this happened at mid-day in a warm day in July, *the fluid was all evaporated in little more than a quarter of an hour, and there remained in the geode a spongy amorphous crystalline mass of carbonate of lime.*

About the same period Count Bournon observed the same thing at Vougy, but the geodes were composed of black oxide of manganese lined with crystals of carbonate of lime.

2. *Quartz Crystals formed in the observer's presence from a siliceous solution in a cavity.*—As we have already given a full account of this fact in this *Journal*, No. iii. p. 141, we shall merely state that Mr B. F. Northrop, of Yale College, found in the centre of a hornstone pebble a cavity *three-fourths of an inch long, by half an inch wide*, a *milky fluid*, like magnesia and water. While the rapid evaporation produced by a hot day was going on, "*minute prismatic crystals shot* from the *fluid even under the eye of the observer.*" These crystals were found to be quartz. In other cavities lined with mammillary chalcedony, he found *a white spongy deposite resembling an earthy precipitate.*

3. *A Gelatinous, Siliceous, and Impressible Mass found in* the *cavities of a Pebble.*—In the centre of a hornstone and chalcedony pebble, five inches by three, Mr Northrop found a cavity 1½ by 1 inch, nearly filled with a spongy siliceous deposite, which was still moist to such a degree, "*as to form a pulpy or gelatinous mass, very soft and impressible*, which also *soon dried by the intense heat of the weather.*" A few crystals also shot here and there as in the preceding cavity. "*In a few cavities the siliceous matter had concreted into well characterized mammillary chalcedony.*"—See this *Journal*, No. iii. p. 141.

4. *Hollow Balls containing from a pint to two quarts of a milky fluid.*—Mr E. Whiting of Newhaven saw in 1806, in Georgia, hollow balls like bombshells, which had been previously found, and which were filled with a milky fluid so nearly resembling white paint or white wash, that it was used to whiten the fire-places and walls of the houses. These shells were from 5-8ths to 3-4ths of an inch thick, and their crust looked like an iron ore. Their capacity was from a pint to two quarts. They were found in excavating a mill-dam in Brier Creek, a stream which passes through Millhaven, and flows into the Savannah river, and at the distance of two or three miles from the road leading from Savannah to Augusta. See Prof. Silliman's *Journal*, vol. viii. p. 285, and this *Journal*, No. iii. p. 142.

5. *Siliceous Tabasheer formed from a milky and viscid*

*juice.*—The regular substance called tabasheer, with which our readers are familiar, is a purely *siliceous substance, transmitting a yellow, and reflecting a fine blue* light like certain opals, is formed in the joints of the bamboo from a milky juice which is sometimes in the state of honey. Those pieces of tabasheer have the veined structures and other properties of chalcedony.

6. *Doubly Refracting Crystals of Quartz formed in the Siliceous Grasses.*—It has been long known that silex existed in these grasses; but Dr Brewster has discovered that this silex occurs in crystals, having the property of double refraction and polarisation, and having all their axes geometrically arranged. These crystals, which exist in thousands in every plant, form an essential part of it. We shall soon lay the author's paper on this subject before our readers.

7. *Crystals of Sulphate of Barytes formed from the fluid in a cavity.*—In this *Journal*, No. ix. p. 135, we have already laid before our readers an account of the curious fact discovered by Mr Nicol, of the fluid in a cavity of sulphate of barytes exuding from the cavity, and forming a crystal of the same mineral. We have seen this crystal, and the most irrefragable proof of its having been thus formed.

8. *Silex formed from the juices in Teak Wood.*—In various specimens of teak wood, Mr Sivright observed actual crystallized quartz, and we have also seen them in his specimens in the distinctest manner.

9. *Beryls found in a soft state in Siberia.* We have somewhere read that M. Patrin, a French mineralogist, found beryls in Siberia, which, when newly taken out of the earth, broke across like a piece of apple.

10. *Opals found in the state of soft tenacious paste in Hungary.*—M. Beudant, a celebrated mineralogist, now in Paris, gives the following account of this fact in his travels in Hungary.

"There exists in the most solid and freshest parts of the rock small nests of a very soft matter, which readily cuts, and produces a particular unctuosity under the edge of the knife. This matter is whitish, yellowish, bluish, and sometimes it presents indications of iridescent reflections. It is very soft to the touch, and when it has imbibed water, becomes sufficiently tenacious to be kneaded between the fingers. I cannot believe that this matter is owing to a decomposition of opal, similar to that which we have just mentioned, since, from the manner in which it occurs inclosed in the rocks, it could not have been exposed to the influence of the air. I am rather of opinion that it is a particular state of opal. The workmen also distinguish those earthy parts, which they regard as opal that is not yet ripe, from those which are produced by the exposure of opal to the air, which they name burnt or calcined opal. These matters harden a little on exposure to the air, and crack in collections, precisely the same way as alumina or silica in a state of jelly, which are desiccated in our laboratories. It has been without doubt observations of this kind, which have led certain authors to say, that opals are found, when in the bowels of the earth, so soft as to receive the impression of the fingers, and that they harden only by exposure to the air. This idea is not perhaps so ridiculous as might at first be imagined; for we know that silica in solution assumes in drying, a certain degree of hardness, and a lustre approaching to that of opal. It is true that the greater number of opals are solid when taken from the rock; but after finding them occasionally still soft, and capable of drying in the air, might it not be supposed, that the rest have undergone this desiccation in a slower manner in the bowels of the earth? By admitting this hypothesis, we can discover the reason of the difference which exists between the hyaline quartz and opal; the quartz will be the product of a crystallization of the siliceous matter, and the opal the result of the desiccation of a gelatinous precipitate. I must remark, however, that this is merely a hypothesis, which, while there are some facts in favour of it, has also others against it; such for example is the existence of opal stalactites, with regard to which it must be admitted that the matter has been in a kind of solution."

## ART. VI.—*On a remarkable Formation of Clouds.* By GEORGE HARVEY, Esq. F. R. S. Lond. and Edin. F. L. S. Honorary Member of the Society for promoting the Useful Arts of Scotland, Member of the Royal Geological Society of Cornwall, &c. &c. Communicated by the Author.

IF the capricious alterations of our climate sometimes produce inconvenience, and augment the calamities of querulous and unquiet minds, there is enough to reward the attention of the most active and watchful meteorologist in the beautiful variety which the ever-changing aspect of the sky presents.

An example occurred at this place, the latter end of the past month, of a remarkable uniformity in the clouds, which it may not be improper to record in a more permanent manner than in the perishable pages of a private journal. About two P. M. on a day which had all the warmth and serenity of June, and when even a freshness seemed to come over "the sear and yellow leaf," a beautiful assemblage of separate and distinct bands of delicately formed cirro-cumuli were observed to spring up from nearly the southern extremity of the magnetic meridian, and, diverging in all directions, became blended at last with the same beautiful uniformity near the northern pole of the same great line, the whole group bearing a strong resemblance to the meridians of a common globe when rectified for the equator. The band which passed through the zenith, and whose axis was nearly coincident with the magnetic meridian, was particularly distinguished by its fine regularity of form, and the symmetry pervading the small masses of cloud that composed it. The bands on either side diminished successively in breadth, the narrowest and lowest on each side being at an elevation of from fourteen to fifteen degrees. The lower bands seemed in some degree to exchange the character of the cirro-cumulus for that of the cirro-stratus.

This very novel appearance continued the whole of the afternoon, and was clearly visible at half-past six o'clock, covering the azure, now studded with innumerable stars, in a manner that very much increased the interest of the scene. At seven gentle vapours began to arise; and before eight the whole hemisphere was shrouded in gloom, presenting a striking contrast to the liveliness and beauty which had characterized all the former part of the day.

A very gentle breeze prevailed from the E. S. E. The barometer at 3 o'clock stood at 301; and the temperature in the shade was 55°.

Plymouth, *Nov.* 1, 1828.

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Art. VII.—*Account of the Steam-Engines in Cornwall.* By W. J. Henwood, Esq. F. G. S., &c. &c. Communicated by the Author.

Shortly after the expiration of Messrs Boulton and Watt's patent right, they relinquished the superintendence of the steam-engines which they had erected on the Cornish mines; and they were consequently committed to the care of those who had been convicted of infringements on the patent, or to that of the mine-agents. None of those persons having been acquainted with the reasons which had influenced Mr Watt's operations, in a very short time, the duty, which had been advanced to an average of above *twenty millions* of pounds weight, lifted one foot high by the consumption of a bushel of coal, subsided to an average not exceeding fourteen millions; and the performance of many engines was not more than *six millions.*

Some of the pirators who were intrusted with the erection of new engines, having, during the continuance of the patent, found it of importance to get their engines into operation as speedily as possible, without regard to accuracy or proportion, with the sanction of the miners, still continued to pursue the same practice; the consequence of which was, that the scientific precision which had been introduced by Mr Watt was regarded as an object of secondary consideration. Some of those erections (for they were scarcely worthy of being termed machines) could only have been viewed as caricatures of the original. Others followed Mr Watt's steps, as closely as, without the assistance of science, they were enabled to do, and produced some tolerable imitations. But all fell more or less short of what had been obtained, whilst his superintendence continued.

The increasing depth of the mines requiring that the mechanical force should be augmented, a greater quantity of steam became requisite. Mr Watt had already made the boilers as large as he considered prudence to warrant, and obtained an increased supply by using several boilers. But the Cornish engine-builders imagined that the dimensions might be enlarged, and that they might thus avoid the necessity of employing a greater number; the consequence of this mistake was, that the boilers were made of the most unwieldy dimensions. The theory of combustion was not in those days so generally and accurately known as it is at present, and the fires in Mr Watt's engines were of much larger dimensions than Mr Smeaton's experiments, now confirmed by more extensive experience, have demonstrated to be most consistent with economy of fuel.

In some of the engines which were erected by the mine-agents, the fire bars were placed more than ten feet below the bottom of the boiler, as much as possible, and often nearly the whole, of the intervening space, being filled with ignited fuel. Under such circumstances, it must be evident that ten millions would have been the extent of their performance. From this general censure, we must, however, except several engines erected by Mr Hornblower, particularly two large double acting engines at the united mines, which, in proportion and performance, were equal, if not superior, to any of those which Messrs Boulton and Watt had erected in Cornwall. Mr Trevithick, who was a large contractor for the erection of steam-engines, made several; but, as he paid but little attention to the proportion of the parts, their performance was not very good. His high pressure engine was first adopted, in consequence of a scarcity of water for injection, and, among many other excursions of his fruitful fancy, was the cylindrical tube boiler, now generally used in Cornwall. About the year 1812, Mr Woolf came into Cornwall. He had also invented a boiler which was said to possess many advantages. It consisted of a body or reservoir beneath, and connected with which were several tubes, and between them the flame and heated air traversed in their passage to the chimney. Being usually made of cast-iron, and continually 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 the 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.

Previously to Mr Woolf's coming into Cornwall, he had revived Mr Hornblower's idea of employing the expansive force of steam in a second cylinder; and by having his engines made and fitted together in a much more accurate manner than had hitherto been the practice in that neighbourhood, he succeeded in obtaining from engines of that construction a very much better performance than had yet been effected by Mr Watt's engines. Mr Woolf and his friend, the late Dr Alexander Tilloch, by their frequent publications on the subject, industriously propagated the opinion of this superiority; and to this and Mr Woolf's alleged experiments are due the very absurd notions of the great economy from the use of highly elastic steam, which for so many years obscured that quarter of the scientific horizon. We believe the explosion of this theory (if it be worthy of the appellation) was effected by Mr Dalton's discovery of the law which determines the dilatation of the permanently elastic fluids by increase of heat. We are informed, that, soon after the erection of some of Mr Woolf's engines in Cornwall, one which worked at Huel Abraham mine, during a trial which was continued for twenty-four hours, lifted seventy millions of pounds one foot high by the combustion of one bushel of coal.

By dint of great attention to the joints, &c. of the engine at Huel Abraham, its average duty was very far beyond that of Watt's engines, then at work in the neighbourhood; a statement of their performance being periodically published. The adventurers in mines and the engineers now began to see the important advantages to be derived from attention to proportion and accurate workmanship, and the founders in Cornwall erected apparatus for the preparation of machinery

The performance of the steam-engines gradually increased to an average of between twenty and twenty-five millions, the latter being by no means a frequent occurrence.

Mr Sims now erected two or three engines on a plan which was a combination of the high pressure with Watt's, and their average was probably little short of thirty millions; however, this advantage was entirely attributable to the greater degree of attention paid to their erection.

During or about the year 1820, the well-known and extensive consolidated mines in Cornwall were put into active operation, and Mr Woolf, who was appointed the engineer, expressed an intention to erect some engines of the two cylinder construction. This was opposed by Mr William Francis, a very intelligent mine-agent in the employ of Mr John Taylor, and in consequence, some very large engines on Watt's principle were made. Every attention was paid to proportion and workmanship, and their performance fully justified Mr Francis's views of the subject.

The unprecedented activity of mining enterprize which immediately succeeded required the preparation of many new and powerful steam-engines, and in their construction as much attention was given to the proportion and preparation of the parts as the scientific attainments of the superintendents afforded. Forty and even forty-eight millions was not now considered a singular occurrence. Much of the credit of this is unquestionably due to Mr Woolf. The superiority of Mr Watt's engines was now considered beyond doubt; and but one of Mr Woolf's has been since erected. Towards the termination of the year 1826, Mr Grose was called on to superintend the preparation of some steam-engines at Huel Towan mine; and the average duty of that which was first worked was nearly fifty millions. A coating of saw dust of about ten inches in thickness was now applied to the steam-pipes, nossel, cylinder, &c. and about an equal depth of ashes to the top of the boiler. The duty was by this means increased to about sixty-five millions. A loss of caloric still obtaining, another coating of about the same depth, and of like materials, was applied outside the former, the consequence of which was a further increase to *eighty-seven millions*, which was the average of a trial at which the writer of this notice was present, with several engineers and scientific men. Following Mr Grose's idea, Mr Woolf has brought one of his engines to an average duty of nearly seventy millions, and other engineers still following are not far behind. Its effect will be traced by inspecting the tabular view which accompanies this article. Ignorance of this important object precludes, in many instances, the *full* benefit being now derived from its application; but its partial adoption must in every case be beneficial.

Mr Grose has realized a similar advantage in other engines, and it would have afforded us great pleasure to have given a view of other important improvements which he contemplates; but as they are not yet in operation, it would now be premature; however, we hope soon to be able to lay a detail of them before the public, in an *early* number of the *Edinburgh Journal of Science.*

*On some peculiarities in the construction and manner of working usual in Cornwall.*

It is found in practice that the maximum effect from a given quantity of fuel, obtains when the fire is from eighteen to twenty-two inches below the highest part of the concavity of the inner tube; when the depth of ignited matter does not exceed fourteen inches, and is not less than eight; and when the boilers are sufficiently capacious to supply the requisite quantity of steam, the damper being so far closed as to allow the whole of the smoke to pass slowly to the chimney, but still so rapidly as to keep a bright fire without any other stirring than the removal of the cinders requires. If the draught be too slow, the brightness of the fire will diminish, and the smoke and heated air will escape at the fire doors, which must be attended by much loss of caloric, as well as by great inconvenience to the attendant. If the draught be too brisk, the gaseous matter will pass so rapidly through the fuel as to escape to the chimney before its temperature has been reduced to that of the boiler.

The same effect will obtain, if a fire deeper than fourteen inches be made, and the damper opened so far as to keep up a brisk flame; and if the fire be less than eight inches deep, it will permit the influx of a disadvantageously large quantity of air into the fire-place; but if the fire do not burn briskly, there is a probability that a portion of coal gas will pass off without undergoing combustion, and consequently without affording any assistance. It is perhaps almost unnecessary to observe, that no more air should be admitted into the fire-place than is requisite for the maintenance of the proper degree of activity in the combustion and draught, and this degree must be the smallest of which the demands of the engine will admit. It is an object of importance, that the pipe by which the steam is conveyed from the boiler to the cylinder should be considerably inclined towards the former; thereby permitting the return to the boiler of any water which may have obtained from condensation in the pipe. For were this water to enter the cylinder, it might be easily apprehended that its effects would be very detrimental; it would probably occasion further condensation, and very much augment the adhesion of the packing of the piston to the cylinder. Hence the importance of coating the steam-pipe with a considerable depth of non-conducting matter. This point is much insisted on by Mr Grose, who maintains that the adhesion, even when the packing is well oiled, is much greater at low than at high temperatures. It seems that a load of between nine and twelve pounds on the inch of the area of the piston, is the most advantageous to the performance of the steam-engine, and we think Mr Watt entertained an opinion not very different from this, although we are not prepared to assign any very satisfactory reason for its being so. The whole of the pumping engines in Cornwall raise the column of water during the returning stroke, and, as but few of them work without an interval between each stroke, the means of considerably assisting their operation is thus afforded. A counterpoise to the weight of the pump rods is always required, and the quantity of this is so adjusted as to occasion the return to be made *very slow*, and to terminate but an instant before it is necessary to make the succeeding stroke. Hence it is evident, the more slowly the returning stroke is made, the smaller the quantity of steam requisite to make the working stroke. But it is obvious that this assistance can never be given either to rotatory or to double reciprocating steam-engines, that which would have been gained on one hand being lost on the other; consequently, the performance of single is better than that of double reciprocating or rotatory engines. But as the latter are never worked "expansively," this accounts for a small portion of the difference. An advantage of some consideration is obtained in the pumping engines, by allowing the exhausting valve to be opened before the steam is admitted on the piston, which consequently meets a considerably smaller resistance at the commencement of its motion than it would have, had both valves been opened at the same instant.

It is not unusual to force the water intended to replace the evaporation from the boilers into a separate vessel kept constantly full of liquid, and around which the flue from the boiler to the chimney is passed. It thus attains a temperature but little below that of the water in the boilers, which are supplied by opening a communication between them and this vessel, into which a portion of liquid is now injected; and this displaces an equal bulk of the warmer liquid which passes into the boiler. There are at Huel Towan engine three boilers, each about thirty-six feet long; the outer tubes are six, and the inner four feet in diameter; the area of the fire grate is in each about twenty-eight or thirty feet. The writer of this notice has observed that engines with boilers of smaller capacity do not perform such duty. Some of those next in goodness have a greater and others a less reservoir of steam. It appears that the dimensions of Huel Towan are most efficient, but that a smaller quantity is preferable to a larger. We believe that the importance of attending to the operation of the air-pump has not since Mr Watt's time been sufficiently noticed. We think the following remarks will help to place the subject in a proper point of view. The quantity of water should be as small as possible, not so much on account of its weight, as of the greater period during which the piston of the air-pump will be exposed to the atmospheric pressure. On the other hand, the smaller the quantity of water injected, the higher will be the temperature of the hot well, and consequently the less perfect the vacuum. It is obvious that the smaller the quantity obtained, by adding the difference between the impeding influence of the vapour of the hot well on the piston, and its accelerating action on the air-pump, to the whole resistance experienced by the latter during its exposure to the atmosphere, the better will be the operation of the machine. Mr Watt thought 102° to 110° to be the temperature of his hot well when the engine performed the best duty.

The following table will exhibit an approximation to the resistance that is opposed by the air-pump at Huel Towan at various temperatures of the hot well.

| Temp. | Resistance to air-pump from atmosphere. | Resistance to piston from vapour. | Accelerating effect of vapour on air-pump. | Total resistance to air-pump. |
|---|---|---|---|---|
| 80° | 33993,26 | 17995,8528 | 903,876 | 51085,2368 |
| 85 | 24114,67 | 21076,224 | 1058,5935 | 44132,3005 |
| 86 | 22650,047 | 21835,53 | 1094,21885 | 43391,35815 |
| 87 | 21475,65 | 22292,16 | 1119,665 | 42658,145 |
| 88 | 20360,62 | 22901,128 | 1150,2 | 42111,548 |
| 89 | 19444,88 | 23710,752 | 1190,917 | 41964,715 |
| 90 | 18577,1 | 24318,72 | 1221,4536 | 41674,3764 |
| 91 | 17768,9 | 25128,6 | 1262,1687 | 41635,3313 |
| 92 | 17006,286 | 25939,968 | 1302,8838 | 41643,3702 |
| 93 | 16350,748 | 26669,5296 | 1339,5374 | 41680,7402 |
| 94 | 15725,736 | 27561,216 | 1384,324 | 41902,628 |
| 95 | 15147,249 | 28371,84 | 1425,0297 | 42094,0593 |
| 100 | 12783,58 | 31614,336 | 1679,4993 | 42718,4167 |
| 105 | 11078,56 | 39315,264 | 1974,684 | 48419,14 |
| 110 | 9769,6 | 45394,944 | 2280,0476 | 52884,4964 |
| 115 | 8752,572 | 52690,56 | 2646,4838 | 58796,6482 |
| 120 | 7911,94 | 60796,8 | 3053,6352 | 65655,1048 |

It appears that about $\frac{1}{46}$ of the first quantity in the first column should be added to it and to each of the succeeding numbers in that column, the quantity of water arising from the steam itself being omitted. Mr Watt's idea seems to have been, that, whatever might have been the temperature of the injected water, that of the hot well should be invariable.

Let $a$ = latent heat (960°) of vapour under ordinary circumstances.
$b$ = difference between temp. of injected water and 212°.
$c$ = difference between temp. of hot well and injection.
$d$ = quantity of water in steam used at each stroke.
$e$ = area of air-pump piston.
$f$ = total pressure of atmosphere on air-pump in lbs.
$h$ = area of steam-piston.

Let $i$ = pressure of steam from water in hot well.

Then $\frac{\overline{a+b}\times\overline{d+d}\times f}{c.e}+h.i-e.i=$ effective resistance opposed to the operation of the engine, by atmospheric pressure on air-pump, imperfection of vacuum, &c.

This leads us to a different conclusion from that at which Mr Watt arrived, and shows us that the temperature of the injection water directly determines the temperature at which the resistance is a minimum. The whole of the preceding investigation has been conducted on the idea that the steam whilst in the cylinder absorbed no heat from the steam case, provided one be used. But we have no correct data for calculating the increase which must thus obtain. On the other hand, the higher the temperature of the hot well, the less the quantity thus abstracted from the case; so that in practice the water in the hot well may, with economy, be worked at between 95° and 100°. It may not be altogether out of place to remark, that Mr Grose found his engine at Huel Hope performed rather better when working $\frac{1}{2}$ than when at $\frac{4}{5}$ expansive. The water passing into the condensing cistern may with economy be first passed over the eduction pipe. The saw-dust placed around the cylinder and steam-pipes is quickly charred, and, if not frequently removed, will act on the iron, especially if it be not quite free from moisture. It has been well observed that the only improvement in the steam-engine since that of Mr Watt is in the dimensions of the valves. At Huel Towan the valve which admits the steam into the cylinder is 8 inches in diameter; the equilibrium valve 12; the exhausting valve 16. As the steam is usually worked at about the pressure of 20 ℔s. on the square inch, the weight on valves of such dimensions is very considerable. Many contrivances have been made for obviating this inconvenience, but the best yet invented is that of Mr Hornblower's, called the skeleton valve, and described in *Gregory's Mechanics.* But there is another recently invented by Mr Sims, a Cornish engineer, and extensively used by him in large engines. In Plate I. Fig. 1, *a a a*, *á á*, *a″ a″* is the seat, which at *a a a* is solid. At *á á* apertures are cut in its sides 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, bored

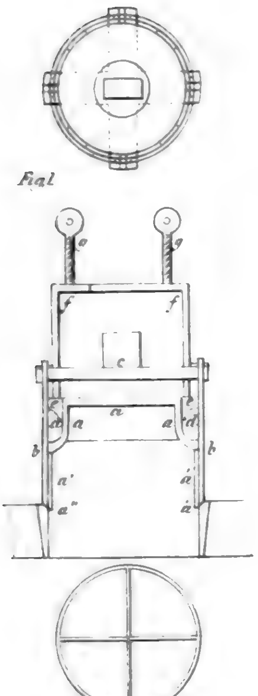


Fig. 4

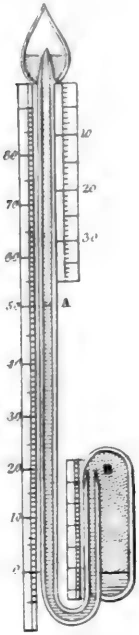


Fig. 5

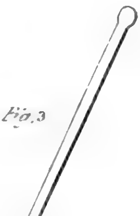

Fig. 3

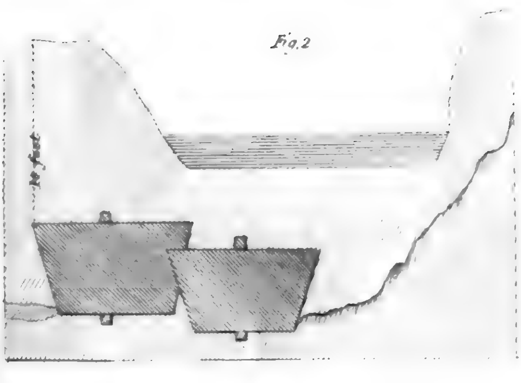


Fig. 2

Fig. 1

Drawn by M. A. Harvey

very accurately; *c* is the bar by which it is lifted. At *d d* it is packed with the usual materials. *e e* is a ring by which the packing is kept in its proper situation; *f f* is a second ring resting on *e e*, and is kept in its place by the screws *g g*, by means of which also the packing is kept in a proper state of compression. It is evident that the steam can exert no pressure to prevent its being lifted; nor when it is closed has the vapour within any power to open it. It so completely answers the purpose intended, that an infant might lift the valves of a 90 inch engine. The packing is not a very desirable concomitant, and it also increases the dimensions of the valve.

In the *Philosophical Transactions* for 1827, Mr Davies Gilbert, the illustrious President of the Royal Society, has published some interesting observations on the steam-engine. But in estimating the efficiency ($f \times s$) or force, multiplied into the space through which it acts, he assumes both these functions to be invariable. Now, in the present case, the value of $f$ is dependent on the quantity of water evaporated by a given portion of fuel. The writer of this has already shown that this is in different engines very variable. The value of $s$ must *(friction disregarded)* depend on that of $f$. But if friction be in operation, and has different amounts in various engines, we cannot compare their efficiency until we reduce the value of friction to a determinate standard. But if the value of $f$ be like in two instances, that of $s$, with the requisite correction for friction, may be determined by the duty performed. And as the ratio which $s$ will bear to $f$ can be determined only by experiment, it does not seem that we have any means of introducing the function $f$ into the estimate of efficiency, without making friction another element; consequently that duty and efficiency are identical, except when expansive working obtains, and then the value of the advantage thus gained is the measure of their difference. Hence the duty is sometimes greater than the efficiency, but never less. In calculating the duty of a steam-engine, it is to be feared we cannot arrive at any very accurate result, in the case of its being applied to spinning-machines, mills, &c. as our knowledge of the resistance opposed by such apparatus is very limited. The only means of arriving at any tolerable approximation appears to us to be, by aseertaining the average pressure of steam on the piston when the machine is moving with its requisite velocity. This opinion is confirmed by the knowledge, that the average performance of the rotatory engines in Cornwall does not exceed seven millions, whilst that of the pumping engines (in estimating the duty of which no difficulty appears) is about thirty millions. That such a difference actually exists cannot be for one moment imagined. The selection of one pound weight lifted one foot high, as a dynamic unit, appears to have been very judicious. The term efficiency seems so far useful, as its illustrious propounder had intended; but we think that consumption of fuel might also be denominated *expence of the efficient.* Eighty-four appears to us a very inconvenient unit. One pound would be much more agreeable to our preconceived opinions of scientific order.

The only difference between the duty of a large and a small engine, supposing them equally good, is only in the value of the friction, which is inversely proportional to their dimensions. Hence, supposing friction to vanish,

Let $r$ = resistance.
$s$ = space through which it is moved.
C = expence of the efficient.

Then $\frac{r\,s}{C}$ = duty,

Which under precisely similar circumstances, would be the same for an engine of any dimensions; the expence of the efficient being always in proportion to the resistance overcome.

## A tabular view of the performance of Steam-Engines drawing water out of the mines in Cornwall.

| Mines. | Diameter of cylinder. | Length of stroke in cylinder. | Length of stroke in pump. | Load in lbs. per sq in. of area of piston | No. of strokes per minute. | Duty 1823. | No. of strokes per minute. | Duty 1824. | No. of strokes per minute. | Duty 1825. | No. of strokes per minute. | Duty 1826. | No. of strokes per minute. | Duty 1827. | No. of strokes per minute. | Duty to 31st May 1828. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dolcoath, | 76 inches single, | 9, | 7,5 | 11,4 | 6,1 | 40,3 | 6,2 | 40,5 | 5,7 | 36,6 | 5,5 | 35, | 6,3 | 36,4 | 7,1 | 38,5 |
| Stray Park, | 64 inches single, | 8, | 5,5 | 8, | 4,3 | 28,6 | 4,7 | 27,3 | 3,9 | 27,9 | 3,4 | 27,2 | 3,7 | 25,7 | 6,2 | 27,5 |
| Tin Croft, | 66 inches single, | 9, | 7, | 8,5 | 6,8 | 32,6 | 7,4 | 33,7 | 6,5 | 32,9 | 6,3 | 33,1 | | | | |
| Huel Charlotte, | 36 inches single, | 9, | 6,25 | 3,8 | 1,9 | 13,1 | | | | | | | | | | |
| Huel Vor, | 63 inches double, | 8, | 6,25 | 17,2 | 7,8 | 25, | 6,9 | 27,3 | 5,7 | 24,2 | 4,9 | 22,6 | 5,4 | 20,5 | 6,3 | 24,5 |
| | 53 inches single, | 8,75 | 7,25 | 19,6 | 8,1 | 29,1 | 5,3 | 23,3 | 5,1 | 29,9 | 4, | 27,6 | 4,6 | 31,7 | 7,2 | 37,6 |
| | 48 inches single, | 7,75 | 5,5 | 10,7 | 7,1 | 37,3 | 8,7 | 41,1 | 8,4 | 38,7 | 6,4 | 31,6 | 4,8 | (59) 27,2 | 5,8 | 29,5 |
| | 45 inches single, | 6,75 | 5,25 | 15,3 | 8,1 | 3,04 | 5,2 | 28, | 3, | (3) 23,8 | | | 5,7 | (60) 33,7 | 7,2 | (85) 38,5 |
| | 80 inches single, | 10, | 7,5 | 11,3 | | | 7, | 37,7 | 6, | 42,3 | 6, | 44, | 5,8 | (81) 47,3 | 6, | 52,1 |
| Crenver, | 70 inches single, | 8,5 | 7,5 | 11, | 7,5 | (1) 31,5 | 8,3 | (4) 12,5 | 7,7 | (25) 15,5 | 8, | 14,8 | | | | |
| Oatfield, | 70 inches single, | 8,5 | 7,5 | 6,6 | 7,9 | (1) 28, 3 | | | | | | | | | | |
| Huel Abraham. | 66 inches single, | 8,5 | 7,25 | 8,4 | 9,3 | 30,2 | | | | | | | | | | |
| (Woolf's) | 45 inches great cyl. | 6,75 | 6,75 | 16,4 | 8,2 | (1) 47. | | | | | | | | | | |
| (Woolf's) | 60 inches great cyl. | 8,75 | 7,25 | 12,3 | 6,9 | (1) 25, | | | | | | | | | | |
| Huel Clowance. | 40 inches single, | 7,5 | 7,5 | 16,3 | 2,6 | (1) 18,8 | | | | | | | | | | |
| | 53 inches single, | 7, | 7, | 13,8 | 6, | (1) 34,4 | | | | | | | | | | |
| Carzise, | 22 inches single, | 4,75 | 4,75 | 23,2 | 14,1 | 25,4 | 13,2 | 21,3 | | | | | | | | |
| | 50 inches single, | 9, | 7, | 6,9 | | | | | 7,8 | 34,1 | 2,1 | (45) 17,4 | 3,1 | (70) 32,6 | 6, | 38,7 |
| United Mines, | 63 inches double, | 9, | 7, | 14,2 | 7,8 | 26,5 | 5,9 | (10) 26,2 | | | | | | | | |
| | 63 inches double, | 9,5 | 7,5 | 13,4 | 7,1 | 25, | 5,2 | (11) 20,3 | | | | | | | | |
| | 65 inches double, | 8, | 6, | 11,4 | 7,4 | 18.2 | 6,2 | 16,4 | | | | | | | | |
| (Sims's) | 63 inches great cyl. | (2) 9,5 | 7,5 | 13,5 | 5,9 | 23,3 | 6, | (12) 23, | | | | | | | | |
| Huel Unity, | 53 inches single, | 6,6 | 5,75 | 10,2 | 7, | 34,3 | 8, | 32,4 | 7,1 | 28,2 | 7,3 | 20,6 | | | | |
| | 58 inches double, | 7,416 | 6, | 14,1 | 5,3 | 22,6 | 5,7 | 21,7 | 5,7 | 21,2 | 5,2 | (47) 24,4 | 5,7 | 24,6 | 7,1 | 27,5 |
| Poldice, | 96 inches single, | 10, | 7, | 8,9 | 5,4 | 39,4 | 6. | 38, | 5,8 | (27) 36,2 | 4,8 | 35,7 | 5,5 | (61) 37,9 | 7, | 46,1 |

| Mines. | Diameter of cylinder. | Length of stroke in cylinder. | Length of stroke in pump. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Duty 1823. | No. of strokes per minute. | Duty 1824. | No. of strokes per minute. | Duty 1825. | No. of strokes per minute. | Duty 1826. | No. of strokes per minute. | Duty 1827. | No. of strokes per minute. | Duty to 31st May 1828. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poldice, | 60 inches single, | 10, | 6,5 | 11,4 | 5,7 | 30,2 | 6,2 | 26,3 | 6,2 | 26, | 4,8 | 18,8 | 5,6 | 23,8 | 8, | 30,4 |
| | 45 inches single, | 5,5 | 4,5 | 6,9 | 5,25 | 11,4 | | | | | | | | | | |
| Consolidated Mines, | 90 inches single, | 9,96 | 7,5 | 9,5 | 6,3 | 40,6 | 5,6 | 36,7 | 6,9 | 33,9 | 5,7 | (46) 33,4 | 5,2 | 37,5 | 7,6 | 50,9 |
| | 90 inches single, | 9,916 | 7,5 | 10,26 | 7,7 | 36, | 7, | 33,4 | 9,1 | (28) 28,6 | 7,9 | 30,1 | 6,6 | 41,7 | 5,2 | 39, |
| | 90 inches single, | 10, | 7,5 | 7,4 | | | | | | | | | 4,7 | 64,3 | 4,1 | 61,8 |
| | 70 inches single, | 10, | 7,5 | 7,8 | | | | | | | 4,8 | (3) 29, | 6,1 | 39,7 | 6,6 | 42,5 |
| | 70 inches single, | 10, | 7,5 | 7,2 | | | | | | | 1,6 | 14,9 | 2,9 | 28,8 | 4,7 | (96) 44,4 |
| | 58 inches single, | 7,75 | 6,5 | 14,9 | 3,4 | 28,3 | 5,9 | (13) 28,8 | 7, | 25,9 | 5,5 | 27,9 | 4,2 | 38,6 | 5,8 | 39,9 |
| Huel Damsel, (Sims's) | 42 inches great cyl. | (2) 7,5 | 5,75 | 20,1 | 4, | 27,4 | 4,4 | 30,4 | 4,2 | 28,2 | 4, | 30,2 | 4,2 | (62) 32,1 | 5,5 | 33,8 |
| | 50 inches single, | 8,5 | 6,5 | 9,8 | | | | | | | | | 2,3 | (3) 32,3 | 2,9 | (89) 33,3 |
| Ting Tang, | 63 inches single, | 7,75 | 6,75 | 9,3 | 5, | 27,7 | 6,2 | (14) 31,2 | 5,6 | (29) 34,6 | 6,3 | (48) 35,5 | 7,3 | (63) 37,3 | 7,6 | (88) 35,2 |
| Tresavean, | 60 inches single, | 9, | 7, | 5,3 | 3,9 | 23,7 | 3,1 | (15) 20,9 | 3,3 | 21,3 | 3,2 | 19,4 | 3,6 | (64) 19,8 | 3,9 | 22,6 |
| Huel Buller, | 36 inches single, | 7,75 | 5,75 | 8,4 | 3,6 | 20,2 | 3,7 | (16) 21,9 | 3,9 | (30) 20,8 | 3,2 | 19.8 | 3,9 | 21,6 | 5, | 22,2 |
| Huel Basset, | 24 inches single, | 7,5 | 5,5 | 9,5 | 9,1 | 19,6 | 10,7 | (17) 19,7 | 9, | (31) 17,6 | 8,9 | 16,3 | | | | |
| Huel Harmony, | 36 inches double, | 6.666 | 6, | 28, | 6, | 24,1 | | | | | | | | | | |
| | 70 inches single, | 9,25 | 7, | 7,4 | | | 6,8 | 35,2 | 8,8 | 34,5 | 4,5 | (56) 26,5 | 4,5 | (83) 28,7 | 6,2 | 30,5 |
| Huel Montague, | 50 inches single, | 8,666 | 6,75 | 6,5 | | | | | | | | | | | 6,1 | 21,7 |
| Huel Squire, | 63 inches single, | 9, | 7, | 12,2 | 5,6 | 26,6 | 6,4 | (3) 24,4 | | | | | | | | |
| Treskerby, (Sims's) | 58 inches great cyl. | (2) 7,75 | 6, | 14,7 | 6,7 | 38,4 | 8,2 | 38,8 | 7,1 | 37,9 | 7,5 | 36,9 | 7,6 | 41,1 | 9,1 | 42,3 |
| | 50 inches double, | 7,583 | 5,75 | 18,4 | 3,8 | 25,3 | 4,1 | 25,9 | 2,4 | 22,5 | | | | | | |
| Huel Chance, (Sims's) | 45 inches great cyl. | (2) 7,916 | 6. | 17,2 | 8,3 | 28,6 | 7,2 | 30,1 | 5, | 29,2 | 5,2 | 30,2 | 4,5 | (65) 25,9 | 6,4 | 29,3 |
| Cardrew, | 27 inches double, | 7,853 | 5,75 | 7,2 | 6, | 17,8 | 8, | (18) 12,1 | 9,2 | 24,4 | 9,7 | 17,7 | 9,6 | (66) 21, | 12,3 | 21,1 |
| West Huel Alfred, | 45 inches single, | 9, | 7, | 12,1 | 10,4 | (1) 25,7 | 10,1 | (8) 24,7 | 8,8 | 24, | | | | | | |
| | 70 inches single, | 9,5 | 5,5 | 6,75 | | | 8,8 | 27,1 | 7,8 | 27,6 | | | | | | |
| Penberthy Croft, | 64 inches single, | 9,25 | 7,23 | 6,9 | 6,7 | 26,1 | | | | | | | | | | |
| Huel Reeth, | 36 inches single, | 7,5 | 7,5 | 11,4 | 3,5 | 26,8 | 3,8 | (9) 28,4 | 3,1 | (33) 25,4 | 2,5 | 25,4 | 3,9 | (76) 29,1 | 5,3 | 23,2 |
| St Ives Consols, | 20 inches single, | 6, | 6, | 13,9 | 10,7 | 24, | 9,2 | (24) 21,4 | 7,4 | (34) 23,9 | 5,5 | 25,2 | 5,4 | (77) 30, | 6,9 | (3) 28,8 |

| Mines. | Diameter of cylinder. | Length of stroke in cylinder. | Length of stroke in pump. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Duty 1823. | No. of strokes per minute. | Duty 1824. | No. of strokes per minute. | Duty 1825. | No. of strokes per minute. | Duty 1826. | No. of strokes per minute. | Duty 1827. | No. of strokes per minute. | Duty to 31st May 1828. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lambo, | 58 inches single, | 8,5 | 7, | 5,2 | 7,4 | 16,8 | | | | | | | | | | |
| Huel Speedwell, | 36 inches single, | 7, | 7, | 9, | 8,8 | 28,3 | 6,4 | (5) 27,3 | 7, | 27,1 | | | | | | |
| Crinnis, | 53 inches single, | 8,5 | 7,25 | 5,5 | 4,4 | 24,1 | 6, | (29) 27,8 | 5,5 | (35) 26,9 | 4,3 | (49) 27,6 | 4,3 | (78) 29,6 | 5,2 | 29,4 |
| | 56 inches single, | 6,75 | 6,75 | 6,7 | | | | | | | | | 4,8 | (3) 26,4 | 5,4 | (87) 24,1 |
| Pembroke, | 60 inches single, | 8,411 | 6,25 | 9,1 | 4,6 | 24,3 | 4,4 | 20,7 | | | | | | | | |
| | 45 inches double, | 8,75 | 6,75 | 19,3 | 4,8 | 28,3 | 5,1 | 24,8 | | | | | | | | |
| | 80 inches single, | 10,25 | 7,25 | 8,6 | | | 6,1 | 32,8 | 5,5 | 36, | 4,3 | (42) 37,9 | 4,3 | 37,3 | 5,5 | 42,5 |
| | 40 inches single, | 9, | 6,5 | 6,1 | | | | | | | | | | | 2,3 | 23,1 |
| East Crinnis, | 60 inches single, | 5,588 | 55, | 11,7 | 6, | 24, | 5,9 | (20) 25,2 | 4,8 | 23.7 | 4,2 | (43) 16,6 | 5,4 | (79) 21,5 | 5,5 | 21,2 |
| | 70 inches single, | 10, | 7, | 2,9 | 3, | (3) 13,9 | 4,9 | (21) 33, | 4,1 | (40) 28,7 | 4,5 | 31,2 | 5,3 | 31,9 | 7, | 36,2 |
| Huel Rose, | 45 inches single, | 8, | 6, | 15,2 | 9,3 | 33,4 | 7,2 | (22) 30, | 5,7 | 30, | 5,6 | (44) 26,2 | 6,6 | (80) 27,8 | 9,6 | 36, |
| Barton, | 40 inches single, | 8,5 | 6,75 | 6,6 | 9, | (1) 28,6 | 10,4 | (23) 29,3 | 8,9 | (36) 37,4 | | | | | | |
| West Huel Rose, | 50 inches single, | 9, | 7, | 3, | 8,6 | (3) 17,5 | | | | | | | | | | |
| Herland, | 80 inches single, | 8,833 | 7, | 3,2 | 12, | (3) 26,3 | 7,1 | (6) 36, | 7, | 36,3 | 4,2 | (50) 39,1 | 4,3 | (1) 35, | | |
| | 80 inches single, | 8,833 | 7, | 3,4 | 10,1 | (3) 20,2 | 5,9 | (7) 33,4 | 4,2 | 37,7 | 4,8 | (51) 40,3 | 6,2 | (3) 36,6 | | |
| Binner Down, | 63 inches single, | 9, | 7,5 | 14,6 | | | 10,1 | 30,2 | 8,1 | (26) 37,1 | 9,6 | (52) 35,3 | 10,3 | (82) 36,9 | 10, | 32,7 |
| | 40 inches single, | 8, | 6,5 | 9, | | | | | 6,6 | 19,7 | 6,8 | 18,6 | 4,8 | (68) 30,2 | 7,8 | 40,6 |
| | 70 inches single, | 10, | 7, | 6,1 | | | | | | | 6,8 | 37, | 9,1 | (71) 40,9 | 8,5 | 55,5 |
| United Mines, | 90 inches single. | 8,75 | 7,75 | 16,5 | | | 7,3 | 28,1 | 5,6 | 35.7 | 3,4 | (38) 34,5 | 3,8 | 34,9 | 6,8 | 35,9 |
| | 30 inches single, | 9, | 8, | 12,9 | | | | | | | | | 6,7 | 26,1 | 6,3 | 32,5 |
| Huel Wentworth, (Woolf's) | 45 inches great cyl. | 7, | 7, | 7,1 | | | 4,5 | 28,6 | 3,8 | 27,6 | | | | | | |
| Great St George, | 60 inches single, | 8,333 | 6,25 | 8, | | | 6,1 | 32,4 | 5,6 | (39) 29, | 5,8 | 31, | 6,1 | (84) 33,4 | 6,6 | 33,6 |
| Huel Busy, | 66 inches single, | 10, | 8, | 11,5 | | | 4, | 23,5 | 3,8 | 31,6 | | | | | | |
| | 70 inches single, | 9,75 | 7,25 | 10,1 | | | 4,2 | 34,3 | 2,9 | 29,8 | 5,3 | 34,8 | 5,7 | 39,7 | 8,3 | (90) 44,4 |
| Polgooth, | 80 inches single, | 10,25 | 7,25 | 7,4 | | | 10,5 | 42,1 | 10,3 | (37) 41,3 | 11,6 | (41) 42,2 | | | | |
| South Huel Treasure, | 26 inches single, | 8, | 6, | 2,87 | | | 3,9 | 9,4 | | | | | | | | |
| Huel Foster, | 53 inches single, | 8,333 | 7, | 7,2 | | | 9,7 | 26,8 | 7,2 | 30,6 | 6,1 | 28,5 | 7,5 | 26,6 | | |

| Mines. | Diameter of cylinder. | Length of stroke in cylinder. | Length of stroke in pump. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Duty 1824. | No. of strokes per minute. | Duty 1825. | No. of strokes per minute. | Duty 1826. | No. of strokes per minute. | Duty 1827. | No. of strokes per minute. | Duty to 31st May 1828. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huel Prosper, | 53 inches single, | 7, | 7, | 4,76 | 4,9 | 22, | 5, | 24, | | | | | | |
| Condurrow, | 40 inches single, | 9, | 7, | 3,9 | | | 2,6 | 13,6 | 21, | (55) 14,4 | 1,9 | (3) 11,6 | | |
| Huel Penrose, | 36 inches single, | 8,5 | 6,5 | 5,13 | | | 3,2 | 17,7 | 3,8 | (54) 21,1 | 5,6 | (69) 23,7 | 7, | (91) 29,8 |
| Huel Hope, | 60 inches single, | 9, | 8, | 5,38 | | | 5,6 | 40,8 | 6,3 | (53) 45,4 | 6,3 | 47,3 | 7,3 | (92) 70, |
| Huel Alfred, | 52 inches single, | 7,666 | 6,75 | 12,4 | | | 5,4 | 27,8 | 5,6 | 42,1 | | | | |
| | 90 inches single, | 10, | 7,5 | 6,48 | | | 5,3 | 41,9 | 5,1 | 30,8 | | | | |
| (Woolf's) | 70 inches great cyl. | 10, | 7,5 | 14,6 | | | 5,6 | 39,9 | 4,2 | 40,4 | | | | |
| Lamin, | 25 inches single, | 7, | 5,5 | 9,9 | | | 5,8 | 22,2 | | | | | | |
| Silver Hill, | 30 inches single, | 7,5 | 6, | 4,93 | | | 4,1 | 17,7 | 6,3 | 18,4 | | | | |
| Huel Tolgus, | 25 inches single, | 6, | 6, | 17,2 | | | 5, | 19, | 6,3 | 23,8 | | | | |
| Huel Sparnon, | 70 inches single, | 10, | 7,5 | 8,88 | | | 6,8 | 38,2 | 5,8 | (57) 37,3 | 6,4 | (3) 35,6 | | |
| Pednandrea, | 70 inches single, | 10, | 7,5 | 9,7 | | | 3,5 | 30,4 | 3,5 | (58) 33,7 | 5, | 33,6 | | |
| North Downs, | 70 inches single, | 9,833 | 7,75 | 7,9 | | | 4,7 | 29,4 | 3,9 | 30,6 | 4, | 31,7 | 6, | 32,4 |
| East Huel Basset, | 50 inches single, | 8,75 | 6,75 | 8,6 | | | | | 7,1 | 33,1 | | | | |
| Poladras Down, | 70 inches single, | 9,5 | 7,25 | 7,1 | | | | | 1,8 | (41) 20,8 | 3,4 | 32,6 | 6,1 | 37,9 |
| Huel Wellington, | 28 inches single, | 6,5 | 6, | 13,9 | | | | | 8,1 | 20,5 | 8,1 | (67) 21,4 | | |
| Huel Fortune, | 45 inches single, | 7,75 | 5,75 | 6,46 | | | | | 5,9 | 23,6 | 7,2 | (72) 25,7 | 8,8 | (93) 31,6 |
| Huel Caroline, | 30 inches single, | 7,5 | 6, | 7,29 | | | | | 9,4 | (1) 25,6 | 9,8 | (73) 25,7 | 10,9 | (94) 27,5 |
| Huel Trevoole, | 30 inches single, | 9, | 7, | 9,7 | | | | | 10,4 | (1) 24,7 | 6,1 | (74) 26,4 | 8,8 | (95) 39,8 |
| Great Work, | 60 inches single, | 9, | 7, | 11,8 | | | | | 3, | (3) 24,3 | 4,2 | (75) 34,9 | 7,4 | 36, |
| United Hills, | 58 inches single, | 8,25 | 6,5 | 6,2 | | | | | 3,8 | 24,3 | 3,2 | 23,7 | 3,7 | 23,1 |
| Huel Maiden, | 63 inches single, | 10, | 7,5 | 13,7 | | | | | | | | | 3,6 | 32,6 |
| Balnoon, | 30 inches single, | 8, | 7, | 5,6 | | | | | | | 3,2 | (3) 19, | 3,3 | 19,2 |
| East Huel Unity, | 45 inches single, | 8,75 | 6,75 | 8,38 | | | | | | | 3,8 | 15,2 | 5,4 | 23,5 |
| Perran Mines, | 38 inches single, | 6,75 | 6,75 | 14,27 | | | | | | | 6,5 | (3) 26, | 7,2 | (86) 24,7 |
| Lelant Consols, | 15 inches single, | 7,5 | 4,5 | 12,3 | | | | | | | | | 3,1 | (41) 12,3 |
| Huel Penwith, | 40 inches single, | 8,75 | 7, | 3,75 | | | | | | | | | 6,5 | (41) 16,2 |
| Huel Towan, | 80 inches single, | 10, | 8, | 4,55 | | | | | | | 3,6 | 48,9 | 4, | 50, |
| | 80 inches single, | 10, | 8, | 9,36 | | | | | | | 7,3 | 58,1 | 6,8 | 77,1 |

NOTES.

| No. | Note | Value |
|---|---|---|
| 1 | 4 months only. | |
| 2 | On Sims's construction. | |
| 3 | 2 months only. | |
| 4 | Load reduced to | 2,6 |
| 5 | augmented to | 16,8 |
| 6 | | 9, |
| 7 | | 7,1 |
| 8 | diminished to | 7,8 |
| 9 | augmented to | 12,5 |
| 10 | | 19, |
| 11 | | 17,1 |
| 12 | and put to work single. | 16,9 |
| 13 | Load augmented to | 17,1 |
| 14 | | 12,76 |
| 15 | | 4,7 |
| 16 | | 11,7 |
| 17 | | 11,1 |
| 18 | | 11,6 |
| 19 | | 6,6 |
| 20 | | 15,1 |
| 21 | | 5,3 |
| 22 | diminished to | 11,7 |
| 23 | augmented to | 8,7 |
| 24 | | 18,4 |
| 25 | | 3,7 |
| 26 | | 16,7 |
| 27 | | 10, |
| 28 | | 9, |
| 29 | diminished to | 11,1 |
| 30 | augmented to | 13,2 |
| 31 | | 11,1 |
| 32 | | 8,2 |
| 33 | Load augmented to | 14,4 |
| 34 | | 25, |
| 35 | diminished to | 10,9 |
| 36 | augmented to | 7,4 |
| 37 | diminished to | 4,69 |
| 38 | | 7,9 |
| 39 | augmented to | 10,3 |
| 40 | | 6,9 |
| 41 | For one month only. | |
| 42 | Load augmented to | 11,3 |
| 43 | diminished to | 4,2 |
| 44 | augmented to | 15 7 |
| 45 | diminished to | 3, |
| 46 | | 5,9 |
| 47 | altered to single. | |
| 48 | Load augmented to | 13,2 |
| 49 | | 14,8 |
| 50 | | 11,9 |
| 51 | | 9, |
| 52 | diminished to | 12,5 |
| 53 | augmented to | 7,4 |
| 54 | | 7,25 |
| 55 | | 5,4 |
| 56 | diminished to | 5, |
| 57 | | 6, |
| 58 | augmented to | 10,5 |
| 59 | diminished to | 7,9 |
| 60 | augmented to | 11,7 |
| 61 | | 11,5 |
| 62 | | 21,5 |
| 63 | diminished to | 9,5 |
| 64 | augmented to | 6,2 |
| 65 | Load augmented to | 20,1 |
| 66 | | 24,7 |
| 67 | | 15,7 |
| 68 | | 10, |
| 69 | | 9,9 |
| 70 | | 6,6 |
| 71 | | 10,1 |
| 72 | | 9,1 |
| 73 | | 21,8 |
| 74 | | 14,3 |
| 75 | | 8,9 |
| 76 | | 15,2 |
| 77 | | 14,5 |
| 78 | | 16,6 |
| 79 | | 9,4 |
| 80 | | 18,9 |
| 81 | | 14,2 |
| 82 | reduced to | 8,2 |
| 83 | augmented to | 6,1 |
| 84 | reduced to | 9,4 |
| 85 | augmented to | 12,6 |
| 86 | | 16,4 |
| 87 | | 9,6 |
| 88 | | 14,2 |
| 89 | diminished to | 8,2 |
| 90 | augmented to | 11,4 |
| 91 | | 11,2 |
| 92 | | 9,4 |
| 93 | | 10,2 |
| 94 | | 24,2 |
| 95 | | 20,1 |
| 96 | | 8,5 |

It has been before observed that the engine reports are deficient in some important respects.

In 1823 there were 55 engines at work in Cornwall, performing on an average 26,9 millions.

| | | |
|---|---|---|
| 1824, | 57 | 28, |
| 1825, | 62 | 28,97 |
| 1826, | 63 | 28,36 |
| 1827, | 62 | 31,9 |
| 1828, | 60 | 34,85 |

## Art. VIII.—*On the Electrical Properties of the Tourmaline.** By M. Becquerel.

Philosophers attribute to molecular attraction an electrical origin, though they are still ignorant where the electrical forces reside by which it is produced. Among the hypotheses, more or less ingenious, contrived for explaining this mystery, there is one which considers the atoms of bodies to be endowed with electrical properties analogous to those which heat developes in the tourmaline. This manner of viewing it rests solely upon conjecture; and in order to verify it, since we cannot isolate an atom in order to study its physical properties, we must examine with the utmost care all the electrical modifications which the tourmaline exhibits when its temperature is varied, as well as the laws which regulate them, and see if it be not possible to draw inferences more or less favourable to an electro-chemical theory. Such is the philosophical object which I had in view in the researches which I have undertaken upon the tourmaline.

The electrical properties of this remarkable stone have for a long time engaged much attention. Some philosophers have even asserted that it was known to the ancients under the name of *Lyncurium*, given to it by Theophrastus; but upon examining with attention the characters assigned to it by this philosopher, we can find none which belong to it in particular. It is known for certain, however, that from time immemorial it was observed in India and in the Island of Ceylon, that this stone, when thrown into the fire, had the property of attracting the cinders. The Dutch, to whom the natives of the country showed the phenomenon, were the first who made it known in Europe. Lemery, in 1717, presented to the Academy of Sciences a tourmaline brought from Ceylon, which possessed the property, he said, of attracting and repelling light bodies. More recently the Duke of Noya, Æpinus, Wilson, Priestley and other philosophers examined the attractive power of this stone. Many of them obtained contradictory results, which

* Read to the Royal Academy of Sciences, 14th Jan. 1828. Translated from the *Annales de Chimie*, Jan. 1828. tom. xxxvii. p. 1. See this *Journal*, No. 16, p. 365.

were the subjects of very long discussions. It was thus that Æpinus asserted, that if, one side was heated more than the other, they each acquired an electricity opposite to that which was natural to them; while Wilson maintained, that, when the sides of the tourmaline were heated unequally, that side which had the highest temperature took the electricity which was proper to it, and transmitted it to the other side. A contradiction so palpable must result from a difference in the manner of making the experiments. They attempted to remove it by making new experiments, but not succeeding, they each thought they were in the right, and employed themselves no longer on the question, which since then has ceased to attract the attention of natural philosophers.

At that period tourmalines, which were only procured in India, were rare in Europe; and hence the same stone passed in succession through the hands of Canton, Æpinus, and Priestley, in order to study its properties. At present they are very common, since the discovery of a stratum in Spain which contained a great quantity of them. Canton, in a paper read to the Royal Society of London in December 1759, asserted, to use his own expression, that the tourmaline neither emits nor absorbs the electrical fluid but by the increase or diminution of the heat. This fact, which should have fixed the attention of philosophers, has been entirely forgotten.

The same philosopher has added another important fact to the theory of the tourmaline, by showing, that, if a crystal is broken at the moment when it is electrical, each piece possesses equally two poles, in such a way that the two separate parts are in two different electrical states. He has also discovered that the topaz of the Brazils, and many other crystallized mineral substances, possess electrical properties analogous to those of the tourmaline. In the treatises on natural philosophy there is very little said about the tourmaline. Even M. Haüy, who attaches great importance to the physical characters of mineral substances, on account of the application which he made of it to mineralogy, his favourite science, has given but an incomplete theory of the tourmaline. He has, however, discovered one important fact, that the crystals which derogate from the laws of symmetry in the configuration of their summits are electrical by heat.

I have thus, I presume, given a summary of all that has been observed respecting the properties of the tourmaline down to the present time.

I commenced my inquiries by observing what took place in a tourmaline, 1*st*, when all its parts were equally heated or cooled at the same time: 2*d*, when one of the sides received more heat than the other, whether this heat was increasing or decreasing. I first suspended the stone in paper by a single silk fibre, which descends into a glass vessel placed in a basin of iron filled with mercury, and the temperature was then raised by a spirit-lamp, upon which it was placed. In proportion as the interior of the vessel became heated, the temperature of the tourmaline was raised, and, as it was very easily set in motion from its mode of suspension, the slightest signs of electricity were quickly observed. A thermometer placed at a short distance from the tourmaline indicated its temperature. With this apparatus I obtained the following results: At 30° Centigrade, the electrical polarity began to be sensible at the approach of a feebly electrified body, and it continued as far as 150°, and beyond it, provided the temperature continued to rise; for if it was stationary an instant the polarity disappeared immediately, so that there was no appearance of electricity as long as the temperature was constant; but the moment it diminished, the polarity reappeared, but of an opposite character. The pole which was originally positive became negative, and *vice versâ*. These effects always took place at whatever time the elevation of the temperature was arrested. The time of the passage from one polarity to another was very short.

From this one would think, that the electrical intensity of each pole was proportioned to the quickness of the heating or of the cooling; but it does not appear to be so. In order to observe what will happen, it is necessary to measure the electrical intensity at any epoch whatever. This is done by placing in the interior of the vessel of glass containing the tourmaline, and at a little distance from each of its extremities, two vertical rods of iron, each communicating with one of the poles of a dry pile, whose electrical intensity may be considered as constant, during the space of one hour, especially if care be taken to keep it from the action of heat.

As soon as the tourmaline is become electrical, it is placed between the two rods, the opposite poles being placed together; and if it is shifted from this position, it returns by a series of oscillations, of which the number in a given time will serve to determine the intensity of the electricity. The following table contains several results:—

| Temperature of the Tourmaline. | Duration of the oscillations. | Number of the oscillations. |
|---|---|---|
| 100 | 30 | 6 |
| 90 | 30 | 10 |
| 80 | 30 | 13 |
| 70 | 30 | 15 |
| 60 | 30 | 15 |
| 50 | 30 | 15 |
| 40 | 30 | 14 |
| 30 | 30 | 13 |
| 20 | 30 | 7 |

The temperature had been raised to 115°; at 105° the tourmaline, although it had been electrical before, began to fix itself between the two vertical rods which communicated with the dry pile; at 100° the oscillations were measureable. The preceding results prove that from 115° to 100°, the time when the cooling is the greatest, the electrical intensity increases very slowly; that from 100° to 70° the increase is rapid; that from 70° to 40° it is stationary; from 40° to 20° it diminishes nearly in the same proportion at which it had increased from 100° to 70°. The electrical polarity disappeared altogether at 15°, although it had began at 30°. Several tourmalines have given similar results. We see, then, that the electrical intensity of each pole is not caused by the suddenness of the cooling. If it is easy to measure the electrical intensity of the tourmaline during its cooling, it is not so during the elevation of the temperature; for although the polarity be then sufficiently strong, it is not, however, strong enough to enable us to determine the difference of intensity which arises from the increase of temperature, by employing the method of oscillations.

Hence we see that there exists a marked difference between the mode of action of the developement of electricity during the increase of temperature, and that which takes place during the cooling. In both cases the temperature varies every instant.

The most delicate experiments seem to show that the tourmaline, while it is electrified, allows none of the electricity to escape, nor takes any from surrounding bodies. The effects are produced by the separation of the two fluids in each particle. In order to prove that there is no discharge of electricity from the tourmaline, it is necessary to place upon the upper plate of an excellent condenser of Volta, a plate of copper of a high temperature, and place it below one of the extremities of the stone. Some moments after, upon separating the plates, no accumulation of electricity will be found.

After having studied what passes in a tourmaline of which all the parts are equally heated and cooled at the same time, I now proceed to examine what takes place when one of the sides receives more heat than the other.

Æpinus and Wilson, as I said before, were much occupied with this question. The contradictory results at which they arrived may be easily explained. To analyse the electrical effects which are exhibited, we must first of all observe if the temperature is increasing or decreasing in the side where it is applied; for the results vary in each case. This is known by inclosing each end of the tourmaline in a little tube of glass, the ends of which are melted by the blowpipe that they may fit exactly; it is then fastened by its middle to a tube of glass by a thread of platina. If one of the extremities which is not fitted in one of the little tubes be heated, for instance that which corresponds to the side positive by cooling when the temperature is everywhere the same, and which I represent by P, this side will at first be heated at the expence of the tube, will take the same temperature as it, and will then cool in the same time. In the first case, whilst the temperature does not begin to rise at the other extremity, which I call N, all that part P will be electrified negatively, and the other will be in the state of zero. The tourmaline then possesses but a single electricity. We know this by presenting successively all the points of the tourmaline to the little tinsel discs of the electroscope of Coulomb, charged alternately with positive electricity and negative electricity.

Its state of electricity is then sensibly the same as that of a Voltaic pile of which the positive pole is in communication with the earth; because the negative electricity goes on diminishing to the opposite pole. This effect is only produced when the temperature goes on decreasing, and the side opposite to that which has been heated has not attained sufficient temperature to develope also electricity. In the pile only one sort of electricity is obtained every time that one of the poles communicates with the common reservoir; it is not so, however, with the tourmaline, which neither gives out electricity nor takes it from surrounding bodies. This fact is in contradiction to our present knowledge of the developement of electricity, which is never found except in two fluids. It follows, then, that in this case there must be one masked or absorbed by the air. but I have never found this indicated by the most delicate observations. It is certain, however, that a single kind of electricity can be produced from one of the sides of a tourmaline without the other acquiring any; and consequently, without our considering the state of this last as transitory, that is to say, passing from one electrical state to another.

I have supposed that the side N had not yet acquired a sufficient temperature to produce any electrical effects; but if it continued to increase, the side would acquire the positive electricity which it should have had if the temperature had been equally increasing in the whole tourmaline.

I return now to the side P, whose temperature I have supposed to be increasing. As soon as it is become stationary its electricity ceases, and afterwards begins again in an opposite direction, when it decreases. At the same time, the side N, according to the temperature, will be at zero, or possessing electricity positive or negative. I conclude from all these facts, that when the two sides of a tourmaline are heated unequally, each of the two acquires an electrical state independent of the other, and is such, that, if the side P for instance has a temperature at first increasing, then stationary and decreasing, it will become negative, zero, and positive. The side N, under the same circumstances, that is, if its temperature be increasing, stationary or decreasing, will have a contrary electricity. The electrical state of each side then will be the same as if all the stone possessed the temperature corresponding to this side.

I have examined before a case where the temperature was increasing at the extremity of the side P, and stationary at the opposite end. To accomplish this we must put the end N into a little tube filled with ice, and cemented to the tourmaline.

After the facts which I have related, we cannot explain chemical actions by admitting in the atoms electrical properties analogous to those which heat developes in the tourmaline; for as electrical polarity does not exist but when there is an elevation or diminution of the temperature, the combinations would cease of themselves at the moment when the temperature becomes stationary. By supposing even a permanent polarity in the atoms, we cannot see how the electrical modifications by the increase of heat, analogous to those which are observed in the tourmaline, could produce the effects due to affinity.

I do not pretend to explain in this paper how the atoms become electrical, or if they possess a permanent electricity. My object has been to study the electrical properties of the tourmaline, and to prove that it is not possible to establish an electro-chemical theory, by considering the atoms of bodies like little tourmalines, or possessed of analogous properties.

Since writing this paper, I have heard of a work of Bergman upon the tourmaline, which has been nearly forgotten. I shall speak of it in my next paper, in which I shall explain some new researches.

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ART. IX.—*Account of an Ancient Vessel recently found under the old Bed of the river Rother in Kent, and containing the bones of men and animals.* In a Letter from WILLIAM M'PHERSON RICE, ESQ. F. S. A. late of the College of Naval Architecture at Portsmouth, addressed to HENRY ELLIS, ESQ. F. R. S. Secretary. *

THE late discovery of a vessel under the ancient bed of the river Rother having given rise to various conjectures and contradictory statements, respecting her age and former service,

* From the *Archaeologia*, vol. xx. p. 553. Lond. 1824.

and the subject being of some interest in naval architecture, I was directed by Sir Byam Martin, at the request of Lord Melville, to repair to the place where she was found, and to obtain a true account of her build and situation, in order, if possible, to ascertain the country she belonged to, and the period of her submersion. My report has been subsequently transmitted to the Admiralty; and, at the suggestion of Mr Barrow, I have taken the liberty of addressing to you a letter, containing the substance of that report; and should the subject be compatible with the regulations as to papers usually read at the Society of Antiquaries, it will afford me much satisfaction if you will do me the favour to introduce it at the ensuing meeting.

The site of the vessel is in the level of East Matham, in Kent, near Matham Wharf, under the bank of a stream or sewer, running into the present river Rother, to the west of the Island of Oxney. She was accidentally discovered, and subsequently dug out, by a person of the name of Elphee, a poor man in the employ of J. Pomfret, Esq. to whom the adjoining land belongs, and with whose permission, and the sanction of the Commissioners of Sewers, the excavation was undertaken.

Mr Elphee informed me, that part of the covering to the after-cabin used to be visible in the side of the bank, when the water in the channel was very low, and about six years ago he took some planking up (thinking at that time that it had been part of an old sheep-wash), which he applied to the repairs of a cart-shed, and some paling; and in the early part of July last, having occasion for some wood for a similar purpose, he drew up a piece, which, from its shape and peculiar fastening, led him to imagine that a vessel must have been sunk there. Having confirmed the surmise by partially digging along the bank, he communicated the discovery to several gentlemen, by whose advice and assurance that he should be at no risk of loss in the event of its proving a bad undertaking, he dammed up the channel, and commenced the work; and in a few days, after digging through ten feet of sea sand, the whole of the vessel was exposed. See Plate I. Fig. 2.

Her principal dimensions are as follow:—

| | ft. | in. |
|---|---|---|
| Length - - - - - - - | 63 | 8 |

| | ft. | in. |
|---|---|---|
| Breadth - - - - - - | 15 | 0 |
| Height of foremost beam from flat of inside planking, | 4 | 11 |
| Height of midship beam from the same, - - | 4 | 2 |
| Height of the after beam, - - - - | 4 | 7 |
| Height of the bulwark above the beams, - - | 1 | 2 |

above which were wash-boards.

She is built entirely of oak, which is perfectly sound, and very hard, but much blackened; her head and stern are sound, and framed nearly alike, but in a very rude manner; stem and sternpost nearly upright; flat-floored, and clinker built. The planks riveted together with iron, and fastened to the timbers with oak treenails, wedged at both ends with wood of the same nature, which is now quite as hard as, and bears much the appearance of ebony. The planks, inside and out, are $1\frac{3}{4}$ inch thick, and some of them of surprising dimensions; one on the starboard side, forward, is 18 feet 10 inches long, 2 feet 5 inches broad at the fore-end, and 1 foot 9 inches at the after-end; another, on the larboard side aft, is 18 feet 7 inches in length, and 2 feet 5 inches and 2 feet 7 inches broad at its extremities, and from its texture certainly not of British growth.

The beams, of which there are five principal ones, are very ingeniously scarphed and put together, and fastened to the sides with bolts, not unlike our "dog bolts," excepting that the plate is secured to the beam with staples instead of bolts; their mean scantling is $5\frac{1}{2}$ by 1 foot 6 inches.

There is a step for a mast, at about one-third of her length from forward, on the *foreside* of the beam; but no part of the mast has been discovered; there is evident proof also that she had had a bowsprit, which has been carried away, the step being visible in the foremost beam, and the head of the stem a little hollowed as a bed; the cable passed over the gunwale, the grooves for which are not much rubbed; neither cable nor anchor have been found; some pieces of cordage were taken out of the after-cabin, in a very decayed state, the strands of which appeared to have been laid in the manner at present practised.

The caulking material is *moss*, and the sides of the vessel are payed with a thick coat of tar or some composition, which, since its exposure to the atmosphere, is entirely decomposed, and falls off as dust on the slightest touch; the seams and projecting edges of the planks are filled with pitch, which remains almost in its original state. The iron which has been exposed to the action of moisture is very much enlarged by oxidation, and breaks with facility, but in all cases where covered with pitch, it is most perfect, and not in the least corroded. This is an important fact.

It is much to be regretted that many of the contrivances and fittings have been disturbed, and either destroyed, or so mutilated as to make it impossible to restore her to the state in which she was first found. There were originally two short decks; the one aft remains, that forward has been taken up; the opening between the deck aft and the next beam was covered with a kind of arched tilt, beneath which was probably the place for cooking, from the situation of the fire-place and the utensils found there.

The space between the after-beam and the deck forward was open; but several stanchions were found standing morticed upon the beams, from which it is obvious that there had been a covering over this part of the vessel also; and from some rabetted boards inclining inwards and upwards, still attached to the sides, we may conclude, that the covering was either arched, or met at an angle in the centre like a roof.

There are carlings at the sides, and scores in the beams in midships, evidently to receive a covering, but no gratings or hatches have been found.

The manner in which the rudder was managed is rather curious, and I owe it to chance that I discovered the method. In examining some pieces of wood which had been taken from the vessel, I observed a beam of singular construction that had been removed from the topside aft, and by some bevelling scores in its ends it was clear that a plank sheer had dropped into them, which was afterwards found and replaced.

A dumb roller is turned upon the middle of the beam, and on each side of the sternpost, and at about a foot below the gunwale are two holes through the side of the vessel, and one also in the after part of the rudder, through which most probably the rudder was yoked. I cannot tell exactly in what way the fall of the steering-rope was traversed, but I imagine there were two distinct ropes, a round turn being made over the roller with the one by which the rudder was governed.

The vessel was floated on the 27th of August. I was on the spot at the time, and in digging a water course towards the dam in the channel abaft her, to admit water into the basin formed by the excavation, a small boat was discovered at about sixteen feet from the stern of the vessel. She appeared to be a wreck, the after part being gone. I ascertained the dimensions of this boat as nearly as I could; (the water was at this time flowing in from the channel forward); her length was about 15 feet, breadth 5 feet, flat floored, and very shallow; the timbers very stout, and few in number; they were generally about 3 feet apart; the planks from $\frac{3}{4}$ to 1 inch and $\frac{1}{2}$ thick; clinker built, and fastened with iron rivets, and no inner sheathing. The seams were caulked with *hair*,* which is not in the least perished; the wood is also in a high state of preservation, but very black. She fell to pieces on attempting to remove her.

From what has been now stated, Sir, there will be no difficulty in pointing out the country she belonged to. The housing, or roof spoken of, is, I believe, although common to barges of all countries, more peculiar to the Dutch.

The Earl of Romney, whom I met at the vessel, did me the favour to mention several peculiarities which he had observed about her, when she was first opened, and which I should otherwise have been ignorant of, as many of them were destroyed prior to my seeing her. He pointed out the situation of

* When on duty at Sheerness dock-yard, I collected several specimens of wood taken from the old ships which have been dug out in the progress of the works carrying on there; and it may, perhaps, be worthy of remark, that among them I found a piece of oak plank with some *hair* adhering to its edge,—a proof that hair had been used as the caulking material for that ship. I have not been able to ascertain if she was of English or foreign build; but Mr John Knowles of the Navy Office obligingly informed me, that these ships were laid aground in the time of Charles II. and in one or two subsequent reigns, and served, some as break-waters, and others as residences for the artificers employed in that establishment, which was then in its infancy: and we find that in his work on the "*Preservation of the Navy*," that *hair* was used in caulking for a long series of years in his Majesty's Navy, and was not discontinued till 1791.

some rings just abaft the mast, on each side of the vessel, to which the straps of the dead eyes were fastened. This mode of securing the dead eyes is peculiar to Dutch vessels.

His Lordship thought she resembled the build of the Hamburgh keels, and observed, that "*moss* is frequently used as the caulking material in the *East* country ships."

A hand-lead having been found in her, renders it probable that she had been a sea-going vessel; and from the situation of the mast-step, it is reasonable to conclude that the mast was fixed; under such circumstances, she could not have been for inland navigation.

From these facts, and from several articles found in her of Dutch manufacture, particularly some rude earthen vases and tiles (which formed the fire hearth), there was little reason to doubt that she was Dutch; but there is nothing in her form, nor has there been any thing found in her, with the exception of the handle and hilt of a sword, that would create a suspicion that she had been a vessel of warfare.

It may perhaps be worthy of observation, that ancient vessels were usually propelled by oars as well as sails; and we find also that galleys were in common use in the reign of Henry VIII. and even up to the time of James I. The vessel in question is of a totally different construction, and shows no signs of having been rowed; but no inference can be drawn from this as to date, since galleys were not the only description of vessels in use. Concluding, therefore, that she was a DUTCH TRADING VESSEL, it becomes difficult to form any idea of her age from the style of her architecture, which, for this kind of vessel, admits of but little variation; and which probably has not materially changed for ages, whilst the contour and equipment of fighting vessels must necessarily have varied with the modes of warfare.

Amongst the sketches which I have forwarded for your inspection, permit me, Sir, to direct your attention to the representation of a *plate of hard lead or pewter*, which was attached to the side of the vessel, at about 15 feet from her stern, bearing two characters (𝔭𝔦) of the black letter, very neatly and distinctly stamped. A similar plate was found on the opposite side, but so much oxidated and battered, that it was impossible to decipher the characters on it.

The lines on a piece of oak slab are very curious, and probably a merchant's mark; but I am at a loss to know if it consists of definable letters or characters, or merely hieroglyphics.

Various articles were found in the after-cabin: such as a circular board of oak, with twenty-eight holes through it, which probably had been used as an almanack or score table; two earthen vases of a reddish brown colour, glazed inside, and standing upon three feet, and of the capacity of 5 pints each; another vase of a dark slate colour, with similar legs, unglazed, and about the measure of 17 pints; all of which had evidently been used on the fire for cooking: a stone jug, very rudely formed, holding rather more than a pint; several bricks of curious manufacture, and some pieces of glazed and ornamented tiles, set up as a fire-hearth; a sounding-lead of an octangular form, about eight inches long; and a small glass bottle of ancient and singular shape, 3 inches in height.

Some human and other bones were found in the cabin; and part of the skull of a child, with a thigh and several smaller bones have been preserved, together with parts of a skeleton of a grown person. In the midship part were found the thigh and leg bones, and several vertebræ of the back-bone of some large animal, thought to be a horse or cow, the horns and part of the skull of a sheep or goat, and the lower jawbone of a boar, with its teeth and tusk; no other part of this last animal was found, so that most probably these were a part of the provisions of the vessel, as also the breast-bone of some large bird. Near the vessel, in the sand, was dug up a human skull, very black, with other parts of a skeleton; and by the side of it, the skeleton of a dog, the skull and a few small bones of which have been preserved.

Several shoes or sandals were found, both in and round about the vessel; among which is a child's slipper, of an unusual shape, with a cork sole; but of the various articles found of this kind there are none which give a clue to any date.*

* The finding of this slipper has by some persons been adduced in argument against the vessel's antiquity; but it is well known that cork was used for this purpose among the Romans in winter. Pliny says, the women more especially used cork soles in winter:—

" Usus præterea in hiberno feminarum calceatu.'

At whatever period this vessel may have sunk, there are strong grounds for supposing that she was *wrecked;* the loss of mast, bowsprit, anchor, and cable, the wreck of the boat, and the human bones found in and near her, are sufficient proofs; but what renders it still more convincing is a hole stove through her bottom forward. And in the fire-place in the cabin was found a conglomerated mass of cinders and charred wood, which proves that the fire must have been extinguished suddenly, or the wood would have mouldered to ashes. Hence, Sir, we may conclude that she was overwhelmed by some convulsion of nature, from which circumstance, and the changes that have taken place in the course of the river Rother, which I shall presently show, we may yet arrive at the probable time of her loss.

By various historians it appears, that at a very early period the river Rother, which takes its rise in the parish of Rotherfield in Sussex, emptied itself at New Romney, the Lemanis of the ancients. At the period of the Norman conquest it issued to sea between Romney and Lydd, at a manor now called North Lade (a Saxon word for an opening to the sea,) and the trench which constituted the body of the river from the Rother at Appledore to the sea at North Lade, through Romney Marsh, by the sea dike called the Rhee Wall, is now distinctly to be traced. This bed of the river was granted by Queen Elizabeth to the corporation of Romney, and by that body it was lately sold for the redemption of the land-tax.

In the reign of Edward the First, about the year 1287, in consequence of a dreadful storm, when the town of Winchelsea was destroyed by the rage of the sea, the mouth of the Rother at Lydd was stopped, and the course of this river diverted into another and nearer track, by Appledore, into the sea at Rye; and by the flux and reflux of the sea, the old channel became so swerved up that, about the time of Queen Elizabeth,* it was scarcely navigable above Rye town for ves-

* "Yet now it (Rye) beginneth to complain that the sea abandoneth it (such is the variable and interchangeable course of the elements,) and in part imputeth it, that the river Rother is not contained in its channel, and so loseth its force to carry away the seas and beach, which the sea doth inbear into the haven."—*Hayley's Manuscript Collections relating to Sussex.*

sels of burden; and higher up, the river was so choked and contracted, that the waters could not find sufficient passage in it, and by documents in the possession of Mr Dawes of Rye, one of the commissioners of the levels (to whom I am very much indebted for civility, and for the assistance afforded me in pursuing this inquiry,) I find that in 1623 a complete stop to the navigation of the Appledore channel was made at Thorney-wall, which is pointed out on the map which accompanies this letter.

It appears, moreover, that that stop has never been removed for the purposes of navigation, since lightermen were allowed a tonnage for carrying goods over the stop; a sluice was afterwards formed at Thorney-wall, simply for sewing the adjacent lands. In May 1635 the navigation higher up the Rother was very much impaired by a former breach made in Spits-wall and Knolls-dam (which is some distance above Matham-Wharf,) being *then* as low as the bottom of the channel, which made the waters of the upper levels forsake that part of the Rother where the vessel has been found, turning them through Wittersham-level. It was now feared there would be no navigation at all between Appledore and Bodiam, and three pens were in consequence put down in the cuts at Spit's-wall, so that the waters might again be turned into their old tract, and discharge themselves as before at the sluice at Appledore; but in October 1635 these pens were taken up, that the waters of the Rother might have a free run into Wittersham-level; and in July 1636 the turning of the river through this level was completely effected; since which time there has been no navigation between Knolls-dam and Matham-wharf, *which limits include the vessel*, and the channel has been used only as a *sewer* for the lands in East Matham-level. And it is further stated, that at the commencement of the works connected with the new channel, "the former navigation upon the Rother was daily decaying; so much so, that, had not the works in Wittersham-level been undertaken and perfected, the navigation upon the Rother had before that time (July 1636) been lost."

To recover, however, a navigable stream from Thorney-wall to Small-hythe, a dam was laid down at the latter place, to keep up the waters between the two places; but the navigation never extended in any shape further then Thorney-wall, since the sluice was laid there in 1623.

It is certain then that the vessel must have perished *prior to* 1623.

And since it appears that for many years before, the Rother had been decaying and gradually becoming, from the accumulation of mud and silt, "scarcely navigable," or even deep enough to sew the waters, it may be inferred, that, from the great depth at which she lay buried in mud, or rather *sea sand*, she must have been there very many years *anterior to that period*, for had she not been below the bed of the river at that time, she must have been discovered; and it is not likely that the commissioners would have allowed her to lie there to be an obstruction to navigation and sewage, when, "previous to 1623, the sum of L. 20,000 had been expended in endeavouring to drain the upper levels in and by the old course of Apuldore."

There is another material fact, which proves, that, at the time the vessel foundered, the river at that place must have been of *considerable breadth*; for in addition to the vessel lying under the bank, a log of oak, roughly hewn, 40 feet long, and about 22 inches square, was found on the larboard side of the vessel, one end of which rested on the gunwale, and the other lay nearly at right angles to her length, upwards of ten feet under the bank; another log was also excavated by the side of the former but above eight feet from the vessel; these logs must have unquestionably drifted and lodged against her.

Having thus far, I trust, Sir, established a *limit*, since which the vessel could not have navigated, I shall proceed to state a few facts relative to the state of the river at a very early period.

"In the 14th of Edward IV. A. D. 1475, certain commissioners were appointed to view, report on, and repair the banks of the Rother, which were much broken and decayed, by the frequent incursions of the sea, and the violence of the tides.*"

And "a charter or letters-patent were granted, and directed to certain knights and other person of quality in the 2d year

* *Hayley's MSS. Collections relating to Sussex.*

of Henry V. (1415) to repair the breaches past, and for preventing the like for the time to come, between Rye and Bodiam Bridge;" and in the intermediate reigns between Edward the First and this period, I find continual documents to the same effect; particularly in the early part of Edward the Third's reign, where, "by letters-patent granted, some new banks were raised which thwarted this river, and prevented such vessels and boats as used to pass on it with victuals, and other things from divers places in Kent and Sussex to Ichingham, and were likewise of the greatest prejudice to the market town of Salehurst, which had been supported by the course of this water. The king afterwards revoked these letters-patent, and commanded those banks to be demolished."

It appears also, that "the tide at this time ebbed and flowed above Newenden," (which is about two miles higher up the river than the site of the vessel,) "and the stream was so strong, that the bridge there was broken and demolished by it, and the lands on each side the river were greatly overflowed, and much damaged by the salt waters."

In the reign of Edward the First an action was brought by the Abbot of Robertsbridge, against the Lord of the Manor of Knell, for inclosing salt marshes from the sea, whereby barges and boats were hindered from bringing up provisions and merchandise, to the market of Robertsbridge.

I have taken much pains in searching those authors who have given the best information respecting the changes which have taken place on the coast of Sussex and the neighbouring coast of Kent, in order to get together the æra of the most remarkable floods and tempests which have happened within these parts within the last five or six hundred years.

Hayley, in his collections for Sussex, states that "in the 12th of Elizabeth chanced a terrible tempest of wind and rain, both by sea and land; the waters came in so vehemently at Rye, that they brake into the marshes and made such way that, where of late years and now before this great flood came, a *cockboat* could not pass in at low water, now *a fisherman* drawing six feet water and more may come in."

This shows the state of the *mouth* of the haven at that period; and as I have given clear proofs that the river was decaying and contracted higher up at a very early period, and also shown that at the period when the vessel foundered, it must have been of considerable breadth at Matham-wharf, which is ten miles from the sea, I think this tempest rather *favours*, than makes against the speculation for her antiquity.

Many other general tempests and storms have been recorded by various writers, but we read of none that have particularly affected this part of the country until the period before cited, when, by a great convulsion of nature, Winchelsea was swallowed up by the sea, and the whole face of the country changed. This storm is mentioned by all the historians of Kent. Stowe in his *Chronicles* thus states it: "In 1287, on new-year's-day at night, as well through the vehemency of the wind as violence of the sea, divers places in England adjoining the sea were flooded, so that an intolerable multitude of men, women, and children were overwhelmed with the waters;" and Somner in his "*Treatise on the Roman Ports and Forts*," says "About 1287, the sea raging with the violence of winds overflowed and drowned Promhill (near Lydd, a town at that time well frequented, the lands where the town stood are now called Broomhill), and made the Rother forsake its channel, which before emptied itself into the sea at Romney, and stopped its mouth, opening a new and nearer way to pass into the sea by "Rhie," now called Rye; and afterwards fell into the Appledore waters, wheeling about, and running into that arm of the sea or estuary insinuating into the lands by Rye." By Jeaks's Charters also we learn, that Winchelsea was drowned in the 16th of Edward the First.

I have now arrived at a period beyond which, speculation becoming more and more doubtful, I am backward in hazarding an opinion; and since history does not furnish us with the æra of any violent or destructive storm on this coast, for very many years prior or subsequent to the one above-mentioned, I shall conclude this letter, leaving it for others to determine, from the facts here stated, as to the probability of the vessel having perished in or before that great tempest, or at a period between that and the storm which took place in the reign of Queen Elizabeth.

Art. X.—*On the Expansion of Vapour.* By Richard Tregaskis, Esq. of Perran, near Truro. Communicated by the Author.

Experiments on the elastic force of vapour in contact with water at high temperatures are attended with difficulty, considerable expence, and some danger. Hence few experiments have been made on steam beyond the temperature of 343° of Fahrenheit under a column of mercury. Even at this temperature steam supports a column of mercury 20 feet in height.

The great difficulty attending experiments *above* this height (which is equal to eight atmospheres) renders it particularly desirable that some correct method be given for the calculation of force by temperature, founded on accurate experiments made *below* it.

Temperature and force increase, it is believed, in some geometrical progression, but their ratios respectively have not been published;—perhaps they are not known. If they increased in the same ratio,—if double the sensible heat would generate exactly double the force,—there would be no difficulty in calculation. But as the increase of force and temperature are very different, a different ratio is required for each factor, and the corresponding terms in each series should point out the relative temperature and force.

In order to this, some known fixed point is necessary for the commencement of the scale. But zero of vapour, like that of temperature, has not been fixed. The freezing point of water, or rather the melting point of ice, naturally presents itself as the zero of vapour; but it has been placed lower on high authority. Yet if the vapour of water has no existence till fluidity is produced, it follows that the commencement of fluidity is low enough; for ice must be liquefied before it can be vaporized.

With this in view, I have examined various experimental results on the elasticity of vapour, and compared the column of mercury supported with the temperature required to maintain vapour of sufficient tension to support the column. The result of this comparison is, that ONE-FIFTH *added to any given portion of heat already communicated to water, as indicated by the thermometer from the freezing point, will double the elastic force of its vapour.* The annexed table is calculated on this principle, and the calculation agrees well with experiment from 30° below the boiling point up to 343° of Fahrenheit, the highest experiment hitherto published. This law is easily reducible to a geometrical ratio for each factor. The ratio of force being 2, we have only to reduce 1/4 to the decimal 1.2 for the ratio o temperature. Having found the ratio, it is easy to calculate the force of vapour at any given temperature, and *vice versa*, (provided the same ratio answers, while vapour retains the same physical condition, (which I think will not be questioned,) viz. from the freezing point upward till vapour is changed into permanent gas.) For, by counting the number of terms in each series produced by the continual multiplication of both factors by their respective ratios, the corresponding temperature and force is seen at once. For example,—

| | 1st. | | 2d. | | 3d. | | 4th. |
|---|---|---|---|---|---|---|---|
| Temp. | 180 | × 1.2 = | 216 | × 1.2 = | 259.2 | × 1.2 = | 311.04. |
| Force, | 30 | × 2 = | 60 | × 2 = | 120 | × 2 = | 240. |

And by adding 32 to either of the terms in the series of temperature, we have the degree of Fahrenheit. For instance, at the fourth term we have for temperature 311°.04, force 240. 311°.04 + 32° = 343°.04, so that the force of vapour by calculation at 343°.04 of Fah. supports 240 inches of mercury, and at 343°.6 of Fah. it supports 240 inches by Mr Southern's experiment.

From this it appears that the calculation answers Mr S.'s experiment to the fraction of one degree on 343°. The fourth line in the annexed table is nearly a mean between the experiments of Ure and Southern. The third agrees with that of Dr Ure to a small fraction. The next term under the boiling point agrees to the fraction of an inch with Mr Dalton. And M. Betancourt's statement, that vapour at 182° has half the tension at 212°, agrees with the table exactly.

It will be observed that the experiments I have selected are in that part of the thermometric range which is most satisfactory, viz. from 182° upwards. In experiments near the freezing point, where one degree does not produce an increase of force equal to the 1-140th part of an inch, the result must be almost inappreciable. It may not be unworthy of remark, that there are only twelve terms in the series from the bottom of the table up to the temperature which Dr Murray states to be equal to red-hot iron, fully visible in daylight,—a temperature which will change vapour into permanent gas; so that this table, which reaches the utmost limit of vapour, has only 12 terms, 5 of which (almost half the table) have been proved by experiment.

*Table of the Elastic Force of Vapour.*

| Distance from the freezing point. | Additional degrees required to double the Force of Vapour. | Degrees on Fahrenheit's Scale. | Inches of Mercury. | Atmospheres. |
|---|---|---|---|---|
| 150° | | 182° | 15 | ½ |
| | 30° | | | |
| 180 | | 212 | 30 | 1 |
| | 36 | | | |
| 216 | | 248 | 60 | 2 |
| | 43 | | | |
| 259.2 | | 291.2 | 120 | 4 |
| | 52 | | | |
| 311.04 | | 343.04 | 240 | 8 |
| | 62 | | | |
| 373.248 | | 405.248 | 480 | 16 |
| | 74 | | | |
| 447.897 | | 479.897 | 960 | 32 |
| | 90 | | | |
| 537.477 | | 569.477 | 1920 | 64 |
| | 107 | | | |
| 644.972 | | 676.972 | 3840 | 128 |
| | 129 | | | |
| 773.967 | | 805.967 | 7680 | 256 |
| | 155 | | | |
| 928.760 | | 960.760 | 15360 | 512 |
| | 186 | | | |
| 1114.512 | | 1146.512 | 30720 | 1024 |

Comparison with Experiment.

| | | Temp. | Force. |
|---|---|---|---|
| Dalton, | | 182° | = 15.86 inches of mercury |

In this all agree.

| | | | |
|---|---|---|---|
| Ure, | - | 248.5 | = 60.40. |
| { Ure, | - | 290 | = 120.15. |
| { Southern, | - | 293 | = 120. |
| Southern, | - | 343.6 | = 240 |

One practical advantage to be derived from the calculation of force by temperature is the application of a thermometer as a check on the safety valves of steam-engines. Many persons, not naturally timid, are unwilling to venture on board a steam-vessel through fear of its blowing up.

A naval officer, distinguished for bravery, told me not long since that he would never trust his life in the hands of a careless fellow, who, by throwing a pocket-handkerchief on the lever of a safety-valve, might blow up the vessel. Prejudice of this kind might be removed and real danger prevented, by means of a small steam-pipe carried from the boiler to a thermometer properly graduated in the cabin. The force of steam in the boiler would then be apparent to the passengers, and the most timid be released from apprehension of danger. A table for that purpose is easily calculated.

ART. XI.—*Theorem for computing the Elastic Force of Vapour.* By RICHARD TREGASKIS, Esq. in a Letter to the EDITOR. (See Article X. in this Number.)

SIR, *Perran, near Truro,* 6*th Nov.* 1828.

THE table in my paper on the expansion of vapour having only twelve terms, requires considerable extension to render it of practical utility. I have therefore to request the insertion of a method for the calculation of a more extended table.

The President of the Royal Society, who is always ready to assist and encourage any attempt at further discoveries in science, however humble, was requested, on his annual visit to Cornwall, to look at the paper in question. He was pleased with its simplicity, and, assuming my statement to be the law of expansion, kindly presented me with the following theorem, by which a table may be easily calculated to any subdivision of parts; or (on the assumed law) the force of vapour may be found by it without a table at any distance above or below the boiling point of water.—I am, Sir, very respectfully, your humble servant,

RICHD. TREGASKIS.

To DR BREWSTER.

THEOREM.

Let $a =$ the number of degrees of Fahrenheit above or below the boiling point.

$$\text{Then } \frac{180 \pm a}{180} = t \text{ the temperature.}$$

Let $E =$ the elasticity, that of steam at the boiling point being unity.

$$\text{Then Log. } E = \frac{\text{Log. } 2}{\text{Log. } 1.2} \times \text{Log. } t. = 3.802 \times \text{Log. } t.$$

$$\text{Log. } t = \frac{\text{Log. } 1.2}{\text{Log. } 2} \times \text{Log. } E = 0.263 \times \text{Log. E.}$$

$$a = 180 \times t - 180 = 180 \times \text{nat. no. of} \left(\frac{\text{Log. } 1.2}{\text{Log. } 2} \times \text{Log. } E\right) - 180$$

$$= 180 \times \text{nat. no. of } (3.802 \times \text{Log. } E.) - 180.$$

## Art. XII.—*Abstract of a Meteorological Journal kept at Funchal, in the island of Madeira, from January* 1*st to December* 31*st*, 1827.* By C. Heineken, M. D. Communicated by the Author.

The *barometer* is one of Newman's mountain instruments, with an iron cistern into which its thermometer plunges. It hangs within doors at a window with a south aspect, fifteen feet from the ground, and eighty-nine above the level of the sea. The *Hygrometer* is Daniel's, used at the same window, but kept in a dry cupboard within the room. The *maximum* thermometer is one of Newman's horizontal instruments. It hangs in an open passage which runs through the house, and has a room over it, is removed from all artificial draught, and quite uninfluenced by the sun either directly or by reflection. The *minimum* one is by Dollond. It hangs against a wall with a north aspect, and is sheltered from rain. They are both at the same height as the barometer. The *sun* observations are made on a black bulb horizontal thermometer by Newman, three feet from the earth, and 280 above the level of the sea. *Rain-gage* No. 1. is on the roof of a house, twenty-five feet from the ground, and ninety-nine above the sea. No. 2. is in the same situation as the *sun* thermometer, and on the ground.

1827.

January.

| Pressure. (Inches.) | | Corrected for temp. | Temperature. | |
|---|---|---|---|---|
| Max. | 30.480 | 61° = 30.400 | Max. | 66° |
| Min. | 29.790 | 62 = 29.718 | Min. | 51 |
| Mean | 30.203 | 64 = 30.118 | Mean | 58.9 |

Diurnal range, max. 12°; min. 5°; mean 9°.

*Rain*, 2.86 in. No. 1; *Dew Point*, max. 64; min. 46; *Dryness*, max. 21, min.

*Winds*, N. 3; N. E. 10; E. 2; S. E. 6; S. 2; W. 6; N.W. 2;=31.

* *Two* observations (10 a. m. and 10 p. m.) are made on the barometer, and *one* (10 a. m.) on the hygrometer *daily*.

A fine winter month, with a remarkable prevalence of east winds. No snow has yet fallen on the mountains, and the north-west winds have been unusually raw.—*N.B.* In speaking of snow, it is always implied, within view from the town, and about 5000 feet above the sea.

### February.

| Pressure. (Inches.) | | Cor. for temp. | | Temperature. | |
|---|---|---|---|---|---|
| Max. | 30.250 | 67 | = 30.159 | Max. | 69 |
| Min. | 29.750 | 60.5 | = 29.678 | Min. | 50 |
| Mean, | 30.045 | 62.3 | = 29.967 | Mean, | 58.5 |

Diurnal range, max. 14; min. 5; mean, 10.

*Rain*, 2.62 in. No. 1; *Dew Point*, max. 65.55, min. 49; *Dryness*, max. 14; min. 0.5.

*Winds*, N. 6; N. E. 4; E. 2; S. E. 1; W. 13; N. W. 2; = 28.

A cold winterly month, excepting the last week. Barometer more variable than I ever remember to have observed it.

### March.

| Pressure. (Inches.) | | Cor. for temp. | | Temperature. | |
|---|---|---|---|---|---|
| Max. | 30.400 | 67 | = 30.314 | Max. | 69.5 |
| Min. | 30.040 | 66 | = 29.955 | Min. | 53 |
| Mean, | 30.224 | 66 | = 30.139 | Mean, | 60.9 |

Diurnal range, max. 13; min. 8; mean, 11.

*Rain*, none; *Dew Point*, max. 63, min. 50; *Dryness*, max. 15, min. 3.

*Winds*, N. 4; N. E. 11; E. 6; S. E. 3; W. 3; N. W. 4; = 31.

A remarkably fine month, more like June than March. Barometer very steady and unusually high.

### April.

| Pressure. (Inches.) | | Cor. for temp. | | Temperature. | |
|---|---|---|---|---|---|
| Max. | 30.210 | 69 | = 30.112 | Max. | 69 |
| Min. | 29.610 | 67 | = 29.521 | Min. | 54 |
| Mean, | 29.994 | 67 | = 29.903 | Mean, | 62.2 |

Diurnal range, max. 13; min. 5; mean, 10.

*Rain*, 2.19 in. mean; *Dew Point*, max. 67, min. 51; *Dryness*, max. 15, min. 1.

*Winds*, N. 3; N. E. 8; E. 4; S. 1; S. W. 2; W. 11; N. W. 1; = 30.

A fine warm month.

### May.

| Pressure. | Inches. | Cor. for temp. | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|
| Max. | 30.310 | 69 = 30.212 | Max. | 73 | 108 |
| Min. | 30.020 | 69 = 29.922 | Min. | 57 | 79 |
| Mean, | 30.189 | 69 = 30.089 | Mean, | 65.2 | 96.3 |

Diurnal range, max. 14; min. 6; mean, 11.

*Rain*, none; *Dew Point*, max. 69, min. 51; *Dryness*, max. 16; min. 2.

*Winds*, N. 1; N. E. 19; E. 1; W. 6; N. W. 4; = 31.

A remarkably fine month. So forward and warm a spring has seldom been remembered.

### June.

| Pressure. | Inches. | Cor. for temp. | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|
| Max. | 30.280 | 74 = 30.166 | Max. | 77.5 | 109 |
| Min. | 29.970 | 74 = 29.859 | Min. | 50. | 83 |
| Mean, | 30.101 | 72 = 29.998 | Mean, | 68.4 | 97.9 |

Diurnal range, max. 14; min. 8; mean, 11.

*Rain*, 0.16 in. mean; *Dew Point*; max. 73, min. 61; *Dryness*, max. 12; min. 1.

*Winds*, N. 1; N. E. 14; E. 4; W. 8; N. W. 3 = 30.

A warm fine summer month.

### July.

| Pressure. | Inches. | Cor. for temp. | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|
| Max. | 30.270 | 77 = 30.153 | Max. | 84 | 116 |
| Min. | 30.020 | 76 = 29.906 | Min. | 62 | 96 |
| Mean, | 30.175 | 76 = 30.061 | Mean, | 71.6 | 102 |

Diurnal range, max. 16; min. 10; mean 14.

*Rain*, none; *Dew Point*, max. 76; min. 57; *Dryness*, max. 16; min. 1.

*Winds*, N. 1; N. E. 25; E. 3; W. 1; N. W. 1 = 31.

A remarkably fine and very hot month.

### August.

| Pressure. | Inches. | Cor. for temp. | | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|---|
| Max. | 30.210 | 77 | = 30.093 | Max. | 83 | 111 |
| Min. | 29.990 | 78 | = 29.871 | Min. | 62 | 96 |
| Mean, | 30.109 | 77,4 | = 29.992 | Mean, | 72.3 | 103.8 |

Diurnal range, max. 17; min. 12; mean, 15.

*Rain*, none; *Dew Point*, max. 77, min. 48; *Dryness*, max. 36, min. 2.

*Winds*, N. E. 27; E. 2; S. E. 2 = 31-

A fine clear month.

### September.

| Pressure. | Inches. | Cor. for temp. | | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|---|
| Max. | 30.310 | 74 | = 30.196 | Max. | 80 | 110 |
| Min. | 30.030 | 73 | = 29.924 | Min. | 60 | 93 |
| Mean, | 30.147 | 75 | = 30.036 | Mean, | 70.9 | 102 |

Diurnal range, max. 17; min. 12; mean, 14.

*Rain*, 0.15 in. mean; *Dew Point*, max. 74; min. 57; *Dryness*, max. 17; min. 2.

*Winds*, N. 3; N. E. 14; E. 3; W. 10 = 30.

A fine seasonable month.

### October.

| Pressure. | Inches. | Cor. for temp. | | Temperature. | Shade. | Sun. |
|---|---|---|---|---|---|---|
| Max. | 30.270 | 75 | = 30.159 | Max. | 77 | 105 |
| Min. | 29.720 | 70 | = 29.622 | Min. | 55 | 73 |
| Mean, | 30.063 | 72 | = 29.958 | Mean, | 67.2 | 95.4 |

Diurnal range, max. 18; min. 11; mean, 15.

*Rain*, 3.24 in. mean; *Dew Point*, max. 74, min. 55; *Dryness*, max. 17, min. 1.

*Winds*, N. E. 16; E. 2; S. W. 4; W. 4; N. W. 5 = 31.

A fine autumnal month, with a moderate fall of rain. The summer has been the dryest and finest long remembered; for months scarcely a cloud was seen.

### November.

| Pressure. | | Cor. for temp. | Temperature. | | |
|---|---|---|---|---|---|
| | Inches. | | | Shade. | Sun. |
| Max. | 30.460 | 66 = 30.371 | Max. | 73 | 101 |
| Min. | 29.400 | 66 = 29.314 | Min. | 51 | 73 |
| Mean, | 30.007 | 68 = 29.984 | Mean, | 62 | 92.1 |

Diurnal range, max. 19; min. 11; mean, 16.

*Rain*, 6.95 in. mean; *Dew Point*, max. 68; min. 55; *Dryness*, max. 13; min. 2.

*Winds*, N. E. 17; E. 5; S. E. 1; S W. 1; W. 5; N. W. 1 = 30.

Rather cold, but seasonable; *much more* rain from the eastward than is at all usual.

### December.

| Pressure. | | Cor. for temp. | Temperature. | | |
|---|---|---|---|---|---|
| | Inches. | | | Shade. | Sun. |
| Max. | 30.440 | 65 = 30.354 | Max. | 73 | 103 |
| Min. | 30.180 | 66 = 30.095 | Min. | 50 | 80 |
| Mean, | 30.313 | 66.9 = 30.215 | Mean, | 69.2 | 92.1 |

Diurnal range, max. 21; min. 9; mean, 15.

*Rain*, none; *Dew Point*, max. 66; min. 50; *Dryness*, max. 18; min. 3.

Winds, N. 4; N. E. 19; E. 5; S. E. 1; W. 2 = 31.

A remarkably dry warm month.

### Annual Results. (1827.)

| Pressure. | | Cor. for temp. | Temperature. | | |
|---|---|---|---|---|---|
| | Inches. | | | Shade. | Sun. |
| Max. | 30.480 | 61 = 30.406 | Max. | 84 | 116 |
| Min. | 29.400 | 66 = 29.314 | Min. | 50 | 73 |
| Mean, | 30.130 | 70 = 30.032 | Mean, | 65.6 | 97.6 |

The observations in the sun were made only for eight months, from May to December inclusive.

*Rain*, 18.17 in.; *Dew Point*, max. 77; min. 48; *Dryness*, max. 21; min. 0.5.

*Winds*, N. 26; N. E. 184; E. 39; S. E. 14; S. 3; S. W. 7; W. 69; N. W. 23 = 365.

1826 and 1827.
Two years.

| Pressure. | Cor. for temp. | Temperature. |
|---|---|---|
| Max. 30.590 | = 30.505 | Max. 84 |
| Min. 29.390 | = 29.294 | Min. 50 |
| Mean, 30.131 | = 30.031 | Mean, 64.9 |

*Rain*, 25.03 in. mean; *Dew Point*, max. 77; min. 40; *Dryness*, max. 30; min. 0.

*Winds*, N. 47; N. E. 341; E. 95; S. E. 34; S. 5; S. W. 14; W. 143; N. W. 52 = 733.

RAIN for THREE YEARS, 1825 to 1827.

Viz. 1825, 20.43 in. 1826, 43.35 in. 1827, 18.17 in. Mean, 27.32.

PRESSURE and TEMPERATURE for the same THREE Years.

*Pressure*, Max. 30.62; min. 29.39; range, 1.23 in.
*Temperature*, Max. 84; min. 50; range, 34°.

In the year 1824 I commenced keeping a meteorological journal, which, in consequence of ill health, occasional residence in the country, and other circumstances, was not pursued with sufficient energy and regularity to warrant its publication before 1826. At first I attempted *three* observations during the four-and-twenty hours; viz. at sunrise, 2 P. M., and sunset; but I soon found that, do what I would, the instruments remaining *stationary* were inevitably *influenced by the sun*, either immediately or by reflection. In an open turret, simply tiled as ours are, the effect was the same; and during at least eight months in the year, the sun was so vertical that *perfect shade* in the *same spot* could not be maintained through-

3

out the day. As, therefore, there appeared to be but two resources against this inconvenience, viz. *several* instruments in *different* situations and noted at *different* times, or a *register* thermometer *within doors*, and having a room over it, I chose the latter, and in the *Philosophical Magazine* for November and December 1827 gave the results. These have been in a very fair and candid manner objected to in this Journal, *(Ed. Jour. of Science*, No. xvii. p. 171,) and I am glad of the opportunity which it affords of repeating *why* I deviated from the *usual* mode of taking the *maximum* observations, and of my doubt whether *any* taken out of doors with a *single* and *stationary* instrument *can* be strictly correct for *shade* maxima, in a latitude where the sun is so vertical. Upon this the whole question appears to me to hinge. If observations made in as perfect, or rather imperfect, shade as a *stationary* instrument can insure, be admitted as correct, then the mode which I adopted is certainly a bad one, and its deductions false; but if *such* as are made upon *several instruments* are alone to be trusted to, it is I think the lesser of two evils; and, was there not the weight of *such authority* against me, I should almost be bold enough to prefer the *mean* which thence resulted to that obtained by the other mode. Dr Brewster's Formula I own staggers me more than the other authorities, because they were not from observations made upon the spot for any length of time. In the quotation of Humboldt's there must, I think, be some mistake. It is stated to be 72.22; but in the translation (I have not the original) of his "*Personal Narrative*," it is given by him, on *the authority* of *Cavendish*, 68.9; and Santa Cruz, on the south side of Teneriffe, four or five degrees more south than Funchal, and *notoriously* hotter, he gives *only* 71.10.* Kirwan makes the mean of Funchal 68.9,—and I in 1824 made it 68.2, and in 1825, 68.6,—by an *out-of-door stationary* instrument. It appears then, I think, satisfactorily, that the dissonance of result is *entirely* to be attributed to the *different mode* of making the observations, and not "to some error either in the instruments or in the observations." In a higher latitude an instrument within doors would, as it is observed, "give a higher temperature than if it had been placed

* M. Von Buch is quoted in the same publication as making it 71¼.

in the open air;" but *here* the result would be, and actually is, diametrically opposite. Should health and other concomitants permit, I shall endeavour next year to obtain maxima from several instruments, and in the meantime, should feel obliged by any hint as to the *readiest* and *most correct* mode of making maxima observations on temperature in such a latitude as this. C. Heineken, M. D.

Funchal, *Madeira, 25th October* 1825.

### OBSERVATIONS BY THE EDITOR.

The very judicious and candid method which Dr Heineken has taken to remove the doubts which we expressed in a former Number, (No. xvii. p. 171,) respecting the accuracy of his measure of the mean temperature of Funchal, has satisfied us of the correctness both of his instruments and his observations. We committed a mistake in asserting that Humboldt made the mean temperature 72°.22, for it is only 68°.5 in his *Treatise on Isothermal Lines*; but it was still a matter of surprise to us, that the mean temperature should be so low as 64°.3, when Humboldt gave 64°.04 for the mean temperature of the coldest month. It will be generally found that the mean temperatures of all warm climates are given too high, not only from the difficulty of protecting the external thermometer from the indirect influence of the sun, but also from the want of a sufficient number of evening and morning observations. Hence we are disposed to think that the temperature of 68°.5, as given by Humboldt, would require to be diminished from both these causes.

The following are the different measures which have been given of the mean temperature of Funchal.

| | | |
|---|---|---|
| Humboldt, | - - | 68°.5 |
| Kirwan, | - - | 68 .9 |
| Dr Heineken in 1824, | - | 68 .2 |
| Do. 1825, | - | 68 .6 |
| Do. 1826, | - | 64 .3 |
| Do. 1827, | - | 65 .6 |
| Mean, | - | 67°.35 |
| Dr Brewster's Formula, | | 68 .65 |

We would beg to request Dr Heineken to observe the thermometer at 10h A. M. and 10 P. M., as it would be interesting to compare the annual temperature thence deduced with that which is obtained from the maximum and minimum thermometer. It would be very desirable also to have a few observations every month on the temperature of springs or deep wells.

The situation of Funchal, near the place where the isothermal lines of the Old World begin to bend towards the equator, and to mark the influence of the cold pole of America, renders the accurate determination of its mean temperature a matter of great importance to meteorology.

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ART. XIII.—*Account of Two Thunder Storms which happened in Worcestershire, in which it appeared the Electrical Discharge passed from the Earth towards the Clouds.* By JOHN WILLIAMS, ESQ. Communicated by the Author.

WORCESTER and its neighbourhood were visited by a thunder storm on the evening of the 14th of December 1825. The barometer throughout the day stood at 29.25, and the thermometer at 8 A. M. was 44°, and at 2 P. M. 50°. The lower wind was brisk from the S. S. W., with a damp mild feel, indicating the presence of much aqueous vapour. Clouds were seen moving in three distinct currents. The uppermost current came from the west, a middle current from the S.W., and the lowest, in which the clouds appeared to move more rapidly, came from the south, and there were openings of clear sky of a deep blue colour. From 7 till 8 o'clock P. M. lightning was seen flashing at intervals in the S. W., W., and N. W., proceeding apparently from light clouds. At half-past 8 the sky became very dark in the N. W., the flashes of lightning more vivid and frequent, and it began to thunder. A storm of very unusual violence for the season of the year immediately followed, attended with wind, rain, and hail. The explosions of thunder were almost incessant for about an hour; and the intensely vivid glare of the lightning, alternating with extreme darkness, produced a most awful effect.

The instantaneous sound of the thunder following the flash of lightning, and the after long-continued roll in the distant parts of the cloud, made me conclude the latter was negatively electrified, and that the electricity passed from the surface of the earth to the cloud. And hearing the following morning that the west side of the lofty beautiful spire of St Andrew's Church in Worcester had been struck by the lightning, I requested a friend to accompany me to the church-yard to examine the mark where the surface of the stone was injured. The mark was and still is distinctly visible about half way between the top of the tower and the weathercock, which terminates the spire; the smooth surface of the stone being torn off about an inch in depth, two or three inches in width, and about two feet in length, presenting the following appearance and inclination from a perpendicular. See Plate I. Fig. 3. Before entering the church-yard, I remarked to my companion that I expected to find all the fragments of stone on the ground on the west side the church, facing the direction of the storm, as I imagined the electrical discharge passed up the surface of the wet stone, till it came to the point where we observed the mark, and from thence through the air in a diagonal direction to the cloud. The fact turned out as I predicted; the fragments of stone were all found scattered on the ground, about thirty feet from the west side of the tower. None could be met with in any other part of the church-yard; and that these fragments (which are still in my possession) were the identical pieces of stone torn by the electrical discharge from the surface of the spire, I could have no doubt, for the stone exactly corresponded in texture with it; the smooth wrought side being of the colour of the general surface of the spire, and the rough fractured portion of each piece presented the appearance of the same stone when recently broken. A gentleman who witnessed the storm from the quay on the opposite side of the Severn, about six hundred yards from the west side of the church, saw the flash, which he described as resembling an intensely bright light, which seemed to come from the spire, and pass over his head towards the dark cloud in the west, attended by a sudden and most tremendous crack, and accompanied by a loud rustling sound, like a high wind passing through the rigging of the barges in the river. The sound gradually terminated in a heavy distant roll of thunder in the clouds westward of him.

*Account of a Thunder Storm at Malvern, Worcestershire.*

The morning of the 1st of July 1826, being warm and sunny, the barometer at 8 A. M. 30.27, the thermometer at the same hour being at 72°, and at half-past 2 P. M. 82°, very heavy dense cumuli began to form soon after 10 A. M., and at 2 P. M. it thundered loud in the S. W. and in the W. N. W. At a quarter before 3 P. M. a very loud clap of thunder was heard in the village of Great Malvern, about seven miles S. W. of Worcester. A party, consisting of two sons and four daughters of Mr Hill of Dymock, Gloucestershire, and Miss Woodgate of Hereford, accompanied by two servants, were upon the hills above the village, and, observing a storm gathering round them, with heavy thunder, they retired to take some refreshment they had brought with them, to a hut situated on a high ridge about three or four hundred yards below the summit of the mountain. Several huts had been erected on the hill by the Countess of Harcourt for the accommodation of the company frequenting Malvern, and for the purpose of affording shelter in case of a sudden shower. These huts were small circular buildings, built with the rough fragments of granite found on the surface of the hills, the outside walls being white-washed with lime; and the roofs were made of sheet iron. It is not a little remarkable that Miss Elizabeth Hill observed when she entered the hut, that she felt alarmed lest the iron roof should attract the lightning. They had scarcely entered this retreat, and were about to take their refreshment, when a violent storm of thunder and lightning came on from the west, and at a quarter before three P. M. one of the Mr Hills, who stood at the entrance which fronted the east, saw a ball of fire which seemed to him moving on the surface of the ground. It instantaneously entered the hut, forcing him several paces forwards from the doorway. As soon as he recovered from the shock, he found his sisters on the floor of the hut, fainting, as he supposed, from alarm. He instantly sent off one of the party who had escaped injury for assistance, and the usual means of recovery were applied by a medical practitioner from the village. Miss Elizabeth Hill and Miss Woodgate appeared to have died instantly, and Miss Margaret Hill and the rest of the party were much injured. The explosion which followed the flash of lightning was terrific, and alarmed the inhabitants of the village below. Soon after I heard of the accident, I went and examined the hut. I found a large crack on the west side the building, which passed upwards from near the ground to the frame of a small window, above which the iron roof was a little indented. The fragments of stone, when first observed, were all found on the west side the hut, and these were readily distinguished from other loose stones, owing to the lime-wash which coated the exterior surface. I found a few of the larger pieces of stone on the *east* side also; but I was informed many curious persons had visited the spot before me; and, after examining and fitting these fragments to the part of the building from whence they had been torn, threw them casually about the hut.

The following is an account of another storm attended with thunder and lightning.

"In the night between the 30th of November and the 1st of December 1821 there was a violent gale of wind from the S.W. A mast of a sloop, lying in the river at Newport in Monmouthshire, was struck by the lightning about twelve feet above the deck and shivered to pieces, and all the splinters were driven to windward."

In these three instances the thunder clouds appear to have been in a negative state of electricity, for, had the stroke of lightning passed from the clouds downwards, the fragments of stone and splinters of wood would have been scattered in a direction opposite to the storm; and, from the observations I have made during the last twenty years, I am inclined to think, when objects are struck by lightning, the passing cloud is often negatively electrified. When a thunder storm is approaching or is gone past in the day-time, the direction of each stroke may often be seen if not too near the observer, say at a distance of from two to about five miles; but when it takes place in the night, or very near the place of observation, the sudden great glare of light prevents our seeing the direction of the stroke. In the day-time, at the distance aforesaid, I have often been able most distinctly to trace the direction of the electrical ball; and it has frequently appeared to me like the motion of a sky-rocket rising with extraordinary rapidity, commonly inclined when first rising from the earth, and becoming more horizontal when it reaches the cloud, where it often divides into two; sometimes it describes a curved line with zig-zags. The thunder seems to proceed first from the quarter where the ball of fire appears to have risen, and terminates in a distant roll amongst the clouds. The cause of the negative state of clouds may perhaps be explained in the following manner:—The capacity of water for electricity is increased when it assumes the state of vesicular vapour, as may be shown by the experiment of throwing water on hot coals. The rising vapour immediately takes the shape of that kind of cloud denominated the cumulus, and is positively electrified, as may be proved by the electroscope. But in the slower process of natural evaporation by the sun and wind, the intensity of the electricity of the rising vapour is not sufficient to be shown in the same way. However, there is reason to think the fact is otherwise; and Dr Franklin's ingenious experiment of the electrified can and chain throws considerable light on the subject. In this experiment, by raising the chain from the can, the connecting electrometer proves that the capacity of the chain for electricity is increased by its increase of surface exposed to the air, as the electrometer indicates a weak intensity. But on again returning the chain into the can, the original intensity is manifested. So each particle of rising vapour as it leaves the earth's surface, combines with caloric, and partakes of the electricity of the common reservoir, the earth. It remains in mixture with the air, but in a state of very minute division; for we observe, whether raised by the sun's heat from moist soil, or from water artificially heated, the particles of vapour or steam disappear, and do not disturb the transparency of dry air, till they rise into a stratum of air, where the cold occasions it to be again condensed into vesicular vapour or clouds. This, in an ordinary summer's day, takes place at different heights in the atmosphere, according to the heat and dryness. It is probably the dew point of that stratum of air where the fleecy clouds begin to form in a clear sunny morning; and, as compared with the known height of mountains, these clouds are first seen at from 1500 to 3000 feet. These small fleecy clouds sometimes re-evaporate soon after they begin to form, especially in settled serene weather, attended by a high barometer, and the *air* in a positive state of electricity. On the contrary, if these clouds increase in size, the upper surface takes the shape of the cumulus, which swells very rapidly in size, becoming very dense, and of a most brilliant white colour on the side exposed to the sun. All the smaller neighbouring clouds are attracted by the larger. But the increase of capacity for electricity, which keeps pace with the increase of vaporous surfaces exposed to air, cannot receive a supply from the earth, and but very slowly from the air. At length its relative state of electricity, as compared with the earth's surface, is of sufficient intensity to overcome the resistance of the plate of air between the earth and cloud, and the discharges of electric matter pass upwards. This opinion is offered as the result of many years observation, and as an humble attempt to explain one of the causes which produce negatively electrified clouds, and those local thunder storms which sometimes prevail for several weeks together in the summer months.

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## Art. XIV.—*On the Parasitic Formation of Mineral Species, depending upon Gradual Changes which take place in the Interior of Minerals, while their External Form remains the same.* By William Haidinger, Esq. F. R. S. Edin.—*(Concluded from last Number, p. 292.)*

### IX. *Changes in some of the Earthy Minerals and others.*

The explanation of many of the cases enumerated above, depends upon the ordinary laws, active in our chemical laboratories. Carbonates are changed into sulphates, metallic substances are oxidized, copper is replaced by iron: in general weaker affinities give way to stronger ones. The conversion of sulphates into carbonates, and other cases, may perhaps depend upon some process of mutual decomposition, in which one of the products has been subsequently removed; but the specimens preserved in collections do not usually present any explanation of the facts which they furnish. We must endeavour to ascertain the causes which have contributed towards successive alterations in the chemical composition of minerals, by observing their natural repositories, veins and beds, and mountain masses, exposed to the action of the atmosphere, and of water, and to the mutual reaction of the mineral species of which they are constituted.

One of these examples, where the cause of a change in appearance is not so palpable, is the well-known one of the substance usually named the Gray Andalusite. Its specific gravity alone being above 3.5, while that of the real andalusite never exceeds 3.2, would be sufficient to prove them to belong to different species. But Prof. Mohs has found the gray crystals actually to consist of a great number of small individuals of disthene, with an easy cleavage, whenever they are large enough to be distinguished from others, and lying in different directions throughout the mass. Both minerals are found in nodules of quartz engaged in mica-slate. From the analysis by Arfvedson, it appears that disthene is a compound of one atom of silica and two of alumina, or $\ddot{A}l^2 \dddot{S}i$. Andalusite contains about 83 per cent. of the same mixture, the rest being a trisilicate of potassa.—Beudant's *Mineralogy*, p. 333 and 363. The loss of this ingredient sufficiently accounts for the chemical difference between the two bodies; but we are at a loss to conjecture in what manner such a change may have taken place.

Mr Allan has in his cabinet several specimens from the trap district near Dumbarton, exhibiting the shape of analcime, but entirely composed of aggregated crystals of prehnite. Mr William Gibson Thomson is likewise in the possession of several exceedingly distinct and instructive specimens of the same description. There is one, among the former, where prehnite, aggregated in globular shapes, is implanted on icositetrahedral masses, once of analcime, but now likewise converted into prehnite. The implanted varieties are green and translucent; I found their specific gravity equal to 2.885: the portions within the faces of the icositetrahedrons are white and opaque, and give 2.842, both of them rather lower than the usual results obtained, which are a little above 2.9, at least in simple crystals. But the arrangement of the divergent individuals in the reniform shapes is highly remarkable, and throws some light also on the gradual formation of the new species within the space occupied by the crystals of analcime. The centres of the single globular groups, aggregated in a reniform manner, are situated on the surface of the icositetrahedrons. From these, the fibres diverge, not only towards the surface of the globules, but also on the other side, in the direction of what formerly was analcime. The original surface of the icositetrahedrons may be laid bare, by breaking off the exterior coat of prehnite. Even in those places where there was no coating of prehnite, the decomposition of the analcime has taken place in the neighbourhood of other decomposed crystals. The ingredients of prehnite are silica, alumina, lime, and water; those of analcime, silica, alumina, soda, and water. There is no similarity between the two in the mode of combination of their ingredients, analcime being considered as a compound of bisilicates of soda and alumina with water, while prehnite is considered as a compound of simple silicates of lime and alumina, with a hydrate of silica.

On another occasion, *Edin. Journ. of Science*, vol. i. p. 380, I have described a very curious instance of pyramidal forms, agreeing as near as possible with those of the pyramidal scheelium-baryte, which consisted in their interior of multitudes of columnar crystals of the prismatic scheelium ore. They were found at Wheal Maudlin in Cornwall, and are partly implanted on quartz, arsenical pyrites, chlorite, &c. and partly imbedded in cleavable blende. The chemical composition of the two species is almost identically the same, at least not more different than in the varieties of pyroxene, or other similar substances. The chemical formula of the first is $\dot{Ca}\,\dddot{W}^2$; that of the second $\ddot{Mn}\,\dddot{W}^2 + 3\,\ddot{Fe}\,\dddot{W}^2$, different only in the isomorphous bases of calcium in the one, and manganese and iron in the other, one atom of the protoxide of each of them being united with two atoms of tungstic acid. This curious resemblance of the chemical mixture was then pointed out to me by Professor Mitscherlich, who supposed, that, from the isomorphism of the bases, the varieties observed might be genuine crystals, of the same ingredients as wolfram, but with the form of the scheelium-baryte: this was disproved, however, by the observation of the mechanical composition of the masses. Of itself, the hypothesis is plausible enough that such was originally the case, and that the cohesion among the particles was so slight, as to be afterwards overpowered by the greater crystalline attraction of the same particles in hemiprismatic crystals, subsequently formed, and as they now apppear; in a manner analogous to the decomposition of the common hydrous sulphates of zinc or magnesia by heat, as described above. The other hypothesis, that the lime in the original species has been subsequently replaced by the oxides of iron and manganese, is rendered more likely by the fact that there are crystals which in part consist of the scheelium-baryte, while near the surface, but within the planes of the original crystals, and where portions of them seem to be wanting, we observe an aggregate of crystals of the scheelium-ore. A specimen of this kind I saw at Schlaggenwald, its native place.

Here we must also consider Haytorite, a substance newly discovered, which has already given rise to various and contradictory hypothesis, and in connection with it some of the pseudomorphoses of rhombohedral quartz in general. Haytorite has been ascertained by Mr Levy to have the shape of the species to which he gives the name of Humboldtite. All those mineralogists who have examined it agree in pronouncing the substance of it to be *Calcedony*, which is itself a granular compound of exceedingly minute individuals of rhombohedral quartz; so much appears from its physical characters. Dr Brewster obtained the same result, by ascertaining its action on light. He has also directed the attention of naturalists to the circumstance, that the planes of composition between the different individuals, and which are always so very distinct in Datolite, are as distinct as possible in Haytorite; and hence he draws the correct inference, that they cannot have been formed in a mould, like the pseudomorphoses.—(See this *Journal*, No. 12, p. 297 and 301.) Datolite contains a notable quantity of silica, 36.5 per cent. according to Klaproth's analysis. The successive exchange of its contents of lime and boracic acid for an additional quantity of silica, if it goes so far as completely to destroy the original species, will transform the substance of the crystals into a mass of calcedony. There is no proof, however, that such a process has actually taken place, so long as we do not discover the remains of the former species included in the other, testifying the progress of the change; and we must be the more careful in establishing hypotheses, if, as in the present case, we are not led by analogous occurrences in other varieties of the same species.

Calcareous spar is one of those species which are very easily acted upon by atmospheric agents. The hollow scalene six-sided pyramids of brown-spar, the macrotypous lime-haloide of Mohs, consisting of imbricated rhombohedrons with parallel axes, form a remarkable instance in this species of the replacement of one substance by another, not sufficiently explained by any of the authors who treat of it, though some of the observations on which the actual explanation of the appearances is founded, may be traced in several of their writings. A specimen of a pale yellowish-gray colour in Mr Allan's cabinet, of the nature alluded to above, and broken across, in order to show the inside, presents a cavity, the sides of which are lined with small rhombohedrons of brown-spar, forming a surface analogous to the external one of the six-sided pyramid. But it shows, besides, also the remains of what formerly filled up the space altogether, of a crystal of the rhombohedral lime-haloide. The planes of cleavage of this crystal are still visibly in the same position in which they originally existed, as appears from the contemporaneous reflection of the image of a luminous object from the portions of it, now no longer cohering. The surface of these portions has the same appearance as fragments of calcareous spar which have been exposed to the corroding action of acids. Crystals of the brown-spar are likewise deposited on some of those portions disengaged from the rest, and, as it were, pushed off from their original position by the gradual increase of the crystals of brown-spar. The mass of this latter species forms a coating of pretty uniform thickness over the whole surface of the original six-sided pyramid. Nearly in the middle of the stratum, wherever it is broken across, may be observed a whitish, or only rather more opaque line, of the same colour as the rest, dividing it into two, without producing the least deviation in the faces of cleavage upon which it is seen. This line is evidently the section of the original surface of the pyramid of calcareous spar, upon which one portion of the brown-spar was deposited, while another portion was formed within the space previously occupied by the calcareous spar, and destroyed in the progress of decomposition. The chemical change is here very distinctly indicated; part of the carbonate of lime is replaced by carbonate of magnesia, so as to form in the new species a compound of one atom of each. How this change was brought about is a difficult question to resolve, though the fact cannot be doubted, as we have, in the specimen described, a demonstration of it, approaching in certainty almost to ocular evidence. It is scarcely surprising that such appearances should be visible in metallic veins, like some of those near Schemnitz in Hungary, the whole nature of which shows that they must have been gradually changed by successive revolutions, the uppermost part being often almost entirely composed of cellular quartz, which is formed in fissures contained in other species or compound masses, subsequently decomposed, and leaving the quartz alone. I shall not enter into an inquiry respecting the probability of such changes in mountain masses, of such an enormous bulk as the dolomite of the Tyrol, to which Von Buch ascribed a similar origin. The facts observed on a small scale do not exclude the possibility of such changes, though we are certainly less prepared to expect them, where powerful and momentary revolutions are supposed to have taken place at the same time, than where any period of time, even the most protracted, may be granted for the successive replacement of one particle of matter by another.

Crystals of calcareous spar, previously coated with small individuals of quartz, often entirely disappear, and leave an empty shell. We sometimes observe particles of the calcareous spar with a corroded surface still contained within the covering, but much diminished in size. A large pseudomorphosis in the shape of a scalene six-sided pyramid, from the zinc mines in Somersetshire, in Mr Allan's cabinet, from which the original species of calcareous spar has entirely disappeared, is of a particularly interesting nature. Beside the superficial coating, the quartzy matter has introduced itself into the fissures of the crystal, parallel to its planes of cleavage, and the interior of it is now not quite empty, but divided into cells by lamellæ of quartz, the cells having the shape of the fundamental rhombohedron of calcareous spar. The formation of what now remains must have begun, therefore, when the original crystal was still perfect, and have proceeded during the decomposition of it. The change was gradual, and so we must conceive these processes to go on in every instance. It is highly probable that the formation of another species, so near, or even within the boundaries of a crystal previously existing, will greatly influence, by its electro-chemical action, upon the arrangement and composition of the particles of that body.

Quartz, more than any other species, is known to fill up the vacuities formerly occupied by crystals of calcareous spar, of fluor, and of gypsum. Such masses of secondary formation are called *pseudomorphoses*, and are usually conceived to have been formed in moulds, arising from a substance which surrounded the original crystals, and was left unchanged, while the latter was destroyed by decomposition, in a manner similar to the process of making first the mould of a bust or statue, and then filling it with plaster of Paris. The cast obtained, from a mineralogical point of view, is a pseudomorphosis of gypsum. We have but rarely an opportunity of observing entire series of specimens illustrative of such a process. Even in extensive collections, it is difficult to bring together a sufficient number of them, in order to give an example of each stage of the gradual formation and decomposition of one species after the other. The moulds in which many of the pseudomorphoses are supposed to have been formed never were seen or described by any mineralogist; for instance those of quartz in the shape of fluor from Beeralston; those of hornstone, in the shape of calcareous spar, from Schneeberg; those of calcedony, in the shape probably of fluor, from Trestyan in Transylvania. We might be inclined to think that actually there have never been any, but that the new substance was formed while the old one was disappearing. A film of quartz deposited on the surface of a crystal, would be the support of any new matter, subsequently added, as we see in many instances, particularly the pseudomorphous hornstone from Schneeberg, that, like the inside, wherever it is not entirely filled up, the outside also often shows the reniform and botryoidal shapes depending upon the undisturbed formation of the component individuals. Water, charged with carbonic acid, and by that means holding silica in solution, may have dissolved the original species, and deposited the siliceous matter in its stead.

In the varieties from Schneeberg, which consist of perfectly compact rhombohedral quartz or hornstone, the original outline of the decomposed crystals of calcareous spar cannot any longer be descried. There are varieties, however, also in the shape of the same species, and consisting likewise of quartz, where this is still possible; and among them I know of none that are more distinct than those from Bristol. The quartz, in well defined individuals, is deposited partly inside the space formerly occupied by calcareous spar, producing as many geodes or drusy cavities, and partly on the outside of the same space, the two sets of deposits being separated by the surface of the original crystal, the only thing still remaining of it. They do not cohere firmly, but the outer deposit may be removed, leaving the inner one in the shape of perfectly formed crystals of calcareous spar, the surface of which is stained brown by oxide of iron. Mr Allan has one in his cabinet, which he disengaged in this way from the surrounding mass, terminated on both ends, and altogether showing only a small portion of its surface, where it might have been attached to an original support.

In the example just now described, the crystals of quartz are deposited pretty regularly, at least in so far as their axes are nearly perpendicular to the surface of the crystals of calcareous spar. This is not the case in the prismatoidal manganese-ore from Ihlefeld, which fills up, and at the same time surrounds, the space formerly containing crystals of calcareous spar, and where likewise nothing but the surface of the original crystals has remained. Both masses, however, are perfectly alike, and consist of granular individuals, still easily recognizable. Such component individuals are sufficiently small to withdraw themselves from observation, in the varieties of compact rhombohedral iron-ore from Johanngeorgenstadt in Saxony, and other places, which exactly, like the manganese-ore, include shapes, or rather surfaces of crystals only, of calcareous spar.

A similar explanation no doubt applies also to the steatite from Gœpfersgrün in Bayreuth, well known to collectors, but as to the causes which have produced it, still unknown to mineralogists. Their perfectly homogeneous appearance excludes every idea of their being formed by a mixture, however intimate, of steatite, and the species whose forms the crystalline shapes affect; for, on this supposition, they still must retain some of the properties peculiar to those species. The fact that several forms are found, not only incompatible with each other, but evidently belonging to other two or more well known species, as quartz, calcareous spar, and pearl-spar, likewise distinctly proves them not to be actual crystals, belonging to the internal nature of steatite. But if we compare the analogy of such bodies as those described above, which, like the steatite, include only the form of another species, we can have no doubt that all of them must have been formed in the same way. The chemical composition of steatite is not well ascertained: it is probably a compound of some silicate and of a hydrate of magnesia. Quartz is entirely composed of one of its ingredients; but the other species, calcareous spar, for instance, whose crystals have been replaced by steatite, do not contain so much as a trace of these substances, so that we must suppose them to have been entirely destroyed, even without giving up part of their ingredients to the new mixture, while the latter was forming within and without the space which these crystals occupied.

Earthy and friable masses are often the result of decomposition, that is to say, of a change in the arrangement of particles, which then are so minute, that none of their natural-historical properties can be ascertained. The pale green friable masses, in the form of crystals of pyroxene, from Tyrol and Transylvania, considered by Werner as crystallized green-earth, by Haüy as a variety of steatite; the red masses sometimes showing the forms of olivine, and dependent upon the decomposition of that species, included in some of the rocks of Arthur's Seat, near Edinburgh; porcelain-earth, probably owing to the decomposition of the porcelain-spar of Fuchs; (*Denkschriften* *der Akad. der Wissenschaften zu München für* 1818 *und* 1819) various kinds of steatite, quoted by authors, some in the form of garnet, others in the form of trigonal-dodecahedrons of an unknown mineral, engaged in the serpentine from Siberia, others in the form of felspar, &c. yield examples of such bodies. They have not yet been examined with that degree of attention which they deserve, not so much perhaps on their own account, as rather for the inferences to which researches of this kind might lead. But it must be allowed, that many of them cannot be instituted in those fragments of the entire series, which, for their more apparent distinctness, are preserved in our mineralogical cabinets. Beside extensive series of the minerals in question, they require the joint efforts of mineralogical inquiry, for ascertaining the species which have been destroyed, and those which have been formed; of chemical examination, for ascertaining the difference in the ingredients of the two; and of geological observation of the specimens in their natural repositories, in order to establish the causes by which the chemical affinities, balanced by the formation of the original compounds, have again entered into action.

From the preceding enumeration, it is but too evident, that our knowledge of the facts, as well as of their causes, up to this moment is scanty and imperfect. A wide field of research is still open, promising a fair return for the labour naturalists may bestow upon its cultivation. I have endeavoured to collect only some of the most remarkable and familiar instances of the changes which may take place in the solid body of a crystal, the ulterior study of which, while it illustrates the idea of species, will throw some light also on the causes of such alterations as do not appear conformable to the known laws of chemical affinity, for which we cannot account at least in the present state of our information.

## Art. XV.—*Observations and Experiments tending to demonstrate that the Granules which are discharged in the explosion of a grain of Pollen, instead of being analogous to spermatic Animalcules, are not even organized Bodies.** By M. Raspail.

This memoir, which ought to form a continuation of the chapter on the *vegetable animalcules of Gleichen* in my Memoir on *Organic Tissues*, † was drawn up at the time when a work on the same subject was presented to the judgment of the Academy of Sciences. As I had obtained results diametrically opposite to those of this last memoir, I felt it my duty to put off the reading of mine, that I might not expose myself to the suspicion of wishing to influence or retard the judgment of the Academy. It is possible that I may at present expose myself to a suspicion of a different kind; but in the difficult position in which my researches have placed me, I must expose myself to criticism to whichever side I turn, so that the only reasonable step which I can take is to neglect my own defence, and enter boldly upon the subject.

I have several times observed the explosion of the grains of pollen during nearly four years, especially at the time of my particular experiments upon the subject of pollen; and I never observed any thing which appeared to me capable of giving the slightest idea of the existence of a spontaneous motion.

Nothing is more variable than the circumstances which accompany explosion. Sometimes we see issue out of what I have called the *hile* of pollen, a vermicular substance which appears to be formed as if drawn through an aperture. This is described by Professor Amici under the name of a *boyau*. But it is easy to prove that this mass is very often nothing less than membranous and vesicular; that it is composed of a substance insoluble in water; and which, after the evaporation of the water, dissolves entirely in alcohol and in ether. Professor

* This important Memoir, which M. Raspail has been so kind as to communicate to us, will appear in the *Mémoires de la Société D'Histoire Naturelle de Paris*, tom. iv. It was read at the Institute on the 10th March, and at the Society on the 14th March 1828.—Ed.

† *Mém. Soc. Nat. Hist. de Paris*, tom. iii. p. 238. 1827.

Amici has thus guessed but not proved the existence of a *boyau* susceptible of issuing during the explosion of the grains of pollen; and I believe I may claim, in virtue of direct and positive experiments, the discovery of an internal tissue, glutinous and elastic, which springs sometimes out of the pollen under the form of a *boyau* or of several vesicles.

Sometimes, instead of the vermicular sinuosities of which I have spoken, there are seen issuing without any order small corpuscles, very variable in their shape, their aspect, and their diameter, not only from different vegetables, but even in the pollen of the same vegetable. In measuring them, it appears to me that observers have paid attention only to those which resembled one another, and that they had neglected those which exceeded or did not reach the measure originally observed. Thus, according to my opinion, they have found that the globules of blood, and those which compose the tissues, invariably affect the same diameter.

Respecting the spontaneous motion which is now believed to be found in all inactive substances, I have never observed the slightest trace of it. The granules issuing from pollen have themselves an appearance which for a long time made me doubt their organized nature, and it is to attempt to clear up these doubts that I have principally made use of the pollen of the Malvaceæ. I shall now proceed to explain, under the form of corollaries, the various results which I have obtained from a great number of consecutive observations.

I. A number of causes, of which it is indispensable to examine the influence, communicate to the most inactive granules an appearance of spontaneous motion.

1*st*, *The Explosion which discharges the Granules.*—The motion communicated will be the more rapid as the explosion is more energetic; and as the medium in which the granules float has itself received an agitation tending to make a variety in the level of the surface, it produces different reactions, which will carry the observed granules in different directions. But this motion will soon subside by gradual and decreasing oscillations.

2*d*, *Capillarity.*—It is very easy to see by the microscope, that the most inactive bodies perform many various and sudden motions during the time they take to become wet The grains of fecula, at the instant they reach the water, perform the part of infusory animalculi, and the grains of pollen themselves then execute motions of recoil sufficiently picturesque up to the very moment of explosion.

3d, *The evaporation of the water which supports the granules.*—As the evaporation causes the level of the different points of fluids to vary every instant, it is evident that the granules floating on the surface must from this cause appear to approach or to retire spontaneously. It is also remarked that the motions of inactive bodies when observed in the microscope, will be always in the direct ratio of the elevation of temperature. An idea may be formed a little exaggerated of the effects of a similar cause, by placing in the focus of a microscope the inactive granules in a drop of diluted alcohol.

4th, *The evaporation of the volatile substances with which the granules in issuing from pollen may be impregnated.*—These substances exist in the pollen in great abundance, as analysis demonstrates. The bodies which issue during the explosion ought to be impregnated with them ; but the evaporation of a volatile substance which covers an inert body, ought evidently to impress upon the latter the most illusory movements. In order to be convinced of this, we have only to throw into the water of the object-plate, grains of fecula previously moistened with ether or alcohol.

5th, *The ordinary motions of great towns.*—In a populous city it is hardly possible to make a single microscopic observation, without remarking a sort of shaking occasioned by the rolling of the carriages.

6th, *The motions caused by the agitation of the air.*—This cause varies according to the currents ; it exists sometimes without the knowledge of the observer, and even when he does not suspect there is the least agitation in the atmosphere. It is sufficient for this that the current of air be only at the level of the object-plate. Even the breathing of the observer renders the effects still more intense.

7th, *The motions caused by the hands of the observer, occupied in drawing or leaning upon the table.*—This cause of agitation is so powerful, that it is easy to count with the microscope the arterial pulsations.

*8th, The inclination of the object-plate.*—It is almost impossible to obtain a geometrical horizontality with respect to the object-plate of a microscope, and the nearer we approach to this point of perfection, the more the movements of the corpuscles suspended in the liquid are illusory. The liquid appears to direct itself towards the point opposite to the side the most inclined, on account of the inversion of the image; but we often then observe two motions in opposite directions, and lying above each other. If an islet is encountered in the way of the corpuscles, they are then seen to turn the obstacle by an act of prudence which can only proceed from a sort of fluid atmosphere, with which all solid bodies are enveloped in water. The illusion of a spontaneous motion becomes greater still, when the islet or promontory is near the limits of the field of the microscope.

But, however illusory we may suppose these various motions, it is easy to distinguish them from the motions which are directed or determined by the will; it is enough for this purpose to observe even superficially the motions of the monads or other infusory animalcules. I should not have been obliged to enter into these details, if the opinion which I oppose had not been revived with a publicity so solemn, that I felt it incumbent on me to repeat all my experiments, and to vary them in every way, as if I had doubted the accuracy of my former ones.

II. For this purpose I made use of the pollen of the Malvaceæ, not only because it has the greatest proportions, but also because it has been used to establish an opinion contrary to mine. Nothing new took place, and if I enter here into some details, it is less to publish discoveries than to make up for my former silence, and to pursue the question relative to spontaneous motion even to its last entrenchments.

*1st.* The grains in issuing from the pollen affect different forms and diameters.

*2d.* It sometimes happens that two agglutinate together in order to form a third, whose diameter then equals that of the two first.

*3d.* If several grains join together, they often form a line more or less crooked or sinuous, which, giving way, appears to bend, especially when it is met by two opposite currents.

*4th.* Sometimes a certain number of granules put themselves in motion towards one of the sides of my microscope, but I have only to raise the opposite side a little, to make my little troop retrograde; and during this retreating movement, they preserve amongst themselves the same distances and the same relations, resembling those automatous regiments which the teeth of the same cylinder cause to pass before the public. When I cease to raise the side of the microscope, all at once and by a sudden motion, but without changing the order of march, they return towards their first direction. But, in observing the monads, it will be advisable to raise or lower one of the sides of the microscope; it never makes them perceptibly change the direction; they are only seen to struggle in a thousand different ways against the force of the current which draws them along.

*5th.* I have seen some of these grains diminish in size, and others disappear all at once from my eyes.

*6th.* At other times no granules are found separately, and I obtained in the explosion only a mass resembling the substance of the granules. The pressure of a microscopic point divided the mass into fragments too large and irregular to be assimilated to animalcules.

*7th.* The appearance of my little granules reminded me in a manner so striking of little drops of resin, half dissolved in an essential oil, or of oil divided in water, that I could not prevent myself from entertaining serious suspicions of their organization; for the greater or less similarity of their diameters is not sufficient to alter the opinion of those who have observed in a microscope the effects of the solution of gum resin in alcohol. In proportion as this menstruum evaporates we shall see myriads of globules equal in diameter bubbling up in the liquid which deposits them and divides them while it is evaporating. Some authors would not fail to see in these motions of evaporation something analogous to the *Nemazoaires*, those monstrous assemblages whose singular developement would have been inexplicable by any known law, had not accurate observation made them disappear from the pages of science.

III. In order to satisfy myself of the accuracy of the relation which I conceived to exist between the effects of evaporation now pointed out, and the nature of my granules, I performed the following experiment. I placed on a very small drop of water a grain of the pollen of mallows. From the instant of the explosion to the complete evaporation of the water, I never lost sight of the insulated granules, during all the extraneous movements which separated them from the pollen.

When they were applied against the surface of a plate of glass I left them till next day without deranging the object frame. Next day they had neither changed their form nor their aspect, whereas after the evaporation of the water all animalcules collapse, and become flat and crumpled in applying themselves against the object-plate. My granules then resembled exactly the resin deposited in mamillated masses, and upon touching them with a microscopic point it made the same impression upon them that it does upon plates of resin softened by the mixture of a dissolving menstruum.

I now poured upon my little flock a drop of alcohol, when they were almost instantly dissolved. But this menstruum makes animalcules more easily seen, from rendering them opaque by the coagulation of the albuminous juices with which they are filled.

The granules which Gleichen first considered as analogous to spermatic animalcules, are therefore only little drops of resin half dissolved, or of essential oil half concreted.

In this experiment we must take into account all the debris of glutinous or gummy tissues projected out of the pollen with the granules, and which the use of alcohol renders more perceptible by coagulating them. They then float in myriads, and like black points.

It is on this account that these kinds of experiments ought to be made by the person who desires to see them, for we cannot expect to show them to another, for fear of the mistakes which could not fail to be committed in changing places.

IV. Having found subsequently that those who are well acquainted with the management of telescopes have very imperfect ideas both of the structure of the instrument, and of the value of microscopical observations, I am compelled to enter into farther details respecting the precautions which researches of this kind require, and the importance which ought to be attached to what is called the use of expensive miroscopes.*

1. I have already proved, in my memoir on *organic tissues*, that the pollens of different plants vary in the quantity of resinous and volatile substances which they contain. It would, therefore, not be surprising, if in using any other pollen than that of the Malvaceæ, we should not find so many globules soluble in alcohol.

2. In order to recognize the chemical nature of the globules discharged by the explosion, we must not pour the alcohol on the object-plate before the evaporation of the water, for in that case nothing would be dissolved, since the alcohol would extend itself over the water instead of dissolving the resin.

3. If we wish to stop the movements arising from the evaporation of the water, or of the volatile substances with which it is impregnated during the explosion of the grain of pollen, we must not content ourselves with covering the water with a film of mica, for the sides of the film being always unevenly applied against the object-plate, would not prevent evaporation at the edges, which would become a still more powerful cause of illusory motions and currents, than if the evaporation continued to be carried on over the whole surface.

We ought to make use of two plates of glass ground upon one another, and one of which has a cavity of the form of a spherical segment. We have then only to put a number of grains of pollen in the cavity, and after passing water over it, to slide quickly the one plate over the other. The explosion of the grains of pollen will at first impress a general motion on the globules, but the granules will soon resume the immobility which characterizes them.

4. It may perhaps be objected, that observations opposite to these, on the animality or the mobility of the granules of pollen, have been made with a microscope superior to mine, and

* A celebrated astronomer (See *Le Globe* for July) has publicly declared that *cæteris paribus* the microscope of Amici is superior to every other microscope, which must mean that the prism which distinguishes it from others adds to the light and the magnifying power. He afterwards laid it down as a principle, that the value of microscopical observations was in the direct ratio of the intrinsic value and the superiority of microscopes.

that they, therefore, deserve more confidence than those which I have made.* This objection, which could only be urged by persons little familiarized with the theory and practice of the microscope, gives me the opportunity of establishing, in the *first* place, that the superiority of microscopes cannot be a guarantee of the accuracy of an observation; and, *secondly*, that microscopes which are vaunted as superior, are, from their very construction, inferior, *cæteris paribus*, to all others.

Leuwenhoek and Swammerdam used the single microscope with more success than other observers did a compound one; and who will venture to pronounce himself more rich in observations than Swammerdam!

I do not know a single discovery accurately established which has ever been attributed to the superiority of an instrument, and which cannot be verified with a single lens of a line focus; and this is easily explained by considering the actual state of our means of observation.

I will not speak of solar microscopes, since, with gigantic magnifying powers, these instruments give outlines too indefinite to permit us to use them in researches which require precision of form and aspect

It has been sufficiently proved that a microscope is rarely susceptible of being employed with a magnifying power of from 800 to 1000 diameters, as the light is then weak, and the outlines indefinite. With a magnifying power, on the contrary, of from 200 to 300, a good microscope shows objects with clearness and distinctness. I shall suppose, however, that with a power of 1000 diameters, any microscope equals in clearness and distinctness the magnifying power of 200 with another microscope; the difference between the two microscopes will cease to appear as marvellous, as it at first seems, when we have once reduced it to its most simple expression, for in this case the one will really magnify only *five times* as much as the other.

* We must not forget that the magnifying power itself may become a new cause of illusion in reference to the automatic movements of inert bodies. As the microscope increases the distance without augmenting the duration of the motion, it is evident that a motion almost inappreciable with a magnifying power of 100 diameters, will acquire the rapidity of lightning with a very high magnifying power.

But it is well known that the power of 1000 diameters can never be compared in point of light and distinctness with inferior magnifying powers; and even if a microscope should magnify 1500 times, the advantage derived from it would perhaps be inferior to that gained by a single lens, for clearness is undoubtedly a great compensation for magnifying power. Of what consequence is it to show us giants, if we can distinguish them only in shadow.

On the other hand, the diameter of organs which we require to study is far from being invariable; and if a microscope should not be able to magnify enough to show an organ in one body, we may expect to meet with the same organ on a large scale in another body, so that its examination will require only a small magnifying power. If, for example, we had occasion to study the fecula in the farina of the small millet, it would be difficult to make the simplest experiment with a power of 1000, but the potatoe presents us with a fecula examinable by very inferior magnifying powers. *

The essential advantages consequently which can be derived from high powers are only ephemeral in relation to natural history; and we ought therefore to be on our guard against attaching to them too much importance.

Supposing, however, that this importance is sufficiently great to enable us to arrive exclusively at the knowledge of truth, let us examine the question, whether this privilege ought to be granted to the microscope of Amici in preference to every other.

The horizontal microscope of Amici does not absolutely differ from the vertical achromatic microscope invented by M. Selligue but in having a triangular prism, the hypothenuse of which reflects horizontally to the eye-glass the image transmitted by the object-glass. The most superficial knowledge of optics is sufficient to convince us that, *cæteris paribus, i. e.* supposing the two microscopes to have the same system of

* We cannot here agree with our author. The examination of the fecula of the potatoe will never stand in natural history for the examination of the fecula of the millet, unless the similarity of all fecula had been previously determined. But as this could only be done by the microscope, the argument of our author has no force. We might as well infer the structure of the sting of minute animals from that of the enlarged organ in the wasp.—Ed.

object-glasses and eye-glasses, and taking care to observe with the same magnifying power, the mere addition of the prism renders the microscope of Amici inferior to every other microscope, since there must be at the three surfaces of the prism a triple loss of the luminous rays. But at present these two kinds of microscopes are constructed with the same lenses, so that my supposition is realized, and the comparative experiment may be made. I request, however, those who desire to be convinced with their own eyes, to observe with the same magnifying power, and not to trust to the tricks of certain artists, who exaggerate the magnifying power of a microscope in order to sell it at a high price.

With regard to the experiments in support of the fact which theory establishes, they have been repeated in England before M. Amici with his own microscope; they have been repeated in France with an instrument made by M. Amici, and recently arrived from Modena for a member of the Institute; and they have been repeated by the most skilful and the oldest observers of the capital; and it has been proved that many objects—for example, the *semen masculinum desiccatum*,—are not perceivable by the microscope of Amici.*

These sort of revelations, perhaps indiscreet, have appeared to me necessary, not only for the interests of science, but even for those of the arts, especially since my humble labours have, as I am informed, introduced the use of the microscope into a number of manufactories and laboratories. They appear to me necessary in reference to the interest of those young observers whom nature has favoured more highly than fortune,

* In the meeting of the Academy of Sciences of the 11th August 1828, M. Arago, in attempting to reply to these facts, the accuracy of which we do not scruple to guarantee, has maintained that we may render these objects visible by the microscope of Amici by drawing out the tubes and making the object approach to the object-glass,—a thing which we have tried in all ways, but without success. Besides, these objects are not invisible in this microscope, on account of their smallness, but on account of their transparency, and of the indistinctness of their edges. But the more you draw out the tubes to magnify the diameter, the more indistinct do these objects become, since you thus increase the loss of a great quantity of the rays of light. The simplest experiment on this subject will serve as a reply to the assertion, no doubt unpremeditated, of this learned astronomer.

and who would no doubt be every day discouraged by the erroneous expression *with an expensive, a powerful, and a fine microscope.*

In justification of my conduct in this matter, it will be sufficient to mention the following fact :—

A manufacturer of painted papers having learned the use which I had made of magnifying glasses in the analysis of the fecula, and of the *encollage à la cuve*, and, deceived by pompous announces in the Journals, eagerly purchased for 1200 francs a microscope of Amici's. If he had done me the honour to consult me, he would have devoted 1185 francs to the purpose of his manufactory; for by the side of my costly microscope of M. Selligue's, I would have shown him the poor mounted single lens which has served me for all my researches on the fecula and on the *encollages à la cuve*; and I boldly hold out a formal defiance that a more expensive instrument will find a single point of these experiments erroneous.

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ART. XVI.—*Note on Mr Brown's Microscopical Observations on the active Molecules of organic and inorganic bodies.** By M. RASPAIL.

THE Society has heard at its last meeting the contents of a work by Mr Robert Brown, entitled, " *A brief account of Microscopical Observations on the particles contained in the Pollen of Plants*," † &c. Such of our members as attended to the discussion which took place at the Institute on the subject of my Memoir *On the granules discharged in the explosion of a grain of Pollen*, which was read on the 18th March 1828, cannot fail to have observed, that the general proposition of Mr Brown is contained in that Memoir; and philosophers will doubtless acknowledge that the phenomena of motion, which Mr Brown left enveloped in a sort of mystery, by representing them as inherent in the molecules of organic and inorganic bodies, may be easily explained by the concurrence of all the foreign circumstances which we have enumerated in the pre-

* This Note was read to the Society of Natural History of Paris on the 29th August 1828, and forms an appendix to the preceding Memoir.

† Printed in our last Number, p. 336.

ceding memoir. The author might have swelled his memoir with myriads of analogous facts; but we consider it unnecessary to adduce individual facts after the general law has been ascertained.

The author might thus have varied infinitely the motions which he has observed, if he had used essential oils, globules that had been kept in ether, or alcohol, or camphor, all whose motions vary with the shape of the fragments which are placed upon the water, since they are owing to the evaporation of the substance itself. To all these causes we may add the electricity which the friction of the file may communicate to metallic particles.

Mr Brown would no doubt have himself recognized the various causes of these motions, if he had seen the criticism which we have published of a Memoir, *Sur les Mycodermes*, (*Bull. des Sc. Nat. et de Geol.* Tom. xii. No. 27, p. 46;)—our Note, *Sur l'Encollage à la Cuve*, read to the Institute on the 24th December, and published in *Le Globe* the end of December 1827;—our Memoir, *Sur les Tissus Organiques*, published in Tom. iii. of the *Memoirs of the Natural History Society of Paris*; and, lastly, the announce of the same Memoir, inserted in *Le Globe* of the 22d March 1828, four months before the publication of Mr Brown's memoir. This article was reprinted verbatim in the *Bulletin des Sc. Nat. et de Geol.* for May 1828, No. 54.

In order to render these motions visible, the microscope is not indispensably necessary. Whenever we place upon water organic or inorganic bodies capable of being wetted, or of imbibing water, we shall observe motions more or less singular, which will vary in each experiment, and which will depend only on the variations in the form of their different faces. Particles of iron, for example, will move differently, according as they have been obtained with a file more or less fine. Porous bodies will move very differently from compact bodies.

Those which have no affinity for water will move when the water is agitated by the causes which we have pointed out in our preceding memoir. Thus wax well freed from its volatile oil, fat, and oil, present motions too vague to be determined. But dry organic fragments, on account of their avidity for liquids, present the most picturesque movements, for the coiled up fibres uncoil themselves, folded membranes will stretch themselves, and empty vesicles will be filled—effects which cannot take place without motions and agitations. To complete, in short, so many wonders, if we place upon water the molecules of a carbonate, of the debris of shells for example, and add an acid to the liquid, we shall imagine that we have before our eyes a kind of artificial fire-works, and shall see fuses flying in all directions.

I shall conclude this note by observing, that the discovery of a membrane, which lengthens itself *en boyau*, or into a cylindrical mass of the pollen, does not belong to M. Brongniart, as Mr Brown seems to announce, but to our *Mémoire sur les tissus organiques*, as may be shown by merely reading the *proces verbal* of the meeting of the 21st July 1826, of the Natural History Society, and printed in the *Bull. des Sc. Nat. et de Geol.* Tom. x. 176,—a paper which is six months anterior to the memoir quoted by the learned English author. If Mr Brown will have the goodness to repeat our chemical experiments on this subject, he will be convinced that nothing is more certain than the existence of these internal membranes of the pollen.

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## Art. XVII.—*Physical Notices of the Bay of Naples.* Communicated by the Author.

### No. II.—*On the Buried Cities of Herculaneum, Pompeii, and Stabiæ.*

" Inde legit Capreas, promontoriumque Minervæ
Et Surrentinos generoso palmite colles,
Herculeamque urbem, Stabiasque et in otia natam
Parthenopen ——————————"

Ovid.

" Hic locus Herculeo nomine clarus erat,
Cuncta jacent flammis, et tristi mersa favilla."

Mart.

In No. I. of the Physical Notices of the Bay of Naples, we took a rapid view of the most remarkable feature it contains, Mount Vesuvius,—of its topography, phenomena, and productions. It seems most natural to proceed next to an account of by far the most extraordinary effect of its volcanic agency now extant, the cities buried under its ejected materials, and now, after a repose of between seventeen and eighteen centuries, opened to the view of mankind, and calling them to survey, in a form more forcible than words can paint, the habits, the peculiarities, the domestic comforts, the public luxuries, the baths, the theatres, the villas, and the tombs, of another age of men; a scene which opens a sort of enchantment to us, preserved as by a miracle from that slow but ruthless power, which in the meantime,

> " So oft has swept the toiling race of men,
> And all their laboured monuments, away."

In a subject like this, I shall be excused for not adhering rigidly to the physical appearances which the buried cities now present to the eye of the naturalist. I shall be permitted to extend some remarks to the ancient history of these ill-fated towns, the event by which they were overwhelmed, and the illustrations of antiquity which their excavation presents.

The authorities to which I can refer in my present work are much more abridged and unsatisfactory than when writing on Vesuvius; and if in combining the results of my personal observation with the remarks of others, I may appear desultory in my arrangement, I must crave the indulgence of the reader, in consideration of the remarkable want of any work on the physical history of the objects I have undertaken to elucidate, and the numerous sources to which I must be indebted for facts in almost every page of the narrative. Pompeii and Herculaneum have been peculiarly unfortunate in the descriptions of all classes of travellers. While some with Eustace confine themselves to a detail of classical and sentimental expressions, which, however interesting to the visitor, and however they may press themselves on his attention, cannot be sufficiently varied in expression to please the public ear, told as they are for the twentieth time; others, with Barthelemy, Caylus, and Mazzochi, have dwelt chiefly upon the benefits, every day becoming more problematical, to be derived from the discovery of papyrus rolls; and a larger number give merely catalogues of the more remarkable features of the excavated buildings, with Stark, Ferrari, and Reichard; or of the objects of domestic use and ornament removed to the museums, of which a splendid account has been published, in nine volumes folio, under the title of "*Antichità di Ercolano.*" Here we may in vain search for any information of a general description, to be found only in some travels of an older date, such as those of Lalande and Swinburne, which contain more general information on the extraordinary phenomena of the buried cities, than the passing and unsatisfactory notices of all that Piozzi, Baretti, Brydone, Nugent, Douglas, Smith, Walker, and others perfectly innumerable, have brought together, in those volumes which, large as is their collective bulk, are but a mite towards the great desideratum of a truly philosophical and complete description of Italy. Nor have those whose province has been more peculiarly philosophical acquitted themselves better in this respect; Breislak, whose valuable "*Topographia Fisica di Campania*" was so often quoted in my paper on Vesuvius, barely mentions as objects in the topography of the bay these remarkable victims of volcanic agency, nor gives us a word of that information which, in a work approaching in its nature to the present "Notices," we might have expected. Spallanzani, one of the few native geologists of Italy, in his four volumes devoted to the natural history of the two Sicilies, hardly mentions the names of Herculaneum or Pompeii; and Della Torre, in his History of Vesuvius, though obliged in the course of his details to allude cursorily to the subject, is singularly trifling in his notices, which he frequently repeats in almost the same terms in the course of his work.

On the whole, our most satisfactory guide is Hamilton, in his *Campi Phlegræi*; yet how meagre and confined is the view he gives of the subject; how short his statements; how incomplete his general views; and what a deficiency in many of the facts we would wish to be possessed of. Among the *desiderata et desideranda* in our present subject, we may consider the investigation of the ancient sea line, extending from the modern Resina to Castel-a-mare; the enumeration of the strata which cover Herculaneum; and the results relative to the ancient condition of Stabiæ which its excavation must have illustrated, but which we shall presently see is even now a matter of great debate. Upon these, and a variety of other topics, Hamilton is entirely silent; but his account is important, as being more original than those of other travellers, and forming an appendix of value to all the accounts which have met my eye.

Upon the whole, I do not despair, within the limits of this short paper, of giving the substance of all that has yet been given to the world in the way of physical facts, regarding the phenomena of the buried cities. I propose to commence by noticing the original condition of these towns as far as bears upon their subsequent catastrophes; next to give an account of the event by which they were submerged, examining the accounts which the ancients have left us upon the subject, more particularly as they are connected with present appearances; and finally, to describe the existing condition of the cities as they now stand, and the circumstances connected with their disinterment, as modified by past events, and calculated to throw light on volcanic agency.

To commence with the original condition of Herculaneum, Pompeii, and Stabiæ, we may remark, that, from decisive classic authorities, they appear to have stood in the order just named from W. to E. along the shore of the Bay of Naples, as is expressed in the motto at the head of this paper, taken from Ovid, and in the two following inscriptions from monumental itineraries given by Cluverius.*

| | | | |
|---|---|---|---|
| Neapoli | | | |
| Herclanium | xi. | Herclanium | |
| Oplontis | vi. | Oplontis | vi. |
| Pompeis | iii. | Stabios | iii. |
| Nuceria | xii. | Nuceria | xii. |

HERCULANEUM, it is generally admitted, derived its name from Hercules, who was supposed to be its founder, for which Strabo is the principal authority; but it would be superfluous to enter here into the details connected with its early history, which, however, Bajardi in his great work seems to have found so entertaining, that in the two first volumes of his "*Antichita di Ercolano*," amounting to 1100 pages quarto, he has

* *Italia Antiqua*, Fol. ii. 1154 and 1155. The reader may also consult, for the position of these towns, *Strabo* l. v. *Florus* I. 16. *Velleius* l. xi. *Pliny* iii. 5. *Columella* l. x. *Mela* xi. 4.

got no farther in his history than the expedition of Hercules, in aid of Theseus *before* the foundation of this city. It will be sufficient simply to mention the conjecture of Mr Hayter (we presume the gentleman who since superintended the unrolling of the papyri) the ingenuity of which scarcely makes up for its improbability, that Herculaneum is derived from two oriental words, Her and Koli, signifying "burning mountain." Be this as it may, Herculaneum seems to have been peopled by a Greek colony, but not to have risen to eminence till later times, since Polybius, 150 years B. C. when mentioning Capua and Nola, does not allude to it. It afterwards became, however, distinguished for its splendour and refinement, and "if we are to judge from its remains," says Ferrari, "we must believe that it had been the most remarkable city in Campania after Capua and Neapolis." It certainly was much admired by the Romans from its situation and climate, and we have reason to believe that it contained many of their most favourite villas. Yet it must be admitted that it is rarely and cursorily mentioned by authors who were contemporary with its days of magnificence, and that its name would hardly now have reached the attention of the learned, but for the remarkable catastrophe of which it was the subject and the scene.

Antiquaries, previous to the eighteenth century, were not agreed as to the site of the ancient Herculaneum. Cluverius, in his "*Italia Antiqua*," inferred from the Monumental Itineraries already cited, that the number xi. there given as the distance between Naples and Herculaneum was a mistake for vi.; since he remarks that the total distance from Naples to Pompeii was xx. by that reasoning, whereas the distance to the river Sarno, which was known to have passed Pompeii, was found to be only xvi., whence he fixed Herculaneum close to Torre del Greco, seated on a small promontory at six miles from Naples, which, on its discovery, proved to be very correctly the spot. The harbour of Herculaneum (for it was a sea-port,) existed on both sides of the promontory, and on both a stream appears to have flowed into the sea, as we learn from Sisenna, an old writer, quoted by Nonius Marcellus, and who flourished in the first cent. B. C. The country in the vicinity was then probably much flatter, and free from the accumulated ejections of Vesuvius, since we learn from Columella that there were salt pits in the vicinity of the city.

> " Quæ dulcis Pompeia palus, vicina salinis
> " Herculeis——"

Pompeii was seated on the river Sarno, a fact which appears, before the discovery of the cities, to have thrown the greatest light upon their true position. The river still flows, though probably changed from its old course, divided into two branches, and passes near the modern village of Scafati, to the east of Pompeii. This city was probably larger, and more important than Herculaneum. Seneca (*Nat. Quæst.* vi. 1.) calls it " Celebrem Campaniæ urbem ;" while Pliny and Tacitus inform us that it was a municipal town. On the other hand, we have reason to believe that Herculaneum was considered a small one, from the authorities of Sisenna, Dionysius, and Strabo.* In this view it is interesting to know what was its real size, which we have now sufficient data for accurately determining. The walls of Pompeii are above three miles in circumference.

Some modern writers have, I think, derived the name from the Pompeian family ; but we have every reason to believe the city to be far more ancient than to render this opinion probable ; and Solinus expressly refers it to the triumphs *(pompæ)* of Hercules, when, on his return from Spain, he founded the city which bore his own name. Although the exploits of Hercules rank among the fables of mythology, we are not to carry our incredulity so far as to imagine that there was never a foundation for these relations, or to invalidate the testimony of antiquity with regard to traditional etymologies. The name has been variously spelt ; Pompeii, Pompeia, Pompejes, Pompei ; but I have adopted the first, not only as warranted by the best English authorities, but as being apparently the true nominative of the Latin (plural) appellation. Pompeii was anciently a sea-port, as we learn indirectly from classical sources, † but especially from the obvious arrangements

* Cluverius. This goes against the opinion of Ferrari, already cited, who considered Herculaneum the third city of Campania.

† The most remarkable authority I am acquainted with is that of Livy, who mentions a Roman fleet being driven into Pompeii, and dispersing marines to the plunder of the Nucerian territory. " Classis Romana in

made for embarkation and the management of merchandise displayed by the excavations; but the same event by which the city was destroyed, forced the sea outwards by the accumulation of volcanic soil, to the distance of a mile,—a striking proof of the real magnitude of the catastrophe, and at the same time easily credible, when we recollect that the neighbourhood was an extended plain, little elevated above the sea, and giving rise to the "palus Pompeia," mentioned by Columella in the lines already quoted. Pompeii, as well as Herculaneum, stood on the sides of Mount Vesuvius, but at a considerable distance (5 miles) from its present crater, and the former one was probably greatly farther off; and this is rather sanctioned than otherwise by Pliny the elder,* in his expression "Neapolis, Herculanium, Pompeii; haud procul spectante Monte Vesuvio;" for as he speaks of these cities nearly in a similar situation with regard to the mountain, if we suppose the crater to have existed considerably to the north of the present one, as in my last paper I showed was probable, the distances are more nearly equalized.

The situation of STABIÆ was very different, being placed at the base of the Surrentine range of hills, composed of Apennine limestone, and a branch of the great chain which passes through Italy. It was near the site of the modern Castel-a-Mare, between the flank of the hills and the sea-shore. Its situation was known to Cluverius long before the time of its discovery. Its neighbourhood was peculiarly remarkable for hot medicinal springs, of which Galen,† Cassiodorus,‡ and Pliny,§ have given an account. Even in modern times these springs remain, and an account of them has been published by Raimondo de Majo.‖ Of Stabiæ we know little as a town, and its history has been a subject of some dispute. Certain it is that it was of great antiquity, as it is said to have been founded by the Osci, and successively inhabited by the Etrusci, Pelagi, and Samniti. We have the distinct testimony of the elder Pliny, that it was destroyed by Sylla in the civil wars,

Campaniam acta et adpulsa Pompeios esset, socii inde navales ad depopulandum agrum Nucerium profecti." (Lib. ix.)

* Lib. iii. cap. v. † *De Meth. Medendi,* lib. v. ‡ Lib. xi. Epist. x.

§ Lib. xxxi. 2. ‖ Napoli, 1745. 8vo. See Ferber.

and under the consulship of Cn. Pompeius and L. Carbo. Cluverius finds, however, no such name as Carbo in the consulship along with Pompey; and we must therefore believe the reading corrupted for Cato, who was consul, which will place it in A. U. C. 664. Thus far all is clear; but now the difficulty in the history commences, and there appear to be three opinions regarding the final fate of Stabiæ. By some it is supposed that it never rose after the destruction by Sylla; others consider it to have been rebuilt, and then destroyed by the eruption A. D. 79; while a third party maintain that it still existed in the sixth century. Each of these opinions has some weight, and the evidence is rather contradictory. Breislak,* in the few words he says on the subject, supports the first. After mentioning the opinion that it was destroyed by the eruption under Titus, he says, " *Pline*, l. iii. c. 5, la renverse formellement lorsqu'il dit que c'est sous le consulat de Cn. Pompée et de L. Carbon, l'an 664 de Rome, que Stabia fut detruit par Sylla, et qu'il nous apprend que de ces ruines il se forma plusieurs villages." Eustace † is nearly of the same opinion; " Stabiæ, now Castellamare di Stabia, had in Pliny's time disappeared as a town, and given place to a villa. It was destroyed by Sylla, and never seems to have revived; quod nunc in villam abiit, Plin. lib. iii." The reading of this important passage of Pliny in the best variorum edition ‡ is as follows:—" In Campano autem agro Stabiæ oppidum fuere usque ad Cn. Pompeium et L. Carbonem consules pridie Calend. Maii, quo die L. Sylla legatus bello sociali id delevit quod nunc in villas abiit." As a various reading, however, in the margin we have " villam" for " villas," which certainly I should rather be disposed to translate a " small town" than a " villa," as Eustace has it; and if we retain the original reading of " villas," we should render it " villages," which is the meaning adopted by Breislak, Swinburne, and Lalande. But besides this, the younger Pliny speaks of it as still existing, in the famous epistle relating the fate of his uncle; § so that I cannot at all coincide in the idea that Stabiæ was finally and irrevocably destroyed by Sylla. The second opinion, that it

* *Campania*, i. 26.
† *Tour*, iii. 127.
‡ Lug. Bat. 1669. 3 vols.
§ Epist. lib. vi. Ep. 16.

was buried by the eruption of A. D. 79, along with Herculaneum and Pompeii, is the most general, though not very distinctly warranted by classical authority. We are, however, distinctly informed in the remarkable epistle of Pliny just quoted, that the ashes fell in such quantity, that at the time of his uncle's death at Stabiæ, they had almost filled the adjoining court of the house in which he was,—an irrefragable proof of the magnitude of the catastrophe, especially when taken in connection with the imperfect modern accounts we have of the excavation of the ruins. Hamilton * mentions the state of the covering soil indirectly, by observing that the ejected masses of scoria at Pompeii weigh sometimes eight pounds, but at Castel-a-mare never above an ounce. From the only circumstantial ancient account of the phenomenon, therefore, we have reason to believe Stabiæ to have been overwhelmed. A second argument in favour of this opinion arises from the style of the objects dug from its ruins, which, if I mistake not, closely resemble those from Herculaneum and Pompeii. At least, the dissimilarity must have been glaringly obvious had they borne a date so far back as the year 89 B. C., or so late as the sixth century of our æra, according to the two other hypotheses. A third evidence that at least it did not fall to natural decay during the middle ages, is derived from the fact, that skeletons and personal ornaments have been found among the remains, though very few,† but a considerable number of papyrus rolls. Lastly, the present appearance of the excavations, as far as the imperfect accounts we have go, (the work being always filled up as they proceed,) and not having been on the spot myself, I must be satisfied with these accounts,—the modern excavations correspond perfectly to the idea of a volcanic eruption; and in fact it is almost incredible that any other event could produce a similar effect. I shall state the appearance of the locality towards the close of this essay.

The third hypothesis which I have already been combating, that Stabiæ existed till the sixth century at least, is supported by Cluverius,‡ who confirms my opinion of a new town having risen

* *Campi Phlegræi*, i. 57.

† "Pochissimi Scheletri"—"pochissimi mobili preziori,"—Ferrari, *Guida di Napoli*.

‡ *Italia Antiqua*, ii. 1159—1161.

upon the ruins of that destroyed by Sylla. He founds it upon a passage of Symonachus,* bearing a date of about 380 years after our æra, which describes Stabiæ as still in existence; and another of the "*Historia Miscellanea*,"† under Justinian, 150 years later, in which occurs the remarkable expression, "villâ, quæ Stabii dicitur." It is sufficiently remarkable that the very same word "villa" should have been employed by this late writer as by Pliny in reference to Stabiæ, which would certainly rather incline me to the opinion I have already stated, that it might be put for a village even in the Augustan age, although Cluverius‡ pronounces it a modern barbarism. At all events, without entering into a philological dispute, the reading of "villas" in Pliny may supply us with the idea of a string of detached houses forming a village; which from Swinburne, who saw the excavation going on, we learn to be much the true appearance.§ With regard to the existence of Stabiæ in late times, the authorities are certainly somewhat perplexing. Yet we cannot, for the reasons already alluded to, relinquish the belief in the fate of Stabiæ under the eruption of 79. It only remains, therefore, to suppose, that, from the great distance of the mountain, and the comparatively slight desolation which the country round had experienced, a new village had speedily risen on the site of the former one.

It is now time to notice briefly the phenomenon by which the cities of Herculaneum, Pompeii, and Stabiæ were destroyed. The event was one sufficiently novel and surprising to ensure us some account of it from an age even less scientific than that of Titus; yet in some of the facts connected with it, especially regarding the fate of the Campanian towns, we are left in remarkable uncertainty.

The letters of Pliny which relate the death of his uncle in the eruption of A. D. 79, are addressed to his friend the historian Tacitus, from whom we might have expected some circumstantial details of the event; but unfortunately the part of his history to which it belongs has been lost. Our principal

* *Italia Antiqua.* vi. 17. † Lib. xvi.

‡ "Vocabulo *villæ* utitur more sui ævi pro vico; ut hodieque fit per omnem Europam ab iis qui Latino barbare loquuntur aut scribunt."

§ *Travels*, vol. i. p. 128.

authorities, therefore, are the *Epistles of Pliny*, and the *Epitome of Dion's History* by Xiphilin. Preceding this remarkable event, a great earthquake took place in the year 63, of which Seneca gives us a particular account, mentioning that Pompeii was excessively injured, and a part of Herculaneum destroyed; * and Tacitus expressly says, "Motu terræ celebre Campaniæ oppidum Pompeii corruit." † This event proved only the forerunner of one more tremendous. Pliny relates, ‡ that the ninth day before the Kalends of September, A. D. 79, at the seventh hour, corresponding to the 24th of August, at 1 P. M., a cloud of very unusual shape was observed to rise from Vesuvius, resembling in form a pine-tree, (the stone pine of Italy, with a tall stem and expanded flat head),—a simile which corresponds so exactly with observed appearances, as to be still the usual object of comparison for the cloud which constantly ascends previous to an eruption. Its form is clearly owing to a cause which Pliny pretty distinctly points out, that where the force of projection is exactly counterbalanced by the decreased density of the air, combined with the loss of original impetus, the particles for a short time must remain pretty nearly in equilibrio, and, therefore, liable to be acted upon by the wind, which is very commonly violent at such moments. From the great height of the extended part of the cloud of ashes, that impalpable powder is carried sometimes to immense distances, § and the more ponderable masses are discharged in large quantities near the foot of the mountain. The phenomenon, therefore, so well described by Pliny, corresponds perfectly to the precursor of a prodigious "*cenere*," or shower of ashes. The elder Pliny, resolved to investigate this extraordinary phenomenon, was just leaving his house at Misenum to cross the bay to the scene of danger, when he received letters from Rectina, the wife of Nascus, who had a villa on the shore below Vesuvius, entreating his assistance in that awful moment. || He set sail, but was unable to pursue his purpose, not only from the enormous masses which rolled from the

* *Nat. Quæst.* vi. 11. † Ann. xv. 22. ‡ Epist. vi. 16.

§ See last Number, p. 206.

|| The reading of this disputed passage I have taken from the famous Aldine edition of 1508.

mountain, and the showers of pumice, but from the sudden retreat of the sea, *(vadum subitum,)*—another feature of the description which exactly corresponds with modern observation. In this dilemma, instead of turning back as the pilot advised, he ordered him to proceed to his friend Pomponianus at Stabiæ. Here he remained the afternoon, and observed broad flames spreading from the mountain, *(e Vesuvio monte in pluribus locis latissimæ flammæ et incendia relucebant,)* which Della Torre * supposes to have proceeded from the stream by which Herculaneum was destroyed. Here, (at Stabiæ,) after supper he went to rest, but was obliged to be roused, from the quantity of stones and ashes *(cinere missisque pumicibus)* which filled the court next which he lay. The roofs shook with earthquakes; they therefore went into the open air, but found the shower of stones so abundant that they tied pillows and napkins round their heads. Proceeding to the shore, the sulphurous fumes became so strong as to affect Pliny, who was of a full habit of body, with breathlessness, and he was shortly after stifled by them. Meanwhile at Misenum, where the younger Pliny remained, the shocks of earthquakes became more vehement. He observed more minutely the regress of the sea; "Certe processerat litus, multaque animalia maris in siccis arenis detinebat." He then mentions the tremendous lightning, which appears to have proceeded from a black cloud, extended as far as Misenum, no less than sixteen miles from the volcano,—a phenomenon which, to more or less extent is almost universal in the case of eruptions; † and this remarkable account of its extension from a credible eye-witness tends to render it probable that this catastrophe is unequalled in the Vesuvian annals. Pliny goes on to give an animated account of the tremendous scene which the descent of the ashes produced, and which he mentions were in such quantity, and of a white colour, as to resemble a deep snow in the morning. We shall not, however, follow him more minutely in his description, of which we have given all the leading facts. ‡

Now it is very remarkable, that in this description we have

* *Storia del Vesuvio.* 4to. Sect. 71.

† See Hamilton's *Campi Phleg.* i. 30; and this *Journal*, No. xiii. Art. ii.

‡ The whole will be found in his *Epistles*, lib. xvi. 16 and 20.

not a word either of Herculaneum or Pompeii, and this silence has given rise to one of the most extravagant conjectures which modern archaeology can afford. During the mania of the French Revolution, when nothing was too sacred or too well established not to be re-examined by the newly enlightened eye of "la grande nation," Citoyen du Theil chose to maintain that the two cities above named did not perish in the eruption of 79 but by one four centuries later. The report of Villar, the secretary to the Institute, upon this paper, will be found in the Abbé Barthelemy's *Travels;* from which it appears that the arguments in favour of this opinion are the unsupported assertion that these cities existed under Adrian; that the characters of the inscription under the statue of Balbus do not belong to the age of Titus; that there is an *indication* of the existence of Herculaneum and Pompeii in a fragment *attributed* to Petronius Arbiter; and that they are noticed in a fragment known under the name of the Map of Pentiger; but not being found in the itinerary *attributed* to Antoninus, it is *presumed* they were destroyed by the eruption of 471. Somewhat more classical authorities are to be found in support of the received opinion; in fact, the only truly classical indications correspond with this idea. Dion Cassius, the historian, who flourished about the 230th year of the Christian æra, expressly informs us, * that in the reign of Titus, the great eruption of Vesuvius ejected such quantities of ashes, as not only to kill many men and cattle, and to reach the very shores of Egypt and Syria; but that it entirely overwhelmed both Herculaneum and Pompeii, even while the people were sitting in the theatres. It appears, however, from the excavations and the small number of skeletons discovered, that if they were in the theatres at the commencement of the eruption, they must have found time to escape. No authority of which we are possessed can invalidate a testimony so distinct and circumstantial as that of Dion, combined with the probabilities of the place and collateral evidence. That the eruption of A. D. 79 was competent for the purpose I think has been already shown, especially when we consider its influence on Stabiæ and Misenum at such great distances from the volcano.

* *Dion ap. Cluver.* ii. 1159.

The argument of the Frenchman, founded upon the characters of the inscription below the statue of M. Nonius Balbus, I consider the most erroneous of all. I do not *very precisely* recollect these letters; but I would simply ask if it is within the bounds of possibility, that a statue like that of Balbus, which has been allowed by judges to equal or even exceed the exquisite one of Marcus Aurelius on the capitol at Rome,* should have been a production of the decline of the empire and of art? I have devoted not a little time and care to the study of the forms which the characters of inscriptions assumed in different ages; I have copied many of the most remarkable in the excavations of Pompeii with my own hand, and carefully compared them with those of different ages, and with others more especially known to be of the age immediately preceding the reign of Titus, and I do not hesitate to declare, that I have not observed one from the buried cities which does not correspond to the period between Augustus and Vespasian,—a period in which the characters are so marked, as in general to prevent the possibility of confusion with those either preceding or following. With this statement, which I could easily substantiate by instances, I shall content myself at present, and will only add, that, had these cities lasted till the fifth century, they must have been filled with barbarisms of sculpture and masonry, as well as of inscriptive characters, which is inconsistent with the state of observed facts.

Nothing is more peculiar in the excavated state of the ruins than the mixture of dilapidation and repair which we observe in the public buildings, obviously occasioned by an earthquake. I have already alluded to the account which Seneca gives of the shocks experienced in A. D. 63. "Pompeios, celebrum Campaniæ urbem," says he "desedisse terræ motu audivimus." And a little after, "Herculanensis oppidi pars ruit; dubièque stant etiam quæ relicta sunt †." At Pompeii many pillars were found lying on the ground; and it would appear that the public buildings were going to have been restored in travertine instead of the tufa, with which they had

Lumisden's *Antiquities of Rome*; appendix on Herculaneum.

† *Nat. Quæst.* vi. 11.

formerly been built. This remarkable coincidence of observed facts with history is too strong to be overlooked.

It cannot, however, be concealed that the silence of historians on the subject is very remarkable; since, except in Dion, we have no other direct testimony of the fall of these cities; but the declaration of Martial, in one of his epigrams, certainly, as far as it goes, is perfectly satisfactory :—

> "Hæc Veneris sedes, Lacedemone gratior illi;
> Hic locus Herculeo nomine clarus erat:
> Cuncta jacent flaminis, et tristi mersa favilla.*"

It has been alleged that Florus, who lived so late as the reigns of Trajan and Adrian, has represented Herculaneum and Pompeii as still existing, which certainly cannot be reasonably inferred from the passage in his history. He is engaged in pointing out the causes of the war against the Samnites, and takes the opportunity of launching out a little into the praises of Campania, as if to give the reader, as is not unfrequent, a picture of the regions where the transactions of the time were carried on (337 before Christ) in a sort of poetical and impersonal style, without using any verb which shall express either present time or past. He says, "Hic illi nobilis portus, Caieta, Misenus, &c. Hic amicti vitibus montes Gaurus, &c. Urbes ad mare, Formiæ, Cumæ, Puteoli, Neapolis, *Herculaneum*, *Pompeii*, et ipsa caput urbium Capua, quondam inter tres maximas, Roman, Carthaginemque numerata."* This mention of Capua, obviously referring to it in its pristine state, and the remarkable want of any verb in the sentence, inclines me to believe that I am not wrong in supposing that he refers to Herculaneum and Pompeii with respect to the time which his history describes; when, in fact, they were in their highest state of independence, not having been subjected to the Roman yoke. Suetonius, in his History of Titus,† briefly mentions the eruption of Vesuvius in 79; but describes the loss of life as so great as to make us believe that some peculiar catastrophe, such as the destruction of a city, must have occurred, though not particularly noticed in the

* *Mart. Epig.* iv. 44.

† *Florus,* i. 16., and *Chronol.* in edit. var. Elz. 1674. ‡ Cap. viii.

passage, where the event is rather incidentally brought in as an example of the Emperor's clemency than recorded as a fact in history. The number of persons who perished was so great, that Titus used his utmost endeavours to yield them relief; and especially devoted the properties of such persons as had no legal heirs preserved, to the aid of other survivors. This intimates a calamity of great extent.

I have now discussed, (and I hope not unsatisfactorily,) all the classical authorities which can throw light on this curious subject. I must now shortly detail the facts regarding the discovery and present condition of the cities, whose original state and memorable catastrophe we have already considered.

It is remarkable enough that Herculaneum was discovered at a depth of 68 feet below ground before Pompeii, which in some places was but just covered with loose ashes. The former city was in fact brought to light by mere accident, which, trifling as it is, is curious. In 1713, the Prince d'Elbeuf from France, having married at Naples, resolved to settle in the vicinity of Portici. He had with him a Frenchman, who made statues for adorning his villa from a composition of powdered marble, of which he got fragments from the country people. The objects discovered by one man in digging a well at his house were so remarkable as engaged the prince to prosecute the excavation. The well, as it appears, came right down upon the theatre; and statues of Hercules and Cleopatra were speedily discovered. The inscription on this theatre was the following:

C.A.P.P.R.O.C.E.T.H.E.R.C.V.L.E.N.S.E.
S.D.D.

Which, I presume, may be thus interpreted:

CAPREÆ PROCHYTA ET HERCVLENSE (oppidum)
SIMVL DEDERVNT.

Whence it would appear that the theatre had not been the property of the Herculanians alone, but built conjunctly with the aid of the two islands now known by the names of Capri and Procida. To detail the objects successively discovered in this extraordinary city, would be quite beyond the scope of this paper. Suffice it to say, that it appears to be more rich in antiquities than Pompeii, probably from the greater haste with which the inhabitants had been compelled to leave it. In statues it is richest; and here alone the papyrus rolls* were found sufficiently dry and well preserved to afford any hope in the task of unrolling them. Perhaps, too, it is from the greater solidity of the covering strata that many of the more perishable articles of curiosity have been preserved in great numbers. The glass of windows,† as well as that used for other purposes, paintings,‡ styles, tablets, pens, fruit, honey-combs, loaves, with the baker's name stamped upon them, opera tickets, " honestæ missiones," or the honourable discharges of soldiers; and all the innumerable objects of domestic use and ornament, which render the museum at Naples unparalleled in the world. The forum, and a temple of Jupiter are the principal discoveries of this city, besides the theatre, which is now the only place open for inspection, the rest having been filled up with rubbish as the workmen proceeded, from the difficulty of removing it from so great a depth below ground. For many years the excavations have been discontinued; but I understand that very lately they have been partially revived by the Neapolitan government.

I consider it one of the most important objects of this paper to make some remarks on the substance in which Herculaneum is buried: curious, not merely in itself, but from the discussion which it has excited, and the light which it is calculated to throw on the geology of the volcanic formations. I have already alluded to the want of a detailed examination of the locality; and I regret to think that I have little or nothing

* Very little has been done commensurate with the expectations formed on the first surprising discovery of the papyri. A few Greek fragments on rhetoric, music, and cookery are the only fruits of the labours of Mazzochi, Rufini and de Jorio. Sir H. Davy himself could not succeed in simplifying this tedious process.

† See a learned dissertation on the glass of the ancients in the Appendix to *Barthelemy's Italy*; also in the *Philosophical Transactions*, where may be found many detached, but generally unimportant, notices on Herculaneum.

‡ Ibid. and Eustace; also Winkelmann.

to add in the way of *facts* to what has already been published on the subject.

During the last century it was usual to call the stony matter which envelopes this unfortunate city a lava. The word is still occasionally employed, and, in the present want of definitive terms in the science, perhaps it would be difficult to object to any particular designation which implies a volcanic production. Yet certainly, according to the authorized use of the term, it cannot be called a lava. In composition, it may rather be supposed to fall under the head of tufa, volcanic dust, or decomposed trachyte. As far as we are acquainted with the constitution of the substance, it would seem improper to place it along with the last rock, and I have always preferred considering it as a tufa; though, whether it flowed originally liquid from the mountain, or in the state of ashes afterwards consolidated by moisture, there has been much dispute. Della Torre, in his work on Vesuvius, seems not very decided on this point, as the short casual notices of the subject which occur throughout his book are somewhat contradictory; but from one very explicit statement,* I think he rather leant to the idea, that a shower of volcanic matter fell, which was afterwards brought to a consistence by atmospheric moisture. Sir William Hamilton gives a masterly sketch of his theory of the origin of the Herculaneum tufa; and, I am happy to say, that it agrees perfectly with the results I myself deduced from the examination of the spot, before I was biassed by any theory on the subject, or had become acquainted with his observations. The resemblance it bears to the tufas of Pausilippo, and the vicinity of Naples, is too striking not to demand an attentive consideration; and I was speedily impressed with the conviction, that their origin must have been extremely similar. Every fact of appearance and structure corroborates the idea, with this only exception, (as I humbly conceive,) that the Herculaneum tufa is more uniform in its structure, and less broken into layers, so as to give us the idea of one

* "Si vede sopra le case di questa antica città (Ercolano) un masso di materia che non è se non che l'unione d'arena, cenere, lapilli e piettruzze insieme uniti coll'acqua e divenute consistenti per l'umido continuo delle acque piovane."—*Storia del Vesuvio*, 4to.

simple and uniform action, the flow of a stream of liquefied matter, (liquefied by water, not by heat,) while the various and remarkable structure of the original tufas, in swelling basin-shaped stratifications, filled up with perfectly horizontal layers, as I have often, with great satisfaction, contemplated in the neighbourhood of Naples, leads me to attribute *their* origin to the action of submarine volcanos. In the ancient tufas, Sir William Hamilton describes various fossil remains as being found, particularly oyster shells, which he has beautifully illustrated in coloured plates of his *Campi Phlegræi**. I am not aware whether such remains are, or are not, met with in the tufa above Herculaneum; but it is not of great importance, for we are well assured that all volcanos hold a particular communication with the sea, which would appear to be a requisite agent in the production of their effects; for they "seem in general to be situated near the sea-coast, and rarely or never in the interior of large continents. Cotopaxi, in South America, is perhaps of all volcanic mountains the most distant from the ocean; and yet it is only 140 miles from the shores of the Pacific†." If I do not mistake, shells are occasionally ejected from Vesuvius itself; and Humboldt assures us, that in the Andes fish are frequently thrown from the craters of volcanos. At all events, it appears strikingly probable, that the substance which covered Herculaneum was ejected in the form of liquid mud, being an accumulation of earthy, pumiceous, and bituminous substances combined, and carried along by the force of water and steam, probably at a red heat when issuing from the pressure it experienced in the bowels of the mountain, which may probably have given rise, as I have before hinted, to the description of the "latissimæ flammæ," mentioned by Pliny; since we know that no true lava

* Naples, Folio, 1776, Vol. ii. Plates xlii. and xlv.—It would be of the highest interest to examine the nature of these fossil remains in the scale of organization; whether the oyster-shells approach nearer to the present existing or fossil species, and if the vegetable remains are monocotyledonous or dicotyledonous. To establish the relative antiquity of these tufas to the other strata would be an acquisition of extraordinary interest in geology.

† *Edin. Encyc.* Art. Physical Geography, Vol. xvi. p. 487.

has flowed from the mountain within the limits of history before the year 1036. The heat of the liquid mass is proved by the carbonization of the timbers, corn, papyrus rolls, and other vegetable substances which have been discovered; and that it dried from a fluid state is rendered in the highest degree probable, from the remarkable appearance which may at present be seen in one of the galleries excavated behind the theatre, of an impression in the solid mass sharply left by a mask which had been accidentally buried *. A similar illustration is still preserved in the museum at Naples, where is a piece of tufa containing a perfect cast of a portion of the human body. I have related a similar fact of the most recent formation, the tufa of 1822, in the last number of these notices †; a specimen of which, in my possession, contains a complete impression of a leaf of a tree,—a convincing proof of the great liquidity of the substance.

Regarding the particular structure of the mass which covers the city of Herculaneum, we may, in the first place, remark its great thickness. Below Resina, the modern village, it is 125 palms (of about 11 inches each,) in depth, and above the theatre, 85 French feet. Della Torre informs us, that at the deepest part it is divided by strata of white volcanic ashes, and above the tufa there are 12 or 14 palms of common soil, containing ancient tombs, and covered again by a modern, true siliceous lava, *(lava di pietra dura.)* This, as far as I know, is the most distinct statement of the strata above Herculaneum. The nature of the tufaceous substance is rather peculiar. When first excavated, it is soft and easily worked, but acquires a considerable degree of induration on exposure to the air, though if it becomes nearly dry it is friable. In structure it is porous, and contains a great number of imbedded masses of various sizes, and decomposed mineral substances, (farinaceous leucites?) but more particularly abundant small black particles have been observed, ‡ which appear to be

* This appearance existed as far back as the time of Sir William Hamilton, who compares its sharpness to that of a cast in Paris plaster contracted by cooling.

† In No. xviii. p. 206.

‡ *Della Torre Storia del Vesuvio,* § 119. Lalande, vii. 479.

of a bituminous nature, and contribute very much to unite the whole into a compact mass. It burns on hot coals with no smell of sulphur, but a cerulean flame. When thrown in powder into hot water, a small quantity of aluminous matter is dissolved.

From a combination of all the circumstances, I should be disposed to believe, that the catastrophe by which Herculaneum was overwhelmed took place in the following manner. I have elsewhere given it as my opinion,* that the alteration in the point of ejection of the volcanic materials, which is generally agreed to have taken place in the year 79, was owing to a peculiar tendency of action towards the sea, by which the wall of the crater of the Monte Somma was totally overthrown in that direction, and its debris formed the plain from which the present cone of Vesuvius rises. As it is also admitted that no siliceous lava has flowed in the memory of man till near 1000 years later, we suppose the vast basin of the original crater filled with the materials fitted for the production of an eruption of mud,— a phenomenon no less naturally to be looked for from the action of the sea-water introduced into the seat of volcanic agency, than established by decisive evidence, more especially on the volcanos of South America. The fall of the southern wall of the crater would bring the whole fiery deluge in the direction of the sea, and, without doubt, the interment of Herculaneum was only a portion of the ravages it produced. During the time of this torrent flowing, which probably took place from a lateral rupture, there is every reason to believe that another mouth of the volcano ejected the ashes which covered the country for so many miles, and which, we have already seen, divided the mass of tufa into layers.

Brocchi, in his "*Suolo di Roma*," † in illustration of a particular theory of the production of tufas, alludes to Herculaneum, and the substances formed by modern volcanos. His wish to generalize too much has led him beyond the limits of probability. He says, that among the productions of modern volcanos in full formation, although we have scoria, ashes, poz-

* See last Number, p. 193. † 8vo, Roma, 1820. Page 194.

zolana, and lapilli, we never find tufa; * and to get over the difficulty which the example of Herculaneum affords, he adopts a theory with which I am not acquainted, though I have before heard of the work by Lippi to which he alludes, and which asserts the apparent paradox, that Herculaneum was not destroyed by an eruption of Vesuvius, by a peculiar diluvium. I am, however, decidedly of opinion, that the phenomena we have considered are not at variance with the theory of submarine volcanos, and that there is no necessity for such far-fetched and problematical explanations of the interment of Herculaneum.

The excavations of Pompeii and Stabiæ demand less attention in a physical point of view than those at Herculaneum. My remarks may be confined within a short compass. The former was discovered in 1750, the latter about two years sooner. A shower of true volcanic ashes was the cause of the catastrophe; and I need not repeat what I have already said on this part of the subject. These ashes, it is to be remarked, are essentially distinct from volcanic dust, which is nearly an impalpable powder; but the covering of Pompeii is composed of real cinereous particles, vitrified, and harsh to the feel. The lower strata approach in nature to white pumice, and the upper part is vegetable soil, in which vines grow. Even below the buildings of Pompeii this vegetable mould is found, and no less than three successive strata of black lava containing leucites, which carry us back to the most remote antiquity. The very houses of the town are a standing testimony to the volcanic productions of primæval times. The following are reckoned among the building stones. 1. The old, dark, leucitic lava. 2. Reddish cellular lava, extremely porous. 3. Gray and yellow volcanic tufa. 4. Calcareous tufa from the river Sarno. † The depth of the shower of ashes varies considerably. It is seldom, however, very great. There are

* "Tra i prodotti dei moderni Vulcani che ardono nei Continenti veggonsi bensi, scoriè, cenere, pozzulane, lapilli; tufa non mai."

† Ferber's *Travels*, p. 152. I cannot help here remarking the extraordinary want of information on the most important points, and the frequent errors of this work, intended solely as a mineralogical tour through Italy.

crystals of leucite intermixed, both fresh and farinaceous. The labour of excavation is extremely small, yet the work proceeds very slowly. It is impossible to imagine anything more interesting than to watch the progress of the first opening to day of the dwelling-houses concealed for 18 centuries; to be yourself the first to tread the street where last the Roman in his *toga* fled from the impending fate. Among the last discoveries which in 1827 I saw, was a fountain decorated with shells precisely in modern style, laid out in patterns with great taste; but the extraordinary thing is, that not a shell appeared to be broken; and the whole resembles strikingly the fountains of the town of Naples. Very near it were found moist olives in a square glass case, and *caviare*, or roe of the cod-fish, in a state of wonderful preservation; an examination of these curious fresh condiments has been published by Covelli of Naples. These are preserved hermetically sealed in the museum there.

The public buildings of Pompeii bear the most perfect evidence to the catastrophe of the earthquake under Nero. The Temple of Isis has the following inscription:—"N. Popidius N. F. Celsinus ædem Isidis, terræ motu collapsam a fundamento P. S. restituit. Hunc Decuriones ob liberalitatem cum esset annorum Sex ordini suo gratis adlegerunt." * A similar inscription, not without interest, was discovered at Herculaneum, which I shall here insert. †

IMP. CAESAR. VESPASIANVS. AVG. PONTIF. MAX.
TRIB. POT. VII. IMP. XVII. P. P. COS. VII. DESIGN. VIII.
TEMPLVM. MATRIS. DEVM. TERRAE. MOTV. CONLAPSVM RESTITVIT.

I have already noticed the internal evidence which Pompeii bears of this catastrophe in the overthrow of part of its public edifices. From a large map of the Gulf of Naples, the distance of the nearest part of the walls of Pompeii to the sea appears to be almost a mile; but we have perfect evidence that the sea once washed its southern extremity. It is probable that the course of the river Sarno is somewhat diverted towards the east, since we have abundant reason to know that the town was in the immediate vicinity of the river, so that Cluverius placed its site about two miles too far east, at Scafati. These changes are therefore owing to the ejected mat-

* Swinburne and Lalande. † *Phil. Trans.* 1758. Vol. L. p. 619.

ter of the volcano, simply in the form of ashes, and independent of eruptions of mud or lava. It may, however, have accumulated to its present extent on different occasions, as, for instance, we find that in the eruption of 1822 the ashes lay three feet deep in Pompeii, whose ruined walls were threatened by a second catastrophe; and the whole has since been cleared of the new deposit.

The excavations of Stabiæ, which afforded little of interest except lachrymatory vases and papyrus rolls, have long since been filled up, so that the curious traveller can gain no information by visiting its site. I shall therefore quote a passage from Swinburne's *Travels*, written about fifty years since, which gives a perspicuous view of the true state of that small town, of the nature of its interment, and throws light upon its original condition, which we have seen has been a matter of some debate. "March 26th, 1776.—Having received an invitation to be present at the opening of some lately discovered rooms at Stabia, I went thither with a party. On our way we visited Herculaneum and Pompeii. We then traversed the rich plain that lies between Vesuvius and the Sorrentine branch of the Apennines, and came by a gentle ascent to the excavations. Stabia was a long string of country houses rather than a town, for it had been destroyed by Sylla, and before the reign of Titus all its rebuilt edifices were overturned by an earthquake. In the catastrophe of 79, the wind blowing furiously from the north, brought the ashes of Vesuvius upon it. All the country was covered with cinders and lapilli, or small pumice-stones, many yards deep. Stabia, though six miles from the mountain, was overwhelmed and lost, till it was casually discovered about twenty-eight years ago. The earthquake had so damaged the buildings that none of them can be preserved, and therefore, as soon as every thing curious is taken out, the pits are filled up again. The ashes penetrated into all parts, and consumed every thing that was combustible. On our arrival the workmen began to break into the subterranean rooms, and, as the soil is all a crumbling cinder, very little labour was requisite to clear them. When opened, the apartments presented us with shattered walls, daubed rather than painted with gaudy colours in compartments, and some birds and animals in the cornices, but in a coarse style, as indeed are all the paintings of Stabia. In a corner we found the brass hinges and locks of a trunk; near them part of the contents, viz. ivory flutes in pieces, some coins, brass rings, scales, steelyards, and a very elegant silver statue of Bacchus, about two inches high, represented with a crown of vine-leaves, buskins, and the horn of plenty." *

In this description we may remark, that the extremely shattered state of the walls here mentioned, could not have been the consequence of the earthquake of A. D. 63, otherwise the houses could not have been sixteen years after in the habitable state which the utensils and papyri buried among the volcanic ashes prove them to have been. We must, therefore, ascribe it to the tremendous earthquake described by Pliny, as accompanying the eruption. If it be asked why the walls of Herculaneum and Pompeii are not in the same condition, (for in general they are sufficiently secure) we may reply, that this circumstance, so instrumental to the marvellous preservation of these two cities, is owing to their situation upon a porous and ill-compacted foundation, which deadened the terrestrial vibrations; while Stabiæ, seated on firm rock of a branch of the Apennines, must necessarily have experienced the shock in a far more powerful degree. The testimony of this extract has formerly been alluded to in support of my opinion of the pre-existent condition of Stabiæ. From it we distinctly gather that the eruption of Vesuvius was the decisive cause of its destruction,—a position which we have seen Breislak and others deny,—and that it appears to have existed rather as a village than a town, with which the inferiority of its paintings agrees. The description of Swinburne, on the whole, is to be considered a valuable one, as supplying a link in the history of the Buried Cities, which, in the sources I have consulted, is generally awanting.

I have now completed the sketch I proposed of the present subject, and perhaps I have filled it up with as much minuteness as most of my readers would be disposed to follow me through. I am not aware of having omitted any material fact which has come to my knowledge, relating to the Physical History of Her-

* Swinburne, vol. i. p. 127—129.

culaneum, Pompeii, or Stabiæ. In an antiquarian point of view, I have done little in this paper; but the title I have adopted for these outlines of "Physical Notices" warns me not to depart too far from the object proposed.

In the preceding pages, we have considered the primitive condition of the once flourishing cities of Campania. We drew from ancient sources and combined information regarding their size, situation, and antiquity, more especially as regarded their rediscovery. We contemplated the circumstances of the event by which they were destroyed, and, with the calm abstraction which the lapse of near 2000 years has afforded, we attempted to trace the facts deducible from the glowing description handed down to us by an eye-witness of the catastrophe. We passed over the lengthened period of their awful repose amidst the ruins of nature, and only paused to notice the conflicting opinions of antiquaries after the revival of letters, regarding the site and history of those towns, over which time as well as nature had thrown her veil; and we resumed the thread of the inquiry, when circumstances brought to light these stupendous monuments of antiquity, preserved to the eyes of later generations almost miraculously, by a cause which in the course of time may never again produce a parallel event; which opened a mine of exhaustless wealth to all who profess any regard for the history of art, of the human race, or of the human mind. "This scene of a city," says the elegant Eustace, "raised from the grave where it had lain forgotten during the long night of eighteen centuries, when once beheld, must remain for ever pictured on the imagination; and whenever it presents itself to the fancy, it comes like the recollection of an awful apparition, accompanied by thoughts and emotions solemn and melancholy!" Δ

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## *Postscript to No. I. of these Notices—on Mount Vesuvius.*

Since the publication of my paper on Mount Vesuvius, I have consulted Humboldt's small work, entitled "*Tableaux de la Nature*," just published at Paris, which contains a paper on the structure and action of volcanos, part of which is especially directed to Mount Vesuvius; and I shall here subjoin one or two remarks connected with that work which may be considered as a postscript to my last paper. The extreme N. W. point of the crater, which received the name of "Rocca Del Palo," from a post which stood upon it, remained, it would seem, unaffected by the internal action of the mountain, at least from 1773 to 1822. This Humboldt points out as an interesting proof that some positions of considerable stability may be found even in a volcano whose aspect is apparently so changeful as Vesuvius. Saussure's measurement in 1773, which I gave in last Number, p. 193, was nearly the same as all succeeding ones; but the same observer remarked that the N. W. and S. E. edges of the crater were precisely equal in that year, but in the eruption of 1794 the latter was lowered 75 toises. What the changes of this discrepancy may be is doubtful; for we have in this instance an example of a general haste and want of attention, which is rather conspicuous in this little essay of Humboldt's, and which gives us room to doubt his accuracy on the measurements of the crater, which are much smaller than those I have given in my paper. He says, the bottom of the crater after the eruption of 1822 was 750 feet below the northern, and 200 below the southern edge. This leaves 550 feet for the difference. Yet he tells us, "d'après mes *dernieres* observations le bord du S. E. que en 1794 etait de 400 pieds plus bas que le precedent (le N. W.) a eprouvé un diminution de 10 toises." Hence for the difference we would have 400 feet + 10 toises = 460 feet instead of 550. I point this out as one of the inconsistencies which occur in this paper. No one I should conceive, who has seen the crater in its present state, could take it on any man's word, that the bottom of the crater is only half as deep below its lowest edge as that is below the highest: and I can more distinctly express my conviction, as in 1826 I descended *two-thirds* of the depth to the bottom from the *lowest* edge. Besides, the numbers I have given in my last paper, chiefly derived from information on the spot from my most intelligent guide, have been corroborated from very different quarters; the general dimensions, by Ferrari's "*Guida di Napoli*," and a statement which appeared in the *Edin. Phil. Journ.* vol. x.: the total height, by Lord Minto's measurements; and the difference which I heard existed between the higher and lower edges of the crater (500 feet) by Humboldt's own account. From the general accuracy of the statements, and the evidence of my own senses, I am disposed to maintain, in great part at least, the numbers I have already given.

Another inconsistency which I at first believed existed in Humboldt's paper, that of stating the proportion of the cone of ashes to the total height as one to *ten*, instead of one to *three*, in contradiction to his own personal narrative, (See last Number, p. 196,) I found to arise from an erroneous translation given in a contemporary journal, which, in presenting this paper to the English reader, has omitted, I think, the most valuable part of it,—the statements of heights of the various portions of the mountain at different times, with which, I think, the reader will thank me for presenting him, as I consider them extremely valuable.

A. Rocca del Palo. Highest N. W. summit above the sea.

| | Toises. |
|---|---|
| Saussure, 1773, barometric measurement, - | 609 |
| Poli, 1794, ditto. - - - | 606 |
| Breislak, 1794, ditto. - - - | 613 |
| Gay-Lussac, De Buch, and Humboldt, 1805, ditto. | 603 |
| Brioschi, 1810, trigonometric measurement, - | 638 |
| Visinti, 1816, ditto, - - - | 622 |
| Lord Minto, 1822, barometer, - - - | 621 |
| P. Scrope, 1822, ditto, (slightly uncertain) - | 604 |
| Monticelli and Covelli, 1822, - - - | 624 |
| Humboldt, 1822, - - - - | 629 |

Probable result, 625 toises above the sea, 317 above the hermitage.

B. Lowest edge of the crater, (S. E.)

| | |
|---|---|
| ——— 1794, - - - - | 559 |
| Gay-Lussac, De Buch, and Humboldt, 1805, - | 554 |
| Humboldt, 1822, - - - - | 546 |

C. Height of the cone of Scoriæ in the crater 1822, above the level of the sea.

| | |
|---|---|
| Lord Minto, (barometer) | 650 |
| Brioschi, (various trigonometric operations) - | 636 |
| or, - - | 641 |

| | Toises. |
|---|---|
| Probable true height, - - - - | 646 |
| **D. Punta Nasone. Highest part of the Somma.** | |
| Shuckburgh, 1794, barometer, - - - | 584 |
| Humboldt, 1822, ditto, - - - - | 586 |
| **E. Valley of the Atrio del Cavallo.** | |
| Humboldt, 1822, - - - - | 403 |
| **F. Foot of the cone of ashes.** | |
| Gay-Lussac, De Buch, and Humboldt, 1805, - | 370 |
| Humboldt, 1822, - - - - | 388 |
| **G. Hermitage of St Salvador.** | |
| Gay-Lussac, De Buch, and Humboldt, 1805, - | 300 |
| Lord Minto, 1822, - - - - | 308.9 |
| Humboldt, 1822, - - | 307.7 |

Humboldt has no doubt that, in the period 1816–22, the height of the Rocca del Palo had been about 12 toises higher than during the period 1773–1805, which he considers a singular proof of gradual internal elevation. The points A, D, and E, correspond respectively to C, A, and B, of my section of Vesuvius in last Number. The continuation of these important observations cannot fail to be of the greatest interest. Humboldt mentions the statement I noticed (No. xviii. p. 206) of gold existing in the volcanic dust, and states, that the recent experiments of the best chemists disprove the assertion. I have learned, that, since the slight eruption of March this year, Vesuvius has been in a state of great agitation during the summer; but particulars have not reached me. I hope the length of this note will be excused, as the facts it notices are of great importance in surveying the phenomena of Vesuvius.

Δ

## Art. XVIII.—*Notice of the performance of Steam-Engines in Cornwall for June, July, August, and September* 1828. Communicated by W. J. Henwood, Esq. F. G. S.

### *Reciprocating Engines drawing Water.*

| Mines. | Diameter of cylinder in inch. | Length of stroke in cylinder. | Length of stroke in the pump. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Millions of lbs weight lifted 1 foot high by the consumption of 1 bush. of coal. |
|---|---|---|---|---|---|---|
| Huel Towan, - | 80 | 10, | 8, | 10,1 | 6,5 | 78,8 |
| | 80 | 10, | 8, | 4,89 | 3,4 | 56,3 |
| Cardrew Downs, | 66 | 8,75 | 7, | 10,1 | 6,4 | 58, |
| Huel Hope, - | 60 | 9, | 8, | 9,9 | 5,8 | 70,7 |
| Huel Vor, - | 63 * | 7,25 | 5,75 | 17,5 | 5,4 | 24,8 |
| | 53 | 9, | 7,5 | 19,58 | 5,9 | 41,9 |
| | 48 | 7, | 5, | 7,9 | 4,8 | 30,7 |
| | 80 | 10, | 7,5 | 14,8 | 6, | 57,2 |
| | 45 | 6,75 | 5,5 | 13,6 | 6,1 | 49,9 |
| Poladras Downs, | 70 | 10, | 7,5 | 8,63 | 5,3 | 48,4 |
| Huel Reeth, - | 36 | 7,5 | 7,5 | 15,29 | 3,1 | 25,5 |
| Balnoon, - | 30 | 8, | 7, | 5, | 3,1 | 17,4 |
| Huel Penwith, - | 40 | 8,75 | 7, | 4, | 7,9 | 22,6 |
| United Hills, - | 58 | 8,25 | 6, | 6,68 | 4,1 | 34,7 |
| Great St George, | 60 | 10,333 | 6,5 | 9,4 | 5,6 | 31,1 |
| Perran Mines, - | 80 | 6,75 | 6, | 9,1 | 7,2 | 23, |
| Crinnis Mines, - | 53 | 8,25 | 7, | 11,5 | 4,7 | 33,4 |
| | 56 | 6,75 | 6,75 | 9,9 | 4,1 | 26,9 |
| Stray Park, - | 64 | 7,75 | 5,25 | 7,5 | 4,4 | 31,6 |
| Huel Penrose, - | 36 | 8,5 | 6,5 | 9,8 | 6,9 | 32,7 |
| Carzise, - | 50 | 8,5 | 7, | 7,34 | 4,6 | 34, |
| Huel Caroline, - | 30 | 7, | 6, | 26, | 10,3 | 35,2 |
| Huel Trevoole, - | 30 | 9, | 7, | 21,25 | 7,2 | 41,7 |
| St Ives Consols, | 36 | 7, | 7, | 14,3 | 6,8 | 33,2 |
| Lelant Consols, - | 15 | 7,5 | 4,5 | 16,1 | 2,7 | 11,9 |
| Huel Damsel, - | 42 † | 7,5 | 5,75 | 21,5 | 5,8 | 37,9 |
| | 50 | 9, | 7, | 8,2 | 2,8 | 27,6 |
| Ting Tang, - | 63 | 7,75 | 6,75 | 14,2 | 7,5 | 44,3 |

*Reciprocating Engines drawing Water.*

| Mines. | Diameter of cylinder in inch. | Length of stroke in cylinder. | Length of stroke in the pump. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Millions of lbs. weight lifted 1 foot high by the consumption of 1 bush. of coal. |
|---|---|---|---|---|---|---|
| Treskerby, - | 58 † | 7,75 | 6, | 15,47 | 9, | 38,3 |
| Huel Chance, - | 45 † | 7,918 | 6, | 19,7 | 5,2 | 27,8 |
| Huel Rose, - | 45 | 8, | 6, | 18, | 7,8 | 32,6 |
| Huel Fortune, - | 45 | 8, | 6, | 10,2 | 7,9 | 36,5 |
| Huel Beauchamp, | 36 | 7,75 | 6, | 12,3 | 4,2 | 30,8 |
| East Huel Unity, | 45 | 8,75 | 6,75 | 7,97 | 4,7 | 22,9 |
| Great Work, - | 60 | 9, | 7, | 8,9 | 6,9 | 40,6 |
| Dolcoath, - | 76 | 9, | 7,5 | 11,9 | 5,4 | 37,4 |
| Huel Tolgus, - | 70 | 10, | 7,5 | 7, | 3,7 | 48,8 |
| Tresavean, - | 60 | 9, | 7, | 5,5 | 4,1 | 23,1 |
| Huel Busy, - | 70 | 10, | 7,5 | 11,4 | 6,9 | 51,2 |
| North Downs, - | 70 | 9,83 | 7,75 | 7,9 | 5,1 | 39,6 |
| Huel Harmony, | 70 | 9,35 | 7, | 5, | 4, | 29, |
| Huel Montague, | 50 | 9, | 7, | 8,1 | 6,1 | 28,1 |
| East Crinnis, - | 60 | 5,5 | 5,5 | 8,57 | 4,7 | 22,9 |
| | 70 | 10, | 7, | 7, | 5,9 | 36,4 |
| Pembroke, - | 80 | 9,75 | 7,25 | 11,27 | 4,3 | 47,1 |
| | 40 | 9, | 6,5 | 6,1 | 2, | 24,3 |
| Huel Unity, - | 60 | 7, | 5,5 | 14,4 | 5,7 | 26,9 |
| Poldice, - | 90 | 10, | 7, | 11,5 | 6, | 51,2 |
| | 60 | 9,5 | 6,25 | 11,9 | 6,8 | 32,1 |
| United Mines, - | 90 | 9, | 8, | 7,9 | 5,2 | 36,2 |
| | 30 | 9, | 7,5 | 12,9 | 8,3 | 34,1 |
| Consolidated Mines, | 90 | 10, | 7,5 | 8,12 | 6,5 | 54,6 |
| | 70 | 10, | 7,5 | 8, | 7,4 | 44,6 |
| | 58 | 7,75 | 6,5 | 17,7 | 4,2 | 37,7 |
| | 90 | 10, | 7,5 | 7,83 | 5, | 62,9 |
| | 90 | 10, | 7,5 | 10,6 | 4,1 | 31,6 |
| | 70 | 10, | 7,5 | 8,8 | 4,7 | 56,1 |
| Binner Downs, | 42 | 9, | 7,5 | 11,8 | 6,9 | 48,5 |
| | 63 | 9, | 7,5 | 7,87 | 9,1 | 35,9 |
| | 70 | 0, | 7,5 | 10,93 | 8,1 | 62,9 |

Average duty 38.2 millions of lbs. lifted a foot high by the consumption of each bushel of coal.

Watt's (double) rotatory engines working machines for bruising tin ores at

| | | | | | | |
|---|---|---|---|---|---|---|
| Huel Vor, | 24 | 6. | 6. | 12. | 16.8 | 18.2 |
| | 27 | 5. | 5. | 12.5 | 18.2 | 21.5 |
| | 16.5 | 5. | 5. | 8.5 | 25.8 | 14.3 |

Average duty of rotatory (double) engines, 18 millions.

* Engines thus distinguished are Watt's double.

† Those thus noted receive the steam first into a high pressure cylinder, whence it passes to a Watt's single engine, the pistons of both cylinders being connected with the same lever.

All the others in the preceding list are Watt's single engines.

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Art. XIX.—*Abstract of a Meteorological Register kept at Rampoor and Kotgurh, in January, February, and March* 1822. By Captain Patrick Gerard, of the Bengal Native Infantry. Communicated by the Author.

The observations from which the following general results are deduced were made at Rampoor and Kotgurh.

*Rampoor* is situated fourteen English miles north east of Kotgurh, and 3398 feet above the level of the sea.

*Kotgurh* is situated in north latitude 31° 19′, and east long. 77° 30′, at the height of 6634 feet above the sea.

All the barometrical observations were made at Kotgurh, and the thermometrical ones were made between January 18th, and 31st, inclusive, and between February 10th and March 31st. The observations at Rampoor were only those with the thermometer and on the weather, and were made on the first 17 days of January, and the first 9 days of February.

January 1822.

Barometer.—Max. 23.700. Jan. 23; wind E.—Min. 23.520, Jan. 28; wind W.
Range of mercury, .180,
Mean of observations, 23.624.

Thermometer.—Max. 70°.8, Jan. 16; wind N. N. E.—Min. 30°, Jan. 28; wind E.
Range 40°.8.
Mean temp. of external air for the month, 48°.7

| | |
|---|---|
| Number of days clear. | 12 |
| Fair, but cloudy, partially cloudy, and overcast, | 11 |
| Rain and snow, | 8 |
| Thunder, | twice. |

FEBRUARY 1822.

Barometer.—Max. 23.760, Feb. 28; wind W.N.W.—Min. 23.330, Feb. 16; wind E.
Range of mercury, 430.
Mean of observations, 23.590.

Thermometer.—Max. 61°.2, Feb. 6; wind S.S.W.—Min. 30°.4, Feb. 24; wind W.
Mean temp. of external air for the month, 41°.6
Range 30.8°.

| | |
|---|---|
| Number of days clear, | 5 |
| Fair, but cloudy and partially cloudy, | 12 |
| Rain, snow, and hail, | 11 |
| Thunder. | 0 |

MARCH 1822.

Barometer.—Max. 23.840, Mar. 20; wind W.—Min. 23.400, Mar. 23; wind E.
Range of mercury, 440,
Mean of observations, 23.661.

Thermometer.—Max. 69°.7, Mar. 21; wind W.—Min. 37°, Mar. 1; wind E.N.E., and Mar. 14; wind E.
Mean temp. of external air for the month, 50.1°.
Range 32.7°.

| | |
|---|---|
| Number of days clear | 7 |
| Fair, but cloudy, partially cloudy, and overcast, | 12 |
| Rain, | 12 |
| Thunder, | 4 times. |

General Results for the three months.

| | Inch. |
|---|---|
| Mean height of barometer, - - | 23.625 |
| Maximum, - - - - - | 23.840 |
| Minimum, - - - - - | 23.330 |
| | |
| Mean height of thermometer, - - | 46.°8 |
| Maximum, - - - - - | 70. 8 |
| Minimum, - - - - - | 30 |
| Range, - - - - | 40. 8 |

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Art. XX.—*Account of the Rain which fell at Bombay in June, July, August, September, and October, from* 1817 *to* 1827. Communicated by Alexander Adie, Esq. F. R. S. Edin.

As it is of great importance to determine the relation which subsists between the quantity of rain which falls annually at any given place, and its mean temperature, the following very valuable results, which have been communicated to us by Mr Adie, will be considered by the meteorologist as of great interest.

From the observations being confined only to five months in each year, we presume that little rain falls during the other seven months, and that the mean results may therefore be regarded as giving nearly the annual quantity of rain which falls at Bombay.

| | June. | July. | August. |
|---|---|---|---|
| | Inches. | Inches. | Inches. |
| 1817 | 45,72 | 23,67 | 9,34 |
| 1818 | 22,54 | 17,69 | 28,45 |
| 1819 | 15,95 | 30,66 | 20,24 |
| 1820 | 18,82 | 28,37 | 19,49 |
| 1821 | 15,18 | 20,60 | 28,52 |
| 1822 | 29,21 | 26,59 | 33,83 |
| 1823 | 21,76 | 15,96 | 19,70 |
| 1824 | 3,89 | 8,07 | 17,86 |
| 1825 | 24,45 | 25,17 | 12,94 |
| 1826 | 17,75 | 26,97 | 8,40 |
| 1827 | 49,15 | 10,29 | 10,51 |

| | SEPTEMBER. | OCTOBER. | Total in all the five months. |
|---|---|---|---|
| | Inches. | Inches. | Inches. |
| 1817 | 24,87 | 0,19 | 103,79 |
| 1818 | 10,39 | 2,07 | 81,14 |
| 1819 | 10,11 | 0,14 | 77,10 |
| 1820 | 10,66 | —— | 77,34 |
| 1821 | 18,29 | 0,40 | 82,99 |
| 1822 | 22,16 | 0,82 | 112,61 |
| 1823 | 4,28 | —— | 61,70 |
| 1824 | 1,78 | 2,37 | 34,33 |
| 1825 | 9,68 | —— | 72,24 |
| 1826 | 23,50 | 1,23 | 77,85 |
| 1827 | 10,16 | 0,92 | 81,03 |
| Mean of eleven years, | | - | 78,34 |

It appears from the detailed register of the pluviometer for 1827, which accompanied these monthly and annual results, that *rain fell every day from the 9th June to the 20th September*, with the exception only of 4 days, viz. June 11th and 31st, and July 1st and 27th. In 1827, the principal showers fell in June; the most remarkable of which were as follows:

| | Inches. | | Inches. |
|---|---|---|---|
| June 13, | 7,00 | June 19, | 3,80 |
| 15, | 3,18 | 20, | 4,04 |
| 16, | 5,17 | 24, | 2,21 |
| 17, | 2,10 | 25, | 3,95 |
| 18, | 3,36 | 28, | 5,92 |

In the able article on HYGROMETRY in the EDINBURGH ENCYCLOPÆDIA, vol. xi. p. 597, and in the article PHYSICAL GEOGRAPHY, vol. xvi. p. 514, Dr Anderson of Perth, by whom these articles were written, has explained an ingenious process for determining the quantity of rain which falls in different latitudes from the equator to the pole; and has given the following table for every five degrees of latitude:

| Latitude. | Inches. | Latitude. | Inches. |
|---|---|---|---|
| 0° | 73,17 | 50° | 25,36 |
| 5 | 71,39 | 55 | 21,72 |
| 10 | 68,72 | 60 | 18,69 |
| 15 | 64,47 | 65 | 16,32 |
| 20 | 59,11 | 70 | 14,49 |
| 25 | 53,12 | 75 | 13,16 |
| 30 | 46,77 | 80 | 12,24 |
| 35 | 40,50 | 85 | 11,72 |
| 40 | 34,92 | 90 | 11,55 |
| 45 | 29,79 | | |

In consequence of Dr Anderson having used, in the construction of this table, Tobias Mayer's law of mean temperature, which gives

For the equator, - - 85° Fahr.
For the pole, - - - 31°

Instead of

For the equator, - - 81½° Fahr.
For the coldest point, - —3½°

the results in the table are necessarily incorrect. But even if we recompute it according to the most approved law of temperature, it does not afford even approximate results.

At the equator, for example, the annual fall of rain should, in the corrected table, be 64½ inches; whereas at Bombay, in 18° of latitude, it is as high as 78 inches. In the east of Scotland, in latitude 55°—57°, the annual fall of rain, as deduced from a most extensive series of accurate observations, is 26 inches; whereas at Paris, in latitude 48°, the annual fall of rain on an average of 20 years is scarcely 20 inches; where, according to the table, it should have been much greater than in Scotland. We shall return again to this subject in an early number.

Art. XXI.—*Experiments on the penetration of water into Bottles immersed to a great depth in the sea, made in a Voyage from India to England.* By Charles H. Weston, Esq. In a Letter to the Editor.

Sir, *London, 6th October* 1828.

Under the article "General Science" in your last Quarterly Journal, you detailed some experiments made by Dr J. Green, which tended to prove that glass-vessels were impervious to water, although submitted to very considerable pressure. As I had during my voyage from India to England directed my attention to the same subject, I am induced to state to you a few of my experiments, which, although insignificant and unsatisfactory in themselves, do, when viewed in connection with those of Dr Green, afford a collateral proof of the justness of his conclusions.

The bottles made use of were of white flint-glass with ground glass-stoppers, round which, at the point of contact with the bottle, a quantity of putty was placed, and, embracing both lute and stopper, some linen was fastened, which prevented a removal of the lute during the descent of the bottle. This I found a simple but effectual mode of rendering bottles water tight, as the putty, independent of its oily nature, suffers a very considerable condensation by the pressure of the superincumbent water.

Some bottles were lowered to twenty fathoms, drawn up and examined, and again lowered an additional ten fathoms, and so on. Others were attached to the line at different distances, and four or five bottles were thus at the same time submitted to various degrees of pressure.

It will be necessary to detail the fate of a few bottles only.

Two bottles were sent to thirty fathoms depth, inclosed in a fine netting to receive the pieces in case of fracture. They were not only destroyed, but the minute state of division of a great part of the glass was such as to give one the idea of its having been literally pounded.

Hollow glass-stoppers were most used, and, as they were beyond all suspicion hermetically closed, they were submitted to every degree of pressure. Several were destroyed, but one at thirty fathoms and another at eighty fathoms formed curious exceptions. They were cracked and half-filled with water, but the water was effectually inclosed within them. Those that came up entire contained not the least water.

Two very strong bottles were then sent down, one to 140 fathoms, which came up quite empty, and the other to 120 fathoms. This last admitted half a teaspoonful of water, but this was between the stopper, as the same bottle, fresh secured, and sent to the increased depth of 140 fathoms, came up unaffected. This last bottle, containing sixty-five square inches of surface, must have suffered a pressure of at least ten tons.

Now, as under every circumstance and under every pressure (for mention is not made of half the number submitted to trial) the glass vessels were either broken or cracked, or had received nothing, it is fair to conclude with Dr Green that glass is impermeable.

I would also remark, that the case of the hollow glass stoppers exhibits a singular proof of the great elasticity of glass; for they had under strong pressure admitted water through those cracks, which so collapsed when that pressure was removed as completely to retain that water.

The cracked stoppers also, as they were but half filled, are incontestable evidence of the manner in which bottles generally are broken, not by being first filled, and then suffering from the expansion of water when under less pressure, as Dr Green seems to think, but by actual pressure from without.

I might here subjoin that a soldered tin canister, as being well calculated from its flexibility to show the manner in which vessels were affected, was lowered to 100 fathoms. It was bulged in and most severely compressed.

I have the honour to be, Sir, your most obedient servant,

Charles H. Weston.

To Dr Brewster, F. R. S. &c. &c.

## Art. XXII.—*On a splendid Luminous Arch seen at Plymouth, Sept.* 29, 1828. By George Harvey, Esq. F. R. S. Lond. and Edin., F. L. S., F. G. S., &c. &c. Communicated by the Author.

At 10 minutes after 8 p. m. on the day above mentioned, a column of white light, about 20° above the horizon, 20° long, and about 1° wide, was perceived in the W. S. W. quarter of the heavens. The appearance was unusual, but still not such as to arrest particularly the attention. After an interval of 5 minutes, its extent had very much increased, appearing with extraordinary splendour between $\alpha$ Lyræ and $\alpha$ Aquilæ, and crossing the meridian about 10° to the south of $\alpha$ Cygni, its breadth at the same time being doubled. Hastening to higher ground, to command more completely the beautiful phenomenon, it was found, at 27 minutes after 8, to extend across the heavens, passing nearly midway between $\beta$ and $\gamma$ Andromedæ, covering with its pure and delicate light the Pleiades, and descending nearly to the eastern side of the horizon. During the changes, the western portion of the arch increased also in length, descending to within 10° of the horizon, where it was obscured by clouds; and at the same time, it was observed to undergo a remarkable inflexion towards the north, at about the elevation of $\beta$ Ophiuchi, over which star it passed.

The whole arch now presented one magnificent zone of clear, white, silvery light, of about 4° wide, having its edges parallel, and beautifully defined. Its general direction, independently of the inflexion, was nearly in the plane of the dipping-needle; and but for that inflexion, its two extremities would have been in a line at right angles nearly to the magnetic meridian.

The brightness of the arch was by far the greatest at its western extremity, the light progressively diminishing to its eastern end. The light also was steady, presenting no coruscations, excepting at about 20 minutes before 9, when a trembling about the Pleiades was perceptible, the arch in that region appearing to separate into somewhat indistinct laminæ, from north to south, at inclinations of about 40°.

As the growth of the arch from west to east, was accompanied by a progressive increase of its splendour in the same direction, so the gentle diminution of its light was, by the same gradual steps, in the opposite direction, from east to west. At 25 minutes before 9, no traces of it could be perceived in the east, and the Pleiades glittered with their primitive lustre. At 10 minutes before 9, a faint portion of its extremity could be seen in the constellation Andromeda; and at 5 minutes before 9, the last traces of it were perceptible in the wing of Cygnus. The clouds that had lingered in the west now began to rise; and at 20 minutes after 9, only a small portion of it could be seen in the west, at about an elevation of 30°. At half past 9, the whole sky was hid in a mass of vapour, and all traces of the splendid phenomenon lost.

From 20 minutes after 8, till the general shrouding of the whole hemisphere in vapour, the entire quadrant of the Heavens, from the north to the western points of the horizon, was illuminated by a strong light, bearing a close resemblance to the clear and beautiful twilight which has sometimes announced the approach of the sun, on those very fine mornings in summer which I have dedicated to the interesting subject of dew.

During the continuance of this beautiful phenomenon, the Milky Way shone with extraordinary brightness, and seemed to derive new splendour from it.

During the time these interesting observations were made, I was accompanied by my intelligent young friend, Mr Richard Rawle, who called my attention to the light existing between the north and western points of the horizon; and I have been favoured by my gallant friend, Captain Rotheram, R. N., with the following extract from his valuable meteorological register.

| | Barom. | Temp. at 10 A. M. | Temp. at 10 P. M. | Rain. | Wind. |
|---|---|---|---|---|---|
| Sept. 28, | 29.90 | 64° | 58° | 0.100 | N. W. and W. |
| 29, | 29.95 | 62 | 57 | 0.066 | W. |
| 30, | 29.85 | 63 | 57 | 0.050 | W. |

Plymouth, *October* 1, 1828.

ART.. XXIII—*On an interesting Meteorological Phenomenon.* By GEORGE HARVEY, Esq. F. R. S. Lond. and Edin. Member of the Royal Geological Society of Cornwall, &c. &c. Communicated by the Author.

THE formation of a cloud of the cirro-cumulus kind, at the extremity of a cape or headland, rolling forward from a point of origin successive masses of dense and visible vapour, so as to create the appearance of an interminable moving cloud, has no doubt often attracted the attention of your meteorological readers; but as peculiar localities sometimes occasion diversities of appearance worthy of being recorded, I have forwarded for your inspection the inclosed sketch. (Plate I. Fig. 4.)

The entrance of Plymouth Sound is situated between two moderately elevated portions of land, that to the right of the drawing in the distance being Penleepoint, and the nearer land, covered with beautiful groves, Mount Edgecumbe; the land on the left or eastern side being Staddon Heights; the dark line in the sea between the hills representing that great monument of skill, the Plymouth breakwater. About noon, on the 11th May, a cirro-cumulus, of a very dense and definite character, was perceived to come from the verge of the western horizon with a moderate velocity, and after passing at a small elevation above the woody summit of Mount Edgecumbe, vanished in the pure and cloudless air over the tower on the distant promontory of Penlee. The moving mass formed a continuous cloud, accommodating itself to all the changes and inequalities of the land. Over the sea, however, not a cloud was to be seen; but on the eastern side, nearly over the flag-staff, the cloud was perceived to form again, and with a steady and uniform velocity to roll its volumes at nearly the same elevation above the land, until it was again lost in the farthest verge of the eastern sky. From the west, therefore, there continued incessantly to come forth large and visible volumes of cloud, which became dissolved in the air just where the sea began to exercise its influence upon them; and where the water lost its power, just above the flag-staff, the vapour became again condensed, so that over the sea, between the well-defined extremities of the clouds, a pure and cloudless sky prevailed, whilst over the land, on both sides, the moving masses continued their courses for upwards of two hours.

It was most interesting to watch the gradual progress of the cloud on the western side; how steadily it advanced with the gentle south-west wind; how it maintained its character and form up to a particular point; and how soon it became mingled with the brilliant expanse of the sky when the temperature of the sea began to exercise its power.

Now and then a denser portion of the moving column would detach itself just before it reached the tower, and, passing on with the breeze, seemed to maintain an ineffectual struggle with the influence of the water below; but gradually losing its dimensions and form, would at last vanish like the mass from which it had been separated.

Mount Edgecumbe has often its natural beauties very much increased by the most varied and interesting formations of mist. About a month ago, a sudden alteration of temperature produced a condensation of moisture, attended with the most striking appearances. The higher parts of the mount became rapidly covered with masses of mist, having a remarkable uniformity in their superior limits, but dropping in their lower extremities, in the most various and beautiful forms. The process of condensation commenced, as in the former example, at the extremity of the hill; and as the gentle S. E. breeze carried forward the rolling volumes of visible vapour, the inequalities of the land, and the groves with which that charming spot abounds, occasioned innumerable alterations of figure; —this moment falling in graceful festoons between the oaks and the cedars, which wave in majesty and beauty; and at the next, rising suddenly above the pines and the elms, losing itself gradually in the cloudless azure above. For two hours and a half this very interesting appearance continued, displaying every variety of light and shade, and endless groups of the most fanciful and lovely forms. Now and then also, tinges of red, and yellow, and gray, falling on different points of the misty forms, increased in a high degree the beauty of the scene. *

* In April 1819, a period never to be forgotten by the writer of this brief

On this occasion, the hill on the opposite side exercised no visible influence on the volumes of air which passed over it, presenting in this respect as striking a contrast to Mount Edgecumbe as its bleak and " wind-swept crest" does to the noble slopes and thick clustering of her " favoured sister hill."

PLYMOUTH, *October* 1, 1828.

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ART. XXIV.—*Description of Nontronite, a new Mineral discovered in the Department of the Dordogne.** By M. P. BERTHIER.

THE arrondissement of Nontron, which occupies the northern part of the department of the Dordogne, possesses an important stratum of manganese ore. This ore is known in commerce under the name of the *manganese of Perigueux.* It has been wrought very languidly for a long time, but the consumption of manganese having of late years considerably increased, the works have been carried on with more spirit, and

notice, the amiable and lamented Mr Dugald Stewart visited this charming place, and remarked, after contemplating its innumerable beauties, " that it had furnished him with materials for enjoyment for the remainder of his life." A native poet, Mr Carrington, a man whose splendid talents, and rich and exuberant genius deserve a better fate, says in his beautiful poem, " *the Banks of Tamar,*"

—— 'Tis not local prejudice that prompts
The lay, when Edgecumbe is the inspiring theme !
Affection for one valued, honour'd nook
Of earth, where haply first the light of day
Broke on our infant eyes, or where our cot
Uprises, render'd precious by long years
Of residence, may throw illusive grace
Upon the hills, the vales, the woods, the streams
That sweetly circle it ;—but *thou* has charms,
Enchanting mount, which not the local love
Too highly values, or the genial west
Alone enamour'd views,—for thou art own'd
Supreme in loveliness in this our isle,
Profusely teeming with unrivalled scenes.

* Translated from the *Ann. de Chim.* vol. xxxvi. p. 22.

it is to this circumstance that we owe the discovery of a new mineral, which I shall describe under the name of *Nontronite.*

The stratum of the manganese of Dordogne is superficial. It consists of ferruginous clay, mixed with quartz, sand, and a little mica. It is evidently of the same formation as the strata of iron called alluvial, which exist in the country.

The ore of mangarese is found in irregular masses more or less considerable in the ferruginous clay; it is a mixture of the hydrate of the deutoxide of manganese, of the peroxide, and of the barytic combination which prevails in the ore of Romaneche.

Nontronite was discovered by M. Lanoue in the ore of manganese wrought near the village of Saint Pardoux. It is disseminated in amorphous onion-shaped masses, commonly very small, and seldom so large as the fist. Hence round masses are almost never pure, and divide easily into smaller masses quite irregular, all these small masses being coated with a slight black pellicle, which is oxide of manganese, and they are often mixed with micaceous clay of a dirty yellow colour, so that when we cut the mineral, and polish it, it presents the appearance of a variolite. It is nevertheless easy to procure *Nontronite* pure by a careful selection of it.

This mineral is compact, of a pale straw colour, with a fine canary yellow slightly greenish. It is opaque, unctuous to the touch, and very tender. Its consistence is the same as that of clay; it is easily scratched with the nail; it takes a fine polish and resinous lustre under the friction of softer bodies; it is flattened, and grows lumpy under the pestle, instead of being reduced to powder; it exhales an odour when breathed upon, and does not act on the magnetic needle. When immersed in water, it disengages many air-bubbles; it becomes translucent at the edges with losing its form, and if at the end of some hours it is taken out of the water, and weighed after it is wiped, it is found to have increased one-tenth in its weight. When heated in a glass tube, it loses its water with a slight heat, and takes the colour of a dirty red oxide of iron. When calcined in a crucible, it assumes the same aspect, and its weight is diminished from 0.19 to 0.21. After calcination, it is sensibly magnetic.

Muriatic acid attacks it very easily; the solution does not contain the smallest trace of manganese, nor protoxide of iron, nor alkali; there were found only peroxide of iron, alumina, and magnesia. The insoluble part is gelatinous, and is composed of silex soluble in the liquid alkalies, and sometimes mixed with a small quantity of argil, when the mineral has not been picked with great care.

Nontronite melts readily with the third of its weight of marble.

The analysis gives

| | | |
|---|---|---|
| Silica, - | 44.0 | containing 22.9 oxygen. |
| Peroxide of iron, | 29.0 | 8.9 |
| Alumina, | 3.6 | 1.7 |
| Magnesia, | 2.1 | 0.8 |
| Water, | 18.7 | 1.6 |
| Clay, - | 1.2 | |
| | 98.6 | |

From the quantities of oxygen in each of its elements, Nontronite is a bisilicate, with a base of peroxide of iron, alumina, and magnesia, and may be represented by the formula,

$$M S^2 + A l S^2 + 10 F e S^2$$

and containing besides a certain proportion of water in combination; but it is difficult to determine this proportion accurately, on account of the facility with which the mineral absorbs, or loses a certain proportion of water according to the smallest changes of temperature. We have seen indeed, that when it is kept long immersed in this fluid, it absorbs one-tenth of its weight of it, and contains from 28 to 30 per cent.; when it is left for several days in the air of a room, it contains only from 21 to 22 per cent.; and when it has been exposed in a stove heated to 80° Cent., it only loses by calcination 18.7 per cent. If we admit this last quantity to be the minimum, it will follow that the water of combination contained in the Nontronite contains $1\frac{1}{3}$ times as much oxygen as the three bases together.

A great number of minerals are known which contain among the number of their elements a hydrosilicate of the protoxide of iron, but none which contain a silicate of the peroxide with water of crystallization. The Nontronite is the first mineral of this kind. As the silicates of the peroxide of iron have generally a high colour of either red or brown, we ought not at first sight to conjecture the existence of it in Nontronite. The colour of this mineral depends evidently on the presence of water; this colour actually disappears by calcination, and we know salts of the peroxide, such as several sulphates, which, when they contain water, are of a pale yellow colour, and sometimes almost colourless.

I have said that Nontronite strongly calcined in a close vessel becomes sensibly magnetic; the silicates, however, of the peroxide of iron do not act on the magnetic needle. This phenomenon may be thus explained: The peroxide of iron is a very weak base; it cannot be combined with silex in the dry way, without the intermedium of another base; but as on the contrary silex has a great tendency to unite itself to the protoxide of iron, it happens, that when we heat to a temperature sufficiently high this substance with peroxide of iron, a portion of this peroxide abandons the oxygen, and transforms itself into peroxide, or at least to an oxide inferior to the real oxide. The combination thus formed may be regarded as a double silicate of the protoxide and the peroxide, in proportions which vary according to circumstances; but the presence of a small quantity of the protoxide is sufficient to communicate to a silicate the magnetic virtue, when the silica does not exist in too great a proportion.

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## Art. XXV.—*Account of two remarkable Cases of Insensibility in the Eye to particular Colours.*

The insensibility of some eyes to particular colours is a much more common defect than is generally believed, and it is a curious circumstance, that three of the most distinguished individuals in Great Britain, Mr Dalton, Mr Troughton, and the late Mr Dugald Stewart, were all incapable of distinguishing particular tints. The case of Mr ——— has recently been well described by a distinguished philosopher, and it is principally for the purpose of laying it before our readers that we have introduced the subject at present. Before doing this, however, we shall describe the case of a young man of about twenty years of age, the son of an eminent scientific gentleman in the vicinity of Edinburgh, whose peculiarities of vision were examined some years ago by Dr Brewster.

The following coloured silks he arranged into two sets of colours, viz. *blues* and *browns* :—

| Colours | |
|---|---|
| Green, Pale Blue, Purple, Carmine Red, Pale Pink, Peach Blossom, Red Lilac Purple, French White, | These were all regarded as Blues of different shades. |
| Dark Green, Duck Green, Vermillion Red, Bright Tile Red, Chestnut Brown, | These are all regarded as Browns of different shades. |

The most precise information, however, was obtained from the following experiments :—

1. The prismatic spectrum was formed with an equilateral prism of flint-glass, which received the light from a very narrow longitudinal aperture. The colours which were thus developed were four, as in Dr Wollaston's spectrum, viz. *red*, *green*, *blue*, and *violet*. When Mr L—— examined this spectrum, it appeared to consist only of two colours,—*yellow* and *blue*.

2. When all the colours were absorbed by a reddish glass excepting *red* and *dark green*, Mr L—— saw only one colour, viz. *yellow*.

3. When the middle of the red space was absorbed, as described in the *Edinburgh Transactions*, vol. ix. p. 439, Mr L—— saw the black space with what he called the *yellow* on each side of it.

The case of Mr ———— is very nearly the same with that now described; but there are some peculiarities in it which merit attention. "We have examined," says the distinguished philosopher who describes it, "the eyes of an eminent optician, whose eyes have this curious peculiarity, and have satisfied ourselves, contrary to the received opinion,* that all the prismatic rays have the power of exciting and affecting him with the sensation of light, and producing distinct vision, so that the defect arises from no insensibility of the retina to rays of any particular refrangibility, nor to any colouring matter in the humours of the eye, preventing certain rays from reaching the retina (as has been ingeniously supposed,) but from a defect in the sensorium, by which it is rendered incapable of appreciating exactly those differences between rays in which their colour depends. The following is the result of a series of trials in which a succession of optical tints produced by polarized light passing through an inclined plate of mica, was submitted to his judgment. In each case, two uniformly coloured circular spaces, placed side by side, and having *complementary tints*, (that is, such that the sum of their light shall be white,) were presented, and the result of his judgment is here given in his own words.

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| Pale green, | No colour. |
| Dirty white, | Darker, but no colour. |
| Fine bright pink, | Very pale tinge of blue. |
| White, | Yellow. |
| Rich grass-green, | Yellow, but more coloured. |
| Dull greenish-blue, | Blue, |
| Purple, rather pale, | Blue. |
| Fine pink, | Yellow, with a good deal of blue. |
| Fine yellow, | Good yellow, |
| Yellowish green, | Yellow with a good deal of blue. |

* We were not aware that any eyes had ever been regarded as absolutely insensible to the *luminous effect* of any particular rays, but only to the *colorific effect* of these rays, though we admit that the language used in trying to explain the peculiarity may bear this construction. When we have spoken of an eye *insensible to red light*, we meant only *insensible to the redness of light*.

It should be stated, however, that T. B. the subject of Mr Harvey's observations, (*Edin. Trans.* vol. x. p. 253,) regarded *indigo* and *Prussian blue* as *black*, and also some *greens* as *black*, that is, certain *blue* and *green* rays made scarcely any impression on his retina.—Ed.

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| Good blue, verging to indigo, | Blue. |
| Red, or very ruddy pink, | Yellow. |
| Rich yellow, | Fine bright yellow. |
| White, | Very little colour. |
| Dark purple, | Dim blue. |
| Dull orange red, | Yellow. |
| White, | White. |
| Very dark purple, | Dark. |

The following colours in the first column are complementary to those in the first column of the preceding table.

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| Pale Pink, | No colour. |
| The same, | No colour, but darker. |
| Fine green, verging to bluish, | Very pale tinge of blue. |
| White, | Blue. |
| Rich crimson, | Blue. |
| Pale brick red, | Yellow, |
| Pale yellow, | Yellow, |
| Fine green, | Blue, with a good deal of yellow. |
| Purple, | Good blue. |
| Fine crimson, | Blue, with a good deal of yellow. |
| Yellow, varying to orange, | Yellow, gay colour. |
| Very fine greenish-blue, nearly white, | Blue. |
| Full blue, | Pretty good blue. |
| Fiery orange, | Yellow, or blood-looking yellow. |
| White, | White, with a dash of yellow and blue. |
| White, | White, with blue and yellow in it. |
| Dull dirty olive, | Dark. |
| White, | White |

Instead of presenting the colours for his judgment, he was now desired to arrange the apparatus so as to make the strongest possible succession of contrasts of colour in the two circles.

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| Pale ruddy pink, | Yellow. |
| Blue green, | Blue. |
| Yellow, | Yellow. |

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| White, | Blue. |
| Pale brick red, | Yellow. |
| Indigo, | Blue. |
| Yellow, | Yellow. |

The following colours in the first column are complementary to those in the first column of the preceding table.

| Colours to an ordinary eye. | Colours to Mr ——'s eye. |
|---|---|
| Blue green, | Blue. |
| Pale ruddy pink, | Yellow. |
| Blue, | Blue. |
| Fiery-orange, | Yellow. |
| White, | Blue. |
| Pale yellow, | Yellow. |
| Indigo, | Blue. |

It appears by this that the eyes of the individual in question are only capable of fully appreciating *blue* and *yellow* tints, and that these names uniformly correspond in his nomenclature to the more and less refrangible rays generally; all which belong to the former, indifferently, exciting a sense of "blueness," and to the latter of "yellowness." Mention has been made of individuals seeing well in other respects, but devoid altogether of the sense of colour, distinguishing different tints only as brighter or darker one than another; but the case is probably one of extremely rare occurrence."

In examining the preceding tables, we observe some results which we think require elucidation. These are principally such as relate to the *whites*, which stand thus:

| Colour to an ordinary eye. | Colour to Mr ——'s eye. |
|---|---|
| White, | Yellow. |
| White, | Very little colour. |
| White, | White. |
| White, | Blue. |
| White, | White, with a dash of yellow and blue. |
| White, | White, with blue and yellow in it. |
| White, | White. |

The examination of this table suggests some important questions.

1. What would be the colour which results from the union

of all the rays in the spectrum, to a person whose sensorium is incapable of appreciating those differences between some of the rays on which their colour depends?

2. If the colour of all the rays thus united is *white*, that is, if it makes the same impression on the defective sensorium as a perfectly white body, how does it happen that *white* was seen by Mr ——— at one time as *yellow*, at another time as *blue*, and at a third time as *white?*

3. If the union of all the colours is *not white*, but is a mixture of *blue* and *yellow*, the only colours which the eye of Mr ——— perceives, why is white seen different from a mixture of blue and yellow?

4. The sensorium of Mr ——— is not only defective in the power of discriminating colours, but it wants the power of appreciating the joint influence of the colours which it does discriminate, or of discovering in combination a colour which it discriminates when seen separately. Fine crimson, for example, is described by Mr ——— as *blue, with a good deal of yellow*, which would be described by a common eye as *greenish;* and in a *rich grass green*, no *blue* is recognized, but it appears only *yellow*.

An answer may be given to some of these questions by simplifying the case. If the eye was devoid altogether of the sense of colour, the spectrum would appear light at the point of maximum yellow, shading gradually off to both extremities, and exactly as it would do to a sound eye if shaded off with Indian ink. In this case it cannot be doubted that such a spectrum would appear *white* if thrown into a circle and whirled rapidly round.

If the eye recognized only one colour, such as *yellow*, the spectrum would appear *yellow* in the middle, and shading off as in the first case; and if it were thrown into a circle and whirled rapidly round the whole would be *yellow*.

If the spectrum now consists of two colours which are alone recognized, viz. *yellow* and *blue*, we know that their union will not be *green*, for the eye is insensible to this tint; we cannot understand how it can be *white*; and therefore we conceive that the retina may be affected in some points with blue and in others with yellow, an effect which may be produced in a sound eye by looking at a white object with a blue glass applied to one eye, and a yellow glass to the other.

The subject is obviously one attended with great difficulty, and requires much more investigation than it has yet received. The author of the description of Mr ——'s vision regards this defect of particular eyes as presenting a formidable objection to the inference deduced from Mr Herschel and Dr Brewster's experiments, relative to the overlapping of the coloured spaces in the spectrum. We cannot at all understand what the objection is which is here alluded to; nor can we conceive how any inference from an obscure physiological fact could set aside the result of a legitimate induction.

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## ART. XXVI.—*Farther Remarks on Self-Registering Thermometers.* Communicated by the AUTHOR.

SIR,

I SHOULD not have now thought of troubling you with any remarks beyond those I offered in a short notice with regard to register thermometers in the last Number of your Journal, had I not since accidentally met with a paper on the subject in an old volume of the *Philosophical Transactions*, to which candour requires me briefly to advert.

Lord Charles Cavendish, to whom we owe some valuable contributions to meteorology in its earliest progress, has described, in the *Transactions of the Royal Society of London* for 1757,* thermometers adapted for the measure of maximum heat and cold: it would appear that Bernoulli had previously made some instruments for the same purpose, but I am not aware of their nature. The principle, however, which Lord Charles Cavendish proposed, was precisely similar to the one described by Mr King, No. xvi. p. 116, the merit of which I was disposed to attribute to Mr Blackadder, whose account appeared in an early number of this Journal. I feel myself bound, therefore, in rectification of the oversight I had committed, to remark that thermometers acting by the quantity of a column of fluid expelled from the extremity of the tube, ap-

* Page 300, or Abridgement, vol. xi. p. 138.

pear to have been the first registering ones described; since that of Six, which acts by indices, was not described in the *Philosophical Transactions* for twenty-five years afterwards, in 1782. I must first notice the construction of Lord Charles Cavendish's thermometer, which had the merit of superseding the necessity of a common attached thermometer, which is required in the construction of Mr Blackadder and Mr King.

A mercurial thermometer had the end of the tube drawn to a capillary orifice, and was capped by a small glass receptacle, exactly as represented in vol. ix. plate ii. fig. 7. and 9. of this Journal; above the mercury some alcohol was introduced into the tube, which of course was expelled into the glass cistern through the capillary opening as the temperature rose, and, as it could not draw it back when the temperature declined, a space was left in the upper part of the tube, measured by a descending scale of degrees, which gave the maximum that had occurred since the last observation, when added to the present temperature indicated by the height of the *mercury* in the tube, which never rises so high as to be expelled by heat.

This description, it will be observed, corresponds almost precisely with that given by Mr King, and on the defects of which I formerly made some remarks: my objection, relative to the uncertainty of a fall of a drop of mercury from the orifice, I find was expressed almost verbally in the same way by Lord C. Cavendish,* in describing another of his thermometers, where the capillary termination could not be so conveniently employed, and which he proposed to rectify by inserting a glass thread into the narrowest part of the tube, an expedient more ingenious than practicable. This was employed in the *minimum* thermometer, where the mercury fell into a globe between the tube and the real bulb, placed at the upper bend of a syphon-shaped thermometer; but the construction of this

* "If no farther contrivance was used, the mercury would fall into the ball in large drops, which would make the instrument less accurate; for the thermometer's beginning to rise immediately after a drop has fallen, or just as it is going to fall, (in which case it will return back to the tube,) will make a difference of such part of a degree nearly as that drop answers to."

rather awkward contrivance I shall not now describe, as its general principle is the same as in a thermometer which has occurred to myself for exhibiting both maximum and minimum results in the same instrument without the aid of indices, which I believe has not before been attempted.

In Figure 5 of Plate I. the dotted portions denote alcohol, the parallel lines mercury. The upper part of the tube, for the measurement of the greatest heat, is exactly upon Lord C. Cavendish's plan, and the altitude of the mercurial part of the column A denotes the actual temperature at any moment. The lower part of the tube is bent upwards, and passed into a cylindrical bulb B, close to one side of it, as shown in the figure. It likewise terminates in a capillary orifice, and, as by the contraction of the alcohol which fills the almost entire bulb, the mercury is withdrawn from the tube and falls to the bottom, the measure of minimum temperature in any period will correspond to the existing temperature, (marked as before by the height of the mercury A,) *minus* the degrees of the tube next the bulb, which contains alcohol, measured by a small scale of their own.

The adjustment of the instrument for a new observation is necessarily somewhat complex. It must first be reversed, and the bulb heated with the hand till the column of alcohol joins the quantity which has been expelled into the upper cistern; retaining the same position, the bulb must be cooled with ether or some evaporating fluid till the alcohol has retired from the lower extremity of the tube; when, from the position, the mercury will obviously join with the portion which before lay in the bottom of the bulb; and by again heating it with the hand till it has nearly regained the temperature of the air, which was known at first by an observation of the summit of the mercury, all the uncertainty will be done away as to when the instrument has regained its proper temperature, which in my former paper I noticed as an error of this principle. By a little practice, too, the degree of heat given artificially will be so nearly proportioned to the atmospheric temperature, that little time will be required to wait in making the adjustment. With regard to the necessity of ether, it is to be observed, that it does little more than counterbalance the use of a magnet to adjust Six's indices, which often requires to be a powerful one, and to meteorologists who observe a dew-point hygrometer it will be no inconvenience whatever. The method proposed by Lord C. Cavendish to adjust his minimum thermometer appears to be precluded in practice, where the tubes are of moderate bore, as it supposes the free passage of the mercury in drops through the alcohol in the tube. Perhaps in executing the thermometer I have now proposed, it might be advisable to have a detached thermometer for the positive temperatures at the moment of observation, and this would preclude the necessity of having any fluid but mercury in the upper portion of the instrument. The less contact we have between the alcohol and mercury, I am inclined to think, the instrument would be more perfect, since the successive passage of two such fluids through the same tube must render it liable to be soiled. Indices, however, at least when they are furnished with springs and moved with the magnet, are, I think, the most detrimental to the perfection and general adoption of the register thermometers. Not merely are they troublesome to adjust, and liable to go out of order, but their formation is always imperfect: for it is difficult to extirpate the air from the interior; and the bulbs and tubes must be so large for the admission of the indices as to destroy all confidence in their sensibility. The principal advantage I therefore hold out, in the adoption of thermometers similar in construction to the one I have here described is, that they may be made to any degree of delicacy; and the finest capillary tubes with small bulbs are in fact more suited to the principles of the instrument, than the largest and widest, which can be said of no other species of self-registering thermometers. I need only mention how unfit either Six's or Rutherford's thermometer, as made by the best makers, are for nice experiments. The former has two contacts of alcohol and mercury, as in my thermometer, and *two indices* besides. For ascertaining maximum and minimum temperatures for a short period of time, and with any delicacy, such as in sending instruments, by means of small balloons, to the higher regions of the atmosphere, all the ordinary ones are quite unsuited; and it is not till register thermometers are considerably improved and simplified, and much more generally adopted, that we can look for very extended deductions of value in this branch of meteorological science. I am, Sir, your most obedient servant, Δ

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ART. XXVII.—*Account of two remarkable Rainbows, one of which enclosed the Phenomenon of converging Solar Beams.* By DAVID BREWSTER, LL. D., F. R. S. Lond. and Edin.

ON the 5th July 1828, there was seen here the most brilliant rainbow that I had ever an opportunity of witnessing. Both the outer and the inner bow were perfectly complete, and equally luminous in all their parts; and they continued in this condition for a very considerable time. I was thus enabled to verify, in every part of the two bows, the fact which I published more than fifteen years ago, of the polarization of the coloured light, in planes passing through the centre of the bow, or, what is the same thing, in the planes of reflection, within the drops of rain. Similar portions of the inner and the outer bow were thus seen to disappear simultaneously, when seen through a plate of tourmaline.

The peculiarity in this rainbow, which has induced me to describe it at present, has I believe never before been noticed. On the outside of the outer or secondary bow, there was seen distinctly a *red* arch, and beyond it a very faint *green* one, constituting a supernumerary rainbow, analogous to those which sometimes accompany the inner bow. It will be interesting to ascertain, if Dr Young's ingenious theory of the common supernumerary bow will apply to the present one.

On the afternoon of Thursday, the 2d of October, a rainbow appeared in the north-east, with considerable brilliancy, and was accompanied with the rare phenomenon of the converging of the solar beams, described in this *Journal*, No. iii. p. 136. As the point to which the solar beams converged below the horizon was exactly opposite to the sun, and, therefore, necessarily coincident with the centre of the rainbow, the two phenomena, when thus accidentally combined, had a very remarkable appearance.

## Art. XXVIII.—ANALYSIS OF SCIENTIFIC BOOKS AND MEMOIRS.

*Elements of Natural History, adapted to the present state of the Science, containing the generic Characters of nearly the whole Animal Kingdom, and descriptions of the principal Species.* By John Stark, F. R. S. E. Member of the Wernerian Natural History Society of Edinburgh, &c. 2 vols. 8vo. Edinburgh, 1828. Pp. 1044. With Plates.

We know of no work connected with the subject likely to be more useful than the present. Natural History, like the other physical sciences, has within the last twenty years made such progress, and the discovery of new and the investigation of known objects, has occupied such a large share of the attention of the continental writers, that the preceding works on Natural Science give but a faint notion of the numbers, structure, and connection of living beings. In France, particularly, expeditions have been fitted out by government for the purpose of investigating the natural productions of distant countries, and the philosophers at home, among whom are the highest names in science, have been no less industrious in availing themselves of all the lights which minute observation and careful dissection afford for tracing the structure and functions of living beings. This information, scattered through an immense number of volumes, many of them by no means of easy access, and in foreign or dead languages, presented powerful obstacles to the general acquisition of knowledge on this important branch of physical science. In the English language, except Dr Turton's translation of Gmelin's edition of the *Systema Naturæ* of Linnæus, and the *Elements of Natural History*, by the late Mr Charles Stewart, also a translation from Linnæus, there existed no general work calculated to excite or gratify a taste for natural history by an explanation of its principles, or an enumeration of the genera and species. The *General Zoology* of Dr Shaw, in fourteen volumes 8vo, was left imperfect by the death of the author; but, independent of other objections, the expence of a work of such extent, illustrated with figures of the animals, must have confined its circulation within narrow limits. In the French language Cuvier's *Règne Animal* is a masterly outline, but totally useless to the student as far as regards generic characters and the enumeration of species. An English translation of this work by Mr Griffiths, with figures and descriptions of new animals, is now in progress. Dumeril's *Elements* is confined to an exposition of general principles; and the German manual of Blumenbach, translated some years ago into English, is merely a short sketch on the Linnæan principle for the use of his pupils. In short, a work was wanted, in which, besides general considerations on the form, structure, and arrangement of natural bodies, and other elementary information, the generic characters of the whole should be given, as well as descriptions of the principal species. This we understand from his prefatory notice was the intention of Mr Stark in the present work; and, so far as we have had leisure to examine, it seems well calculated to serve all the purposes of the student or traveller, by enabling them to identify and class the greater number of species they are likely to meet with.

This work, from the multifarious nature of its contents, is scarcely susceptible of analysis; as it is itself a scientific analysis of all the late discoveries and improvements in Natural History. Combining with the general views of Cuvier the investigations of other writers on the different departments of Nature, we are presented, under the modest title of Elements, with a connected view of the Animal Kingdom, characters of nearly the whole genera, and the greater portion of the ascertained species. Without entering into details upon the minutiæ of generic and specific distinctions, we shall give a short analytical view of the principal classes.

Natural History, Mr Stark remarks, in its most extensive sense, includes the whole material world. All that is on the earth or around it—the atmosphere—the heavenly bodies—land and water—is the province of the naturalist. The attributes of animated beings,—the constituent principles of unorganized bodies and their affinities,—the "stars in their courses,"—and even man himself, whose power and intelligence raises him so far above the level of the beings around him, and connects him with the Supreme Intelligence, is in his mortal part subjected to the same general laws which regulate the other parts of the organized creation, and his history, animal and intellectual, forms part of the great science of nature. "A field so extensive, compared with the limited powers of the human faculties, is too vast for the subject of individual research; and in detail, its objects are so numerous, that to possess a knowledge of even a small portion of these, has been considered a competent task for a life spent in investigation."

In this view all the sciences have their origin in the study of nature; but to facilitate the acquisition of knowledge, it has become matter of necessity to subdivide and arrange the objects of the material world into portions suitable to the human powers. Hence has originated the division of Physical Science into Natural Philosophy,—Chemistry,—and Natural History, properly so called; the last being limited to the consideration of the Animal, Vegetable, and Mineral Kingdoms, as they have not unappropriately been termed. "To examine and arrange these in connection with the laws by which they are governed; to investigate their structure, their history, and their uses, is the province of the naturalist." Natural History is besides distinguished from the other two great divisions of physical science, in that, while the several branches of Natural Philosophy rest chiefly on calculation, and Chemistry on experiment, its basis rests principally upon observation.

The term *Nature*, Mr S. remarks, bears various significations. It is sometimes used to signify the properties which a being derives from original conformation in opposition to those which it has acquired from art; sometimes to express the whole objects which compose the universe; at other times the laws which regulate this universe; and these laws being, in point of fact, the will of that beneficent and omnipotent Being who formed all this "gay creation," the word Nature is frequently employed by a figure of speech to designate its Great Author.

The first great division of natural objects is into organic and inorganic bodies; the first including *Animals* and *Plants*—the second *Minerals*. These are further arranged into three principal divisions, appropriately enough called Kingdoms. *Animals* have been defined, as organized bodies possessing life, sensation, and voluntary motion :—*Vegetables* organized bodies endowed with a vital principle, but destitute of sensation and the power of locomotion :—and *Minerals* as unorganized bodies destitute of life, and of course of sensation. Animal life is distinguished from vegetable life by many considerations, of which we only mention two—Life in the first is active—in the second passive. The nourishment of plants is derived through the medium of their roots; that of animals through a central organ of digestion destined to receive the food. All living bodies, however, possess some characters in common, as absorption, assimilation, developement, and reproduction : all have a limited and determinate term of life according to the species ; and while nature as a whole exhibits the picture of perennial youth and interminable existence, each individual leaves the scene to make room for others at an allotted term.

After detailing the forms and structure of these three great divisions of natural bodies in a general introduction, Mr S., under the head " Animal Kingdom," gives, as the basis of the arrangement which he has followed, an outline of the method proposed by Cuvier, founded upon the comparative organization of the animal races. Animals are thus divided into 1. Those possessed of a skull and vertebral column, in which the nervous matter is inclosed, or Vertebrata ; and 2. Those destitute of a vertebral column and internal bony skeleton, or Invertebrata. These last are divided into 1. Molluscous Animals, including those in which the muscles are simply attached to the skin, and which are either without other covering, or have the soft body protected by a shell. 2. Articulated Animals, in which the covering of the body is divided by transverse folds into rings or segments, to the interior of which the muscles are attached : and 3. Radiated Animals, or those in which the organs of movement and sensation have a circular or radiated form round a common centre. This division includes the Polypi or Zoophytes.

The first class of Vertebrated animals is the Mammalia. To this class is prefixed an introduction, giving a short history of the principal writers on this branch of natural history,—a description of the general forms and structure of the animals of the class,—the methods which have been proposed for classifying them by various authors,—and their uses in the economy of nature. This is followed by the detailed characters of the orders, families, genera, and species. The Mammalia are arranged by Cuvier into eight orders—by Mr Stark into ten—Cuvier having placed the Cheiroptera and Marsupialia as two families of his order *Carnassiers*. These orders are, 1. *Bimana* ; 2. *Quadrumana* ; 3. *Cheiroptera* ; 4. *Feræ* ; 5. *Marsupialia* ; 6. *Glires* ; 7. *Edentata* ; 8. *Pachydermata* ; 9. *Ruminantia* ; 10. *Cetacea*. At the head of the class stands man, the isolated species of the order Bimana, so different even in physical conformation from all the other tribes of animals. " Man stands alone in the order and genus to which naturalists have referred his species. Distinguished by reason and the power of speech, this wonderfully constructed being seems the bond of connection between the material and immaterial worlds. While the inferior animals enjoy unalloyed the blessings of life and present enjoyment, man combines the past, the present, and the future, in his calculations of happiness; and while some parts of his organization connect him with the creatures around him, and sober his rule over beings with animal feelings of pleasure and pain as acute as his own, his intellectual powers trace the Divinity in all the parts of creation, and connect him with the Great Author of his Being."—"The physical structure of man also widely separates him from the other portions of the mammiferous class. But these variations in form and proportion are neither so prominent nor so totally different in character from the other animal structures, as to account for the superiority which he enjoys. Destined to be nourished on substances used in common by other animals, the mechanism of his frame must so far correspond with theirs, as to be able to convert these substances to the fluids which support his animal life; and his organs of sensation must necessarily be analogous in some degree to those of beings on whom the material world is destined to make similar impressions. But no material organs which Man possesses, abstracted from the mind of which they are but the instruments, can account for his intellectual supremacy; and all those hypotheses which would trace Man's intellectual and moral powers from the absolute or relative size of the brain or other material organs, have miserably failed in connecting mind with matter, or thought with organic structure."—"In other respects Man appears to possess nothing resembling the instinct of animals. He is not stimulated to any regular or continuous exertion of industry by an uncontrollable impulse. His knowledge is the consequence of his own sensation and reflection, or of those of his predecessors; and from these results, transmitted by language or example, and applied to his various wants and enjoyments, have originated all the arts. Language and letters, by affording the means of preserving and communicating acquired knowledge, hold out to the human race indefinite sources of improvement." After some remarks on the varieties of the human species, Mr S. adds, "Some French naturalists have endeavoured to raise the varieties now observable among the human race into different species; but, as Cuvier justly remarks, the indiscriminate sexual intercourse and consequent production of an offspring capable of propagation prove mankind to be but a single species. And it is remarked by Blumenbach, that all national differences in the form and colour of the human body are not more remarkable, nor more inconceivable, than those by which varieties of so many other organized bodies, and particularly of domestic animals, arise as it were under our eyes."

The second order of *Mammalia* is the Quadrumanous Animals. These approach nearest in bodily structure to man. Of the first family it is remarked, that, "if the conformation of the body always implied corresponding intellectual attributes, the *Simiæ* or apes should approach the nearest to man. But this is not found to be the case; and though the family of apes have, like man, their anterior hands free, and opposable thumbs, though in a less degree, yet it is not found that their sagacity is superior or equal to some other tribes of mammiferous animals. The structure of their body, indeed, enables them to perform many movements similar to man, but this, when it approaches the usages of the human race, is in general the mere effect of imitation or education in individuals withdrawn from their kind. Possessed of hands at both extremities, capable, were they directed by intelligence, of turning the soil or the inhabitants of the forest to their use, they are inferior in sagacity to the beaver and many other animals which live in society. The social instinct of the apes indeed seems limited to the tendency which frugiverous animals have in general to live in wandering troops, for the purposes of mutual protection." In this division an interesting account is given of the great ourang-outang, the *Simia Satyrus* of Linnæus or the Pongo of Wurmb, a gigantic animal, whose height, when full grown, exceeds seven feet and a half.

The third order, *Cheiroptera,* including the Galeopitheci and Bats, to the singular membrane extended between their fore-feet and fingers in the form of wings, which enables them to fly like birds, adds two pectoral mammæ, and have the male organ of generation similar to the preceding order. Next comes the order *Feræ,* part of the *Carnassiers* of Cuvier, divided into three families, *Insectivora, Carnivora,* and *Amphibia.* We would willingly here copy some of the notes in which the history and habits of the most interesting species are detailed did our limits permit. Regarding that very useful and widely distributed animal, the Dog, it is stated, that "the domestication of this animal is, in Cuvier's opinion, the most complete, the most singular, and the most useful conquest man has ever made. All the species have become his peculiar property; and each individual, devoted to his master alone, accommodates itself to his manners, protects his goods, and remains attached to him till death. This connection arises not from constraint, nor from the want of man's protection; for the dog has naturally powers of defence and attack superior to most of the quadrupeds, but from a species of confidence approaching to friendship. Its strength, its speed, and its smell, have made it a powerful ally in the subjugation of the other animals; and it is the only animal which has followed man through every quarter of the globe, and the only one whose existence and propagation does not seem to be determined by certain limitations of latitude."

"The bodily strength of the lion, his carnivorous regimen, and predaceous habits, place him at the head of the beasts of prey. Less savage than the tiger and other carnivorous animals, the lion seems to derive no gratification from the destruction of animal life beyond the immediate cravings of appetite; and hence, compared with the cruel dispositions of many of the minor inhabitants of the forest, he has acquired a character of generosity superadded to his courage, which has long made him be regarded as the noblest of the feline race. Unlike the tiger, whose social attachment, lasts only during the period of reproduction, and whose thirst for blood often leads him to destroy his own issue, the lion is permanently attached to his mate; while the maternal feeling of the lioness is strikingly displayed in the subsequent fury of this noble animal when by any accident she is 'bereaved of her whelps.'"

The fifth order, *Marsupialia,* are those singularly constructed animals in which the young are for some time protected in an abdominal pouch, in which also the mammæ are placed. The *Glires* or gnawers form the sixth order. To this division belong the beaver, distinguished for its in telligence and social instinct—the Lemming, well known for its migratory habits—the rat, the mouse, the hamster, the marmot, as well as the squirrel, the porcupine, and the hare. The peculiarities of these animals are described in notes at considerable length.

Order seventh, *Edentata,* includes the *Bradypus* or sloth, the *Armadillo,* the *Echidna,* and the *Ornithorynchus,* the singular anatomy of the two last of which has been so ably illustrated by the dissections of Sir Everard Home and Dr Knox. Order eighth, *Pachyderma,* divided into three families, viz. *Proboscidea, Pachyderma,* and *Solidungula,* includes the largest of quadrupeds, the elephant, the mammoth, and the hippopotamus. We copy the note regarding the first of these :—" The Elephant is the largest of existing quadrupeds, and has been known from the earliest ages. The Asiatic species is found throughout the whole of Southern India and the neighbouring islands; but though extensively employed it can scarcely be considered as a domestic animal, as it does not breed in captivity. The supply is therefore kept up by the capture of wild ones; and elephant-hunting forms a princely sport among the inhabitants of Asia. The elephant inhabits forests in the neighbourhood of rivers, and swims with great ease. It is a gregarious animal, and is generally found in herds, sometimes to the amount of hundreds together. Its extreme docility renders it easy to be tamed ; and numerous facts have been related of its sagacity in a state of domestication. The specimen long in Mr Cross's collection at Exeter Change, and which he was forced to kill to preserve the building, was between 10 and 11 feet in height, and weighed by computation between four and five tons. Its daily allowance of food was three trusses of hay, about 200 lbs. of carrots and other fresh vegetables, and from 60 to 80 gallons of water. A strong elephant can carry 2000 pounds weight and travel 60 miles a-day ; though in long marches its feet are apt to become tender. The period of gestation is twenty months. At birth the young elephant is about three feet long, and it sucks with its mouth, putting back the proboscis when doing so. It arrives at full growth in about twenty years ; and lives, according to the opinion entertained in India, for three centuries, witnessing the successive rise and decay of the ephemeral generations of men. The tusks, an object of commerce, are changed but once during the life of the animal, but the molar teeth are renewed as often as detrition renders it necessary. These teeth, however, are not renewed in the usual manner, by the new teeth pushing out the old ones, but by a lateral succession from back to front. The most wonderful part of the structure of the elephant is its proboscis, which to it serves all the purposes of a hand ; and while it is able with this powerful instrument to lift the greatest weights, its lip possesses all the delicacy of a finger, and is capable of seizing the smallest substances.—The white variety is rare, and is held in much esteem by the eastern sovereigns. Horace alludes to its exhibition in ancient Rome, Epist. i. B. ii."

To this division also belongs that very useful animal, the Hog. " The fecundity of the hog is very great. A hog belonging to Mr Thomas Richdale, Leicestershire, had produced, in the year 1797, three hundred and fifty young ones in twenty litters ; four years before it brought forth two hundred and five in twelve litters ; and in Vauban's opinion in twelve generations the produce of a single pair would produce as many as Europe could support. Among the ancients the hog was in much esteem; it was the peculiar sacrifice to Ceres; and in the island of Crete it was regarded as sacred. In ancient Rome the art of rearing and fattening them was much studied, and a dressed hog was among the most expensive of the imperial dishes."

The third family of this order includes the horse. "The different races of the horse are numerous, most of the principal countries in the world possessing breeds peculiar to themselves. But the Arabian race has long been considered as the noblest of the species, and as combining the qualities of endurance, vigour, and temper, in a higher degree than any of the other varieties. As breeders of horses have ascertained that the qualities of the Arabian horse may be perpetuated in his descendants, in the countries of Europe where attention is paid to the raising of this valuable animal for various purposes, the deterioration which a northern climate induces in a native of warmer latitudes is counteracted by crossing with the original breed. From the importation of the pure breed of Arabia into Europe, and the different crossings of these and their descendants with the native breeds, has arisen all that variety in appearance and qualities of the horse, which fits them for heavy draughts, the plough, or the saddle."

The ninth order of Mammalia is the *Ruminantia* or Ruminating animals, including that large group of quadrupeds which possess the singular faculty of masticating their food twice, and among these the goat, the ox, and the sheep. At the head of this order stands the Arabian Camel, which has from ages been the medium of commercial communication between the countries on either side of the great deserts of Arabia, and has been emphatically termed the *ship of the desert*. We notice here also the Reindeer, the only one of the genus *Cervus* which has been domesticated; and the Giraffe, known to the Greeks and Romans, and which has after a long interval been again brought alive to Europe. The last order of mammiferous animals is the Cetacea, which, to the form and habits of fishes, join some of the essential characteristics of quadrupeds. This order includes the Dolphin, the Porpoise, and the Whale, the largest of animals, the mass of the body of a full grown specimen being nearly equal to that of a hundred elephants.

"The total number of mammiferous animals described by Desmarest (and Mr S. has inserted the whole ascertained species) is about 850, including, however, many species imperfectly ascertained and the fossil Mammalia; of which belonging to the order Quadrumana are 141,—Cheiroptera 97,—Feræ 176,—Marsupialia 47,—Rodentia 149,—Edentata 24,—Pachydermata 55,—Ruminantia 97,—Cetacea 62. Of these about 330 are frugivorous or herbivorous, 80 omnivorous, 150 insectivorous, and 240 carnivorous, in a greater or lesser degree. The number of terrestrial species domesticated by man (but perhaps including all that are really useful) amount only to thirteen.

We have thus shortly enumerated the principal divisions adopted by Mr S. in the class Mammalia, without attempting to give any of the scientific, generic, and specific descriptions; and omitting entirely the general considerations on the anatomical structure, food, and habits of the different groups. For these we refer to the book itself. We only remark, that Mr S. has very properly followed Cuvier and Desmarest in the distinctions of genera and species; and that in the popular details much of the wonderful related by travellers is softened down to the capability of sober belief, without lessening the interest excited by the real wonders in the structure and instincts of living beings.

The second class of Vertebrated Animals, Birds, next follows; and here the scientific details are also preceded by an introduction explaining the anatomical peculiarities of structure, the general forms and habits of this group of animals, with explanations of the terms used in description, and a historical summary of the chief methods of arrangement. "The arrangement of Birds into orders (says Mr S.) has for its basis the conformation of the bill and feet, which are adopted to their different modes of living and food. Birds of Prey are characterized by a hooked bill, and feet armed with strong and crooked nails; Climbers are those, the structure of whose feet is calculated for motion on an inclined or vertical surface; and web-footed birds are evidently adapted for swimming. Others again have the legs very long and naked for wading; and a large number, with the claws short and feeble, live chiefly on insects. But though it be thus easy to separate the more strongly marked groups into extended families, yet it has been found extremely difficult to distribute them in subordinate groups, so as to facilitate the knowledge of species in a class so widely extended. In adopting the arrangement of Temminck, therefore, though his Orders are more numerous than those proposed by Cuvier and Vieillot, yet the families of the latter are in much greater number; and in an elementary work it has been judged proper to follow that system which involves the least change of the established nomenclature as likely to be most generally useful." The number of orders in this class, which it is not necessary to enumerate here, is sixteen, and Mr Stark gives, besides the generic characters of the whole class, descriptions of all the European species, and the principal foreign species. The notes on this portion are extremely interesting, and convey much information not generally known. We copy one or two of the general remarks. "The Class of Birds, though not so apparently useful to man as the Mammalia, serve important purposes in the general economy of nature. Those whose food is chiefly insectivorous check the excessive reproduction of the insect races, and for this purpose migrate at certain seasons to places where their food abounds. The indiscriminate destruction of crows and sparrows in some districts has accordingly been found to give rise to an infinitely more prejudicial multiplication of creatures still more destructive. Some families of birds destroy field-mice, snakes, frogs, and lizards; and others again are led by choice to feed on carrion, or dead animal matter. Birds are, besides, extensive agents in the spread of vegetables and even animals. It is well ascertained that wild ducks in their emigrations carry impregnated spawn into remote ponds, and thus stock them with fish; and many, by swallowing seeds whole, and subsequently expelling them, are the means of spreading vegetation over an extent of surface which scarcely any other means could accomplish. A great portion of the class and their eggs may be used as food, and the feathers of many form an object of commerce."—"The flights of migratory birds have been noticed from the earliest periods.—'The stork in the Heaven knoweth her appointed times, and the turtle and the crane and the swallow observe the time of their coming;' and, as if their passage through the air or the structure of their bodies made them sooner perceive the incipient changes of weather, the appearance and cries of birds have long been considered to afford presages of the coming storm or the cessation of the tempest. The institution of a College of Augurs at Rome may therefore be conceived to have reference to something better than mere superstition; and though the flight of particular species might, in the hands of interested individuals, be made to presage the wished-for result of a battle, or direct a march already determined on, yet in the absence of the barometer and thermometer the appearance or disappearance and cries of birds was the signal to the husbandmen to sow his fields or to secure his crop.

Jam veris prænuncia venit hirundo.—*Ovid.*
Tum cornix plena pluvium vocat improba voce.—*Virg.*

" In this country the great migrations of birds take place in spring and autumn. Those which arrive in spring come from warmer climates, and after incubation leave us in autumn; and another host, chiefly Palmipedes, from the arctic regions, arrive in autumn, and pass the winter on our lakes and shores, departing again in the spring. Each species has a particular mode of flight in these annual journeys, and a certain period of arrival and departure. Assembled in large flocks the cranes cleave the air in the form of a long triangle; wild-geese fly in angular lines; and the smaller birds associate in less numerous families, and reach their destination by less continued flights."

The third class of Vertebrated Animals or REPTILES is treated as the preceding classes. The orders are four, viz. Chelonian Reptiles or Tortoises; Saurian Reptiles or Lizards; Ophidian Reptiles or Serpents; and Batrachian Reptiles or Frogs. To this class belong the crocodile of the Nile, known from the earliest times, and apparently much more common formerly than at present, as Scaurus during his ædileship displayed no fewer than five of these animals in an artificial lake for the gratification of the Roman populace; the celebrated Chamælcon; and the most dangerous serpents.

FISHES form the fourth class of Vertebrated Animals. These are divided into two sub-classes—distinguished as Cartilaginous or Osseous, and into nine orders, according to the form and position of their branchiæ or gills, and fins. On this important class of animals the general details are full, and the list of species numerous. We quote only one passage. " The amazing reproductive powers of fishes are well known. In the ovary of the Cod in December were found 3,686,760 ova; in the Flounder in March, 1,357,400; in the Herring in October, 36,960; and in the Tench 383,252. And Bloch relates, as the result of an experiment regarding the reproductive power of the Carp, that, in a pond of seven acres, in which were placed four males and three females, the increase was 110,000 young carp,—a number far too great for the size of the pond, and the necessary supply of food. But this astonishing capability of increase is modified by a thousand circumstances which regulate the number produced to the supply of their food. Myriads of these ova form the food of different species; and myriads more of the young may be supposed to be destroyed in an element where almost all are destined to become the prey of one another. But notwithstanding these deductions, the importance of this class as an object of commerce, and as a supply of food, hold out an inexhaustible field for the enterprise of nations whose territories approach the sea.

"Of the migrations of fishes, and the causes which prompt these annual influxes of certain fishes on certain coasts, little is with certainty known. Probably they are regulated by the same causes which influence the migrations of birds,—to find food and proper places for reproduction; and the same instinctive impulse which induces the salmon at certain seasons to ascend rivers, may bring myriads of fishes to the shores for the same purpose.

"Little is known with regard to the comparative age of fishes. The carp has been known to reach 200 years, and the pike to 260; and if the whale be found of less size now than in former ages, when their fishery was but little attended to, it may be conjectured, that their age is still more considerable."

In these four classes, which compose the first volume of the work, besides the recent genera of animals, Mr S. has also given in their place the characters of the fossil genera, and has thus, by placing the former with the present races of animals, connected Natural History with Geology. The volume is concluded with a chapter on the Preparation and Preservation of Objects in Natural History; a List of the principal Writers on the different classes; and characteristic Engravings, exhibiting the various forms and structure of the animals, upon which the leading characters of their distribution is founded.

The Second Volume contains the Invertebral animals, under the heads of Mollusca, Articulata, and Radiata. The first division contains four classes, viz. Mollusca proper, Conchifera, Tunicata, and Cirripeda. The second the Annelides, Crustacea, Arachnides, Myriapoda, and Insecta. And the third division includes the Echinodermata, Entozoa, Acalepha, Polypi, and Infusoria. This Volume is concluded by a short sketch of the Vegetable Kingdom, exhibiting the arrangement of Linnæus, and the Natural orders of Jussieu; and an Introduction to Mineralogy and Geology.

After the analysis which we have given of the first volume of this important and valuable work, it is almost superfluous to add any farther recommendation of it. There is indeed no English work that comes in competition with it, and therefore it must be regarded as supplying an important desideratum in the literature of Natural History. To the Student of Nature, and particularly to the Traveller, we would recommend it as invaluable. Even the learned naturalist, who may possess many of the best materials to which Mr Stark has had access, will find it a most useful manual; while the general reader will obtain much amusing and instructive information, in the account which Mr Stark has given of the structure, functions, manners, and habits of many of the species.

The technical arrangement of the materials is judicious, the style is simple and perspicuous, and a right tone of feeling pervades the whole work.

The volumes are terminated with copious Indexes, with Descriptions of the Plates, and a List of Works on Natural History.

## Art. XXIX.—PROCEEDINGS OF SOCIETIES.

### 1. *Proceedings of the Royal Society of Edinburgh.*

*November* 24*th*, 1828.—At a general meeting of the Society held this day, the following were elected Office-bearers and Counsellors.

President.—Sir Walter Scott, Baronet.

Vice-Presidents.—Right Hon. Lord Chief-Baron, Professor Russel,
The Hon. Lord Glenlee, Hon. Lord Newton,
Dr T. C. Hope, H. Mackenzie, Esq.

General Secretary.—John Robison, Esq.

Secretaries to the Ordinary Meetings.—P. F. Tytler, Esq.
Rev. E. B. Ramsay, A. B.

Treasurer.—Thomas Allan, Esq.

Curator of the Museum and Library.—James Skene, Esq.

Counsellors.—Sir T. M. Brisbane, Bart., Dr Alison,
Hon. Lord Meadowbank, Dr Brunton,
Dr Graham, Dr Brewster,
Thomas Kinnear, Esq., Captain Basil Hall, R. N.,
James Hunter, Esq., Sir Henry Jardine,
Sir William Hamilton, Bart., Professor Jameson.

*Dec.* 1.—A paper was read, entitled "Observations on Topographical Modelling and Delineation." By William Bald, Esq. M. R. I. A. and F. G. S.

### 2. *Proceedings of the Cambridge Philosophical Society.*

*November* 10, 1828.—The Reverend Professor Cumming, Vice-President, in the chair.

A paper by J. Challis, Esq. Fellow of the Trinity College, was read, *On the law of the planetary distances as applied to the Satellites.* In the case of the planets, it is well known that if we take the excesses of their distances above the distance of Mercury, these excesses form a geometrical series, of which the common ratio is 2. Mr Challis has examined the distances of the satellites from their centre, with a view to ascertain whether a similar law prevails with regard to them; and from the results of his calculations it appears incontestible that this curious analogy, hitherto entirely unexplained, obtains in the secondary as well as in the primary systems. The common ratio in the case of Jupiter is 2½ nearly. In the case of Saturn it appears to be 2 for the first five, and 3 for the last three. In the case of Uranus the ratio is 1½ nearly. Mr Challis suggests that the apparent irregularity in the case of Saturn may be connected with the disturbing influence of his ring. In the system of Uranus it is necessary to suppose 9 satellites; and thus, in the same manner in which the law applied to the planets led astronomers to conjecture the existence of a planet between Mars and Jupiter, it leads us to suppose, when we apply it to the satellites of Uranus, that there exist, as yet undiscovered, two satellites between the fourth and fifth, and one between the fifth and sixth of those at present known.

Mr Whewell gave an account, illustrated by drawings, of the *Phenomena of granite veins in Cornwall*, especially at Trewavas Head, Polmear Porth, and Wicka Pool.

*November* 24, 1828.—The Bishop of Lincoln, the President, in the chair.

A memoir was read by Professor Airy *On the Longitude of the Cambridge Observatory*. He observed that differences of longitude, as determined by *geodetical* operations, and by differences of sidereal *time*, do not necessarily coincide. They depend upon different definitions and are useful for different purposes. The geodetical longitude of Cambridge Observatory from Greenwich, as proved by the trigonometrical survey, is 24″ 6. of time east. But on the 21st, 22d, and 23d of October last, a comparison of the transit clocks at the two places was made by means of six pocket chronometers, carried four times from one place to the other; and this gave the astronomical difference of longitude 23″ 54. which Professor Airy considers as the quantity to be used in future.

A paper was also read by Mr Willis of Caius College, *On the Vowel Sounds;* and after the meeting experiments were exhibited illustrative of the doctrines asserted. It appears that the vowel sounds may be produced by means of a *loose reed* in the order *i, e, a, â, o, ô, u,* by successively contracting the aperture of the cavity in front of the reed. It appears also, that by fitting on a tube of gradually increasing length, the sounds produced are, the above series of vowels in a direct order, and the same in an inverse order, with intermediate positions giving no sound; and that this cycle is repeated at equal lengths of the tube. A variety of other interesting facts and principles were brought forward.

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## Art. XXX.—SCIENTIFIC INTELLIGENCE.

### I.—NATURAL PHILOSOPHY.

#### ASTRONOMY.

1. *Observations on Encke's Periodical Comet.*—This comet was discovered on the 3d October by M. Pons at Florence. Our able countryman, Mr Dunlop, discovered it at Makerston, in the observatory of Sir Thomas Brisbane, on the 25th of October, and has observed it diligently since that time.

2. *Ephemeris of Encke's Comet continued.*

| 1828. | | Right Ascen. | Declination North. | Log. Dist. from Earth. |
|---|---|---|---|---|
| Nov. | 15.3 | 329° 31′ | 18° 25′ | 9.6942 |
| | 17.3 | 327 24 | 17 20 | 9.6911 |
| | 19.3 | 325 20 | 16 13 | 9.6881 |
| | 21.3 | 323 17 | 15 5 | 9.6863 |
| | 23.3 | 321 20 | 13 57 | 9.6843 |

| 1828. | | Right Ascen. | Declination North. | Log. Dist. from Earth. |
|---|---|---|---|---|
| Nov. | 25.3 | 319° 24′ | 12° 48′ | 9.6826 |
| | 27.3 | 317 29 | 11 38 | 9.6811 |
| | 29.3 | 315 35 | 10 27 | 9.6796 |
| Dec. | 1.3 | 313 41 | 9 14 | 9.6783 |
| | 3.3 | 311 46 | 8 1 | 9.6751 |
| | 5.3 | 309 50 | 6 45 | 9.6761 |
| | 7.3 | 307 50 | 5 27 | 9.6751 |
| | 9.3 | 305 48 | 4 7 | 9.6745 |
| | 11.3 | 303 40 | 2 42 | 9.6742 |
| | 13.3 | 301 27 | 1 14 | 9.6744 |
| | | | South. | |
| | 15.3 | 299 7 | 0 20 | 9.6754 |
| | 17.3 | 296 40 | 1 58 | 9.6774 |
| | 19.3 | 294 5 | 3 42 | 9.6809 |
| | 21.3 | 291 23 | 5 32 | 9.6863 |
| | 23.3 | 288 39 | 7 28 | 9.6946 |
| | 25.3 | 285 42 | 9 28 | 9.7046 |
| | 27.3 | 282 49 | 11 31 | 9.7189 |
| | 29.3 | 260 0 | 13 35 | 9.7360 |
| | 31.3 | 277 22 | 15 38 | 9.7575 |

3. *Comet of September* 1827 *and September* 1720.—In No. xvi. p. 362 of this *Journal,* we gave M. Walz's elements of the comet of September 1827, compared with those of the comet of 1720.

The following elements of it, given by M. Nicolai, bring it still closer to that of 1780.

| | |
|---|---|
| Passage of Perihelion. | |
| Mean time at Manheim, 1827, September, | 11.69837 |
| Perihelion distance, - - - | 0.13750 |
| Long. of Perihelion, - - | 250° 58′ 13″ 4 |
| Long. of Node, - - | 149 39 4 3 |
| Inclination of orbit, - - | 54 3 19 2 |
| Motion retrograde. | |

4. *Elements of the orbit of the Planet Juno.*—In this *Journal,* No. xv. p. 167, we have given the position of the planet at the time of her opposition on the 25th of March 1828.

The following elements of this planet have been given by Professor Nicolai of Manheim.

| | |
|---|---|
| Epoch of her mean long. on the 25th March, - | $0^h$ |
| At Manheim, - - - - | 160° 29′ 13″.71 |
| Mean daily tropical motion, - - | 813″.69304 |
| Long. of Perihelion, - - - | 53° 32′ 13″.12 |
| Eccentricity, - - - | 14° 52′ 21″.66 |

| | | |
|---|---|---|
| Long. of Node, | - - | 171° 12′ 11″.18 |
| Inclination of her orbit to the ecliptic, | - | 13 3 18 51 |
| Long. of half the greater axis of her orbit, | . | 0.4264129 |

METEOROLOGY.

5. *Captain Kater's account of the Luminous Zone of the 29th September.*—At Chesfield Lodge, near Stevenage, Professor Moll and Captain Kater observed at $8^h$ 35′ a luminous belt stretching from the eastern to the western horizon. Its light was uniform, and greater than that of the Milky Way, and its breadth throughout was 3° 45′; the stars were distinctly seen through it. It covered the Pleiades, and seemed equidistant from α Arietis and γ Andromedæ. It passed between α Aquilæ and α Lyræ, at the distance from α Aquilæ of one-third or two-fifths of the distance between the stars. Its edges were upon β and γ Ophiuchi lower down, near the western horizon. It was remarkably inflected to the N. and was soon lost in the clouds. It seems to have occupied nearly a great circle, meeting the horizon about the E. N. E. and W. by S. points. The height of the centre of the most elevated part, appears to have been about 72°, so that it must have been nearly in the plane of the dipping-needle, and nearly at right angles to the magnetic meridian. It had no coruscations. At $8^h$ 42′ mean time, the belt began to fade slowly from the E. to the W., and at $9^h$ 22′ no trace of it was perceptible. There was much wind from the S. E. The barometer was 29.12 inches, and the thermometer 59°. Chesfield Lodge is about 43″ of time west of Greenwich, and in lat. 51° 56′ 15″ north.

6. *Observations on the Luminous Arch at Islay-House, Islay.*—On Monday the 15th of September this interesting phenomenon was seen at Islay-House. It appeared at ten minutes before nine o'clock, and crossed the heavens in the form of a luminous arch, stretching from the south-east to the north-west. It was pointed at each end, and broad at the centre, the south-eastern extremity being rather fainter than that observed to the south-west. Small radiations appeared to issue from it at the south-east; and the middle of the arch, where it was broadest, had an inclination to the west, and was not so bright as the two ends. The south-eastern part extended about one-third of the horizon beyond the Pleiades.

The arch remained stationary. When first seen, it was to the westward of the Pleiades. At half-past ten it was much fainter, and the Pleiades were considerably to the westward of the Arch.

In the south-east part of the horizon, there was seen at the same time a most brilliant Aurora, changing from *rose*-colour to *yellow* and *pale green*.

7. *Observations on the Luminous Arch near Edinburgh.*—On the evening of the 15th September, the Aurora Borealis began about $9^h$ P. M. A ray of light stretched from the western horizon with great brilliancy towards the zenith, and formed an arch of great beauty, perhaps not inferior to that of the 19th March 1825. About $9^h$ 17′ mean time it was in its greatest beauty, and then rose from the constellation Serpens in the west,

passing through α *Lyræ* and α *Cassiopeiæ,* and terminated in the east exactly at the Pleiades. By tracing this course on the globe, I found that its direction was E. 23° N. and W. 24° S. which coincides with a direction at right angles to the magnetic meridian. At the hour above-mentioned it must have been almost precisely in the zenith of the place of observation. Its motion was extremely slowly south in the same direction, but not nearly so rapid as the arch I observed in January 1826, and described in my paper on the phenomena of 1826-7, published in this Journal. The wind was W. the breadth of the arch was small, and its brilliancy great at both ends, especially the west. It became more diffused and fainter as it approached the zenith, where its breadth was about 5° or 6°, and it did not conceal minute stars. At the western extremity it rendered stars of the third magnitude nearly invisible. By half-past ten it had disappeared. Δ

8. *Notice of the Mean Temperature of Falmouth and the vicinity.*—In the following tables are comprised the mean monthly results of observations made at Huel Gorland twice a-week; at Dolcoath three times a-week; and in the neighbourhood of Falmouth daily. The thermometers were each four feet long, and their bulbs were sunk to the depth of three feet under the surface, so that the variations from day to day, and even from week to week, were frequently very inconsiderable. The first was in granite, and the two latter in clay-slate. The station at Falmouth is estimated at about 120 feet, and the two others at rather more than 300 feet above the level of the sea.

| | | Huel Gorland, | Dolcoath, | Falmouth. |
|---|---|---|---|---|
| 1822. | November, | | | 53.° |
| | December, | | | 47.2 |
| 1823. | January, | | | 43.5 |
| | February, | | | 43.55 |
| | March, | | | 44.6 |
| | April, | | | 47.55 |
| | May, | | | 51.3 |
| | June, | 52.74 | 53.6 | 53.8 |
| | July, | 53.94 | 53.35 | 54.75 |
| | August, | 55.3 | 56.6 | 56.1 |
| | September, | 56.2 | 57.8 | |
| | October, | 53.7 | 52.7 | |
| | November, | 49.1 | 49.67 | |
| | December, | 46. | 47.57 | |
| 1824. | January, | 44. | 44.44 | |
| | February, | 43.63 | 44.85 | |
| | March, | 42.8 | 44.08 | |
| | April, | 43 78 | 44.62 | |
| | May, | 46 69 | 47.85 | |
| | September, | | | 58. |
| | October, | | | 54.75 |
| | Mean, | 48.99 | 49.94 | 50.67 |

Giving for the mean of the three places, 49.86. The author considers the mean temperature of the earth's surface in the vicinity of Falmouth to be under 51°, and even less than 50° in a considerable portion of the mining district of Cornwall.—From Mr Fox's paper "on the Temperature of Mines." *Cornwall Geological Trans.* vol iii.

9. *Description of the luminous arch, as seen at Perth on the* 15*th October*.—On the evening of Monday last, an electro-magnetic arch of singular beauty was distinctly visible here, for more than an hour, during the greater part of which it underwent little or no change of appearance. It was preceded by a vivid Aurora in the north, flitting along the skirts of a dark cloud, which appeared and disappeared as the coruscations of light darted in irregular vertical columns along its surface. A few minutes before 9 o'clock a bright pencil of luminous rays began to issue from the eastern side of the horizon, exactly on the N. E. by E. ½ E. point, and in a short time it extended itself entirely across the heavens in the form of a most magnificent arch. In the mid-heaven the breadth of the arch was about 4 degrees, but it contracted gradually towards each extremity, and at the opposite points where it intersected the horizon, it was barely visible,—an appearance which was owing to the greater distance of the lower parts of the arch, which must have been about 750 miles from the observer, on the supposition that the portion of it over his head was 60 or 70 miles above the surface of the earth. At 9 o'clock the northern edge of the arch was nearly in contact with the Pleiades, which were then about 10 degrees above the horizon. Passing between Mirach and Almaac, it covered near the zenith the bright star in Cygnus, and stretching onward a little to the northward of Vega, it touched Ras Alhagus in Ophiuchus, after which it intersected the horizon, in the S W. by W. point. As it cut the horizon in two points which were almost diametrically opposite, it had the appearance of being nearly a great arch of the celestial sphere. It did not pass, however, through the zenith of Perth, but through a point which was about 7 degrees southward from it. The axis of the arch coincided very accurately, during the whole time of its appearance, with the plane of the magnetic meridian, thus indicating the intimate connection between this striking phenomenon, and the electro-magnetic influence.

10. *Aurora Borealis seen at Perth on the* 29*th October*.—On Monday night, between the hours of 10 and 11, the coruscations of the Aurora Borealis were uncommonly vivid and changeful; exhibiting themselves in broad flashes of the most varied forms, which darted with inconceivable velocity from the horizon to the zenith, and resembled rather an immense conflagration of the atmosphere, agitated by a violent tempest than the usual appearance of that flitting meteor.

### ELECTRICITY.

11. *Foerstemann's experiments on the conducting Power of different Fluids for Voltaic Electricity*.—The first column shows the specific gravity of the fluid, the second the quantity of electricity which the fluid con-

ducts in a given time, and the third the time required for the conduction of equal quantities of electricity.

| | | | |
|---|---|---|---|
| Muriatic acid, | 1.126 | 2.464 | 0.410 |
| Acetic acid, | 1.024 | 2.398 | 0.423 |
| Nitric acid, | 1.236 | 2.283 | 0.438 |
| Ammonia, | 0.936 | 2.177 | 0.459 |
| Solution of muriate of ammonia, | 1.069 | 1.972 | 0.509 |
| Sulphuric acid, | 1.848 | 1.737 | 0.575 |
| Solution of potash | 1.172 | 1.709 | 0.585 |
| Solution of common salt, | 1.166 | 1.672 | 0.598 |
| Solution of acetate of lead, | 1.132 | 1.560 | 0.632 |
| Distilled water, | 1.000 | 1.000 | 1.000 |

## II. NATURAL HISTORY.

### MINERALOGY.

12. *Notice of the produce of the Tin Mines of Cornwall and Devon.*—

| | Cornwall. | Devon. |
|---|---|---|
| 1822, | 3127 tons. | 10 tons of tin. |
| 1823, | 4010 | 21 |
| 1824, | 4770 | 49 |
| 1825, | 4100 | 70 |
| 1826, | 4320 | 86 |

13. *Of the Cornish Copper Mines.*—

| | | Tons of ore. | Average produce of metal. | Sold for |
|---|---|---|---|---|
| 12 Months to 30th June | 1823, | 97.470 | $8\frac{3}{4}$ per cent. | L.618,933 |
| Do. | 1824, | 102.200 | $7\frac{7}{8}$ | 603,878 |
| Do. | 1825, | 110.000 | $7\frac{5}{8}$ | 743,253 |
| Do. | 1826, | 118.768 | $7\frac{3}{4}$ | 798,790 |
| Do. | 1827, | 128.459 | $7\frac{1}{8}$ | 755,358 |

14. *Of the quantity of Metallic Copper, the produce of the mines in Great Britain and Ireland.*—

| Year to 30th June | 1823. | 1824. | 1825. | 1826. | 1827. |
|---|---|---|---|---|---|
| Cornwall, | 8070 tons. | 8022 tons. | 8417 tons. | 9140 tons. | 10450 tons. |
| Devon, | 510 | 451 | 554 | 482 | 424 |
| Other parts of England, | 5 | 23 | 20 | 21 | 89 |
| Anglesea, | 740 | 726 | 726 | 758 | 735 |
| Other parts of Wales, | 120 | 126 | 131 | 186 | 143 |
| Scotland, | 13 | | | | |
| Ireland, | 257 | 488 | 502 | 482 | 540 |
| | 9715 | 9836 | 10350 | 11069 | 12381 |

From the *Trans. Cornwall Geological Society*, vol. iii.

GEOLOGY.

15. *General Summary of the Geology of India.* By JAMES CALDER, Esq.—The able memoir, of which the following observations form a part, was read at the Asiatic Society of Calcutta on the 19th March 1828.

" Casting our eye over the map of India," says Mr Calder, " we are struck with the grand and extensive mountain ranges which form the principal boundaries. On the north we have the stupendous chain of the Himalaya, extending from the confines of China to Cashmeer, and the basin of the Oxus. That vast accumulation of sublime peaks, the pinnacles of our globe, is so extensive, that a plane, resting on elevations 21,000 feet, may be stretched, in one direction, as far as the Hindoo Cosh, for upwards of 1000 miles, above which rise loftier summits, increasing in height to nearly 6000 feet more. Primitive rocks alone have been found to compose all that has yet been explored of the elevated portion of that chain; gneiss being, according to Captain Herbert, the predominating rock, along with granite, mica, schist, hornblende, chlorite slate, and crystalline limestone. On these repose clay-slate and flinty-slate; and towards the base we find sandstone composing the southern steps of the chain, and forming the north-east barrier of the valley of the Jumna and Ganges, by which, and the diluvial plains of Upper Hindoostan, this great zone is separated from the mountain ranges of the Peninsula. The opposite or southern boundary of this valley is of the same rock. Advancing to the south, we come to three inferior mountain ranges, on which the Peninsula table-land of India may be said to rest, or more properly, to which it owes its peculiar form and outline. We may consider these ranges separately: the western or Malabar, the eastern or Coromandel, and the central or Vindya. Of these, the principal in elevation, and most remarkable in continuity of extent, is the western, which may be said to commence in Candeish, and runs along the Malabar coast, within a short distance of the sea, in an unbroken chain to Cape Comorin, excepting where it is interrupted near its southern extremity by the great chasm which forms the valley of Coimbitoor. The direction of this chain deviates but little from north and south, bending a little eastward towards its southern extremity. Its elevation increases as it advances southward; the highest points being probably between latitudes 10° and 15°, where the peaks of granite rise to 6000 feet and upwards.

The northern extremity of this range is entirely covered by part of the extensive over-lying trap formation, to be more particularly described hereafter; extending in this quarter from the sea-shore of the northern Concan to a considerable distance eastward, above and beyond the ghauts, as far east and south as the river Tumboodra and Nagpore. These rocks assume all the various forms of basaltic trap, passing from the columnar (of which some fine specimens are to be seen opposite to Bassein, near Bombay) into the globular, tabular, porphyritic, and amygdaloidal; the two latter containing an unusual abundance and interesting variety of included minerals peculiar to such rocks. The landscape here exhibits all the characteristic features of basaltic countries; the hills rising abruptly in perpendicular masses of a tabular form, or in mural terraces piled on each other, and frequently separated by immense ravines; the whole clothed with luxuriant forests of teak and other trees, producing some of the most beautiful and romantic scenery of India. The elevation of this part of the range seldom exceeds 3000 feet; but advancing to the south, its height gradually increases, and the granite rocks begin to re-appear, continuing to form the summit of the chain with little interruption all the way to Cape Comorin. In nearly the same parallel of latitude, this trap formation is observed to terminate also on the sea-coast, a little to the north of Fort Victoria, or Bancoote, where it is succeeded by the iron-clay, or laterite (a contemporaneous rock associating with trap,) which from thence extends as the overlying rock, with little interruption, to the extremity of the Peninsula, covering the base of the mountains, and the whole of the narrow belt of low-land that separates them from the sea, exhibiting a succession of low rounded hills and undulations, and reposing on the primitive rocks, which occasionally protrude above the surface, as at Malwar, Melundy, Calicut, and some other points, where granite, for a short space, becomes the surface rock. From the main-land the laterite passes over into Ceylon, where it re-appears under the name of *kubook*, and forms a similar deposit of some extent on the shore of that island. Passing onward from the western or Malabar coast, round the extremity of the Peninsula, we leave this extensive iron-clay formation behind, and crossing the granitic plains of Travancore, which are strewed with enormous blocks of primitive rocks, we arrive at the termination of the chain. Here the mountain ranges, which support the central table-land, meet from both sides of the Peninsula, and converge to a point, within about thirty miles of Cape Comorin, ending abruptly in a bluff granite peak of about 2000 feet high, from the base of which a low range of similar rocks, forming a natural barrier to the kingdom of Travancore, extends southward to the sea. The whole of this western mountain range, and the narrow coast which lines its base, is remarkable for the absence of rivers, and vallies of denudation, and consequently of alluvial plains or deposits. The abrupt precipitous sides of the mountains, rising almost perpendicularly from the sea, are nevertheless covered, in general, by forests of the tallest trees and impenetrable jungles, which admit of gaining but a vague and scanty knowledge of the mineral treasures with which they probably abound, if we might be allowed to draw inferences from the striking analogy in geological feature and outline between the mountain ranges and western coast of the South American continent and that just described, in some parts of which traces of copper, gold, silver, and other ores have been found.

Proceeding on to the eastern side of the Peninsula, and northward along the foot of the mountains, we observe a country differing very considerably from the Malabar coast in appearance and geological character. The plains of the Coromandel coast form rather a broad though unequal belt of low land between the mountains and the sea, exhibiting the alluvial deposits of nearly all the rivers and streams that descend from the southern portion of the table-land. The mountain chain that forms the eastern boundary of the Peninsula, after a short northerly course from Cape Comorin, begins to diverge to the east, near where the great valley of Coimbitoor (already mentioned) interrupts its continuity. From thence it breaks into a succession of parallel ranges, inferior in elevation and in unbroken continuity, to the western chain, and in the further progress northward after breaking off into subordinate hilly ranges, occupying a wide tract of unexplored country, and affording vallies for the passage of the great rivers that drain nearly all the waters of the Peninsula into the bay of Bengal. This eastern range may be said to terminate at the same latitude as that of the commencement of the western. Granite rocks, and principally sienite, seem to form the basis of the whole of these eastern ranges, appearing at most of the accessible summits from Cape Comorin to Hydrabad. Gneiss and mica-slate, that form the sides and base of the mountains, are sometimes seen, as also clay-slate, hornblende, slate, flinty-slate, chlorite, and mica-slate, and primitive or crystalline limestones, affording, in some places, marbles of various colours, as in the district of Tennivelly, where also granite appears rising above the surface, in remarkably globular concretions, and in perfectly stratified masses, forming low detached hills near Palemcotta, the strata of which dip at an angle of about 45° to the south-west. Partial deposits too of overlying rocks exist in this district, and of the black cotton soil, which is supposed to be produced by the *debris* of trap. In the neighbourhood of Pondicherry there are beds of compact shelly limestone, and some remarkable siliceous petrefactions, chiefly of the tamarind tree, which have never yet been well described. The beds of the Cavery, or rather the alluvial deposits in the vicinity of Trichinopoly, produce a variety of gems, corresponding to those of Ceylon. In general, however, the surface of the level country, as far north as the Pennar river, seems to consist of the *debris* of granite rocks, and plains of marine sand, probably left by the retreat of the sea; with occasional fresh water alluvial deposits, and partial beds of iron-clay and detached masses of the overlying class. In approaching the Pennar river, the iron-clay formation expands over a larger surface, and clay, slate, and sandstone begin to appear. On the hills behind Nellore are found specimens of a very rich copper ore, yielding from fifty to sixty per cent. of pure metal, according to Dr Heyne, besides argentiferous galena.

It is to the observations of Drs Heyne and Voysey that we owe all the information we yet possess of the vallies of the Pennar, the Kistna, and the Godavery rivers. This interesting tract of country is not more remarkable, as the ancient source of the most valuable productions of the mineral kingdom, being the repository of the Golconda diamonds, than for the extraordinary geological features which it presents. The Nella Malla range of mountains, in which the diamond breccia is found, is described, by Dr Voysey, as exhibiting a geological structure that cannot easily be explained by either the Huttonian or Wernerian theorists; the different rocks being so mixed together with regard to order of position, each in its turn being uppermost, that it is difficult to give a name to the formation that will apply in all cases. The clay-slate formation is the name he has adopted, under which are included clay-slate, every variety of slaty limestone, sandstone, quartz rock, sandstone breccia, flinty-slate, hornstone slate, and a tufaceous limestone, containing imbedded in it fragments, round and angular, of all these rocks, all passing into each other by such insensible gradations, as well as by abrupt transitions, that they defy arrangement, and render description useless. It is bounded on all sides, however, by granite, which passes under it and forms its basis; some elevated points, such as Naggery Nose, having only their upper third composed of sandstone and quartz, while the basis is of granite.

The rocks above enumerated, with the addition of the iron-clay and basaltic rocks, occupy extensive portions of the valleys of the Kistna and Godavery, covered in some places by the black trap soil. The granite rocks, on which they rest, are often penetrated and apparently heaved up by injected veins or masses of trap and dikes of green-stone. Mr Calder hopes soon to be enabled to lay before the Society a detailed description of the curious formations, accompanied by sections of the strata, between Madras and Hydrabad. The waters of the Kistna and Godavery expand as they approach the sea, dividing into numerous branches, and depositing their alluvial contents during inundations over a considerable extent of land bordering the coast. The largest portion of deposits consists of decayed vegetable matter, yielded by the extensive forests through which they flow; and here may be noticed the characteristic difference that marks the alluvial deposits of the principal river of the south—the Cauvery. This river, flowing in a long course through the Mysore country, over an extensive and generally barren surface of granitic and sienitic rocks, with scarcely any woods or jungle on its banks, brings down little or none of decayed vegetable alluvium; but a rich yellow clay, produced by the felspar, which predominates in the granites of Mysore and the south, and which, mixed with carbonate of lime, renders the plains of Tanjore by far the most fertile portion of the south of India. Passing on to Vizagapatam and Ganjam, the granite rocks appear occasionally covered by laterite. The granite of Vizagapatam assumes a new and singular appearance, being small-grained and intimately intermixed with amorphous or uncrystallized garnets, in round grains or specks. This peculiar rock passes into the province of Cuttack. The only information we possess regarding that interesting district is derived from Mr Stirling's valuable paper in the last volume of the Asiatic Society's *Researches*. The rocks of the granite class form the basis and predominant elevations of this district; they are remarkable for their resemblance to sandstone, and abounding in imperfectly formed garnets, disseminated throughout with veins of steatite. Here too traces of coal have recently been discovered, which is likely to be productive, and gold is frequently found in the sands of the Mahanuddee, probably from the valley of Sumbulpore. We next trace the laterite, increasing in extent all the way to Midnapore, and thence continuing northwards by Bissunpore and Bancorah to Beerboom.

16. *Organic Remains at Clash-bennie Quarry in Forfarshire.*—Specimens of these interesting products of former ages have lately been found in Clash-bennie quarry, which is situated on the south-west boundary of the parish of Errol, and on the left bank of the Tay. These specimens have at first sight very much the appearance of shells, but on closer inspec-

tion, they resemble more nearly the scales of a fish. They vary considerably in size, from being an inch to two inches in length, from a half to an inch and a half in breadth, and from a tenth to an eighth of an inch nearly in thickness. Their structure is entire. In some of them the portion of the scale which enters the cuticle, and which resembles so much that of the human nail, is perfect, preserving all its original smoothness; in others, the different plates of which the scales are composed can be distinctly traced; and in some specimens, where a number of the scales are conjoined, they are imbricated as when in the living animal, like the slate of the house. No entire skeleton has yet been found, although there is one specimen which bears a very strong resemblance to the shoulder of a fish, and another of very small dimensions, can, with a little help from the imagination, be made out as an impression of the whole animal. This quarry has now been opened for several years past; and it is to be lamented that no amateur of the science should have been made acquainted with the fact of the imbedded relics, until within these few weeks, as, from their great abundance (being disseminated through the whole rock) many of the finest specimens must have been destroyed or fallen into the hands of individuals incapable of estimating their value. What particularly enhances the value of this discovery is, that the rock in which it has been made is the *old red sandstone*, which belongs to that series and geological epoch in which so few organic remains have hitherto been found, and from which we first date the existence of the vertebral animals. The prodigious antiquity of this rock, and of course of the animals which lie entombed in it, may be estimated from the fact, that the old red sandstone invariably dips beneath the masses of trap which constitute the hills around us, and forms the basis on which rests the coal and limestone of all the Scottish districts.

17. *Fossil Turtle.*—Another of those interesting productions of nature, the fossil organic remains of a sea turtle, has been discovered, and is now in possession of Mr Deck of Cambridge. It is imbedded in a mass of septaria, weighing upwards of 150 pounds, with two fine specimens of fossil wood, and exhibits in a most perfect state this singular animal of a former world, once undoubtedly an inhabitant of our shores. It was obtained in dredging for cement-stone, about five miles from Harwich, in three fathoms water, and, as a mass of stone, been used for some time as a stepping-block, from which humble station it was accidentally rescued by its possessor for the admiration of the virtuosi.

BOTANY.

18. *Account of the Sensitive Properties of the Stylidium graminifolia.*—This species, in common with several others, possesses a singular irritability of the column, which, in its natural state, is bent over the reflexed lip of the corolla, between the two upright appendices, so as to bring the anthers and stigma nearly in contact with the germen. When slightly touched near the base, the column suddenly springs up, carrying the anthers and stigma with a sudden jerk over to the opposite side of the flower. When left quiet, after a short time, it gradually resumes its former position, but is

ready to spring again when exposed to any sudden irritation; though when irritated too frequently the force of each successive spring becomes diminished. The use of this curious mechanism does not appear to be very evident. It is supposed to be intended as a means of assisting the plant in dispersing its pollen, the better to insure a fertilization of the ovary, which, notwithstanding a close approximation of anthers and stigma, is perhaps impossible to be effected by its own individual anthers, from the stigma not becoming exposed till after the bursting of the latter.—*N. S. Wales Paper.*

19. *Singular phenomenon in the Sensitive Plant.*—Mr Burnet and Mr Mayo have found that at the moment the expansion at the foot of the leaflets or other parts of the sensitive plant was touched, so as to occasion the motion of the plant, *it changed colour.* They also found that when a sensitive plant had been made to droop, the part in which the moving power resides is blackened, so as to absorb the light of the sun, the restoration of the plant to its natural state is much longer in taking place.

### III. GENERAL SCIENCE.

20. *Notice of the Saline Lake of Loonar in Berar.*—This curious lake is contained in a sort of cauldron of rocks amidst a pleasing landscape, and is of course the object of superstition. The taste of the water is uncommonly brackish. Mr Alexander, who describes it, found by a rough analysis that 100 parts contains

| | |
|---|---|
| Muriate of soda, | 20 parts |
| Muriate of lime, | 10 |
| Muriate of magnesia, | 6 |

The principal purpose to which the sediment of the water is applied is cleansing the shawls of Cashmere. It is also used as an ingredient in the alkaline cake of the Mussulmans.—*Trans. Lit. Soc. Madras,* Part i.

21. *Inflammable Gas after boring for Salt.*—While boring for salt at Rocky Hill in Ohio, about one mile and a-half from Lake Erie, the auger fell when it reached the depth of 197 feet, and salt water spouted out for several hours When the water was discharged, great volumes of inflammable air continued for a long time to issue from the aperture, and formed a cloud; and in consequence of its having been set on fire by the fires in the workshops, it consumed and destroyed every thing in the neighbourhood.—*Trans. Phil. Soc. New York.*

22. *Bequest to Science by Dr Wollaston and Mr Davies Gilbert.*—In order to promote the interests of the Royal Society by providing a fund which may render it less necessary to elect members more for the sake of the revenue they furnish than of their scientific attainments, Dr Wollaston has bequeathed L. 2000 to the Society, and its eminent President, Mr Davies Gilbert, has added L. 1000 for the same purpose.

23. *Adjudication of a Royal Medal to Dr Wollaston.*—On the 1st December the Royal Society adjudged one of the Royal Medals to Dr Wollas-

ton for his paper on the Processes and Manipulations by which he prepared platinum and the other metals which accompany it.

24. *Adjudication of a Royal Medal to M. Encké.*—The Royal Society has adjudged the other Royal Medal to M. Encke for his determination of the orbit of the interesting periodical comet which bears his name.

25. *Obituary of Members of the Royal Society of London.* The loss which the Royal Society of London has sustained since last year is unusually severe. The following is a list of the Members which it has lost:

| | |
|---|---|
| Professor Dugald Stewart, | Mr Mills, |
| Sir James Edward Smith, | Dr J. Mervin North, |
| Archdeacon Coxe, | Mr Planta, |
| Mr William Phillips, | Dr George Pearson, |
| Major Denham, | Professor Woodhouse, |
| Reverend Professor Nicoll, | M. Thunberg. |

26. *Two Royal Medals established for the Society of Antiquaries.*—At the second meeting of the Society on the 27th November, Mr Hallam announced that his Majesty had signified to the President and Council his intention of conferring two Gold Medals annually, of the value of Fifty Guineas each, for the two best papers on Antiquity which may be presented to the Society.

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## Art. XXXI.—LIST OF PATENTS GRANTED IN SCOTLAND SINCE SEPTEMBER 9, 1828.

24. September 9. For a New mode of communicating Heat to various Purposes. To Joshua Taylor Beale, county of Middlesex.

25. September 22. For a New and Improved Method of applying Iron in the Sheathing of Ships and other Vessels, and of applying Iron Bolts, Spikes, Nails, Pintals, Braces, and other fastenings used in the construction of Ships and other Vessels. To Granville Sharp Pattison, county of Middlesex.

26. October 1. For the Improved application of Air to produce Heat in Fires, Forges, and Furnaces, where Bellows or other Blowing Apparatus are required. To James Beaumont Neilson, county of Lanark.

27. October 6. For a New Method of propelling Vessels, which Method is also applicable to other Purposes. To Andrew Motz Skene, Esq. county of Middlesex.

28. October 6. For an Improved Cartridge for Sporting Purposes. To Edward Forbes Orson, county of Middlesex.

29. October 6. For certain Improvements in Machinery for Hackling, Dressing, or Combing Flax, Hemp, Tow, and other Fibrous Materials. To Peter Taylor, county of Lancaster.

30. October 9. For an Improvement in the Waterproof Stiffening for Hats. To JOSEPH BLADES, county of Surrey.

31. November 29. For a Method of, and an Apparatus for, generating Steam and various Gasses to produce Motive Power, and for other Useful Purposes. To SAMUEL HALL, county of Nottingham.

32. December 6. For certain Improvements in the Method of manufacturing and cutting Paper by means of Machinery. To JOHN DICKINSON, county of Hertford.

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## ART. XXXII.—CELESTIAL PHENOMENA,

*From January 1st, to April 1st, 1829. Adapted to the Meridian of Greenwich, Apparent Time, excepting the Eclipses of Jupiter's Satellites which are given in Mean Time.*

N. B.—The day begins at noon, and the conjunctions of the Moon and Stars are given in Right Ascension.

### JANUARY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 8 | | | ☿ ☌ λ ♐ |
| 1 | 12 | 12 | 20 | ☽ ☌ γ ♎ ☽ 61′ N. |
| 1 | 20 | 3 | 25 | ☽ ☌ θ ♎ ☽ 70′ S. |
| 5 | 3 | 52 | | ● New Moon. |
| 6 | 6 | 19 | 34 | ☽ ☌ β ♑ ☽ 6′ N. |
| 8 | 5 | 28 | 9 | ☽ ☌ θ ♒ ☽ 34′ N. |
| 9 | 18 | 13 | 45 | Im. II. Sat. ♃ |
| 10 | 8 | | | ♀ ☌ ε Ophiuchi. |
| 11 | 11 | 16 | 23 | ☽ ☌ δ ♓ ☽ 21′ S. |
| 11 | 19 | 18 | | ☽ First Quarter. |
| 12 | 1 | 38 | 55 | ☽ ☌ ε ♓ ☽ 25′ N. |
| 13 | 17 | 15 | | ☿ Sup. ☌ ☉ |
| 15 | 1 | 1 | 34 | ☽ ☌ 1 δ ♉ ☽ 3′ S. |
| 15 | 1 | 33 | 18 | ☽ ☌ 2 δ ♉ ☽ 4′ S. |
| 19 | 12 | 17 | | ○ Full Moon. |
| 19 | 17 | 37 | 8 | Em. III. Sat. ♃ |
| 19 | 17 | 44 | | ☉ enters ♒ |
| 20 | 10 | 49 | 6 | ☽ ☌ 2 α ♋ ☽ 49′ N. |
| 20 | 14 | 45 | | ♄ ☍ ☉ |
| 21 | 18 | 33 | 11 | ☽ ☌ π ♌ ☽ 30′ N. |
| 22 | 1 | 15 | | ♅ ☌ ☉ |
| 27 | 17 | 21 | | ☾ Last Quarter. |
| 27 | 18 | | | ♀ ☌ 1 ν ♐ |
| 28 | 17 | | | ☿ ☌ γ ♑ |
| 28 | 18 | 12 | 2 | Im. I. Sat. ♃ |
| 28 | 21 | 12 | 7 | ☽ ☌ γ ♎ ☽ 55′ S. |
| 29 | 5 | 18 | 31 | ☽ ☌ θ ♎ ☽ 19′ N. |
| 29 | 18 | | | ☿ ☌ δ ♑ |
| 29 | 21 | 31 | 13 | ☽ ☌ φ Oph. ☽ 57′ S. |
| 30 | 15 | | | ♀ ☌ π ♐ |

### FEBRUARY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 10 | | | ♂ ☌ ε ♓ |
| 2 | 17 | 21 | 36 | ☽ ☌ β ♑ ☽ 6′ N. |
| 3 | 14 | 31 | | ● New Moon. |
| 4 | 15 | 32 | 40 | ☽ ☌ θ ♒ ☽ 27′ N. |
| 5 | 10 | | | ♂ ☌ ξ ♓ |
| 7 | 18 | 33 | 3 | ☽ ☌ ξ ♓ ☽ 36′ S. |
| 7 | 21 | | | ☽ ☌ ♂ |
| 8 | 8 | 27 | 37 | ☽ ☌ ο ♓ ☽ 9′ N. |
| 10 | 4 | | | ☿ ☌ λ ♒ |
| 10 | 7 | 23 | | ☽ First Quarter. |
| 10 | 17 | 46 | 41 | Im. II. Sat ♃ |
| 11 | 6 | 33 | 1 | ☽ ☌ 1 δ ♉ ☽ 9′ S. |
| 11 | 7 | 4 | 35 | ☽ ☌ 2 δ ♉ ☽ 65′ N. |
| 11 | 12 | 26 | 51 | ☽ ☌ α ♉ ☽ 70′ N. |
| 12 | | | | ☿ Greatest Elong. |
| 13 | 16 | 27 | 15 | Im. I. Sat. ♃ |
| 15 | 18 | | | ♀ ☌ ♅ |
| 16 | 15 | 42 | 49 | ☽ ☌ 1 α ♋ ☽ 70′ N. |
| 16 | 16 | 39 | 48 | ☽ ☌ 2 α ♋ ☽ 47′ N. |
| 17 | 10 | 4 | 49 | ☽ ☌ ξ ♌ ☽ 45′ S. |
| 17 | 14 | 51 | 28 | ☽ ☌ ο ♌ ☽ 2′ N. |
| 18 | 0 | 46 | 7 | ☽ ☌ π ♌ ☽ 32′ N. |
| 18 | 7 | 15 | | ○ Full Moon. |
| 18 | 8 | 24 | | ☉ enters ♓ |
| 19 | | | | ☿ Stationary. |
| 19 | 23 | 7 | 5 | ☽ ☌ τ ♌ ☽ 70′ S. |
| 21 | 23 | | | ☿ ☌ θ ♑ |
| 22 | 4 | 53 | 35 | ☽ ☌ θ ♍ ☽ 64′ S. |
| 23 | 12 | 46 | 53 | ☽ ☌ κ ♍ ☽ 48′ S. |
| 25 | 4 | 18 | 26 | ☽ ☌ γ ♎ ☽ 43′ S. |
| 25 | 12 | 38 | 31 | ☽ ☌ θ ♎ ☽ 31′ N. |
| 26 | 5 | 21 | 50 | ☽ ☌ φ Oph. ☽ 46′ S. |
| 26 | 8 | 20 | | ☾ Last Quarter. |
| 28 | 3 | 15 | | ☿ ☌ ☉ |

### MARCH.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 2 | 4 | 18 | 10 | ☽ ☌ β ♑ ☽ 11′ N. |
| 3 | 15 | 7 | 59 | Im. } III. Sat. ♃ |
| 3 | 17 | 25 | 55 | Em. } III. Sat. ♃ |
| 4 | 3 | 0 | 48 | ☽ ☌ θ ♒ ☽ 27′ N. |
| 4 | 9 | 30 | | ♃ □ ☉ |

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 4 | 10 | | | ☽ ☌ ☿ |
| 5 | 0 | 36 | | ● Full Moon. |
| 7 | 4 | 35 | 15 | ☽ ☌ ζ ♓ ☽ 43′ S. |
| 7 | 17 | 8 | 56 | Em. II. Sat. ♃ |
| 7 | 18 | 2 | 7 | ☽ ☌ ε ♓ ☽ 1′ N. |
| 8 | 16 | 35 | 48 | Im. I. Sat. ♃ |
| 10 | 13 | 52 | 25 | ☽ ☌ 1 ϑ ♉ ☽ 26′ S. |
| 10 | 14 | 23 | 10 | ☽ ☌ 2 ϑ ♉ ☽ 18′ S. |
| 10 | 19 | 37 | 26 | ☽ ☌ Ald. ☽ 55′ N. |
| 11 | 21 | 49 | | ☽ First Quarter. |
| 13 | | | | ☿ Stationary. |
| 14 | 17 | 16 | 39 | Im. II. Sat. ♃ |
| 15 | 21 | 57 | 30 | ☽ ☌ 1 α ♋ ☽ 65′ N. |
| 15 | 22 | | | ♀ ☌ λ ♒ |
| 15 | 23 | 14 | 42 | ☽ ☌ 2 α ♋ ☽ 43′ N. |
| 16 | 16 | 22 | 49 | ☽ ☌ ξ ♌ ☽ 48′ S. |
| 16 | 21 | 10 | 5 | ☽ ☌ ο ♌ ☽ 1′ S. |
| 17 | 7 | 6 | 0 | ☽ ☌ π ♌ ☽ 30′ N. |
| 19 | 5 | 24 | 58 | ☽ ☌ ρ ♌ ☽ 70′ S. |
| 20 | 1 | 51 | | ○ Full Moon. |

20 Moon Eclipsed, invisible at Greenwich.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 20 | 0 | 49 | | Begins. |
| | 1 | 51 | | Ecliptic ☍ |
| | 2 | 0 | 15 | Middle. |
| | 3 | 11 | 30 | End. |
| | | 40 | 29 | Digits Eclipsed on the ☽'s N. limb. |
| 20 | 8 | 37 | | ☉ enters ♈ |
| 20 | 16 | | | ♀ ☌ φ ♒ |
| 21 | 10 | 52 | 49 | ☽ ☌ θ ♍ ☽ 61′ S. |
| 22 | 18 | 35 | 16 | ☽ ☌ κ ♍ ☽ 45′ S. |
| 24 | 10 | 7 | 39 | ☽ ☌ γ ♎ ☽ 39′ S. |
| 24 | 14 | 51 | 9 | ☽ ☌ θ ♎ ☽ |
| 24 | 18 | 31 | 11 | Im. I. Sat. ♃ |
| 25 | 11 | 25 | 43 | ☽ ☌ φ Oph. ☽ 35′ N. |
| 26 | 22 | | | ☿ ☌ λ ♒ |
| 27 | 19 | 19 | | ☾ Last Quarter. |
| 27 | | | | ☿ Greatest Elong. |
| 28 | | | | ♄ Stationary. |
| 29 | 13 | 5 | 47 | ☽ ☌ β ♑ ☽ 14′ N. |
| 31 | | | | ♃ Stationary. |
| 31 | 13 | 22 | 33 | ☽ ☌ θ ♒ ☽ 28′ N. |
| 31 | 16 | 44 | 43 | Im. I. Sat. ♃ |

*Times of the Planets passing the Meridian.*

JANUARY.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | h. | ′ | h | ′ | h | ′ | h | ′ | h | ′ | h | ′ |
| 1 | 23 | 30 | 21 | 35 | 4 | 46 | 21 | 21 | 13 | 29 | 1 | 26 |
| 7 | 23 | 46 | 21 | 40 | 4 | 35 | 21 | 0 | 13 | 1 | 1 | 13 |
| 13 | 0 | 2 | 21 | 45 | 4 | 24 | 20 | 39 | 12 | 33 | 0 | 41 |
| 19 | 0 | 17 | 21 | 52 | 4 | 14 | 20 | 18 | 12 | 5 | 0 | 9 |
| 25 | 0 | 34 | 21 | 59 | 4 | 4 | 19 | 57 | 11 | 38 | 23 | 57 |

FEBRUARY.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 53 | 22 | 8 | 3 | 54 | 19 | 33 | 11 | 7 | 23 | 18 |
| 7 | 1 | 5 | 22 | 16 | 3 | 45 | 19 | 12 | 10 | 41 | 22 | 56 |
| 13 | 1 | 7 | 22 | 24 | 3 | 37 | 18 | 52 | 10 | 16 | 22 | 34 |
| 19 | 0 | 52 | 22 | 32 | 3 | 29 | 18 | 32 | 9 | 51 | 22 | 11 |
| 25 | 0 | 17 | 22 | 39 | 3 | 22 | 18 | 12 | 9 | 27 | 21 | 50 |

MARCH.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 | 41 | 22 | 44 | 3 | 18 | 17 | 59 | 9 | 11 | 21 | 36 |
| 7 | 23 | 1 | 22 | 51 | 3 | 11 | 17 | 39 | 8 | 48 | 21 | 25 |
| 13 | 22 | 36 | 22 | 57 | 3 | 5 | 17 | 18 | 8 | 25 | 20 | 53 |
| 19 | 22 | 23 | 23 | 4 | 3 | 0 | 16 | 58 | 8 | 2 | 20 | 33 |
| 25 | 22 | 20 | 23 | 9 | 2 | 54 | 16 | 37 | 7 | 40 | 20 | 12 |

*Declination of the Planets.*

JANUARY.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | ° | ′ | ° | ′ | ° | ′ | ° | ′ | ° | ′ | ° | ′ |
| 1 | 24 | 36 S. | 19 | 56 S. | 3 | 23 S. | 20 | 22 S. | 20 | 0N. | 20 | 28S. |
| 7 | 24 | 28 | 21 | 11 | 1 | 34 S. | 20 | 35 | 20 | 7 | 20 | 20 |
| 13 | 23 | 30 | 22 | 6 | 0 | 14N. | 20 | 46 | 20 | 14 | 20 | 19 |
| 19 | 21 | 35 | 22 | 37 | 2 | 1 | 20 | 57 | 20 | 21 | 20 | 14 |
| 25 | 18 | 44 | 22 | 43 | 3 | 47 | 21 | 6 | 20 | 28 | 20 | 10 |

FEBRUARY.

| D. | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ |
|---|---|---|---|---|---|---|
| 1 | 14 18 S. | 22 20 S. | 5 48 N. | 21 16 S. | 20 36 N. | 20 4 S. |
| 7 | 9 54 | 21 34 | 7 30 | 21 24 | 20 43 | 19 58 |
| 13 | 5 47 | 20 25 | 9 9 | 21 30 | 20 49 | 19 52 |
| 19 | 3 19 | 18 59 | 10 46 | 21 36 | 20 54 | 19 46 |
| 25 | 3 23 | 17 4 | 12 18 | 21 40 | 20 59 | 19 41 |

MARCH.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 4 50 S. | 15 34 S. | 13 18 N. | 21 43 S. | 21 2 N. | 19 43 S. |
| 7 | 7 40 | 13 21 | 14 44 | 21 46 | 21 5 | 19 38 |
| 13 | 9 46 | 10 50 | 16 6 | 21 48 | 21 8 | 19 33 |
| 19 | 10 32 | 8 9 | 17 22 | 21 50 | 21 10 | 19 28 |
| 25 | 10 2 | 5 19 | 18 33 | 21 51 | 21 11 | 19 24 |

The preceding numbers will enable any person to find the positions of the planets, to lay them down upon a celestial globe, and to determine their times of rising and setting.

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ART. XXXIII.—*Summary of Meteorological Observations made at Kendal in September, October, and November* 1828. By Mr SAMUEL MARSHALL. Communicated by the Author.

*State of the Barometer, Thermometer, &c. in Kendal for September* 1828

| Barometer. | Inches. |
|---|---|
| Maximum on the 16th, - - - | 30.40 |
| Minimum on the 12th, - - - - | 29.15 |
| Mean height, - - - - | 29.78 |
| Thermometer. | |
| Maximum on the 9th, - - - | 73° |
| Minimum on the 16th, - - - - | 33.5° |
| Mean height, - - - - - | 55.05° |

Quantity of rain, 4.497 inches.
Number of rainy days, 13.
Prevalent wind, west.

For the first week in this month, the weather was as fine as that which we had at the latter part of last month, affording abundant opportunity to conclude the labours of the harvest in this district. We then had a succession of wet days till the 14th, and again a portion of remarkably fine, clear weather to the 23d, since which time we had heavy rain very frequently. The temperature has been very variable. On the 8th the thermometer stood at 73°, whilst on the 13th it did not attain a higher altitude than 51° during the day. On the 24th we had sudden, violent squalls of wind, such as are usually prevalent, about the time of the equinoxes, and which have occurred almost daily since that period. The changes from a clear to a cloudy sky have been very sudden in that period, the sky being remarkably clear at times, and in a few minutes, completely overcast, and attended with sudden squalls and heavy rain.

*October.*

| Barometer. | Inches. |
|---|---|
| Maximum on the 29th, | 30.40 |
| Minimum on the 6th, | 28.95 |
| Mean height, | 29.86 |
| **Thermometer.** | |
| Maximum on the 14th, | 60.5° |
| Minimum on the 29th, | 28.5° |
| Mean height, | 47.86° |

Quantity of rain, 4.916 inches.
Number of rainy days, 13.
Prevalent wind, west.

During the first week of October we had very heavy rain and high winds, since which time there has generally been remarkably fine weather. Almost all the rain measured this month fell during the first eight days. The barometer is seldom so high at this season as it has been during this month. For fifteen days it was above 30 inches, which occasions the mean to exceed what is usual. The weather has been generally very open, and we have had but three nights of frost. No Aurora Borealis has been noticed, but some thunder and lightning occasionally at the beginning of the month. The autumnal tints did not appear much till the latter part.

*November.*

| Barometer. | Inches. |
|---|---|
| Maximum on the 3d, | 30.18 |
| Minimum on the 16th | 29.09 |
| Mean height, | 29.65 |
| **Thermometer.** | |
| Maximum on the 29th, | 54.5° |
| Minimum on the 12th, | 26° |
| Mean height, | 44.64° |

Quantity of rain, 4.786 inches
Number of rainy days, 17.
Prevalent wind, west.

This month has, towards the latter part especially, fully redeemed its ancient character of gloominess. In the early part there were several clear and fine days. The mountains in the neighbourhood, even those of the lowest elevation, were seen on the 10th, for the first time this season, clothed in their winter garb of snow. On the evening of the 19th about ¼ past 6 o'clock, a portion of a lunar rainbow was seen, though nearly colourless. No Aurora Borealis has been observed during the month. Though the weather has been dull, and from the 12th to the end of the month, there was frequent rain, the barometer has mostly been high. Before the 12th but .087 inch fell. The mean temperature of this month is rarely so high as 44.64,° and there have been but two frosty nights. The quantity of rain, calculating to the end of November, falls short of the annual average (51.8 inches) by more than six inches.

## ART. XXXIV.—REGISTER OF THE BAROMETER, THERMOMETER, AND RAIN-GAGE, *kept at Canaan Cottage.* By ALEX. ADIE, Esq. F.R.S. Edin.

THE Observations contained in the following Register were made at Canaan Cottage, the residence of Mr Adie, by means of very nice instruments, constructed by himself. Canaan Cottage is situated about 1½ mile to the south of Edinburgh Castle, about 3 miles from the sea at Leith, and about ¼ of a mile N. of the west end of Blackford Hill. The ridge of Braid Hills is about 1 mile to the south, and the Pentland Hills about 4 miles to the west of south. The height of the instruments is 300 feet above high water-mark at Leith. The morning and evening observations were made about 10 A.M. and 10 P.M.

### SEPTEMBER 1828.

| D. of Week. | Day of Month. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| M. | 1 | 57 | 48 | 52.5 | 51 | 61 | 56 | 29.98 | 23.01 | |
| T. | 2 | 62 | 55 | 58.5 | 41 | 67 | 54 | 29.94 | 29.99 | |
| W | 3 | 56 | 53 | 54.5 | 53 | 58 | 55.5 | 30.02 | 29.99 | |
| T. | 4 | 60 | 54 | 57 | 50 | 63 | 56.5 | 29.93 | 29.87 | |
| F. | 5 | 59 | 49 | 54 | 49 | 59 | 54 | 29.86 | 29.85 | |
| S. | 6 | 57 | 54 | 55.5 | 40 | 63 | 51.5 | 29.86 | 29.87 | |
| S. | 7 | 56 | 57 | 56.5 | 47 | 59 | 53 | 29.85 | 29.83 | |
| M. | 8 | 64 | 63 | 63.5 | 55 | 71 | 63 | 29.70 | 29.55 | .08 |
| T. | 9 | 58 | 58 | 58 | 53 | 64 | 58.5 | 29.55 | 29.55 | .68 |
| W. | 10 | 65 | 59 | 62 | 51 | 70 | 60.5 | 29.55 | 29.31 | |
| T. | 11 | 57 | 55 | 56 | 53 | 64 | 58.5 | 29.21 | 29.14 | .24 |
| F. | 12 | 59 | 49 | 54 | 48 | 58 | 53 | 29.06 | 29.27 | .61 |
| S. | 13 | 54 | 40 | 47 | 45 | 55 | 50 | 29.57 | 29.82 | .16 |
| S. | 14 | 52 | 43 | 47.5 | 33 | 55 | 44 | 30.00 | 30.16 | |
| M. | 15 | 56 | 44 | 50 | 35 | 57 | 46 | 30.26 | 30.33 | |
| T. | 16 | 56 | 48 | 52 | 36 | 60 | 48 | 30.36 | 30.26 | |
| W. | 17 | 54 | 51 | 52.5 | 39 | 59 | 49 | 30.15 | 30.02 | |
| T. | 18 | 57 | 52 | 54.5 | 41 | 62 | 51.5 | 29.94 | 29.85 | |
| F. | 19 | 57 | 50 | 53.5 | 42 | 61 | 51.5 | 29.93 | 29.97 | |
| S. | 20 | 61 | 54 | 57.5 | 44 | 61 | 52.5 | 29.98 | 29.95 | |
| S. | 21 | 58 | 53 | 55.5 | 51 | 61 | 56 | 29.87 | 29.78 | |
| M. | 22 | 55 | 55 | 55 | 50 | 57 | 53.5 | 29.76 | 29.82 | |
| T. | 23 | 62 | 60 | 61 | 51 | 62 | 56.5 | 29.85 | 29.65 | |
| W. | 24 | 65 | 62 | 63.5 | 58 | 66 | 62 | 29.53 | 29.43 | |
| T. | 25 | 70 | 60 | 65 | 58 | 71 | 64.5 | 29.37 | 29.39 | |
| F. | 26 | 64 | 55 | 59.5 | 55 | 67 | 61 | 29.46 | 29.58 | |
| S. | 27 | 56 | 54 | 55 | 45 | 63 | 54 | 29.60 | 29.42 | |
| S. | 28 | 60 | 54 | 57 | 48 | 65 | 56.5 | 29.33 | 29.05 | .39 |
| M. | 29 | 58 | 50 | 54 | 49 | 60 | 54.5 | 28.79 | 29.00 | .05 |
| T. | 30 | 56 | 45 | 50.5 | 44 | 57 | 50.5 | 29.15 | 29.13 | .10 |
| | Sum, | 1761 | 1584 | 1672.5 | 1415 | 1856 | 1635.5 | 891 45 | 889.94 | 2.31 |
| | Mean. | 58.7 | 52.8 | 55.75 | 47.17 | 61.87 | 54.52 | 29.715 | 29.66.5 | |

### OCTOBER 1828.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| W. | 1 | 50 | 46 | 48 | 41 | 56 | 48.5 | 29.12 | 29.31 | .10 |
| T. | 2 | 52 | 45 | 48.5 | 39 | 56 | 47.5 | 29.59 | 29.68 | |
| F. | 3 | 53 | 52 | 52.5 | 37 | 56 | 46.5 | 29.57 | 29.15 | .02 |
| S. | 4 | 53 | 45 | 49 | 47 | 58 | 52.5 | 29.22 | 29.28 | |
| S. | 5 | 56 | 51 | 53.5 | 41 | 59 | 50 | 29.13 | 28.85 | .16 |
| M. | 6 | 55 | 50 | 52.5 | 47 | 59 | 53 | 28.80 | 28.85 | .09 |
| T. | 7 | 55 | 48 | 51.5 | 46 | 57 | 51.5 | 28.88 | 28.90 | .06 |
| W. | 8 | 56 | 47 | 51.5 | 43 | 60 | 51.5 | 29.15 | 29.50 | |
| T. | 9 | 53 | 51 | 52 | 40 | 56 | 48 | 29.68 | 29.70 | |
| F. | 10 | 58 | 50 | 54 | 48 | 59 | 53.5 | 29.59 | 29.62 | .20 |
| S. | 11 | 57 | 56 | 56.5 | 45 | 58 | 51.5 | 29.97 | 29.90 | .05 |
| S. | 12 | 64 | 58 | 61 | 51 | 66 | 58.5 | 29.97 | 30.08 | |
| M. | 13 | 56 | 49 | 52.5 | 54 | 61 | 57.5 | 30.10 | 30.18 | |
| T. | 14 | 55 | 50 | 52.5 | 44 | 60 | 52 | 30.18 | 30.16 | |
| W. | 15 | 55 | 46 | 50.5 | 44 | 58 | 51 | 30·07 | 30.06 | |
| T. | 16 | 53 | 49 | 51 | 42 | 56 | 49 | 30.00 | 29.87 | |
| F. | 17 | 55 | 42 | 48.5 | 47 | 58 | 52.5 | 29.88 | 30.12 | |
| S. | 18 | 42 | 48 | 45 | 29 | 49 | 39 | 30.13 | 29.92 | |
| S. | 19 | 54 | 52 | 53 | 44 | 57 | 50.5 | 29.82 | 29.85 | |
| M. | 20 | 54 | 49 | 51.5 | 47 | 58 | 52.5 | 29.95 | 29.88 | |
| T. | 21 | 53 | 48 | 50.5 | 44 | 57 | 50.5 | 29.78 | 29.58 | |
| W. | 22 | 57 | 47 | 52 | 45 | 59 | 52 | 29.33 | 29.45 | .14 |
| T. | 23 | 48 | 39 | 43.5 | 38 | 53 | 45.5 | 29.56 | 29.71 | |
| F. | 24 | 48 | 46 | 47 | 35 | 52 | 43.5 | 29.78 | 29.82 | .02 |
| S. | 25 | 55 | 46 | 50.5 | 42 | 58 | 50 | 29.92 | 30.03 | |
| S. | 26 | 51 | 44 | 47.5 | 39 | 55 | 47 | 30.03 | 30.04 | |
| M. | 27 | 50 | 40 | 45 | 29 | 54 | 41.5 | 30.15 | 30.27 | |
| T. | 28 | 43 | 40 | 41.5 | 33 | 46 | 39.5 | 30.40 | 30.42 | .02 |
| W | 29 | 37 | 39 | 38 | 29 | 43 | 36 | 30.36 | 30.26 | |
| T. | 30 | 44 | 36 | 40 | 35 | 47 | 41 | 30.22 | 30.11 | |
| F. | 31 | 45 | 46 | 45.5 | 32 | 47 | 39.5 | 30 07 | 29.96 | |
| | | 1617 | 1455 | 1536 | 1277 | 1728 | 1502.5 | 922.40 | 922.51 | .86 |
| | | 52.16 | 46.94 | 49.55 | 41.19 | 55.74 | 48.47 | 29·755 | 29.758 | |

### NOVEMBER 1828.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| S. | 1 | 48 | 48 | 48 | 39 | 53 | 46 | 29.91 | 29.90 | |
| S. | 2 | 51 | 48 | 49.5 | 41 | 55 | 48 | 30.03 | 30.06 | |
| M. | 3 | 53 | 43 | 48 | 43 | 55 | 49 | 30.12 | 30.07 | |
| T. | 4 | 48 | 47 | 47.5 | 37 | 50 | 43.5 | 29.94 | 29.87 | |
| W. | 5 | 47 | 42 | 44.5 | 42 | 50 | 46 | 29.85 | 29.84 | |
| T. | 6 | 46 | 45 | 45.5 | 37 | 49 | 43 | 29.80 | 29.80 | .05 |
| F. | 7 | 48 | 42 | 45 | 40 | 50 | 45 | 29.82 | 29.86 | |
| S. | 8 | 42 | 35 | 38.5 | 37 | 47 | 42 | 29.92 | 29.81 | |
| S. | 9 | 42 | 44 | 43 | 32 | 44 | 38 | 29.72 | 29.48 | .08 |
| M. | 10 | 36 | 34 | 35 | 35 | 44 | 39.5 | 29.42 | 29.25 | .68 |
| T. | 11 | 32 | 34 | 33 | 26 | 38 | 32 | 29.21 | 29.28 | |
| W. | 12 | 37 | 37 | 37 | 30 | 43 | 36.5 | 29.25 | 29.21 | |
| T. | 13 | 45 | 5 | 45 | 36 | 50 | 43 | 29.25 | 29.28 | |
| F. | 14 | 45 | 46 | 45.5 | 41 | 49 | 45 | 29.28 | 29.14 | |
| S. | 15 | 47 | 45 | 46 | 45 | 49 | 47 | 29.11 | 29.11 | .11 |
| S. | 16 | 47 | 43 | 45 | 42 | 47 | 41.5 | 29.11 | 29.27 | .10 |
| M. | 17 | 5 | 42 | 43.5 | 40 | 46 | 43 | 29·44 | 29.59 | .30 |
| T. | 18 | 42 | 42 | 42 | 39 | 44 | 41.5 | 29.70 | 29.59 | .20 |
| W. | 19 | 45 | 50 | 47.5 | 39 | 51 | 45 | 29.73 | 29.47 | |
| T. | 20 | 52 | 54 | 53 | 48 | 54 | 51 | 29.55 | 29.28 | |
| F. | 21 | 56 | 49 | 52.5 | 52 | 57 | 54.5 | 29.24 | 29.18 | |
| S. | 22 | 45 | 43 | 44 | 43 | 49 | 46 | 29.40 | 29.47 | .08 |
| S. | 23 | 47 | 52 | 49.5 | 41 | 52 | 46.5 | 29.30 | 29.10 | |
| M. | 24 | 54 | 50 | 52 | 48 | 55 | 51.5 | 29.10 | 29.24 | .05 |
| T. | 25 | 50 | 50 | 50 | 45 | 50 | 47.5 | 29.45 | 29.23 | |
| W. | 26 | 55 | 48 | 51.5 | 48 | 55 | 51.5 | 29.18 | 29.22 | |
| T. | 27 | 47 | 52 | 49.5 | 42 | 51 | 46.5 | 29.58 | 29.48 | |
| F. | 28 | 53 | 49 | 51 | 48 | 54 | 51 | 29.45 | 29.56 | .19 |
| S. | 29 | 46 | 58 | 42 | 40 | 50 | 45 | 29.69 | 29.95 | ·50 |
| S. | 30 | 38 | 36 | 37 | 37 | 39 | 38 | 29.88 | 29.51 | 1.60 |
| | | 1389 | 1333 | 1361 | 12.15 | 1480 | 1346.5 | 886.41 | 885.08 | 3.94 |
| | | 46.3 | 44·43 | 45.37 | 40.43 | 49.33 | 44.88 | 29.547 | 29.503 | |

THE

EDINBURGH

JOURNAL OF SCIENCE.

ART. I.—*Biographical Sketch of the late* DUGALD STEWART, *Esq. F. R. SS. Lond. and Ed.*

ALTHOUGH Mr Dugald Stewart was not the Author of any express work directly connected with the mathematical or physical sciences, yet he has been pronounced by a competent judge* to have been "a distinguished writer in the higher departments of Mathematics;" and from this cause, as well as from the happy application which he made of his mathematical and physical knowledge to illustrate the philosophy of the human mind, we have considered it not unappropriate, in the pages of a scientific Journal, to record the labours of a man, who, while he was one of the brightest ornaments of his own country, contributed so powerfully to advance the intellectual and moral interests of his species.

Dugald Stewart 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

* Davies Gilbert, Esq. M. P. the distinguished President of the Royal Society of London.

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 the 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 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 superintendence; 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.

This 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 superintendence, 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 been long 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 interests 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 particularly 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 strongly 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 1280, 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 this 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 superintendence of persons capable of studying the developement 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 Encyclopædia 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 in 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 of Naples, of the American Philosophical 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.

Before closing this brief sketch, we cannot withhold from our readers the following admirable observations on the philosophy of Mr Stewart, pronounced at the anniversary meeting of the Royal Society of London on the 1st of October 1828, by their distinguished president, Mr Davies Gilbert.

" And here I would call your attention to the loss sustain-

* 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 this *Journal*, No. xix. p. 153.

ed by the world at large in the person of another philosopher, and fellow of this society, although not a contributor to our annual publications. Mr Dugald Stewart, imbued with a taste for mathematical learning by his father's eminence in that department of knowledge, has done more than almost any of his contemporaries towards preserving from mystery and paradoxes the science which should naturally be of all the most clear and precise. Following the steps of Bacon and of Locke, and stored with an extent of reading and of acquired knowledge almost beyond example, there can be found few subjects which he has not illustrated; and in respect to conclusions which seem to differ from the deductions of his great predecessors, his arguments are so fairly stated on either side, that every intelligent reader is placed in a situation to form his own opinions on those profound and abstruse points. Mr Stewart has somewhere quoted *Μειζον εστι το δυναμιν αναλυτικην κτησασθαι του πολλας αποδειξεις των επι μερους εχειν.* And 'Mathematica multi sciunt, mathesin pauci. Aliud est enim nosci propositiones aliquot, et nonnullos ex iis elicere, casu potiusquam certa aliqua discursendi norma, aliud scientiæ ipsius naturam ac indolem prospectam habere, in ejus se adyta penetrare, et ab universalibus instructum esse præceptis quibus theoremata ac problemata innumera excogitandi, eademque demonstrandi facilitas comparetur. Ut enim pictorum vulgus, prototypon sæpe sæpius experimendo, quendam pingendi usum, nullam vero pictori artis, quam optica suggerit, scientiam adquirit, ita multi, lèctis Euclidis et aliorum geometrarum libris, eorum imitatione, fingere propositiones aliquos ac demonstrare solent, ipsam tamen secretissimam difficiliorum theorematum ac problematum solvendi methodum prorsus ignorent.' By reverting to the long neglected controversies of the Nominalists and Realists, and by adopting the theories of a most acute and subtle reasoner, who for centuries past has been remembered (such is the caprice of some) by a reference only to the frailties and to the misfortunes of his youth, this able metaphysician has either fully explained, or has pointed out the method of explaining, every difficulty which seemed to obstruct the use of imaginary quantities. And by pursuing the same track, if ancient prejudices, derived from far different speculations, could once be banished from our minds, it would soon be found that all circumlocution for avoiding the terms *infinitely small, infinitely great*, and even orders of infinities, might be dismissed from mathematical language, without producing uncertainty, mystery, or confusion. I consider, therefore, Mr Dugald Stewart as a distinguished writer in the higher departments of mathematics, and *eo nomine* entitled to our respect and our regard."

The following general view of Mr Stewart's character is given by one who had every opportunity of knowing it well. *

"In general company, his manner bordered on reserve; but it belonged more to the general weight and authority of his character, than to any reluctance to take his share in the cheerful intercourse of social life. He was ever ready to acknowledge with a smile the happy sallies of wit, and no man had a keener sense of the ludicrous, or laughed more heartily at genuine humour. His deportment and expresion were easy and unembarrassed, dignified, elegant, and graceful. His politeness was equally free from all affectation, and from all premeditation. It was the spontaneous result of the purity of his own taste, and of a heart warm with all the benevolent affections, and was characterized by a truth and readiness of tact that accommodated his conduct with undeviating propriety to the circumstances of the present moment, and to the relative siuation of those to whom he addressed himself. From an early period of life, he had frequented the best society both in France and in this country, and he had in a peculiar degree the air of good company. In the society of ladies he appeared to great advantage, and to women of cultivated understanding, his conversation was particularly acceptable and pleasing. The immense range of his erudition, the attention he had bestowed on almost every branch of philosophy, his extensive acquaintance with every department of elegant literature ancient or modern, and the fund of anecdote and information which he had collected in the course of his intercouse with the world, with respect to almost all the eminent men of the day, either in this country or in France, enabled him to find suitable sub-

* Notice of the late Dugald Stewart, Esq. in the Annual Biography and Obituary for 1828.

jects for the entertainment of the great variety of visitors of all descriptions, who at one period frequented his house. In his domestic circle, his character appeared in its most amiable light, and by his family he was beloved, and venerated almost to adoration. So uniform and sustained was the tone of his manners, and so completely was it the result of the habitual influence of the natural elegance and elevation of his mind on his external demeanour, that when alone with his wife and his children, it hardly differed by a shade from that which he maintained in the company of strangers; for although his fondness, and familiarity, and playfulness were alike engaging and unrestrained, he never lost any thing either of his grace or his dignity: 'Nec vero ille in luce modo, atque in oculis civium magnus, sed intus domique præstantior." As a writer of the English language,—as a public speaker,—as an original, a profound, and a cautious thinker,—as an expounder of truth,—as an instructor of youth,—as an elegant scholar,—as an accomplished gentleman;—in the exemplary discharge of the social duties,—in uncompromising consistency and rectitude of principle,—in unbending independence,—in the warmth and tenderness of his domestic affections,—in sincere and unostentatious piety,—in the purity and innocence of his life,—few have excelled him: and, take him for all in all, it will be difficult to find a man, who, to so many of the perfections, has added so few of the imperfections of human nature."

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## ART. II.—*Notice respecting the existence of Chrysolite in Obsidian, as discovered* by Professor DEL RIO.

SIR,

IN the eighth volume of the *Edinburgh Journal of Science*,* the following article appears under the head of Mineralogy.

Chrysolite in the cavities of obsidian.—Professor Gustavus Rose of Berlin has found in the cavities of obsidian, in the Jacal Rock, near Real del Monte in Mexico, little crystals, greenish and reddish yellow, and transparent, which belong to the species of prismatic chrysolite.—*Poggendorf's Annalen*, vol. x. p. 323.

* No. xv. p. 121.

Fig. 1.

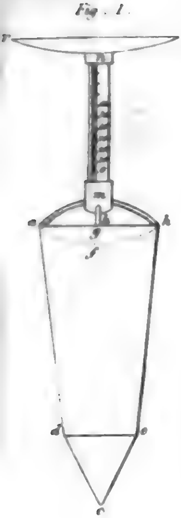



Fig. 2


Fig. 9

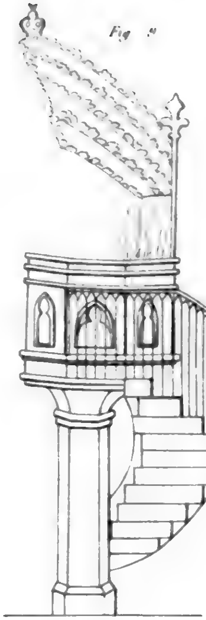


Fig. 3.

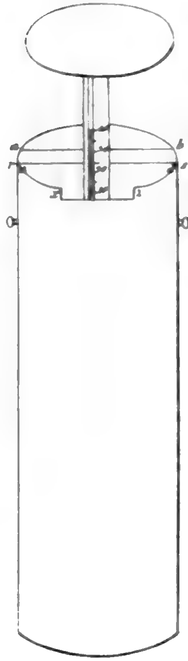



Fig. 5.

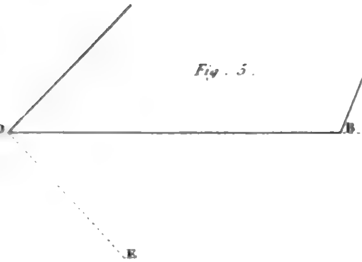



Fig. 4

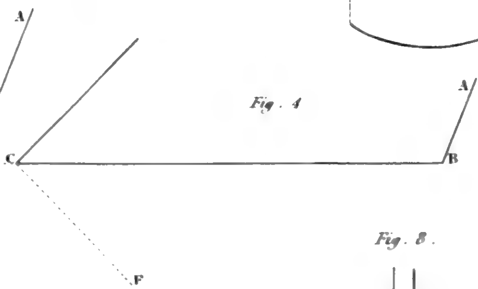



Fig. 8.

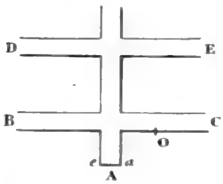



Fig. 7

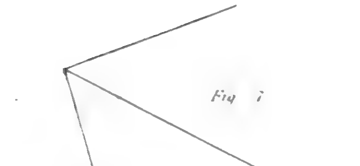


Fig. 6.

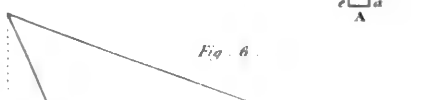


Fig. 10.

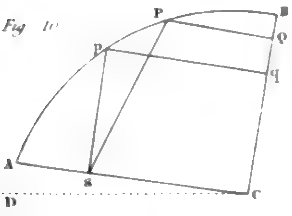
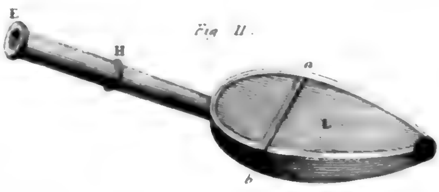



Fig. 11.




Lizars Sculpt.

One of the English pupils of Professor Del Rio presumes to suggest, that it would be but an act of justice to that profound mineralogist and eminent scholar to state, that, as far back as the year 1804, he stated in a note at page 33 of his translation of Karsten's *Mineralogical Tables*, that he had made the same discovery, as will be seen from the following extract:—

Los cristalitos de olivino de Zinapéguaro estan de canto sobre las cras ó quadritos de la substancia blanca nueva que he Uamado *equinolita* contenida an las cavidades de la obsidiana de alli; siendo muy pegueños juzgué al principio por el color que fueran de obsidiana; pero al soplete no se funden, solo toman un viso negro de hierro y con borax se funden eǹ vidrio verde claro. Son de color verde a ceytuna, transparentes, rayados á lo largo, y parecen tablas octagonas prolongadas con todas las aristas laterales truncadas."

The above is from a note to Olivine, extracted from a work replete with profound mineralogical knowledge; but which, from its being published in Mexico and in Spanish, is but little known in Europe.

At the same time that I submit this for your consideration, I beg to inclose the description and drawing of an instrument for weighing specific gravities, invented by Don Jose Maria Bustamente; the ingenuity and simplicity of which will, I have no doubt, induce you to take notice of it in your excellent *Journal.* It appears calculated to supersede altogether the use of Nicolson's balance weight.—I have the honour to be, Sir, your faithful and obedient servant,

X.

MEXICO, 31*st October* 1828.

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ART. III.—*Description and use of a new Gravimeter.* By DON JOSE MARIA BUSTAMENTE.

IT is known, that, to be able to use Nicolson's Balance, a set of small and correct weights is necessary, and that it requires to be sunk in water to a certain depth, that is, to place it in its index three times during the operation. For this it is ne-

• It will give us great pleasure to be favoured with the continuance of the correspondence of X.

cessary to be adding and taking away the weights as may be required, to bring that point exactly level with the surface of the water, which proceeding is tedious. Besides on journeys, where the conveniences one has at home are generally wanting, it is very easy to lose some of such small weights, by which means an instrument so useful to the travelling mineralogist is rendered useless. To avoid these inconveniences, facilitate the transport of the instrument, and simplify the operation, I make use of the instrument which is represented in Fig. 1, 2, and 3 of Plate II., which gives the necessary instructions for ascertaining the specific weight of minerals with great exactness without weights.

2. The part *a b c* of the instrument, which may be of tin, brass, &c. is composed of two inverted cones, hollow and united at *d e*, as Fig. 1 shows, the base of which is a concave plate, *a f b*, which receives the minerals that are weighed in water. Before soldering this plate, the instrument must be ballasted, that is, a portion of lead is put into it so as to sink it in the water till near the base *a b*.*

3. In four points of this base, opposed at right angles, are soldered two arches of wire *a b*, *g h*, which cross, and sustain the hoop *m*, which receives the end of a crystal tube *m n*, made fast with sealing wax. In the interior of the tube is placed a scale of lines, of millimetres or of equal arbitrary parts traced on paper, and the divisions of which are numbered from zero upwards.†

4. Finally, on the other end of the tube is fixed, by means of a hoop and sealing wax, the plate *r s*, which is used for putting the minerals into when they are required to be weighed in air.

5. Figure 2 is a cylindrical box of tin with its cover, of the

* The ballast may be of lead, in flat pieces, or small shot. In the first instance, it is well fitted, and stuck to the sides of the inferior cone; but in the other two it will be necessary to fix it with a cover of tin soldered to the cone, so that they do not shake about, and are always kept at the bottom.

† Instead of a glass tube, one of silver or brass might be used of the corresponding size and weight. On the outside let there be a scale of equal parts; then suppress the hoops; and the arches, as well as the plate, will be better fixed to the tube, and the instrument less exposed to get damaged.

same length as the instrument, and the diameter of which is a little greater. In the interior of the bottom is firmly soldered the conical end *x z*, in which is fitted a part of the cone *d e c*, and, as the diameter of the upper plate ought to be very little less than that of the box, the instrument placed within this cannot be shaken so as to spoil it; and in this manner it can be moved about with much convenience and security. This box is also best for using the instrument, because a sufficient quantity of water being put into it, and the instrument being submerged, the water only reaches the brim without spilling.

6. When the instrument is left to itself in the water, it sinks to very near the base *a b*, as we have said, and it is necessary, in order that the zero of the scale should reach the level of the water, to put some little weights of lead in the upper plate; the weight of which ought to be ascertained, so that it may always sink to that one point; and this new weight we will call additional weight.

7. If when in this state we put on the plate any weight, the greater the weight the deeper it sinks; and there is no doubt that this new weight is equal to that of a cylinder of water equal to the portion of tube that has been sunk, because the space that this occupies in the liquid is equal to that occupied by the cylinder of water which it dislodged, and the force of the liquid to sustain it is also equal to that of the weight of the substance, to be able to keep immersed that portion of the tube. Thus, then, if the instrument sinks one of the divisions of the scale, we can say that the weight with which it is charged is equal to that of a cylindrical portion of water whose base is the section of the tube, and whose height is one division. A greater load will immerge it 20 divisions, and will be equivalent to the weight of 20 portions equal to the preceding. Knowing, then, the number of drachms or grains that each of these portions weighs, we shall be able to ascertain the weight of the substance that we put on the plate.

8. Afterwards we will show how the weight of each portion is known, although there is no necessity for its being known; because the divisions of the scale show us the correspondence of the weights that we put on the plate, in the same manner

as there is no necessity for knowing the weight of the mercury contained in the tube of the barometer for ascertaining and comparing the various pressures of the air. It is sufficient, then, for us to fix with precision the point of the scale at which the water stands, before loading the instrument, and that to which it sinks in consequence of the loading applied: To this alone is its use reduced.

9. Suppose that, being loaded with an additional weight, the level of the water reaches exactly the zero of the scale, if in this state we put on the upper plate a fragment of calcareous spar for example, the weight of which produces an immersion, so that the level of the water should mark the division 54, this number shows us the weight of the fragment weighed in air (§ 7.) If we change then the fragment to the lower plate the immersion only reaches to 34, and this number shows us the weight of the same fragment weighed in water. Then the difference of 20 between these two numbers is exactly the weight of the volume of water dislodged by this substance, or the weight lost in the second operation. There remains only to divide 54, the weight of the fragment in air, by 20, which is that which is lost in water. The quotient, 2.7, shows us the specific weight of the calcareous spar; and this simple method must be followed for all other bodies.

10. It is easily perceived that the additional weight may be greater than we supposed, without its altering the data, because if, instead of sinking the instrument to zero, it should be sunk to the division 8 for example, then the same fragment of calcareous spar would have immerged it not only to 54 but to 62, and always its weight in air would be the same as before, that is to say, 62 — 8 = 54. The same happens with the weight in water. In the second instance the immersion would not be to 34, but would rise to 42, and the loss would be equal to the former, that is 62 — 42 = 20; and this is one of the advantages of the instrument, that it is not requisite to bring it to any fixed point, but only to observe the divisions of the scale which mark the level of the water, as already said (§ 8.)

11. If we take away from the upper plate not only the substance that has been weighed, but also the additional weight, the instrument rises till it leaves the lower plate above the

water (§ 2), and from this construction results the convenience of being able to place the substance on this plate, without taking the whole instrument out of the water, and without being exposed in the second immersion to any bubbles of air rising, which was not the case in the first, but which often happens with Nicolson's balance, which alters the results.

12. The level of the water always leaves some doubt in the determination of the precise point of the scale to which it reaches, chiefly when it is to mark the parts of a division; and in its stead we could use another index much more exact, the simplicity of which recommends its constant use. It consists in placing two threads of silk, *a b*, *c d*, (Fig. 3.) well stretched, or of very fine wire, called hair-wire, on the opposite points of the edge *r s*, of the box or case, so as to encircle the glass tube without pressing it, and allowing it to move freely in the middle, for which purpose are placed the buttons *m*, *n*, soldered strongly to the case, and the small grooves *a*, *c*, *b*, *d*, made on the same edge; then observing through the hollow *x z*, which is about two lines high and one inch long, the level of the threads and also of the scale, the thread that is on the side of the observer marks the divisions and parts of each to which the immersion reaches, and by these means, if the scale is of millimetres, (French measure,) may be seen at one view the fifth part of each, or two-tenths of a millimetre, which is equivalent in the instrument which I use to a weight of 0.3 grains. It is true that this mode indicates the point of partition a little above zero in the scale; but as we have seen, (§ 10,) this does not alter the results.

13. Till now we have only spoken of the mode of weighing substances, the specific gravity of which is greater than that of water. We have then two other cases to consider that can occur, and they are those in which the specific gravity of the substance is equal to or less than that of water.

14. If knowing the weight of a body in air, for example 24, we weigh it in water, and find that the immersion reaches exactly to zero, in this case we should say that it had lost all its weight, or that it is equal to the body of water which it dislodges, because the difference between zero and 24 is 24, and its specific gravity will be $\frac{24}{24} = 1 =$ to that of the water.

15. But if, instead of the second immersion reaching zero, it should remain six divisions below this point, supposing that the scale should have negative divisions, that is, that it should continue below zero, this would show us that the volume of water dislodged weighs more than the substance, because it not only loses from 24 of its weight, but besides, makes the instrument lose six, with which it forms a whole, and the difference between + 24, which it weighs in air, and— 6 in water, observing the rules of the signs, is + 30, dividing 24 by 30, we get 0.8, that is, the specific gravity of the substance is less than that of water.

16. We have not put on the scales negative divisions, because it would increase much the neck of the instrument, and, besides other inconveniences, would render it more bulky. There is no necessity for these divisions, if we consider, that, by increasing the additional weight, we can sink the greater part of the scale, in order that the substance that we might weigh in water should afterwards make it rise, and by this simple proceeding we can say, that, without altering the size of our scale, we have doubled it. An example will illustrate this.

17. Suppose a small piece of oak weighs in air 43.3, taking it from the upper plate, and increasing the additional weight, we shall make the scale sink to 60 for example. Marking this point, which we shall consider as though it were the zero of the scale, and weighing afterwards the wood in water, the immersion only reaches to 53, that is, it has seven divisions, which certainly correspond below zero. The difference, then, between + 43.3, weight of the oak in air, and— 7.0, its weight in water, is + 50.3. Dividing 43.3 by 50.3, the quotient, 0.860, results, which is the specific gravity of oak; and this operation will be observed in other instances.

18. If, when the instrument is at zero, we place known weights, such as drachms and grains, we shall know the corresponding weight of each division of those that are immersed, dividing the number of drachms or grains by the number of divisions; so then, if with 3 drachms or 108 grains it sinks 54 divisions, each one will correspond to 2 grains, and in this manner we shall know how far the greatest weight that can be weighed in this instrument ascends.

3

**Art. IV.**—*Notice of the performance of Steam-Engines in Cornwall for October, November, and December* 1828. By W. J. Henwood, Esq. F. G. S., Member of the Royal Geological Society of Cornwall. Communicated by the Author.

*Reciprocating Engines drawing Water.*

| Mines. | Diameter of cylinder in inch. | Length of stroke in cylinder in feet. | Length of stroke in the pump in feet. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Millions of lbs. weight lifted 1 foot high by the consumption of 1 bush. of coal. |
|---|---|---|---|---|---|---|
| Huel Towan, - | 80 | 10, | 8, | 10,3 | 6,4 | 75,2 |
| | 80 | 10, | 8, | 5,1 | 3,7 | 58,5 |
| Cardrew Downs, | 66 | 8,75 | 7, | 10,1 | 5,5 | 63,8 |
| Huel Hope, - | 60 | 9, | 8, | 10,38 | 5,2 | 70, |
| Huel Vor, - | 63* | 7,25 | 5,75 | 17,5 | 5,1 | 22,5 |
| | 53 | 9, | 7,5 | 19,58 | 5,1 | 38, |
| | 48 | 7, | 5, | 8,09 | 3,9 | 27,5 |
| | 80 | 10, | 7,5 | 14,96 | 5,4 | 57,5 |
| | 45 | 6,75 | 5,5 | 13,6 | 5,7 | 49,1 |
| Poladras Downs, | 70 | 10, | 7,5 | 8,97 | 4,9 | 45,6 |
| Huel Reeth, - | 36 | 7,5 | 7,5 | 15,29 | 3,9 | 24,5 |
| Balnoon, - | 30 | 8, | 7, | 6, | 3,9 | 20,6 |
| Huel Penwith, - | 40 | 8,75 | 7, | 4, | 6,3 | 25,3 |
| United Hills, - | 58 | 8,25 | 6,5 | 6,79 | 4,1 | 36,6 |
| Great St George, | 60 | 10,333 | 6,5 | 9,4 | 4, | 30,3 |
| | 70 | 10, | 7,5 | 10,4 | 3,8 | 34,1 |
| Crinnis Mines, - | 53 | 8,25 | 7, | 11,68 | 4,4 | 27,9 |
| | 56 | 6,75 | 6,75 | 10, | 5,1 | 32,3 |
| Perran Mines, - | 38 | 6,75 | 6, | 8,2 | 7,7 | 19,4 |
| Stray Park, - | 64 | 7,75 | 5,25 | 7,66 | 4, | 26,7 |
| Carzise, - | 50 | 8,5 | 7, | 7,34 | 4, | 27,6 |
| Huel Penrose, - | 36 | 8,5 | 6,5 | 10,35 | 6,3 | 33, |
| Huel Caroline, - | 30 | 7, | 6, | 28, | 10,2 | 36,2 |
| Huel Trevoole, - | 30 | 9, | 7, | 22,19 | 7,5 | 37,9 |
| St Ives Consols, | 36 | 7, | 7, | 16,1 | 6,2 | 30,6 |
| Lelant Consols, | 15 | 7,5 | 4,5 | 17, | 2,9 | 14,6 |

| Mines. | Diameter of cylinder in inch. | Length of stroke in cylinder in feet. | Length of stroke in the pump in feet. | Load in lbs. per sq. in. of area of piston. | No. of strokes per minute. | Millions of lbs. weight lifted 1 foot high by the consumption of 1 bush. of coal. |
|---|---|---|---|---|---|---|
| Huel Damsel, - | 42 † | 7,5 | 5,75 | 21,5 | 6, | 34,1 |
| | 50 | 9, | 7, | 8,2 | 2,4 | 31, |
| Ting Tang, - | 63 | 7,75 | 6,75 | 15, | 6,4 | 41,8 |
| Huel Beauchamp, | 36 | 7,75 | 6, | 11,6 | 4,1 | 33, |
| Huel Montague, | 50 | 9, | 7, | 8,1 | 5,7 | 31,9 |
| Great Work, - | 60 | 9, | 7, | 8,9 | 6,2 | 37,4 |
| East Huel Unity, | 45 | 8,75 | 6,75 | 7,97 | 4,1 | 27,9 |
| Tresavean, - | 60 | 9, | 7, | 5,6 | 4,2 | 20,8 |
| Huel Unity, - | 60 | 7, | 5,5 | 14,4 | 5,5 | 27,6 |
| Poldice, - | 60 | 9,5 | 6,25 | 11,9 | 5,9 | 31,2 |
| | 90 | 10, | 7, | 10,9 | 5,5 | 54, |
| North Downs, - | 70 | 9,833 | 7,75 | 7,9 | 6,6 | 47,4 |
| Huel Busy, - | 70 | 10, | 7,5 | 11,4 | 6,2 | 46,8 |
| Huel Tolgus, - | 70 | 10, | 7,5 | 7,5 | 3,4 | 44,8 |
| Dolcoath, - | 76 | 9, | 7,5 | 11,8 | 5, | 43,4 |
| East Crinnis, - | 60 | 5,5 | 5,5 | 8,57 | 4,5 | 21,7 |
| | 70 | 10, | 7, | 8,4 | 4,1 | 31,9 |
| Binner Downs, | 70 | 10, | 7,5 | 10,93 | 7,6 | 61,9 |
| | 63 | 9, | 7,5 | 7,87 | 8,9 | 36,6 |
| | 42 | 9, | 7,5 | 11,8 | 6.8 | 46, |
| Pembroke, - | 40 | 9, | 6,5 | 6,1 | 2, | 24,5 |
| | 80 | 9,75 | 7,25 | 11,27 | 3,4 | 44,1 |
| United Mines, - | 30 | 9, | 7,5 | 12,9 | 7,1 | 33.1 |
| | 90 | 9, | 8, | 7,9 | 4, | 38,7 |
| Consolidated Mines, | 90 | 10, | 7,5 | 8,82 | 5,1 | 58,1 |
| | 70 | 10, | 7,5 | 9,1 | 5,2 | 55,1 |
| | 58 | 7,75 | 6,5 | 17,7 | 6,3 | 39,9 |
| | 90 | 10, | 7,5 | 10,6 | 3,7 | 29,2 |
| | 70 | 10, | 7,5 | 8,8 | 4,7 | 60,4 |
| | 90 | 10, | 7,5 | 7,83 | 5,5 | 63,2 |

Average duty 38.6 millions of lbs. lifted one foot high by the consumption of each bushel of coal.

Watt's rotatory double engines working machines for bruising tin ores at

| | | | Length of crank in feet. | | | |
|---|---|---|---|---|---|---|
| Huel Vor, | 24 | 6. | 3. | 12. | 16.9 | 17. |
| | 27 | 5. | 2.5 | 12.5 | 17.3 | 19.7 |
| | 16.5 | 5. | 2.5 | 8.5 | 25.6 | *13.4 |

Average duty of rotatory double engines, 16.7 millions.

* Watt's double engine.

† The steam is first admitted into a high pressure cylinder, whence it passes into a Watt's single engine, both pistons being connected with the same lever. All the others are Watt's single engines.

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## Art. V.—*Observations relative to the Motions of the Molecules of Bodies.* By David Brewster, LL. D. F. R. SS. London and Edinburgh.

Notwithstanding the great interest which has been everywhere excited by the observations of Mr Brown respecting the motions of the Molecules of Bodies, I should not have thought of calling the attention of the Society to the opinions which I entertained, or to the experiment which I had accidentally made in reference to this subject.

As I am, however, the only surviving member of those who took an active part in the discussion and examination of this matter when it was presented to the consideration of this Society nearly fifteen years ago, I feel it incumbent upon me to call your attention to the facts and views which then came under our notice.

On the 2d May 1814, Dr Drummond of Belfast communicated to this Society a paper "*On certain appearances observed in the dissection of the Eyes of Fishes.*" Having washed off the silvery part of the choroid coat of the haddock into about half a teaspoonful of water, the water became of a milky colour, owing to innumerable slender, flat, silvery spicula, which composed the substance of the choroid. "They seemed," says Dr Drummond, "to be in constant motion, apparently rolling upon their axis, but having no degree of progressive movement. The light reflected from their surface was very brilliant, like that from polished silver, and often disappeared, and again returned, with alternations so rapid, as to produce a twinkling very like that of a fixed star.

"Sometimes on examining an individual specimen it would disappear altogether, but in a few minutes return, renew its twinkling and apparent revolution on its axis, and again disappear to return as before.

"Frequently, also, some were observed to be in the fluid, or on its surface, for a long time motionless, but very brilliant; then they would give a few slight twinkles, seem to turn round, and almost disappear; then resume their original situation for a moment, appear more brilliant than at first, partly disappear again, and again return, and so on for a number of times, till at length they would disappear entirely; but after a time (perhaps five or ten minutes) show themselves in the same spot as before. These observations could be made only on the larger spicula; the minute ones being in incessant motion.

"The motion continues in a great many of the spicula even after the fluid containing them has become putrid; but it is then more slow. The addition of ardent spirits deadens but does not destroy the motion. After exposure to a heat of boiling water, the number of spicula seems much diminished, and those which remain move less rapidly than before. The addition of vinegar, in a quantity equal to the fluid containing the spicula, suddenly causes a great diminution of the number of moving ones, probably from coagulating the albuminous matter which had been washed from the eye along with the spicula, and entangling them in it. Many, however, continue their motion as before.

"The spicula of the eye of the herring are jointed, being generally thus divided into three distinct portions, of which that which forms the centre is much larger than the two others. In common daylight, the entire spiculum is silvery; but if it be observed in the sunshine, it will be found to reflect different rays from the jointed portions; the end joints being generally of a light *straw colour*, while the central one is *steel blue*, like the main spring of a watch, or of a red or light rose colour, sometimes silvery, green, or purple; but never of the same colour as the extremities of the spiculum. The colours of the different joints do not shade into each other, but terminate abruptly by a well defined line."

Dr Drummond next proceeds to account for the motion of these spiculæ, and after discussing many objections against the supposition that they are animalcules, and especially the formidable objection drawn from their surviving the heat of boiling water, he concludes with the following opinion of their probable origin.

"Perhaps many other objections may be opposed to the supposition of animalcular life in these bodies, and yet the strong *expression* of animation, if I may so term it, and air of seeming design, with which the varying motions (sometimes slow and sometimes rapid) are performed, and the difficulty of otherwise accounting for their motion, whether real or apparent, lead, upon the whole, I think, to this supposition, not as one which we can admit with confidence, but as the *least improbable* conjecture, which, in the present limited state of our knowledge, we can venture to form."

Although I never could assent to this conclusion, yet I can bear testimony to the perfect accuracy of the statement published in Dr Drummond's paper. The late Dr Thomas Brown and I repeated most of the experiments, and witnessed all the movements and revolutions of the spicula above-mentioned. I was disposed at that time to regard them as the result partly of a polarity in the spicula themselves, and partly of certain physical changes, to which bodies are peculiarly liable when suspended in a fluid medium.

In order to determine whether or not these minute scales acted upon one another, I prepared a considerable quantity of the milky fluid, and spread it out upon a large square of glass, in the expectation that the spicula would (like the minute particles of crystalline matter) form an organized film that would exhibit the proof of molecular polarity by its action upon polarized light. When the water had evaporated, I obtained a film or crust exactly similar to that which converts glass balls and spheres of gypsum into artificial pearls; but it exhibited no organized structure, and consequently indicated no polarity in the elementary spicula.

In making these experiments, I was often surprised by a singular variation in the *whiteness* of the large plate of fluid when spread over the square of glass. It sometimes appeared to be quite dark, and at other times to recover its whiteness without any apparent cause. This, however, I found to arise from currents of air arising from my own motion across the room, and I could make the fluid appear white or dark at pleasure, by merely blowing over its surface. When the fluid surface was in a state of rest, the spicula settled in certain positions in relation to a vertical line; but whenever a breath of air affected the fluid they were thrown into new positions, and reflected the incident light in a different manner.

Owing to the great extent of surface which was thus exposed to accidental impressions, the movements of the spicula were much more lively than when they were examined in small portions of fluid; but the slightest examination was sufficient to satisfy me that their movements were entirely the result of the position of unstable equilibrium which they occupied in the fluid medium.

Since these experiments were made, I have observed analogous motions, though arising from a different cause, in the juice of the *Semecarpus anacardium*, and I am persuaded that they will be found in all organized fluids. When this fluid, or a portion of the black Indian varnish, (which is a mixture of the sap of the *Semecarpus anacardium* with that of the *Jowar*,) is placed between two plates of glass, and illuminated in the microscope by the sun's rays, the particles seem to be all in motion, and there appears a most singular and rapid play of colours, arising from the inflexion of the light which passes between the organized molecules. The very same phenomenon has been observed by M. Dutrochet in blood taken either from the veins or arteries of an animal, and the motion of its particles ceases only when the blood coagulates.

In examining the motions of the granules of pollen suspended in water, (which I have done since the publication of Mr

Brown's observations), I recognized the same changes which I have already mentioned; but I have never perceived a single motion in the least degree characteristic of animal life. The difference between these two kinds of motions, and the causes to which the former may be ascribed, are so admirably explained in a memoir which I have lately received from that eminent French physiologist, M. Raspail, that I need make no apology for laying before the Society a translation of the most prominent part of it. It was read at the Institute of France before Mr Brown's observations had reached Paris, and was drawn up in reference to the Memoir of M. Adolphe Brongniart, which had excited much notice.*

It is impossible, we think, for any person familiar with the microscope, to read these observations of M. Raspail without being satisfied of their accuracy, and without believing that they are applicable to almost all the phenomena observed by Mr Brown and M. Brongniart. But even if they did not afford a sufficient explanation of the motions in question;—nay, if these motions resisted every method of explanation, it is the last supposition in philosophy that they are owing to animal life; and in future times, when the science of molecular organization shall be farther advanced, it will be viewed in the same light as the opinion of Kepler, that the planets themselves were living animals, swimming in the ethereal ocean of the heavens. What, indeed, are all the motions of the planets,—what are their progressions, their stations, their retrogradations—their revolutions—their nutations, but so many movements in the larger molecules of the universe. Why, then, need we wonder that the microscopic molecules of this lower world should exhibit their attractions, their rotations, their combinations, their dilatations, and their contractions? We are disposed, indeed, to go much farther, and to ask, Why should not the molecules of the hardest solids have their orbits, their centres of attraction, and the same varied movements which are observed in planetary and nebulous matter? The existence of such movements has already been recognized in mineral and other bodies. A piece of sugar melted

* The whole of this Memoir was published in our last Number, p. 96.

by heat, and without any regular arrangement of its particles, will in process of time gradually change its character, and convert itself into regular crystals, possessing a mathematical regularity of structure, and displaying all the wonderful phenomena of double refraction. A mineral body will, in the course of time, part with some of its ingredients, or take in others, till it has become a new mineral, and has entirely lost its personal identity;—and (what has recently been discovered by a foreign member of this Society,) a regular crystal may, by the mere introduction of heat, have the whole arrangement of its molecules converted into an opposite arrangement, developing new physical properties which it did not before possess. In these changes the molecules must have turned round their axes, and taken up new positions within the solid, while its external form has suffered no apparent change, and while its general properties of solidity and transparency have remained unaltered. Before another century passes away, the laws of such movements will probably be determined; and when the molecular world shall thus have surrendered her strongholds, we may look for a new extension of the power of man over the products of inorganic nature.

ALLERLY, *December* 13, 1828.

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ART. VI.—*Remarks on the formation of Anchors.* By Commander JOHN PEARSE, R. N. Communicated by the Author.

IT does not appear that the formation of anchors has been very generally viewed by seamen on such principles as would enable them to form a just conclusion of that best adapted for the safety of a ship. Very old seamen argue in favour of a long shanked anchor, without being able to offer anything satisfactory in support of it; and such an opinion is no doubt generally formed from custom or prejudice. I shall therefore endeavour to illustrate, on mathematical principles, what appears to be the advantages of a short shank.

Figures 4th and 5th of Plate II. are intended to represent anchors of the same weight, differing in the length of their shanks, but having arms of equal length, and forming the same angles with the shanks. The lower arms are supposed to be buried in the ground, as denoted by the dotted lines DE and CF. The lines AA represent the cables.

It will appear evident that the strain of the ship must operate at the points B,B, and, therefore, by the principles of the lever, CB, in Figure 4th, being longer, and consequently producing a greater power than DB in Figure 5th, the former must be more liable to break its hold than the latter, and a ship, consequently, must ride the safest with a short-shanked anchor.

It is a great advantage to have a good holding anchor, when getting a ship under weigh in a confined harbour, when anchored among many ships, or when blowing strong, as it admits of the cable being hove very short, without danger, before the sails are hoisted. It lessens also the labour and time in heaving in cable afterwards, and often prevents the anchor from breaking its hold before the cable is up and down, or perpendicular. And at those times the advantage must appear in favour of a short shank.

If two anchors are of the same weight, and the same length in their arms, but differing in the lengths of their shanks, the several parts of the short one must be of greater substance, and consequently much stronger.

There appears, however, to be another advantage in favour of a short shank. Figures 6th and 7th represent two anchors of the same dimensions as Figures 4th and 5th. They are both supposed to have just taken the ground. It will be seen that the lower arm of Figure 7th is nearer a perpendicular than the arm of Figure 6th ; consequently, it will at first strike deeper, and take a firmer hold in the ground, and be more likely to retain it in the event of being checked by the cable. This will be an advantage when anchoring and confined for room, or when pointing a cable and having to let go the short or spare anchor.

As far as I can speak from my own practical experience, I give the preference to the short shank. I have commanded different vessels nearly eight years, and the whole time accustomed to wild open roadsteads, and I believe no ships ever started their anchors so seldom; and I have always selected the shortest shank anchors I could get. I did it also before I commanded vessels, when the selection was left to myself. I did this at first, in consequence of the appearance of their formation pleasing me better, and I afterwards viewed it on the principles I have now explained, and I have found the theory and practice completely to agree.

PLYMOUTH, *December* 17, 1828.

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ART. VII.—*Summary of the state of the Barometer, Thermometer, &c. in Kendal, for the year* 1828. By Mr SAMUEL MARSHALL. Communicated by the Author.

| 1828. | Barometer. | | | Thermometer. | | | Quantity of Rain in Inches. | Number of Rainy Days. | Prevalent Winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | Max. | Min. | Mean. | | | |
| Jan. | 30.17 | 28.98 | 29.67 | 50° | 23° | 39.17° | 6.192 | 17 | S. W. |
| Feb. | 30.18 | 28.89 | 29.57 | 54 | 23 | 38.93 | 4.625 | 15 | S. W. |
| March, | 30.12 | 28.75 | 29.69 | 56 | 25 | 42.09 | 2.440 | 18 | W. |
| April, | 30.14 | 29.08 | 29.54 | 58 | 28 | 45.45 | 4.012 | 21 | W. |
| May, | 30.17 | 29.29 | 29.69 | 68 | 35 | 53.12 | 1.961 | 10 | W. |
| June, | 30.09 | 29.08 | 29.78 | 81. 5 | 44 | 59.07 | 3.078 | 11 | W. |
| July, | 29.83 | 29.12 | 29.50 | 76 | 40 | 58.62 | 3.502 | 12 | W. |
| Aug. | 30.14 | 28.89 | 29.65 | 73 | 40 | 58.25 | 5.581 | 17 | W. |
| Sept. | 30.40 | 29.15 | 29.78 | 73 | 33. 5 | 55.05 | 4.497 | 13 | W. |
| Oct. | 30.40 | 28.95 | 29.86 | 60 5 | 28. 5 | 47.86 | 4.916 | 13 | W. |
| Nov. | 30.18 | 29.09 | 29.65 | 54. 5 | 26 | 44.64 | 4.786 | 17 | W. |
| Dec. | 30.27 | 28.99 | 29.64 | 52 5 | 31 | 44.20 | 9.226 | 25 | W. |
| Means, | 30.17 | 29.02 | 29.66 | 63. 16 | 31. 41 | 48.87° | 54.816 | 189 | W. |

The year 1828 has been distinguished by its being a warmer year than any of the preceding five years, the latter part being seldom equalled in uniform mildness; the thermometer never having indicated frost from summer to the end of the year, but three times in October, twice in November, and twice in December. The appearance of the Aurora Borealis has not been more frequent than has occurred within the last few years. Thunder and lightning have oftener occurred during the latter part of the year than is usual in winter. Though it is only by simultaneous observations in different parts of the globe, on a large and extensive scale, and by comparing these with each other, that great and important results can be obtained, and fresh discoveries made in the imperfectly developed science of meteorology, yet more humble efforts, confined to particular districts, are requisite to confirm and establish them. Such labours are, therefore, needful and decidedly auxiliary to forming the great outline, which every one conversant in this science acknowledges to be a desideratum. To decide on the causes which produce certain atmospheric phenomena that are regularly occurring in any particular district, has yet been imperfectly obtained; and yet that they depend on general principles, capable of producing those phenomena, can hardly be denied. It is to be regretted that few are willing to undertake the labour requisite for obtaining this local information, and without which, the deductions derived from more extended observations would be incomplete.

I shall attempt in this paper, to make a comparison of the weight of the atmosphere at different times of the year, for the last six years, in which I have kept a regular register of the weather,—point out the months in which the greatest and least quantities of rain have been taken, &c. by which certain inferences may be drawn of the meteorological facts of the disstrict. It is requisite, however, to state, that the situation in which these observations have been taken is about forty-two yards above the level of the sea; that the time of registering the daily observations is nine o'clock, A. M.; and that the quantity of rain which has fallen within the preceding twenty-four hours (if any) is registered daily at that time. The mean height of the barometer for 1828, is the exact average of the last six years, including the year 1828. The greatest height which the barometer attained was on the 16th of September and the 29th of October, 30.40 inches, in both which instances remarkably fine clear weather had preceded and followed, though in September it was rather succeeded by fine weather, than preceded by it, as before that date we had heavy rain, till within two days of its having attained its greatest altitude.

During the month of October it exceeded 30 inches for fifteen days, from the 11th to the end of the month, with the exception of six days. To this circumstance may be attributed the reason of the means being greatest for that month than any through the year. The greatest depression was on the 21st of March, about which period we had frequent rain, snow, and sleet showers.

The mean height of the thermometer is greater than in any other year for the last six years. It was at its greatest altitude on the 28th June, 81.5°. Thunder and lightning were very frequent during a great part of this month, and the weather was mostly dull and cloudy. The greatest degree of cold was experienced on the 11th of January, and on the 12th and 16th of February. In the early part of January the weather was mostly severe, and about the middle of February we had heavier falls of snow than in any other part of the year. In 1823, 1825, and 1827, the month of July was the hottest; (deducing this conclusion from the mean for the month,) in 1826 and 1828, that of June, and in 1824, August. In 1823, 1824, 1825, and 1826, January was by the same rule the coldest month; and in 1827 and 1828 February. The average temperatures of the hottest months for the last six years is 59.06°, and that of the coldest months is 34.57.° The hottest month in that period was June 1826, and the coldest January 1826.

The quantity of rain for 1828 is less than that of any other year for the last seven years, excepting only 1826, which was but 43.060 inches. The mean quantity of rain for the last seven years is 57.727 inches. The greatest quantity taken in any year in that period was in 1824, 62.762 inches, and the least in 1826. The greatest quantity of rain in any month was in November 1824, 13.433 inches, and the least in May 1826, 0.369. The greatest quantity in a day, in 1828, taken for the preceding twenty-four hours, was on the 8th of October, 1.420 inch.

The number of rainy days has not been equalled in any of the last six years, except in 1823, which was 198. The number of days on which rain has fallen in the months of April, May, June, July, August, and September, is 84; and in the months of January, February, March, October, November, and December, 125. The west wind has been this year more prevalent than any other, though in general the wind from the S. W. is decidedly the prevalent wind of Kendal. The wind from the west has prevailed 124 days during the course of the year; from the S. W. 83 days; from the N. 40; N. W. 32; S. 30; E. 23; N. E. 22; and from the S. E. 12 days.

Perhaps it will be thought that these remarks are too minute for the purpose for which they are designed; but I conceive the imputation will be allowed to be groundless, when it is recollected that they are intended to describe some of the peculiarities for which this district is remarkable.

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ART. VIII.—*Account of the great Congress of Philosophers at Berlin on the* 18*th September* 1828. Communicated by a CORRESPONDENT.

THE existence of a large society of cultivators of the natural sciences meeting annually at some great capital, or some central town of Europe, is a circumstance almost unknown to us, and deserving of our attention, from the important advantages which may arise from it.

About eight years ago, Dr Okens of Munich suggested a plan for an annual meeting of all Germans who cultivated the sciences of medicine and botany. The first meeting, of about forty members, took place at Leipsic in 1822, and it was successively held at Halle, Wurtzburg, Frankfort on the Maine, Dresden, Munich, and Berlin. All those who had printed a certain number of sheets of their inquiries on these subjects were considered members of this academy.

The great advantages which resulted to these sciences from the communication of observations from all quarters of Germany soon induced an extension of the plan, and other departments of natural knowledge were admitted, until, at the last meeting, the cultivators even of pure mathematics were found amongst the ranks of this Academy.

Several circumstances, independent of the form and constitution of the academy, contributed to give unwonted splendour to the last meeting, which took place at Berlin in the middle of September of the last year.

The capital selected for its temporary residence is scarcely surpassed by any in Europe in the number and celebrity of its Savans.

The taste for knowledge possessed by the reigning family has made knowledge itself fashionable; and the severe sufferings of the Prussians previous to the war, by which themselves and Europe were freed, have impressed on them so strongly the lesson that "knowledge is power," that its effects are visible in every department of the government; and there is no country in Europe in which talents and genius so surely open for their possessors the road to wealth and distinction.

Another circumstance also contributed its portion to increase the numbers of the meeting of the past year. The office of president, which is annually changed, was assigned to M. Alexander de Humboldt. The universality of his acquirements, which have left no branch within the wide range of science indifferent or unexplored, has connected him by friendship with almost all the most celebrated philosophers of the age; whilst the polished amenity of his manners, and that intense desire of acquiring and of spreading knowledge, which so peculiarly characterizes his mind, renders him accessible to all strangers, and insures for them the assistance of his counsel in their scientific pursuits, and the advantage of being made known to all those who are interested or occupied in similar inquiries.

Professor Lichtenstein, (Director of the Museum of Zoology,) as Secretary of the Academy, was indefatigable in his attentions, and most ably seconded the wishes of its distinguished President.

These two gentlemen, assisted by several of the residents at Berlin, undertook the numerous preliminary arrangements necessary for the accommodation of the meeting.

On the 18th of September 1828, there were assembled at Berlin 377 members of the Academy, whose names and residences (in Berlin) were printed in a small pamphlet, and to each name was attached a number, to indicate his seat in the great concert room, in which the morning meetings took place. Each member was also provided with an engraved card of the

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hall of meeting, on which the numbers of the seats were printed in black ink, and his own peculiar seat marked in red ink, so that every person immediately found his own place, and knew where to look for any friend whom he might wish to find.

At the hour appointed for the opening of the meeting, the members being assembled, and the galleries and orchestra being filled by an assemblage of a large part of the rank and beauty of the capital, and the side-boxes being occupied by several branches of the royal family, and by the foreign ambassadors, the session of the Academy was opened by the eloquent address of the President.

Speech made at the opening of the Society of German Naturalists and Natural Philosophers at Berlin, the 18th September 1828. By Alexander Von Humboldt.

Since through your choice, which does me so much honour, I am permitted to open this meeting, the first duty which I have to discharge is one of gratitude. The distinction which has been conferred on him who has never yet been able to attend your excellent Society, is not the reward of scientific efforts, or of feeble and persevering attempts to discover new phenomena, or to draw the light of knowledge from the unexplored depths of nature. A finer feeling, however, directed your attention to me. You have assured me, that while, during an absence of many years, and in a distant quarter of the globe, I was labouring in the same cause with yourselves, I was not a stranger in your thoughts. You have likewise greeted my return home, that, by the sacred tie of gratitude, you might bind me still longer and closer to our common country.

What, however, can the picture of this our native land present more agreeable to the mind than the assembly which we receive to day for the first time within our walls; from the banks of the Neckar, the birth-place of Kepler and of Schiller, to the remotest border of the Baltic plains; from hence to the mouths of the Rhine, where, under the beneficent influence of commerce, the treasures of exotic nature have for centuries been collected and investigated, the friends of nature, inspired with the same zeal, and, urged by the same passion, flock together to this assembly. Everywhere, where the German language is used, and its peculiar structure affects the spirit and disposition of the people. From the Great European Alps to the other side of the Weichsel, where, in the country of Copernicus, astronomy rose to renewed splendour; everywhere in the extensive dominions of the German nation we attempt to discover the secret operations of nature, whether in the heavens, or in the deepest problems of mechanics, or in the interior of the earth, or in the finely woven tissues of organic structure.

Protected by noble princes, this assembly has annually increased in interest and extent. Every distinction which difference of religion or form of government can occasion is here annulled. Germany manifests itself as it were in its intellectual unity; and since knowledge of truth and performance of duty are the highest object of morality, that feeling of unity weakens none of the bonds which the religion, constitution, and laws of our country, have rendered dear to each of us. Even this emulation in mental struggles has called forth (as the glorious history of our country tells us,) the fairest blossoms of humanity, science, and art.

The assembly of German naturalists and natural philosophers since its last meeting, when it was so hospitably received at Munich, has, through the flattering interest of neighbouring States and Academies, shone with peculiar lustre. Allied nations have renewed the ancient alliance between Germany and the ancient Scandinavian North.

Such an interest deserves acknowledgment the more, because it unexpectedly increases the mass of facts and opinions which are here brought into one common and useful union. It also recalls lofty recollections into the mind of the naturalist. Scarcely half a century has elapsed since Linné appears in the boldness of the undertakings which he has attempted and accomplished, as one of the greatest men of the last century. His glory, however bright, has not rendered Europe blind to the merits of Scheele and Bergman. The catalogue of these great names is not completed; but lest I shall offend noble modesty, I dare not speak of the light which is still flowing in richest profusion from the North, nor mention the discoveries in the chemical nature of substances, in the numerical relation of their elements, or the eddying streams of electro-magnetic powers.* May those excellent persons, who, deterred neither by perils of sea or land, have hastened to our meeting from Sweden, Norway, Denmark, Holland, England, and Poland, point out the way to other strangers in succeeding years, so that by turns every part of Germany may enjoy the effects of scientific communication with the different nations of Europe.

But although I must restrain the expression of my personal feelings in presence of this assembly, I must be permitted at least to name the patriarchs of our national glory, who are detained from us by a regard for those lives so dear to their country;—Goethe, whom the great creations of poetical fancy have not prevented from penetrating the *arcana* of nature, and who now in rural solitude mourns for his princely friend, as Germany for one of her greatest ornaments;—Olbers, who has discovered two bodies where he had already predicted they were to be found;—the greatest anatomists of our age—Soemmering, who, with equal zeal, has investigated the wonders of organic structure, and the spots and *faculæ* of the sun, (condensations and openings in the photosphere;) Blumenbach, whose pupil I have the honour to be, who, by his works and his immortal eloquence, has inspired everywhere a love for comparative anatomy, physiology, and the general history of nature, and who has laboured diligently for half a century. How could I resist the temptation to adorn my discourse with names which posterity will repeat, as we are not favoured with their presence?

These observations on the literary wealth of our native country, and the progressive developement of our institution, lead us naturally to the obstructions which will arise from the increasing number of our fellow-labourers. The chief object of this assembly does not consist, as in other societies whose sphere is more limited, in the mutual interchange of treatises, or in innumerable memoirs, destined to be printed in some general collection. The principal object of this Society is to bring those personally together who are engaged in the

* The philosophers here referred to are Berzelius and Oersted.

same field of science. It is the immediate, and therefore more obvious interchange of ideas, whether they present themselves as facts, opinions, or doubts. It is the foundation of friendly connection which throws light on science, adds cheerfulness to life, and gives patience and amenity to the manners.

In the most flourishing period of ancient Greece, the distinction between words and writing first manifested itself most strongly amongst a race, which had raised itself to the most splendid intellectual superiority, and to whose latest descendants, as preserved from the shipwreck of nations, we still consecrate our most anxious wishes. It was not the difficulty of interchange of ideas alone, nor the want of German science, which has spread thought as on wings through the world, and insured it a long continuance, that then induced the friends of philosophy and natural history in Magna Græcia and Asia Minor to wander on long journies. That ancient race knew the inspiring influence of conversation as it extemporaneously, freely, and prudently penetrates the tissue of scientific opinions and doubts. The discovery of the truth without difference of opinion is unattainable, because the truth in its greatest extent can never be recognized by all, and at the same time. Each step, which seems to bring the explorer of nature nearer to his object, only carries him to the threshold of new labyrinths. The mass of doubt does not diminish, but spreads like a moving cloud over other and new fields; and whoever has called that a golden period, when difference of opinions, or, as some are accustomed to express it, the disputes of the learned will be finished, has as imperfect a conception of the wants of science, and of its continued advancement, as a person who expects that the same opinions in geognosy, chemistry, or physiology, will be maintained for several centuries.

The founders of this society, with a deep sense of the unity of nature, have combined in the completest manner all the branches of physical knowledge, and the historical, geometrical, and experimental philosophy. The names of natural historian and natural philosopher are here, therefore, nearly synonymous, chained by a terrestrial link to the type of the lower animals. Man completes the scale of higher organization. In his physiological and pathological qualities, he scarcely presents to us a distinct class of beings. As to what has brought him to this exalted object of physical study, and has raised him to general scientific investigation, belongs principally to this society. Important as it is not to break that link which embraces equally the investigation of organic and inorganic nature, still the increasing ties and daily developement of this institution renders it necessary, besides the general meeting which is destined for these halls, to have specific meetings for single branches of science. For it is only in such contracted circles,—it is only among men whom reciprocity of studies has brought together, that verbal discussions can take place: Without this sort of communication, would the voluntary association of men in search of truth be deprived of an inspiring principle.

Among the preparations which are made in this city for the advancement of the society, attention has been principally paid to the possibility of such a subdivision into sections. The hope that these preparations will meet with your approbation imposes upon me the duty of reminding you, that, although you had entrusted to two travellers, equally, the duty of making these arrangements, yet it is to one alone, my noble friend, M. Lichtenstein that the merit of careful precaution and indefatigable activity is due. Out of respect to the scientific spirit which animates the Society of German Naturalists and Natural Philosophy, and in acknowledgment of the utility of their efforts, government have seconded all our wishes with the greatest cheerfulness.

In the vicinity of the place of meeting, which has in this manner been prepared for our general and special labours, are situated the museums dedicated to anatomy, zoology, oryctognosy, and geology. They exhibit to the naturalist a rich mine for observation and critical discussion. The greater number of these well arranged collections have existed, like the University of Berlin, scarcely twenty years. The oldest of them, to which the Botanical Garden (one of the richest in Europe) belongs, have during this period not only been increased, but entirely remodelled. The amusement and instruction derived from such institutions call to our minds, with deep feelings of gratitude, that they are the work of that great monarch, who modestly and in simple grandeur, adorns every year this royal city with new treasures of nature and art; and what is of still greater value than the treasures themselves,—what inspires every Prussian with youthful strength, and with an enthusiastic love for the ancient reigning family,—that he graciously attaches to himself every species of talent, and extends with confidence his royal protection to the free cultivation of the understanding.

This was followed by a paper on magnetism, by Professor Oersted; and several other memoirs were then read.

The arrival of so many persons of similar pursuit, for 464 members were present, rendered it convenient to have some ordinary at which those who chose might dine, and introduce their friends or families. This had been foreseen, and his Majesty had condescended to allow the immense building used for the exercise of his troops to be employed for this purpose. One-third of it was floored on the occasion, and tables were arranged at which, on one occasion, 850 persons sat down to dinner. On the evening of the first day, M. de Humboldt gave a large *soirée* in the concert rooms attached to the theatre. About 1200 persons assembled on this occasion, and his Majesty the King of Prussia honoured with his presence the fête of his illustrious chamberlain. The nobility of the country, foreign princes, and foreign ambassadors, were present. It was gratifying to observe the princes of the blood mingling with the cultivators of science, and to see the heir-apparent to the throne, during the course of the evening, engaged in conversation with those most celebrated for their talents, of his own, or of other countries.

Nor were the minor arrangements of the evening beneath the consideration of the president. The words of the music selected for the concert were printed and distributed to the visitors. The names of the most illustrious philosophers which Germany had produced, were inscribed in letters of gold at the end of the great concert room.

In the first rank amongst these stood a name which England, too, enrolls amongst the brightest in her scientific annals, and proud, as well she may be, of having fostered and brought to maturity the genius of the first Herschel, she has reaped an ample reward in being able to claim as entirely her own, the inheritor of his talents and his name.

The six succeeding days were occupied in the morning by a meeting of the academy, at which papers of general interest were read. In the afternoon, through the arrangement of M. de Humboldt and M. Lichtenstein, various rooms were appropriated for different sections of the academy. In one, the chemical philosophers attended to some chemical memoir, whilst the botanists assembled in another room, the physiologists in a third, and the natural philosophers in a fourth. Each attended to the reading of papers connected with their several sciences. Thus every member was at liberty to choose that section in which he felt most interest at the moment, and he had at all times power of access to the others. The evenings were generally spent at some of the *soirées* of the Savans resident at Berlin, whose hospitality and attentions to their learned brethren of other countries were unbounded. During the unoccupied hours of the morning, the collections of natural history, which are rapidly rising into importance, were open to examination, and the various professors and directors who assisted the stranger in his inquiries, left him equally gratified by the knowledge and urbanity of those who so kindly aided him.

A map of Europe was printed, on which those towns only appeared which had sent representatives to this scientific congress; and the numbers sent by different kingdoms appeared by the following table, which was attached to it:—

| | | | |
|---|---|---|---|
| Russia, - | 1 | Wirtemburg, - | 2 |
| Austria, - | 0 | Sweden, - | 13 |
| England, - | 1 | Naples, - | 1 |
| Holland, - | 2 | Poland, - | 3 |
| Denmark, - | 7 | German States, - | 43 |
| France, - | 1 | | —— |
| Sardinia, - | 0 | | 206 |
| Prussia, - | 95 | Berlin, | 172 |
| Bavaria, - | 12 | | —— |
| Hanover, - | 5 | | 378 |
| Saxony, - - | 21 | | |

The proportion in which the cultivators of different sciences appeared was not easy to ascertain, because there were few amongst the more eminent who had not added to more than one branch of human knowledge. The following table, though not professing to be very accurate, will afford perhaps a tolerably fair view :—

| | | | | | |
|---|---|---|---|---|---|
| Geometers, - | 11 | | Anatomy, - | | 12 |
| Astronomers, - | 5 | | Zoology, - | 14 | |
| Natural Philosophers, | 23 | | Natural History, | 8 | |
| | — | 39 | Botany, - | 35 | |
| Mines, - | 5 | | | — | 57 |
| Mineralogy, - | 16 | | Physicians, - | | 175 |
| Geology, - | 9 | | Amateurs, - | | 9 |
| | — | 30 | Various, - | | 33 |
| Chemistry, - | 18 | | | | —— |
| Geography, - | 8 | | | | 381 |

A medal was struck in commemoration of this meeting, and it was proposed that it should form the first of a series, which should comprise all those persons most celebrated for their scientific discoveries in the past and present age.

The free interchange of knowledge between the members of such an assembly did not fail to produce beneficial results.

Amongst the persons present were,

| | | |
|---|---|---|
| Berzelius, | Von Buch, | Hufeland, |
| Oersted, | Humboldt, | Reinwardt, |
| Gaus, | Ehrenberg, | Mitscherlich, |
| Babbage, | Heusinger, | Rose, |
| Von Martius, | Tromsdorff, | Dobereiner, |
| Encke, | Oltmans, | Wohler, |
| Seebeck, | Crelle, | Link. |
| Oken, | | |

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Art. IX.—*A Summary of Experiments recently made on the Temperature of Mines.* By W. J. Henwood, Esq. F. G. S., Member of the Royal Geological Society of Cornwall. Communicated by the Author.

It appears that Mr R. W. Fox, and his friend, Mr Lean of French-hay, but then resident in Cornwall, were the first persons whose attention was directed to this subject. At their request, Mr Thomas Lean, brother of the latter, and then agent at Huel Abraham Mine, was requested to make some experiments on the temperature of that mine, of which he forwarded the results to Mr Fox; although he subsequently published them,* before the communication of Mr Fox's paper on the same subject, to the Cornwall Geological Society in 1819†. In this paper, Mr Fox inserted these and other experiments, made about the same time in various mines, and insisted on the general fact of an increase of temperature at considerable depths in the earth.

At the same meeting of that society, a paper on the same subject was communicated by John Forbes, M. D. ‡; but although they agreed in the facts which had been adduced, his inferences were different, indeed opposed to those of Mr Fox, as to there being evidence of a native heat of the earth itself. The observed elevation of temperature he attributed to the presence of workmen, combustion of candles, &c. and in support of this opinion he entered into elaborate calculations. His subsequent inquiries led him to a different conclusion; and in a second memior, read to the same society in 1820, he admitted the existence of a terrestrial heat, independent of adventitious circumstances; although he still thought the observed elevation of temperature was materially affected by these causes. This gentleman's publication contained the facts in both these papers, but not the conclusions which appeared in the first of them.

A second communication from Mr Fox was laid before the society at the same meeting, in which many more observations were adduced in support of his original conclusions §.

In 1819, Mr Bald's observations on the temperatures observed in some of the coal mines in the North of England were laid before the Royal Society of Edinburgh‖, of which the

* *Phil. Mag.* xlii. 204.

† *Cornwall Geol. Trans.* ii. 14; *Annals,* N. S. xxii. 41; and *Phil. Mag.* lxi.

‡ *Cornwall G. Trans.* ii. 159; *Annals,* xxii. 447; *and Phil. Mag.* lxi. 436.

§ *Cornwall G. Trans.* ii. 19; *Annals,* xxii.; and *Phil. Mag.* lxi.

‖ *Edin. Phil. Journal,* i. 134; and *Phil. Mag.* lxii. 105.

results nearly coincided with those of the observations made in Cornwall. In 1822, Mr M. P. Moyle read to the Cornwall Geological Society a paper on the same subject, strongly opposing the idea of a high internal temperature, * having previously done so in the *Annals of Philosophy*. The other papers which have appeared on this subject are by Dr John Davy †, Mr Fox ‡, Mr Moyle §, and Dr Barham ‖. It appears from Mr Fox's observations, that the mean temperature of the mining district in the vicinity of Falmouth is 49.86. ¶ "The water pumped from the Gwennap Mines is conveyed through different branch adits into a large adit or tunnel," the temperature of the stream passing through which, near the point of its discharge into the Carnon Vale, is 69°.25, the quantity being computed at 60,000 tons per day. In one of the branches in which the water is conveyed from the United, the consolidated and other mines, of which the average depth may be estimated at 150 or 160 fathoms, the temperature of the water is 73°.5. 66°5 is the temperature of the water in a second branch, which leads from Poldice, Huel Unity, Huel Gorland, and other excavations, estimated at a mean depth of 110 or 120 fathoms; whilst a third division, proceeding from Treskerby, Huel Chance, and other mines, of about an average depth of 100 or 110 fathoms, contains water at 65°. Dr Forbes states, that when the depth of Huel Neptune Mine was 90 fathoms, the temperature of the water discharged at the pump head was 60°; an increase of 36 fathoms subsequently obtaining in the depth, an elevation of the temperature of the water to 62° was the consequence; and that an increase of 17 fathoms in the depth of Botallack Mine augmented the temperature of the water 5°. Mr Fox informs us, that an accident to the machinery at Ting Tang Mine occasioned an accumulation of water at the bottom, which was then 117 fathoms in depth. When within ten fathoms of the bottom, the temperature of the liquid was 63°.5, whilst that drawn *from the bottom* was at 65°. The following

* *Cornwall G. Trans.* ii. 404; *Annals*, xxii. and *Phil. Mag.* lxii. 94.

† This *Journal*, vol. iii. 75.

‡ *Annals*, xix. 381, *Cornwall G. Trans.* iii. 313. and *Phil. Mag.* lxii. 58.

§ *Annals*, xix. 308—415; xxi. 35. xxiv. 446, xxvi. 259.

‖ *Cornwall G. Trans.* iii. 150.

¶ This *Journal*, vol. x. p. 178.

table contains a selection of such observations as have been made on the temperature of water immediately, or at a very short interval after it had gushed from the rock.

| Place. | Depth in fathoms. | Temp. | Observers. |
|---|---|---|---|
| Well at Southwark, * | 23 | 54° | Fox. |
| South Towan Mine. S. | 45 | 60 | —— |
| Wellington. S. | 50 | 57 | —— |
| | 50 | 58 | —— |
| Oatfield. S. - | 70 | 56 | Moyle. |
| Liscombe, - | 82 | 64 | Fox. |
| Unity Wood, - | 86 | 64 | —— |
| Huel Trumpet. G. | 86 | 53 | Moyle. |
| Botallack. G. - | 115 | 72 | Barham. |
| Ting Tang. S. - | 117 | 65 | Fox. |
| Beer Alston, - | 120 | 66.5 | —— |
| Trumpet. G. - | 128 | 65 | Moyle. |
| Chacewater Mine. S. | 128 | 68 | Fox. |
| | 128 | 75 | —— |
| Huel Vor, - | 131 | 70 | Forbes. |
| Poldice, - | 144 | 78 | Fox. |
| | 144 | 80 | —— |
| Consolidated, - | 150 | 76 | —— |
| | 150 | 80 | —— |
| Huel Alfred, - | 155 | 67 | —— |
| | 155 | 70 | —— |
| Huel Friendship, - | 170 | 64.5 | —— |
| United Mines, - | 170 | 87 | —— |
| | 180 | 87.5 | —— |
| Stray Park, - | 200 | 72 | —— |
| | 200 | 74 | —— |
| Oatfield Mine. S. - | 236 | 82 | Moyle. |
| | 236 | 86.5 | —— |
| Dolcoath Mine. G. - | 240 | 80 | Fox. |
| | 240 | 82 | —— |

"Not only" (observes Mr Fox) "are the gushing streams at great depths generally warmer than the water or the air in the shallower parts of mines, but they are not unfrequently

* Mean Temp. of London 49°.5, Howard. The letters G and S denote the mine being in granite or slate (primitive clay.)

more so than the air which surrounds them." The truth of this assertion will be seen from the following comparison of the temperatures of air and water in various mines, and at different depths.

| Place. | Depth in fathoms. | Temperature, Air. | Temperature, Water. | Observers. |
|---|---|---|---|---|
| Little Bounds Mine, | 26 | 54.° | 54.° | Forbes. |
| | 35 | 57 | 55 | —— |
| Huel Vor, | about 40 | 57 | 57 | Barham. |
| Little Bounds, | 50 | 57 | 59 | Forbes. |
| Wellington, | 50 | 58.5 | { 57 / 58 | Fox. |
| Botallack, | 83 | 67 | 68 | Forbes. |
| Ding-dong, | 108 | 64 | 64 | —— |
| Chacewater, | 128 | 76 | 75 | Fox. |
| | 128 | 74 | 68 | —— |
| Huel Vor, | 140 | 66 | 66 | Forbes. |
| Huel Abraham, | 140 | 70.5 | 73.5 | Fox. |
| | 200 | 78 | 78.5 | —— |
| Stray Park, | 200 | 71 | { 72 / 74 | —— |
| Dolcoath, | 240 | 80 | { 80 / 82 | —— |

It is admitted by all parties, that the temperature of such parts of mines as are wrought by many men without a free circulation of air, is somewhat above that of the water, and of the air in properly ventilated stations, excepting, perhaps, at or near the bottom of deep mines, notwithstanding the influence which the copious ascent of vapour constantly obtaining must exert in diminishing the temperature of the lower portions, and elevating that of the shallow ones. On examining the directions of the aerial currents in 25 of the principal shafts of Dolcoath mine, Mr Rule found them to be descending in 13, and ascending in the others. But a change in the direction of the wind reversed that of the currents in some of the shafts, and other parts of the mine. Having been favoured with a sight of some of Mr Fox's communications to a scientific friend on this subject, I am permitted to make some interesting extracts relative to the influence of the seasons on the temperature at considerable depths, &c. In Fig 8. Plate II. which refers to Dolcoath mine*, A is the bottom of the engine shaft, 235 fathoms deep; B,C the deepest galleries or levels on the course of the vein at 230 fathoms deep; D E galleries 220 fathoms deep on the same vein. A great portion of the water finds its way to A, whence it is pumped by a steam-engine, the quantity discharged at the pump head in 24 hours being estimated at 500,000 gallons. At *a*, a stream at the temperature of 82° issued, and at *e*, a smaller one at 78°, the air near A being at 80°. These results were obtained at intervals of some years. A hole, three feet in depth, was made at *o* in the deepest level, 15 fathoms from the engine shaft. It was usually quite dry, and for some years no men had been employed nearer to it than at A. In this hole was inserted the bulb of a thermometer, four feet in length, the space round the lower extremity of the instrument being carefully filled with clay. The persons employed below DE were usually two, and occasionally three at a time, on an average say $2\frac{1}{4}$ constantly. In DE there were four or five at a time.

| | | | | |
|---|---|---|---|---|
| In the galleries, | 10 | fathoms higher up, | 10 | men at a time, |
| Do. | 10 | do. | 14 | do. |
| Do. | 10 | do. | 14 | do. |

The total number of men was 360, but as each worked only six hours at a time, say, equal to about 100 constantly in the mine.

The thermometer, which was placed at *o* in January 1821, being taken up in September 1822, did not seem to be affected by the seasons; but the influx of water into the gallery, which, in consequence of the stoppage of the machinery, sometimes took place, caused the mercury to rise a little, to the extent of 1° or 1.°5, the observations being made as soon as the station became again accessible. At other times the temperature was 75° to 75.°5. A thermometer, buried eight inches in the rock, at different stations, in many of the superior galleries of this mine, that nearest to the surface being 100 fathoms deep, indicated temperatures varying, according to the depth, from

* The experiments here detailed were made before the shaft was sunk so deep as 240 fathoms, mentioned in the preceding tables.

57.°5 to 70°. The surface of this mine is about 62 fathoms above the level of the sea, the deepest workings being in granite, and those nearer the surface in clay-slate. The Treskerby mine is worked under circumstances of strata and elevation very similar to Dolcoath. In December 1819, the temperature at the surface being 50°, those of two streams proceeding from the opposite extremities of the deepest gallery, 149 fathoms below the surface, were 72° and 76°. The temperatures of these streams were precisely the same in January 1820, that at the surface then being 30°. In September 1820, the temperatures of the streams were respectively 73° and 76°, the air at the surface being at 67°. The galleries nearest to the surface are almost universally more extended than those at great depths, consequently affording space for the employment of a greater number of labourers; and this being invariably the case, were the high temperatures prevailing in mines due to their presence, the shallower levels would be much warmer than those at considerable distances beneath. Moreover, the tin, copper, and other veins, as well as the arrangement of stratification in Cornwall, approach nearly to a perpendicular direction. As a consequence, the water from the surface and superior parts of mines descends to the inferior excavations. Thus every mine drains the neighbouring district to a considerable extent, not unfrequently to a distance of two, three, or even more fathoms in length for every fathom in depth. Hence it would seem that the temperature of streams, when gushing from the rock, is probably below that of the earth at that depth. In opposition to the facts and arguments in favour of an internal terrestrial heat, considerable stress has been laid by Mr Moyle on the comparatively low temperature of the water accumulated in abandoned deep mines. The substance of the greater number of observations on this division of the subject is included in the following table :—

| Place. | Depth in fathoms. | Temp. | Observers. |
| --- | --- | --- | --- |
| Alverton, (well,) - | Surface. | 55.5° | Dr Davy. |
| Huel Maid Mine, - | | 55 | —— |
| Marazion, (well,) - | | 54 | —— |
| Huel Fortune Mine, | | 55.5 | —— |

| Place. | Depth in fathoms. | Temp. | Observers. |
|---|---|---|---|
| Huel Fortune Mine, another shaft, | | 56° | —— |
| Herland, - | | 53 | Moyle. |
| ——— another shaft, | | 54 * | —— |
| Huel Rose, - | 10 | 53.5 | —— |
| Trevenen, - - | 14 | 52 | —— |
| Huel Alfred, - | 18 | 56 | —— |
| Relistian, - | 25 | 55 | —— |
| | 50 | | —— |
| Huel Rose, - | 54 | 53 | —— |
| Little Bounds Mine, | 52 | 55 | Forbes. |
| Botallock, - | 65 | 62 | —— |
| Ding Dong, - | 74 | 52.5 | —— |
| Huel Alfred, - | 112 | 56 | Moyle. |
| Huel Vor, - - | 115 | 64 | Forbes. |
| Tresaveax, - | 100 | 60 | Fox. |
| Gunnis Lake, - | 125 | 57 | —— |
| United Mines, - | 170 | 80 | —— |
| Oatfield, - - | 182 | 67 | Moyle. |

That the veins are much more pervious to the passage of water than the contiguous strata is a notorious fact; and I have before alluded to the greater extent of the superior than of the inferior galleries. It therefore appears that the greater portion of water coming from above is probably intercepted by the superior galleries, and passing through them to the shafts, if of a relatively low temperature, descends. It may be presumed that the water in the lower levels, being comparatively stationary, exerts but little influence on that in the shafts; of which, however, it appears that we might expect to find the temperature invariable at all depths. But we must not forget that the mean temperature of wells, and at the surface in stopped mines, is somewhat more than five degrees above the mean of the climate; and that in some mines, in the lower levels of which operations have been suspended, and accumulations of water permitted, the temperature is *very far above* 49.°86, as reference to the preceding table affords ample evidence. On this part of the question Mr Fox remarks, "the

* The water at 10, 20, 40, and 60, fathoms deep was also at 54.°

effects are doubtless variously modified in different places by the nature and thickness of the strata, and the more or less pervious state of the veins; besides, the workings communicating with the shafts are in some mines much more open and excavated than in others; and, considering all these circumstances, we might anticipate that the results of experiments on the temperature of water in stopped mines must be discordant and inconclusive as to the actual heat of the earth itself, however strongly they may corroborate the truth of its existence." In connection with this part of the subject it may be mentioned, that the stopping of one of the engines at the united mines permitted the accumulation of water in the two deepest galleries, viz. 190 and 200 fathoms deep, which continued for two days. Immediately on its being pumped out, and before the mines had resumed their operations, the temperature of the upper one was 87°.5 and of the lower 88°. The observations being repeated some days after the workmen had recommenced operations, the temperature was found to have *rather diminished* than otherwise. The same conclusion, resulting from various views of the subject, seems to put the fact beyond dispute, although it does not appear that the ratio of increase can be so readily determined. Notwithstanding some few insulated facts had been previously noticed by other philosophers, it will be seen from the preceding observations that to Mr Fox we are indebted for the first annunciation of the general law, as well as for a great portion of the information which has now so satisfactorily established its accuracy. That the matter was thus correctly viewed on the continent, he had, in February 1820, the satisfaction of learning from an eminent French philosopher, who observes, that "Baron Humboldt, who had previously noticed similar facts in the mines of Mexico, and *who then attributed the augmented temperature to accidental causes*, since the experiments of Mr Fox have been communicated to him, unites in the opinion, that this increase of heat in the interior of the earth is a general fact, and not dependent on local circumstances. He wished that the experiments should be multiplied, and that, by keeping them as free as possible from all disturbing influences, the question might be placed beyond doubt." The influence of this important principle seems to affect the preservation of vegetable life, by protecting the roots of plants from the rigour of the winter's cold, and in summer preventing their being parched by the intensity of solar heat. That evaporation obtains at all times, even in the severity of winter, may be readily ascertained by the inversion of a glass over a spot from which the frozen earth has been removed. The conversion of this vapour (which, by parting with its caloric, must mitigate the severity of the cold to plants,) must also materially operate on the atmosphere. Indeed, many meteorological phenomena seem intimately connected with this subject. The condensation of vapour in hills and elevated stations must be the principal, if not the entire, cause of the formation of springs.

The source of this moisture is another object well deserving attention. It does not seem probable that the atmosphere can be the only one. Some of Mr Fox's discoveries seem to afford us light in the inquiry. He observes that the relative purity of the water seems to have no reference to the temperature or depth of the mines. The deposit from the water from Huel Abraham and Dolcoath, the two deepest mines in Cornwall, did not in either case exceed two grains from a pint, whilst that from the consolidated mines yielded, from a like quantity of liquid, ten grains; from Huel Unity, 16 grains; from one shaft in Poldice, 19 grains; and from another, 92 grains. The salts most abundantly afforded by evaporation are the chlorides, especially that of calcium, although Mr Fox has frequently detected the presence of chloride of sodium, particularly in the water from the united and consolidated mines, Huel Unity and Poldice. Of the 92 grains from the latter, 52 grains were of the chlorides of calcium and magnium, 24 grains of the chloride of sodium, the remainder being muriatic acid, with iron and sulphate of lime. The water from another part of the same mine afforded, by the evaporation of the same measure of water, 5.5 grains of the chloride of calcium. "All these mines are in killas, or primitive clay-slate, and are several miles from the sea." From such facts may it not with propriety be inferred, "that the sea-water penetrates into the fissures of the earth, and may, in a greater or less degree, assist in supplying the loss of moisture by evaporation ?" Mr Fox is disposed to think that the isothermal lines within the earth may in some measure coincide with the form of its surface.

Another point to which attention has been directed is the relative temperatures of the metalliferous veins, and the adjacent strata at some distance from them. Of these observations the following table contains the substance.

| Mine. | Depth. | Distance from the veins at which observations were made in the strata | Temperature.* Vein. | Temperature.* Strata. | Observers. |
|---|---|---|---|---|---|
| Little Bounds, | 52 | Unoticed. | 54° *w* / 56 *w* | 54° *w* | Forbes. |
| Huel Neptune, | 49 | ——— | 55 *w* | 54 *w* | —— |
| Ting Tang, | 80 / 90 | 30 fathoms. | 64 *e* | 64 *e* | Fox. |
| | 110 | ——— | 68 *e* | | |
| Huel Squire, | 110 | unnoticed. | 72 *a* | 69 *a* | —— |
| Chacewater, | 110 | ——— | 82 *e* | 79 *a* | —— |
| Treskerby, | 120 | ——— | 72 *a* | 66 *a* | —— |
| Dolcoath, | 130 | 60 fathoms. | 63 *e* | 62 *e* | —— |
| United Mines, | 140 | 9 ——— | 67 *w* | 67 *e* | —— |
| | 160 | 8 ——— | 75 *e* | 69 *e* | —— |

An obvious inference is, that the temperature of veins is generally rather superior to that of the contiguous strata. The subject of the temperature of the interior of the earth has led to many ingenious theories of its structure and relations. Among these, that which supposes the central regions to exist in a liquid state, subject to the action of a very elevated heat, seems to be gaining ground. Were the high temperatures observed due to such agency, it would naturally be expected that the closer the texture and the better the conducting power of any given substance, the greater would be the elevation of temperature observed therein. But *cæteris paribus*, our granite and porphyritic rocks, although far surpassing clay-slate and metalliferous veins in both these circumstances, are generally found at a lower temperature than any other of our strata or formations. Mr Fox remarks, that the high temperature "may

* Of the letters, *a* signifies that the experiment was in the air, *e* the earth, and *w* the water.

perhaps be attributed to the circulation of water and vapour ascending from greater depths; and if this be the case, it may be difficult to arrive at any just notion of the extent of the progressive increase of the heat in the interior of the earth, from observations made at any depth now accessible." On the exciting cause of the caloric requisite for the formation of vapour, &c. it would, in the present state of the investigation, be premature to speculate. That electricity may be an active agent does not seem improbable; and to a detail of some facts in support of this opinion I may, on some future occasion, allow myself the pleasure of returning.

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## Art. X.—*Physical Notices of the Bay of Naples.* By James D. Forbes, Esq. Communicated by the Author.

### No. III.—*On the District of Pausilipo and the Lago d'Agnano.*

> "Pausilypi colles, et candida Mergellina,
> Et myrteta sacris consita littoribus
> Me tibi, terra beata, dico ——————"
>
> Flaminius.

We have already noticed the great active volcano which forms the leading feature of the Bay of Naples, and the cities which fell a prey to its early ravages. Proceeding now westward, according to our plan in this paper, we shall consider the most prominent features between the hill of Pausilipo and the extinct crater of Astroni, including the lake Agnano and its interesting environs. The succeeding number of these notices I intend to devote to the Solfatara; the one following to the temple of Serapis at Pozzuoli, and the curious natural facts which it illustrates, and which have so long perplexed naturalists: I intend next to proceed with an account of the Monte Nuovo, Lake Avernus and its vicinity; and lastly, to add a notice upon the Islands of Procida and Ischia. We may then in a concluding paper, take a view of the ground we have passed over, and the general conclusions which may be drawn from a survey of this interesting district.

In the meantime, we proceed with the objects of our present inquiry. Immediately to the west of the town of Naples lies the fertile and beautiful hill of Pausilipo*, a ridge of volcanic tufa, somewhat steep on both sides, but exhibiting on the top a flat appearance and saddle-shaped stratification. Nothing of its kind can be more truly delightful, than the drive along the Strada Nuova, or new road formed by Murat, the late Governor of Naples. It keeps nearly at an equal distance from the sea, which washes the base of the hill as it gradually declines to the southward, and, acting upon the soft rock, of which it is composed, has rendered it every where somewhat precipitous, and here and there beautifully picturesque, from the fantastic masses it has detached from the coast, and the water-worn caves and arches through which here and there it rolls. The trifling tides do not prevent the high luxuriance of all vegetable nature from descending almost to the water; every flat patch is assiduously cultivated for the vine, and the richest wild shrubs clothe every rock and crevice. The aloe especially, throws out its long and thorny leaves, either where it has naturally taken root, or where it has been planted to decorate and diversify the villas and casinos of the Neapolitans, which thickly spread over the banks and dells of this favoured promontory. The glowing scene in the foreground, with all the retiring bays and salient points of Pausilipo, contrast finely with the majestic summit of Vesuvius rising across the bay, and the more distant ridge of the Apennines, stretching in perspective from the central part of Italy to their bold termination in Minerva's Point. Nearer on the left, the busy and populous city of Naples, spread in glorious array upon the theatric station which it occupies, and crowned behind by the imposing batteries of the castle St Elmo, which rise upon the summit of the hill behind. Dead must that soul be to all the magnificence and luxuriance of nature, which has not caught a glow of enthusiasm upon the shores of Pausilipo!

* This name is derived from the ancient one of a Villa of Vedius Pollio on this promontory, which he called Pausilypum from its *care dispelling* beauty and seclusion; (παυω and λυπος) and all will to this day admit the propriety of the appellation. It is now written Pausilipo, Pausilippo, or sometimes Posillipo. I have here adopted the first as being more consonant to the original orthography, though Pausilypo would be more strictly accurate.

The country houses which we have already mentioned are curiously contrasted with some dwellings of the lower classes, which appear on the mountain side of the road. They are excavated from the mass of soft and homogeneous tufa, with the proper accompaniments of doors, windows, and chimneys. An amusing example of this will be recollected by those who have visited the "Villa Barbaia," which once belonged to the king of Naples, and where the excavations are extremely fantastic. The extreme facility with which this stone is cut has given rise to extraordinary subterranean quarries, by which the internal constitution of the hill is interestingly shown, as we shall presently have occasion to notice.

As we continue along the Strada Nuova several sections meet the eye, through which the road passes, too remarkable not to attract the most superficial observer. At the west extremity of the ridge, where it abruptly falls into the plain below, a cut of considerable depth has been made. Here we have an admirable contrast of the superficial strata to those constituting the centre of the tufaceous mass, and which is elsewhere exposed. The layers succeed each other with great regularity and sharpness. They are composed of various alternating volcanic conglomerates, in which the common pale yellow tufa predominates, replaced by pumiceous compounds of various shades of colour, some of which are so friable as to require to have the space their thin stratum occupied built up with stone and lime, to support the more consistent formations, as the angle of section on both sides of the road is very steep. The whole presents a very curious appearance. The form of the stratification deserves particular remark. It is by no means uniform, but bears the most irresistible marks of diluvial deposition. In most cases, it is gently undulating, not unlike the newer deposits of sand which so abundantly occur near Edinburgh, but usually still more irregular. Superimposed on this stratification, there often occurs a perfectly horizontal one, filling up the basins caused by the undulating surface with dark, thin, and friable deposits. The whole general line of the strata is conformable to the shape of the hill, as far as I have observed, but the thin depositions just described occur only on the flatter part, and seem awanting at the sides of the ridge which I have already remarked descend abruptly to the plains. This is more particularly the case at the western side of the hill, where it is so remarkably steep that the road has been carried down by a long oblique traverse, where the soft rock is obliged to be so steeply cut away, that every winter accidents happen by the rains.

This steep and elevated portion of Pausilipo stretches boldly into the sea, and the contorted chasms formed in its shores by the waves afford many picturesque subjects for the painter. A little out to sea, in the line of the ridge, and obviously separated from it either by some convulsion of nature or the slow operation of time, rises the small island of Nisida, and between it and the shore a fragment of rock on which a Lazaretto is built. The island is most picturesquely green, and has the appearance from the land of perpetual spring. It is interesting in a geological view, from the perfect remains of a volcanic crater it displays, filled with water, and communicating by a breach to the south-west with the sea: it forms the harbour, and is named Porta Pavone. Nisida is composed of tufas, apparently similar to those of Pausilipo, and detached lavas also occur, which may be referred to the eruptions of the extinct crater. A beautiful and characteristic view of the harbour is given in Hamilton's *Campi Phlegræi*, Plate xxii.

By the fortuitous excavation of the grotto of Pausilipo, a subterranean passage of near half a mile through the heart of the hill, we have the rare advantage of a geological section at a great depth below the surface of the earth. Though in this instance it happens that there is almost no variety to be exhibited in the nature of the rock, yet we could not otherwise have been assured of this interesting fact. The darkness of the grotto renders it difficult to examine the structure of the mountain; but Spallanzani observes,* that, when viewed by the morning sun, when it penetrates the grotto, the tufa is distinctly stratified, and evidently by the action of water,—a fact now rendered far more distinct by the frequent alternations in the sections on the upper part of the hill. What I believe has sometimes been taken for stratification, is nothing else than the grating of the wheels of vehicles against the sides in

* Travels, i. 43.

former times before the road was lowered, yet there seems no doubt that some divisions of strata do occur, as is seen at the east end before entering the lofty arch.* At either end are vast quarries, and, as far as the light penetrates, we have an opportunity of admiring the lofty faces of homogeneous tufa which are exposed. In making these excavations, several interesting objects have been discovered, particularly wood and shells; the latter I have noticed in Hamilton's *Campi Phlegræi*, since writing the last of these notices, † are actually the shells of fish inhabiting the Bay of Naples at present, particularly oysters,—a very curious fact, which is confirmed by Mr Scrope in a paper read before the Geological Society ‡.

The history of this singular work of art mounts to the earliest ages of tradition. It appears originally to have been formed by the Cimmerians, the mysterious original inhabitants of the district, and afterwards employed, probably enlarged, by the Romans. By them it was named the "Crypta Puteolana," and is several times mentioned by classic authors §. Its total length is 2322 English feet, or not far from half a mile; it is 22 feet wide; and its height is generally from 70 to 90, but at the west end only 10. This arises from the cut towards the opposite extremity, made in modern times to render the rise uniform, and was performed by Alphonso I. of Arragon, ‖ by whom the shafts from above, in one or two places which had existed in ancient times, as we learn from Strabo, ¶ were cleared out for the admission of air, which is very necessary, as even now the central part of the grotto is oppressively ill ventilated. It is well known that towards the end of October, the sun, when nearly setting, shines directly through the grotto. Assuming then his declination = 13° S. on the 26th, his azimuth, when 5° above the horizon, which we may allow partly for the elevation of the west end of the grotto, will be 69° W: the direction, therefore, of this passage is very nearly W. S. W. With regard to its primæval use,

* Hamilton, Plate xvi. † Last Number of this *Journal*, p. 126, note.

‡ *Philosophical Magazine*, New Series, i. 388.

§ Seneca, Ep. 38. Strabo, lib. iii. Petronius Arbiter.

‖ De Jorio, *Guida di Pozzuoli*. p. 19.

¶ Cluverius, *Italia Antiqua*, vol. ii. folio.

it would be bold to give an opinion; but till the formation of Murat's new road, it formed the only communication between Naples and Pozzuoli and its neighbourhood, and is still the shortest. At the end next Naples, raised far above the road, by its subsequent reduction of level, stands the sepulchral monument dedicated by the voice of tradition, and by the opinion of most modern literati to the shade of Virgil. I dare only mention its existence, for to enter on the proofs of its authenticity even in the slightest degree would carry me too far from the object of these pages. *

Following up the ridge of Pausilipo further from the sea, we find it divide into two circular sweeps, one of which forms the theatrical back-ground upon which part of the town of Naples stands, and is surrounded by the Castle of St Elmo, while the other, stretching westward, terminates in the hill on which stands the Convent of the Camaldoli di Napoli, which, by a barometrical measurement by Saussure is 1419.5 French feet above the sea, equal to 1513.0 English, which is the highest point to which the tufaceous formation rises in this neighbourhood. The ride from Naples is truly delightful, the ascent of the hill being gradual when we keep the summit of the ridge, which is abundantly clothed with olive, ilex, and copse-wood of the chestnut, which is grown here for fire-wood. When we reach the summit, all labour taken in the ascent is amply repaid by the surprising extent and interest of the prospect; for here we find ourselves in the midst of the Phlegræan fields, which, from the height of the eye, lie pictured below us in all their true relations,

* In connection with these remarks on the Grotto of Pausilipo, I cannot help mentioning a discovery which is *said* to have been made in the part of the hill which I described as descending very rapidly a short way from the sea, and near the Island of Nisida. On the left hand of the road where the hill is abrupt, the opening of a passage into it is observed. This was explored a few years ago, and is little higher and broader than a man. The party, headed by a man of rank at Naples, penetrated a long way with torches, till they came to a chamber containing a fine spring of water, and seats in the rock, with bones of large animals strewed about. They explored the remainder of the passage for a long way, and at last came out at the other side of the hill. This I learned from a Neapolitan, who said he had been of the party; but I cannot vouch for its accuracy.

magnitudes, and bearings. To gain a true idea of the arrangements of this wonderful district, nothing can be more proper than a visit to the Camaldoli: from it we have a view of at least fifty miles in one direction only, that of Terracina. In constitution, the ground over which we pass to this convent, resembles much the upper strata of the hill of Pausilipo, and is particularly pumiceous, the beds varying in colour, but little in composition, and invariably friable and harsh to the feel, showing few of the characters of the tufa, which probably constitutes a great part of its mass, as it does of that part of the ridge with which it is connected, and indeed, it is seen to alternate with the pumiceous strata; and the latter are found divided by others, in which clay and sand are mixed with the pumice. Indeed, I have remarked in my memoranda of this interesting excursion, that part of the beds resemble so strongly simple formations of alluvium, that, to an unpractised eye, it requires the sense of touch to prove that the materials are harsh volcanic cinders, which so remarkably assume the characters of alluvial deposits. This marks unequivocally the true origin of these tufaceous mountains; and it may be proper here to say a word or two on the subject, though some time hence, when treating of the theoretical conclusions to be drawn from the physical appearances of the Bay of Naples, we shall have an opportunity of considering it with more connection.

Enough has been already said in this and my last paper, to show how much facts tend to prove, in the vicinity of Naples, that the volcanic agency has been combined in these formations with all the peculiarity of subaqueous deposits. Indeed this is one of the very few points on which geologists are pretty generally agreed, and Nature has seldom written the history of her revolutions in former ages in more legible characters. When I first viewed these formations myself, and endeavoured, though with the eye of a novice, to compare them with those in the Campagna di Roma, before I was initiated into the doctrines of more profound observers who had preceded me, by a separate track I gained the same general conclusions, and saw spread before me in the fields of volcanic fire, proofs that nature had performed these great acts of creative energy by submarine eruptions. The fact, that the ocean once washed the foot of the Apennines at Capua, since suggested by Scrope, appeared then to me the inevitable conclusion from the state of facts; and that Vesuvius has gradually raised itself by successive accumulations to its present character, and proudly surveys the regions of its own creation, is a simple induction from an attentive view of the physiognomy of the country. The minutiæ of those localities under our present review, are best calculated to explain plausibly the mode of formation, though in this I shall be disposed not to go so far as Breislak has done, and even to dissent somewhat from his doctrines. This geologist was an indefatigable crater hunter, and he has often strengthened most palpably the features of his maps, to writhe the most gentle and detached rising grounds into portions of the boundaries of vast basins. This is most conspicuous in his Plan Physique de Rome,* as may be seen by comparing it with any good map of the city, where antiquaries, for the honour of the seven hills, are not usually averse to mark strongly the inequalities of the surface. About 30 craters have been put down by Breislak between Naples and the point of Misenum, and he freely acknowledges the strength of imagination necessary to decypher some of them. He even admits the preconceptions which aided him in finding a crater in every group of hills, however large, distant or undefined. But, according to my idea of subaqueous formation, there is no occasion for the number of craters he supposes, and perhaps we should be nearer the truth were we to reduce the number to a dozen. The points of emission of fluid tufa under water would naturally be *below the hills formed by it;* the hollow of a crater is caused by the eruption of the materials which once filled it, into the air, and the emission of streams of lava from its sides; but this would not be the mode of action under the sea. If the volcanic materials were ejected through extended fissures formed by the elastic force beneath, and afterwards modified by the action of the waves, we shall have the exact result which the hill of Pausilipo, for instance, would seem to afford. This will account at once for the varying directions and obvious ramifications of the hills which Breislak

* See *Campanie,* tom. ii. and Daubeny *on Volcanos.*

sought for only in aboriginal craters, since they were not readily accounted for by the abrading influence of the water. Craters no doubt may be found prior to the retirement of the waters, according to this theory; but they are extremely broken down, and low, and imperfect in their outline. Such we may conceive to have been the case with the basin in which the Lake of Agnano lies, and perhaps that of Avernus; but as to the scarped craters of Astroni, Solfatara, &c. I believe I am not singular in thinking that they owe their present features to eruptions subsequent to the elevation of this district, or the lowering of the level of the water; which action is most probable I shall not here consider. It is at least certain that Solfatara was in eruption in the 12th century, which proves it in that particular.

Respecting the hill of Pausilipo, of the features of which I have given some account, it seems especially to answer to the supposed course of nature above proposed. Its interior solidity answers well to the supposition that it was the substratum of a great elevated fluid mass, while the more refined and pumiceous substances are disposed in strata on the top. In as far as these strata follow the shape of the hill, we may be disposed to admit that they were first deposited, and the elevation of the subjacent mass then took place; and we may observe, that the features of the hill quite unfit it for a portion of the wall of a great crater extending to Agnano, as Breislak supposes. He has completely perverted the form of the promontory, by giving it a turn to the westward; instead of which, in reality, its line of direction makes it tend to the island of Nisida; and the small hill of Sta. Teresa, which he enlists as a fragment of this degraded crater, is far liker a small regular crater of itself. Besides all this, the hill of Pausilipo will not bear the test of the most established rules, as to the true designation of a volcanic crater. Daubeny judiciously remarks, I think from Von Buch, that a true crater has all the lines of its stratification directed to the apex of the cone which would be formed, were the hill complete; but we have seen how totally inconsistent the spot before us is with such a supposition, being both internally and externally of a flattish saddle-shaped stratification. With these few remarks, which will convey my general ideas of submarine volcanos, I shall at present content myself, hoping at a future time to recur to the subject in a more general form.*

Resuming our account of the hill of the Camaldoli Convent, we must notice one fact of importance. Mr Scrope remarks, that a bed of graystone appears beneath the tufa to the N. W. of the hill, though, from the very short abstract I have seen of his paper,† the description is not very satisfactory. It would appear, however, to be the same stratum as Breislak particularly notices in this direction under the name of Piperino.‡ The want of consistent geological nomenclature, especially in what relates to the volcanic formations, is found to be a great drawback in every inquiry; but by a combination of the two descriptions, we may arrive at some pretty distinct conclusions on the subject before us. Mr Scrope elsewhere states,§ that graystone, according to him, is equivalent to the trachytes of most authors; and from this gentleman's intimate acquaintance with the most characteristic trachytes of the extinct volcanos of Auvergne, we may feel confidence in his designation of this rock wherever he meets with it. We therefore consider it as a rough porphyritic rock, composed almost entirely of felspar, and once in a state of fusion. Mr Scrope particularly mentions, as occurring in the bed beneath the tufa of the Camaldoli, " a singular concretionary separation of the augitic from the felspathose parts, the former appearing as lenticular patches in a base consisting of the latter." Breislak describes the base of the rock as whitish, and containing crystals of mica and specular iron; and he draws some curious inferences from the form of the cavities interspersed through it, which he says contain basaltic crystals, sometimes resembling pitch-stone, which undoubtedly correspond to the concretionary augite of Scrope. The shape of the cavities he describes

* I have not here touched on the more general and abstract facts, which lead us to the conclusion, that the sea had formerly a higher level, the marks it has left on the rocks of Capri, and this limestone coast of Italy, and the occurrence of shells in the tufas.

† *Phil. Mag.* New Series, i. 388.

‡ *Campanie*, tom. ii. p. 41, &c.

§ See Memoir on the Ponza Isles, *Geol. Trans.* New Series, vol. ii.

as lenticular, having the greater axes all parallel, and coinciding with the direction in which the current, when fluid, (of which he entertains no doubt,) must have progressed. Dr Thompson considered this trachyte (if we may so call it) intermediate between true lavas and the tufaceous formations; for it must be distinguished, as Breislak remarks, from the piperino of Rome and Albano, its name being nearly alike; but these being merely species of tufa exhibiting no marks of fusion like the mass before us. Its situation, too, I consider very interesting, since, as it is overlaid by the ordinary tufa of Pausilipo, it must either have had a prior existence to that substance, and appeared while the waters of the ocean retained their higher relative level, or it must have been subsequently elevated from below, like our trap rocks, which in some points of view must be considered as the most probable hypothesis, since Mr Scrope has failed in detecting any peculiar geognostical position in trachyte, in a neighbouring district to that we are now considering. *

Let us now descend from the elevated ridge to the basin in which Lake Agnano is contained at the foot of the steep southern descent of the hill of the Camaldoli; and we must here introduce a remark or two upon the origin and history of this curious lake. After consulting all the authorities of which I am possessed on this subject, and attentively considering the state of the localities as I myself observed them, I feel unable to come to any decisive opinion on the subject. Certain it is that this lake is never mentioned by classic authors, and is first noticed by some writers of the middle ages, under the name of Lacus Anclanus, supposed to have been so called from a town named Angulanum, which is thought to have stood on its banks, and which some still absurdly maintain is to be seen in ruins under water, † a fable not uncommon in its nature, and which, I believe, is entirely refuted. The question which remains to be solved is, why this lake, if it existed in the time of the Romans, is never mentioned by their authors, in a region, the other features

* *Geological Transactions,—ubi. sup.*

† Ferrari, *Guida di Napoli*, and Breislak, ii. 48.

of which we are so well acquainted with through their writings; and if it did not then exist, what was its origin? The explanations which have been given may be reduced to two classes; that the Lake Agnano was nothing else anciently than the fish-pond of Lucullus, or that it was formed by a volcanic subsidence in the middle ages. The former opinion is not without plausibility, and is strongly upheld by Eustace.* Cluverius seems also disposed to it. It is universally believed that Lucullus had a villa on this spot, and ruins are shown on the banks of the Lake, which may very probably have formed part of it. We are told by Pliny that the ponds cost more than the villa itself, which gives us a surprising idea of their magnitude; and we are likewise told that there was a communication between them and the sea. An artificial cut through a portion of the hills which bound the Lake I have certainly observed, and considered it in this view; but as things stand at present, it seems unlikely that a low enough level can exist for that purpose, but it is by no means impossible, and would be worth a trial. I had intended to have made one, but the accident which occurred to the barometer which I destined for the measurement of Vesuvius disappointed me. Others with Breislak suppose that the Lake of Agnano owes its existence to volcanic action in the middle ages; and, as the former opinion derives most weight from historical evidence, so does the present one from its physical constitution, and I am disposed to think that the latter testimony predominates. All writers seem to agree, that the hollow in which the Lake of Agnano is situated displays the features of a true, though much degraded, volcanic crater, and forms one of a class of objects quite peculiar, of which we have undoubted examples in Lake Avernus, and the Lakes of Albano and Nemi. I have ascertained, too, by examination, that there is neither introduction or emission of water by streams in the example before us, which is a frequent character of volcanic lakes, and furnishes a presumption that Lucullus could not have employed as a fish-pond a basin in which there is no free current, and which sometimes approaches to stagnation, for

* *Italy*, iii. 430. Leghorn Edit.

we cannot suppose that his only pond would be that of sea water; and it may pretty safely be affirmed, that no spring of pure water occurs on the banks of this lake.

But here the difficulty arises, why does this lake appear not to have existed under the Romans? Some historical and Christian writers of the period of the decline of the empire allude to the district of the Lucullan Villa, and the tower which was employed as a fortification, and retained his name; but we have not a word of the lake, which would probably have been the case, if it had been the fish-pond then fallen into a state of nature. The first mention of Anclanum was in the time of the Normans, and Mazzochi assigns the 9th century as the period of its formation; but it seems more natural, if we are to fix upon a hypothetical date, to suppose with Breislak that the eruption of the Solfatara which took place in 1198, and desolated the country round by earthquakes, shook the foundations of the valley, and made the water collect in its bottom. The appearances of the country round well correspond with the idea of volcanic action at no great depth, when we recollect that the Grotto Del Cane, the vapour baths of San Germano, and the hot spring of La Pisciarella occur on its banks. Agnano as it exists at present is a very agreeable spot, the hills around which in some places rise abruptly from the shore being covered with copsewood. The water of the lake is dark-coloured, but not stagnant, though, with that thoughtlessness of consequences which so much characterizes the inhabitants of this favoured climate, the practice of steeping flax was formerly carried on here to such an extent in the hot season, as to render the air absolutely pestilential, and compel government to put a stop to the practice.

In one of my visits to Agnano, (December 7th, 1826,) my attention was forcibly directed to the peculiar colour of the water of the lake near its edges. A crimson matter dyed it in zones, parallel I think to the direction of the banks, and part of it was thrown up upon the reeds near the Grotto Del Cane. On examination, it had the appearance of an immense collection of minute organic bodies, all of this uniform crimson colour. I have reason to believe that this appearance continued at least till March 1827. On my return from the Continent, I observed in the number of this *Journal* for April 1827, an interesting account of a similar fact, observed on the Lake of Morat in Switzerland, in 1825, by Professor Decandolle. It appears to occur there every spring, and to last from November to March or April, which coincides very well with my account. It is then subject to many variations, disappearing in the night, and during high winds. M. Decandolle found this colouring matter to be composed of a new species of animals of the genus *Oscillatoria*, and imputes their origin to the decomposition of organic matter in its sluggish waters. Such an explanation will apply equally to the Lake Agnano. These animals are described as less than $\frac{1}{4000}$ of an inch in diameter, and have received the name of *Oscillatoria rubescens*. When kept in bottles for twenty-four hours they exhaled a fetid odour; but the specimens I took from Agnano, though dried merely in paper, emitted none, and even now, when macerated, have no smell whatever. The appearance of the matter in a dry state is compact, homogeneous, and brittle, of a reddish brown colour. I shall be happy to furnish any one interested in the subject with part of the minute quantity I possess of this substance, for the purpose of microscopic examination.

Some authors have particularly described bubbles of air which rise through the water of Lake Agnano. Hamilton says this is so strong near the Grotto del Cane as to give the appearance of ebullition,—a statement which is confirmed by Ferrari, the Neapolitan topographer, who says it is observed when the lake is full. Breislak denies it, and supposes the mistake to have risen from the motion of insects; but there seems no reason to doubt that so natural a phenomenon should occur, as it is nothing but aerial fluids which we know take their rise under ground here, whether simply carbonic or sulphureous, ascending through the fine felspathose and augitic sand which composes the bottom of the Lake Agnano; and from the porous nature of the soil, nothing can be more easy to imagine than that when the water assumes a higher level than usual, a portion of it is imbibed, and gas developed. This will explain the different relations of travellers on the subject.

At the south-east edge of the lake occurs the small emissary of carbonic acid gas, which has so long been vaguely or inaccurately treated of, named the "Grotto del Cane;" and the reader need not fear that I shall trouble him with a long drawn narration of this simple phenomenon. Ever since the description by Pliny of these "Charoneæ Scorbes" and "Spiracula Ditis *, travellers seem to have tried to outvie one another in their description of the wonders of this little spot. Spallanzani exhausts almost as much space upon it as on Vesuvius; and in all the topographical works it receives its meed of admiration or mystery. Professor Vairo of Naples long ago asserted, that in the Grotto del Cane, the muscular fibres of animals have no irritability; that there is no electricity; that the loadstone draws no iron; and that the needle is remarkably declining †;—absurdities, to refute which, if they are worth refutation, it is sufficient to consult the decisive experiments of Breislak ‡. Without wasting time upon past errors, we may collect in a few words the principal facts ascertained regarding this grotto, and we may notice in the first place, that it is certainly excavated from Pozzuolana, and not out of lava, as Ferber asserts §. It is about ten feet long and four broad, and the height of the carbonic acid vapour at a mean, eight Paris inches. Its temperature is considered by Breislak as 3° R. above that of the air; but Mr Adolphus Murray found no difference; and I am disposed to consider the heat as accidental, for which the great want of circulation in the cavern, and the quantity of combustibles, burnt there by way of experiment, will pretty well account. The composition of the mephitic vapour may be taken as follows: Oxygen 10 per cent.; carbonic acid 40 per cent.; azote 50 per cent. It appears to contain no sulphureous matter.

The editor of the French edition of Sir William Hamilton's works ‖, who has subjoined numerous notes, justly remarks, that one of the most surprising phenomena of the Grotto del Cane is the continuance of its exhalations during so many

* II. 93.

† Ferber's *Travels*, 177.

‡ *Campanie*, ii. 56; and in Spallanzani's *Travels*, i. 108.

§ P. 177. This author lays particular weight on this point, in which, from the testimony of Breislak and my own observation, I am convinced he is mistaken.

‖ The Abbé Giraud-Soulavie. 8vo. Paris, 1781.

ages, since not merely have Pliny and Seneca recounted the general phenomena, but Tiberius actually killed two slaves by the vapour,—an example which, if we may believe report, has been repeated in more modern times *. The explanation offered by Spallanzani seems satisfactory, that since the basis of this whole volcanic region is undoubtedly the Apennine limestone, and as we have abundant proof of the present action of heat in the immediate vicinity manifested by hot springs and sulphureous exhalations, the inference is obvious, that the carbonic acid is disengaged from the limestone, and rises through the cracks of the strata; and if we are inclined to admit that the descriptions of the ancients are too lofty for the present condition of the vapour, we may easily see how the quantity emitted may be gradually on the decline.

This opinion regarding the origin of the foul air, or Mofetta, as it is called in Italy, is strengthened by the consideration that the Grotto del Cane, though the most remarkable example in this neighbourhood, it is by no means a solitary one. Hamilton † gives us several examples, particularly of mofette appearing in spots where they had not been before known. In the excavations of Pompeii they are very abundant. I recollect one underground drain near the temple of Isis being pointed out to me as abounding with them. Similar exhalations occur at Naples and at Mount Vesuvius, the latter containing some sulphuric acid, and most baneful to vegetable as well as animal life. Those who interest themselves in the influence of gases upon the vegetable physiology would do well to notice the relations of Breislak regarding the Vesuvian mofette, which, though they are perhaps of a nature to excite incredulity, seem to be warranted by the observations and experiments of that able naturalist. He remarks, that "it is a very extraordinary phenomenon that this mephitic vapour, which destroys all vegetation, and kills in a few days trees and shrubs from the root, has no bad effect either upon olive or pear trees. It is a fact confirmed by all the cultivators of the district, and which I have sometimes verified by seeing these

* See Jorio, Pozzuoli e Contorui, 183.

† *Campi Phlegræi*, fol. Naples, i. 88.

two kinds of trees green and in full vigour in the midst of the general destruction of all other plants."*

It is to exhalations such as these, and there seem to be many more dangerous than that of the Grotto del Cane, as those which occur at Sinuessa, that we must ascribe several of the facts mentioned by the ancients, such as those Tartarean waters,—

"Quam super haud ullæ poterant impune volantes,
"Tendere iter pennis;" ———————

expressions which apply to Lake Avernus, whose very name, derived from the Greek Ἄορνος, seems to indicate the reality of the statement; but of this we shall have occasion to speak at a future period. It has been asserted that water-fowl are rarely to be seen on Lake Agnano. This, however, is a mistake. For the theory of the evolution of mephitic vapours I may refer the reader to Daubeny's work on *Volcanos*, p. 371—378.

When we advance from this lake towards the base of the Solfatara, we enter a retired glen, and, soon after passing a solitary cottage, reach a muddy rivulet, rolling in a bed full of boulders in soft volcanic strata. This is the water of La Pisciarella; and, by ascending a little way, we reach the hot spring itself, which is now covered with a small hut. Since I last published some remarks on this spring,† I have collected the observations of authors upon its temperature, which prove it to be liable to remarkable alternations. Hamilton‡ declares that he saw the thermometer in the spring rise to the boiling point, though he admits that after rain he found it much

* *Campanie*, i. 221. Daubeny (*Description of Volcanos*, 170,) tells us, that he has been assured that this paradoxical statement is not without foundation. An interesting paper on the influence of gases on plants, by Drs Turner and Christison, was published in this *Journal*, (vol. viii. 140;) but the ingenious authors have not alluded to the influence of natural exhalations. Sulphurous and muriatic acid gases, however, which they chiefly employed, are those produced by Vesuvius, and in this view the experiments are very interesting. Towards the close they mention, that different plants are very differently affected; and it would be interesting to subject the pear tree to this examination. The inquiry is well worthy of farther investigation.

† See this *Journal*, No. xiv. p. 265.

‡ *Campi Phlegræi*, folio, i. 68.

lower. Della Torre* found it to be 68° R. = 185° Fahr. From my own very careful observations, which were made in the month of December 1826, when the temperature of the air was 48°.5, the interior of the hut was 70°.5, and the warmest part of the spring 112°.5. The Abbé Giraud Soulavie† stated it so low as 101° Fahr. Humboldt, in his *Personal Narrative*,‡ states the Pisciarelli of the Lake Agnano to have a temperature of 93° Cent. = 199°.4 Fahr. At the same time there seems to be some mistake in this part of Humboldt's work; for a few pages farther on, when speaking of the hot springs of Nueva Valencia in South America, one of which has the temperature of 90°.3 Cent. = 194.5 Fahr. he considers it the warmest in the world, except that of Urijno in Japan, said to be pure water at 100° Cent. Humboldt seems to be too general in this assertion, not only in the example he himself gives of the Pisciarella, but Dr Webster ‖ has found the temperature of several springs in St Michael's, one of the Azores, to be 207°, 203°, and 200° respectively. The Pisciarella, however, probably never attains now the temperature at which Hamilton and others observed it. Breislak § notices some changes which it seems to have experienced towards the close of the last century, apparently by the falling in of the soil, which may have materially affected it. It would appear, however, to have been always very sensible to the effects of the weather, and particularly to the percolation of rain water.

The water of this spring contains sulphate of alumina, some uncombined sulphuric acid, a little sulphur, and sulphate of iron in great abundance. So predominant is the last salt, that, if the water be mixed with galls, it immediately becomes black, and by evaporation forms very tolerable writing ink, as I proved experimentally. The origin of these ingredients is easily pointed out. The alumina and vitriol it derives from the decomposed volcanic strata of the hill from which it issues, appropriately named Monte Secco; and the abundant streams of sulphuretted hydrogen gas which rise through the water, and give it the appearance of ebullition, by uniting with the

* *Storia del Vesuvio*, 4to, Napoli.

† In his notes to the French edition of Hamilton's works, 8vo, p. 445.

‡ Vol. iv. p. 171. ‖ *Edin. Phil. Journ.* vi. 308. § *Campanie*, ii. 66.

oxygen of the atmosphere, form water on the one hand, and deposit part of the sulphur, and, on the other, sulphuric acid is produced; or rather, according to Daubeny, hypo-sulphurous acid. Monte Secco forms the eastern boundary of the hill of the Solfatara, and will therefore come to be considered as to structure in a more general manner afterwards. I may mention, however, that its basis seems to be principally decomposed lava, which assumes a white and plastic condition, being a union of felspar and silex in a minute state of division. The vapours of the Pisciarella seem to cause the most compact lavas to exfoliate with great ease, the constituents of which, suspended in the water, are deposited, according to Breislak, in beds of clay and siliceous sinter. The range of hills of which Monte Secco forms a member, seem to have been named by the ancients Colles Leucogæi; and Pliny * mentions waters good for the eyes, as existing between Puteoli and Neapolis, under the title of Fontes Leucogæi, which some have imagined were identical with the Pisciarella; but Breislak shrewdly remarks, that, from the component parts of this spring, we should not be tempted to consider it a very salutary lotion for the eyes.†

We shall now shortly notice the last conspicuous feature of the interesting circuit to which this paper limits us. The valley, or rather basin of Astroni, lies to the north of the Lake Agnano, and between the hills of the Solfatara and the Camaldoli. It is one of the best marked extinct volcanic craters in existence, and besides, one of the most agreeable spots in the whole range of the Bay of Naples. It is a hollow in a truncated cone like a regular volcano, and its size has been variously estimated, apparently from the small attention which this delightful spot has excited, so that probably few of the visitors at Naples have ever approached it, as the guide-books rarely mention it, or leave it out altogether.

* *Nat. Hist.* lib. xxxi. 2.

† The fountains mentioned by Pliny were probably similar to those which rose in the academic villa of Cicero, and which have been recorded in verse by his freedman Tullius:—

Hinc etiam apparent lymphæ non ante repertæ,
Languida quæ infuso lumine rore levant.

Its circumference has been estimated at $2\frac{1}{2}$ *, 3 †, $4\frac{1}{2}$ ‡, and 6 miles §. We shall not probably go far wrong if we consider the *road* made round the bottom $2\frac{1}{2}$ miles, and the circumference at top 4. Its depth is very considerable, and the sides precipitous, and even overhanging. Part of the edge of the crater is cut down to facilitate the descent at one place, which is still very steep. It affords an interesting section represented by Hamilton, Plate xix. This spot must once have been the seat of continued volcanic fires at a period subsequent to the formation of the tufaceous hills below, and, I have little doubt, subsequent also to the retirement of the waters of the sea. This seems demonstrated by the absence of the degrading effects of water; and Astroni is happily placed among the surrounding eminences, to exhibit the two conditions of ancient and immemorially extinct volcanos. I give it merely as a hint, not being qualified to speak from experience on the comparison, that perhaps Astroni has a geological antiquity resembling that of the extinct volcanos of the Vivarais, beyond the memory of man, but similar in constitution to craters which have suffered recorded paroxysms, such as the Solfatara in 1198.

In conformation, this crater exhibits not merely tufa and pumiceous conglomerates, but beds of real lava. Breislak seems to say, that obsidian is to be reckoned among the productions of Astroni ‖; but I did not meet with any, and it is not usually mentioned. He also particularly notices a beautiful siliceous incrustation, which, from his description, must, I think, be fiorite. Both this substance and obsidian occur in the Island of Ischia. As we have already noticed that the walls of the crater are precipitous, so the bottom is flat and extensive, upon which rise several parasitic cones, as Scrope terms them ¶, three of which are transformed into lakes. The distinctness of these phenomena are sufficient to prove the later date of this volcanic crater. It has been asserted that there are mineral springs here which supply the lakes, particularly

* Eustace. † Breislak and Daubeny. ‡ Starke. § Hamilton.

‖ "L'interieure de ce cratere abonde en verres noirs, qu'un principe de decomposition rend très fragiles."—*Campanie*, ii. 64.

¶ See his *Considerations on Volcanos*, p. 165.

by Carletti, a modern Italian writer on this region, who so late as 1787 gave a marvellous account of their contents; but this would appear to be an absolute fiction.

In its present condition, Astroni is a richly wooded hollow, or (to use the only word which can express its form) crater, which, particularly in winter when I visited it, from the abundance of evergreens which clothe its precipices and chasms, exhibits a scene of the most romantic seclusion. Its summit is surrounded by a wall, which is rendered hardly necessary, from the barrier with which nature has furnished it; and it forms a delightful royal hunting park. Strangers are most liberally admitted; and none should neglect the opportunity of enjoying a tranquillity so unique within two or three miles of such a city as Naples. Its thickets are abundantly stocked with wild boar,—a noble animal of its kind,—which is extremely active, and shuns the approach of man. They generally feed in herds, and are the favourite objects of the royal chace in this part of Italy. A single hunting cottage does not interrupt the repose of this sequestered region; and the painter might find many delightful subjects for his pencil, in the combination of the fine foliage of majestic trees, the craggy eminences of the rudely piled lava, and the little lakes already mentioned, which serve to diversify the scene. It is interesting to reflect that the delightful scenery of Astroni was once realized in the now desolate crater of Vesuvius. Previous to 1631, for a considerable period of years, that great chasm was wooded like Astroni, and like it was stocked with wild boar, and had its miniature lakes.* It is impossible to divine whether the quiescent spot now before us may not again be disembowelled by volcanic ravages after a longer repose, but in a condition similar to the crater of Vesuvius.

We have now surveyed in sufficient detail the region which we proposed for our present consideration, and have made the circuit of several ranges of hills, which are of great interest in their constitution to the physical observer, and lead him, as I have already observed, with great ease to several remarkable conclusions. Some of these we endeavoured to draw, as connected with the theory and origin of volcanos; and when we

* See No. I. of these Notices in this *Journal*, October 1828, p. 194.

have completed the view of the Bay of Naples, some more general consequences will probably present themselves. To proceed analytically from phenomena to hypotheses, and from the present to the past or future, should be the endeavour of the observer of nature; and before we can hope to account satisfactorily for the appearances of extinct volcanic agency, which we have now been describing, we must deduce a foundation of facts from craters in a state of present activity. It would be unnecessary, therefore, to speculate farther upon the origin of the tufaceous hills of the Campi Phlegræi, till we are prepared to take a more extensive view of the subject.

The substance named Pozzuolana I have not here touched upon, because, though some have imagined it to form the basis of the common tufas of Naples, in its more useful form it is best seen in the Bay of Pozzuoli, from which it took its name, both ancient and modern *. We shall therefore speak of it when we come to consider that quarter.

The district we have described is not less interesting, from its picturesque or gently beautiful features, than for its physical importance. Imaginative as well as natural beauties combine to enhance the scene, and Parthenope, while she enjoys the lustre of classical and poetic associations, is surrounded by the lavish profusion of nature's most attractive charms;

> "Earth, sea, and sky, the brightest in the world!"

We cannot doubt that the Italian poets, modern as well as ancient, have embellished their descriptions with scenes taken from the Phlegræan fields; and Tasso in particular, who was a native of this part of Italy, seems to have had in his view, when describing the enchanted gardens of Armida, scenes like those of Pausilipo or Astroni.

> "Acque stagnanti, mobili cristalli
> Fior vari e varie piante, erbe diverse
> Apriche collinette, ombrose valli
> Selve e spelunche, in una vista offerse."
>
> Ger. Lib. xvi. 9.

* It is the *Pulvis Puteolanus* of Vitruvius.

**Art. XI.**—*Abstract of the Meteorological Register for* 1822, 1823, 1824, *and* 1825, *from Observations made by the Surgeons of the Army at the Military Posts of the United States Army.* Prepared under the direction of Joseph Lovell, M. D. Surgeon-General of the United States Army.

It is with a satisfaction of a very peculiar kind that we observe the great exertions made in the cause of science, not only by the general government of the United States, but even by the local governments of that extensive and interesting country.

We have already seen (see this *Journal*, vol. viii. No. xvi. p. 303,) that the legislature of the State of New York has enjoined the Regents of the different Universities within their bounds to make annual returns of the state of the thermometer, rain-guage, and weather, and that the first report has been given to the public. Long before this, in 1821, Mr Calhoun, Secretary of State for the War Department, had suggested and ordered to be carried into effect a regular series of meteorological observations to be made by the surgeons of the United States army. This great work, which will immortalize the name of Mr Calhoun, has been carried into effect for *four complete years;* and, as no account of the register has been published in any of our scientific journals, we trust our readers will be gratified with the following abstract of it. We are enabled to do this through the kindness of Captain Basil Hall, who has been so good as to put into our hands a copy of the printed report.

"On the question whether in a series of years there be any material change in the climate of a given district of country; and if so, how far it depends upon cultivation of the soil, density of population, &c. the most contradictory opinions have been advanced. While one contends, that, as population increases and cultivation extends, the climate becomes warmer, another is equally convinced that it becomes colder, and a third, that there is no change in this respect. These opinions are for the most part founded on a comparison of the climate of Europe at the present day with what it is supposed to have been two thousand years ago; and their great discrepancy may in some measure be accounted for from the circumstance, that the facts are few and the period of observation remote; while the changes, if any, have been exceedingly slow, and their ratio to the alleged causes exceedingly uncertain.

"The United States, however, appear to offer an opportunity of bringing the question to the test of experiment and observation. For here within the memory of many now living, the face of whole districts of country has been entirely changed; and in several of the States two centuries have effected as much as two thousand years in many parts of Europe. In this respect, the 'Landing of the Pilgrims' in 1620 is as remote a period as that of the invasion of Gaul or of Britain by Julius Cæsar.

"The time for improving this opportunity, however, like that for recording the history, language, manners, and customs of the aborigines of the country, is fast passing away; and in a few generations, both these sons of the forest and the interminable wilderness they inhabited will, for all useful purposes, be as though they had never been. As, therefore, the military posts within the United States afford every convenience for making numerous observations over an extensive district of country, and regular diaries of the weather have for some years past been kept at most of them, the following tables have been prepared in the form that appears best calculated for reference, in order to preserve the facts thus collected.

"The first twelve tables for each year give the mean of the observations at the several posts for each month, and the thirteenth the mean for the whole year. The last, or general table, gives the average of all the observations at the several stations, and also the average for the several years, calculated in the manner hereafter stated. Should it be practicable to obtain similar observations for eight or ten years, it is proposed to collect, if possible, such as may have been made at an early period after the settlement of the country, in order to ascertain what changes, if any, have taken place, either in the mean temperature, the range of the thermometer, the course of the winds, or the weather in the Atlantic States.

"The posts at which these observations were made are situated between 27° 57′ and 46° 39′ of north latitude, and between 67° 04′ and 95° 48′ of longitude west from Greenwich; embracing an extent of 18° 42′ of latitude, and 28° 39′ of longitude. The elevation of the north-western or interior stations above those on the Atlantic coast has not been accurately ascertained. The following, however, is believed to be near the truth. Fort Brady, situated at the outlet of Lake Superior, is 595 feet above the level of tide water; Fort Howard, at the southern extremity of Green Bay, which empties into Lake Michigan, 600 feet; Fort Crawford, at Praire du Chien, near the junction of the Wisconsan and Mississippi rivers, 580 feet; Fort Snelling, near the junction of the St Peters and Mississippi rivers, 780 feet; Council Bluffs, a few miles above the junction of the Platte and Missouri rivers, 800 feet. Baton Rouge, on the Mississippi, 120 miles above New Orleans, and Cantonment Jesup, near the Sabine river, 25 miles from Natchitoches, are in Louisiana; Cantonment Clinch, near Pensacola, Cantonment Brooke, near Tampa Bay, and St Augustine, in Florida. Fort Moultrie is in the harbour of Charleston, South Carolina; Fort Johnston near Smithville, North Carolina; Fort Severn at Annapolis in Maryland; Fort Mifflin in the Delaware, 6 miles below Philadelphia; Fort Columbus in the harbour of New York; Fort Wolcott in the harbour of Newport; and Fort Sullivan near Eastport, in the State of Maine. The observations at the city of Washington are introduced by way of comparison, as the latitude of this city is very nearly the same with that of the centre of the several military posts. They were made by the Rev. Mr Little, by whom they were very politely furnished for the present purpose.

" Although, from the circumstances under which these observations were made at several of the posts, they may not be as accurate as could be wished, yet they are perhaps sufficiently so for the purpose of general abstracts; for the mean of each month being deduced from 90, and of each year from 1095 observations, occasional errors would not materially affect the general result.

" The chief object at present being to record facts, the following remarks are premised merely for the convenience of those who may be curious in these matters without wishing the trouble of tedious calculations. In order to ascertain the means for the several years, as given in the last table, the extreme stations are taken, and as many intermediate ones, at the north and south respectively, as are found to be equi-distant from them, or nearly so. Thus in 1822, Fort Snelling is the extreme northern, and Cantonment Clinch the extreme southern post; Council Bluffs is 3° 28′ south of the former, and Fort Johnston 3° 36′ north of the latter, &c. The aggregate of these should give the mean of the centre of the district of country in which the observations were made; and the result appears to be near the truth. For the latitude of the city of Washington is 38° 53′, and the average mean temperature is 56.56; the centre of the several stations at which these observations were made is in latitude 38° 13′, and the average mean temperature is 56.52. In comparing the eastern and western posts, those in about the same latitude are of course taken; thus, Council Bluffs is 24° 25′ west, and but 0° 05′ north of Fort Wolcott; Fort Snelling is 26° 04′ west, and but 0° 09′ north of Fort Sullivan. To prevent the constant repetition of the terms east and west, the numbers only are stated; it being always understood that the first relates to the east and the second to the west; thus, in January 1822 the means are stated to be 22.20 and 16.25, that is, 22.20 at the east, and 16.25 at the west.

"In 1822 the aggregate mean temperature of the year was 57.06; the highest degree 108; the lowest —29; and the range 137. The proportion of winds was N. 5.07, S. W. 4.95, N. W. 4.93, S. 4.60, S. E. 3.39, W. 3.10, N. E. 2.67, E. 1.71. The proportion of weather, fair 18.90, cloudy 5.03, rain 5.63, snow 0.85. At Fort Snelling, the most northern station, the mean for the year was 44.32; the highest degree 92, the lowest —29, and the range 121. At Cantonment Clinch, the most southern station, the mean for the year was 68.97, the highest degree 93, the lowest 20, and the range 73. On comparing the eastern and western posts, it appears that at the former the mean temperature of the winter months is much higher, and that of the summer months much lower than at the latter. Thus in January it is 22.20 and 16.35, February 27.40 and 26.40, March 35.52 and 41.10, April 42.31 and

46.53, May 55.21 and 62.60, June 62.63 and 72.10, July 68.33 and 77.54, August 66.52 and 75.02, September 63.54 and 64.19, October 51.25 and 45.84, November 42.29 and 32.96, December 29.55 and 80.03. During the six winter months the means are 34.73 and 28.44; being 6.26 *higher* at the east, and during the summer months they are 59.76 and 66.33; being 6.67 *lower* at the east than at the west; making but a fractional difference for the year, which was 47.24 at the east, and 47.38 at the west. The highest degrees were 88 and 108, the lowest — 9 and — 29, the ranges 97 and 137; and it was greatest at the west, not only for the year, but also for every month except July and August, when it was about the same. The course of the winds was N. 3.54 and 5.08, N. W. 6.29 and 7.25, N. E. 1.91 and 3.08, E. 1.21 and 0.96, S. E. 17.9 and 3.63, S. 504 and 304, S. W. 7.37 and 5.37, W. 3.26 and 1.96. Weather, fair 18.34 and 19.75, cloudy 7.37 and 4.17, rain 4.00 and 4.33, snow 0.34 and 2.16. Prevailing winds at the east, S. W. N. W. and S. at the west, N. W. S. W. and N. The proportion of fair weather and rain was nearly equal; of cloudy weather much more; and of snow much less, at the east.

"In 1823 the aggregate mean temperature of the year was 55.22; the highest degree 100; the lowest — 38; and the range 138. The proportion of winds was S. W. 7.22, N. E. 4.84, S. E. 4.10, N. W. 3.85, S. 3.19, N. 3.15, W. 2.29, E. 1.65. Weather, fair 16.48, cloudy 6.16, rain 5.98, snow 1.77. At Fort Brady, the most northern post, the mean of the year was 39.66; the highest degree 90; the lowest — 30; and the range 120. At Cantonment Clinch, the most southern station, the mean was 68.25; the highest degree 94; the lowest 11; and the range 83. On comparing the eastern with the western posts, the mean of the winter months for this year also is *higher*, and of the summer months *lower*, at the east. Thus in January it is 24.12 and 21.05, February 21.90 and 15.62, March 32.65 and 32.42, April 42.41 and 48.82, May 51.19 and 57.02, June 64.60 and 72.50, July 66.76 and 75.36, August 66.65 and 72.89, September 58.79 and 60.14, October 49.92 and 49.12, November 35.79 and 35.67, December 32.05 and 23.77. During the winter months the means are 32.73 and 29.61, being 3.12 *higher* at the east; and during the summer months 58.40 and 64.45, being 6.05 *lower* at the east. The means for the year are 45.50 and 47.03, being 1.53 higher at the west, where the winter was comparatively warmer than in 1822. The highest degrees were 90 and 102, the lowest — 10 and — 30; the ranges 100 and 132. Course of the winds, N. 3 and 2.03, N. W. 7.50 and 2.79, N. E. 2.83 and 6.87, E. 1.24 and 1.87, S. E. 1.83 and 2.23, S. 5.08 and 3.20, S. W. 5.95 and 9.50, W. 2.95 and 1.83. Weather, fair 15.12 and 18.41, cloudy 9.62 and 7.95, rain 4.16 and 2.40, snow 1.50 and 1.58. Prevailing winds at the East N. W., S. W. and S.; at the West S. W., N. E. and S. The proportion of fair weather was considerably less, of cloudy weather and rain considerably greater, at the east; the proportion of snow about the same.

In 1824 the aggregate mean temperature of the year was 55.56; the highest degree 96; lowest — 33; and the range 129. The proportion of winds, S. 5.33, S. W. 4.73, N. W. 4.65, N. 3.85, S. E. 3.83, W. 3.40, N. E. 2.84, E. 1.79. The proportion of weather, fair 17.55, cloudy 5.03, rain 6.29, snow 1.49. At Fort Brady, the most northern post, the mean temperature was 40.94; the highest degree 89, the lowest — 33; and the range 122. At Cantonment Clinch, the most southern station, the mean temperature was 69.10, highest degree 95, lowest 24, range 71. On comparing the eastern and western posts, the means for January were 27.22 and 25.82, February 26.62 and 22.70, March 33.45 and 28.45, April 44.12, and 44,78, May 50.61 and 58.43, June 60.77 and 66.28, July 67.49 and 74.49, August 65.61 and 71.53, September 60.44 and 62.00, October 49.96 and 46.91, November 38.50 and 30.28, December 32.41 and 26.53. During the winter months the means were 34.69 and 30.11, being 4.58 *higher* at the east; and during the summer months 58.17 and 62.92, being 4.75 *lower* at the east. The means for the year 46.43 and 46.51, a difference of but 0.08. The highest degrees were 86 and 103, the lowest — 19 and — 21, the range 105 and 124. Course of the winds, N. 3.16 and 4.45, N. W. 6.83 and 1.20, N. E. 2.58 and 6.70, E. 1.50 and 1.00, S. E. 1.70 and 187, S. 4.28 and 6.78, S. W. 6.33 and 8.12, W. 3.45 and 0.36.

Weather, fair 16.58 and 18.04, cloudy 8.50 and 7.04, rain 4.70 and 3.33, snow 0.70 and 2.08. The prevailing winds at the east were N. W., S. W. and S.; at the West S. W., S. and N. E. The proportion of fair weather was less, and of cloudy weather and rain greater, at the east, the proportion of snow much less.

"In 1825 the aggregate mean temperature of the year was 58.27; the highest degree 102; the lowest—25; and the range 127. The proportion of winds, S. E. 5.52, N. W. 4.81, N.E. 4.72, W. 3.24, N. 3.23, S. W. 3.09, S. 2.79, E. 1.45. The proportion of weather, fair 16.91, cloudy 5.67, rain 6.49, snow 1.32. At Fort Brady, the most northern station, the mean for the year was 40.60; highest degree 89; lowest—25; range 114. At Cantonment Brooke, the most southern station, the mean for the year was 72.37; the highest degree 92; the lowest 40; range 52. On comparing the eastern and western posts, the means in January were 26.34 and 17.63, February 27.67 and 29.58, March 36.89 and 38.31, April 45.12 and 57.32, May 53.37 and 63.94, June 65.04 and 71.86, July 70.98 and 75.42, August 68.12 and 74.83, September 59.86 and 63.60, October 51.94 and 50.36, November 41.13 and 38.50, December 31.65 and 19.26. During the six winter months the means were 35.94 and 32.27, being 3.67 *higher* at the east; and during the summer months 60.41 and 67.83, being 7.42 *lower* at the east. The means for the year were 48.17 and 50.05, being 1.88 warmer at the west; the highest degrees were 94 and 102, the lowest—5 and—25, the ranges 99 and 127. The course of the winds was N. 2.91 and 4.03, N. W. 6.25 and 5.74, N. E. 3.50 and 2.16, E. 1.54 and 1.50, S. E. 1.62 and 4.58, S. 3.62 and 5.29, S. W. 7.83 and 4.37, W. 3.54 and 2.66. Weather, fair 16.53 and 16.25, cloudy 9.62 and 6.62, rain 3.62 and 6.12, snow 0.60 and 1.41. Prevailing winds at the East S. W., N. W. and S.; at the West N. W., S. and S. E. The proportion of fair weather was about the same; of cloudy considerably greater; and of rain and snow much less, at the east.

"By the last table it appears that the aggregate mean temperature was highest in 1825 and lowest in 1823, there being, however, but a fractional difference between this and the following year. The average of the whole period is 56.52, being about one degree lower than at Bourdeaux in latitude 44° 50′. The range was greatest in 1822 and 1823, and nearly equal; and several degrees less in 1824 and 1825, being least in the latter year. The N., N. W., W. and E. winds are most uniform in the several years; the rest are more variable. The prevailing winds are S. W., N. W., and S. E. The proportion of fair weather was greatest in 1822, and least in 1823, which, however, differed but little from 1825. The proportion of cloudy weather, rain, and snow, is pretty equal, except that there was much less snow in 1822. The aggregate mean for the whole period was, fair 17.46, cloudy 5.47, rain 6.10, snow 1.36.

"In 1822 the mean temperature at the east and west was nearly equal. In 1823, 1.74 lower at the east, and but 0.33 lower at the west, than in the previous year; the winter being comparatively milder at the west. In 1824, the mean temperature was again nearly the same, but about one degree lower than in 1822. In 1825, it was higher than in any previous year, and 1.88 higher at the west than at the east. The average for the four years was 46.83 and 47.74, being 0.91 higher at the west. In 1822 the range was 40° greater at the west; in 1823 it was 32° greater; in 1824, 19°; and in 1825, 25°. The greatest proportion of fair weather, both at the east and west, was in 1822; with rather the most at the west. In 1823 there was much less at the east, and somewhat less at the west, than in the former year. In 1824, there was rather more at the east, and about the same at the west as in 1823; and in 1825 it was about the same at the east, and considerably less at the west, than in the previous year. The proportion of rain was nearly the same at the east during the four years, but somewhat less in 1825. There was a great difference at the west, being much greater in 1825, than in any other year, and much less in 1823. The proportion of snow was much the greatest at the east in 1823, and least in 1822; at the west it was greatest in 1822 and 1824, and least in 1825. The average for the four years was, fair 16.64 and 18.11, cloudy 8.86 and 6.44, rain 4.12 and 4.04, snow 0.78 and 2.05; being rather more fair, and less cloudy weather, with about the same proportion of rain, and much more snow, at the west.

"The following table may serve to compare the annual mean temperature at some of the military posts in the United States, with that at several places on the other side of the Atlantic, and shows that it is considerably greater at the latter, and especially in the higher latitudes.

| Places. | North Latitude. | Longitude. | Mean Temperature. |
|---|---|---|---|
| Petersburg, - | 59° 56′ | 30° 24′ E. | 38° 80 |
| Stockholm, - | 59 20 | 18 00 E. | 42 39 |
| Edinburgh, - | 55 57 | 3 00 W. | 47 70 |
| Berlin, - | 52 32 | 13 31 E. | 49 00 |
| Leyden, - | 52 10 | 4 32 E. | 52 25 |
| London, - | 51 31 | ——— | 51 90 |
| Rouen, - | 49 26 | 1 00 W. | 51 00 |
| Paris, - | 48 50 | 2 25 E. | 52 00 |
| Vienna, - | 48 12 | 16 22 E. | 51 53 |
| Nantes, - | 47 13 | 1 28 E. | 55 53 |
| Poitiers, - | 46 39 | 0 30 E. | 53 80 |
| Fort Brady, - | 46 39 | 84 43 W. | 41 37 |
| Padua, - | 45 23 | 12 00 E. | 52 20 |
| Fort Snelling, - | 44 53 | 93 08 W. | 45 00 |
| Bourdeaux, - | 44 50 | 0 26 W. | 57 60 |
| Fort Sullivan, - | 44 44 | 67 04 W. | 42 44 |
| Fort Howard, - | 44 40 | 87 00 W. | 44 50 |
| Marseilles, - | 43 19 | 5 27 E. | 61 80 |
| Fort Crawford, - | 43 03 | 90 53 W. | 45 52 |
| Fort Wolcott, - | 41 30 | 71 18 W. | 51 02 |
| Council Bluffs, - | 41 25 | 95 43 W. | 50 82 |
| Pekin, - | 39 54 | 116 29 W. | 55 50 |
| Washington, - | 38 53 | 76 55 W. | 56 56 |
| Algiers, - | 36 49 | 2 17 E. | 72 00 |
| Fort Johnston, - | 34 00 | 78 05 W. | 66 68 |
| Cantonment Clinch, | 30 24 | 87 14 W. | 68 77 |
| Grand Cairo, - | 30 00 | 31 23 E. | 73 00 |
| St Augustine, - | 29 50 | 81 27 W. | 72 23 |

From this it appears that in the higher latitudes the average difference for the same degree of mean temperature is 14° 30′, and in the lower ones 7° 30′, the mean of which is 11°. Thus the mean temperature at Stockholm, in latitude 59° 20′, is about the same as at Fort Sullivan, in latitude 44° 44′; while that at Rouen, in latitude 49° 26′, is about the same as at Fort Wolcott, in latitude 41° 20′; and at St Augustine, in latitude 29° 50′ it is but 0.77 lower than at Grand Cairo, in latitude 30°."

JOS. LOVELL.

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Before we proceed to give the general abstract of all the observations at the different stations, we shall give the situation and elevation of the places of observation, so far as they have been determined.

| | | N. Lat. | W. Long. | Elevation in feet. |
|---|---|---|---|---|
| Fort Brady, | - | 46°39′ | 84°43′ | 595 |
| Fort Snelling, | - | 44 53 | 93 08 | |
| Fort Sullivan, | - | 44 44 | 67 04 | |
| Fort Howard, | - | 44 40 | 87 0 | 600 |
| Fort Crawford, | - | 43 03 | 90 53 | 580 |
| Fort Wolcott, | - | 41 30 | 71 18 | 0 |
| Council Bluffs, | - | 41 25 | 95 43 | 800 |
| Fort Columbus, | - | 40 2 | 74 02 | 0 |
| Fort Mifflin, | - | 39 5 | 75 12 | 0 |
| Fort Severn, | - | 38 58 | 76 27 | |
| Washington, | - | 38 53 | 76 55 | |
| Fort Johnston, | - | 34 0 | 78 05 | |
| Fort Moultrie, | - | 32 42 | 79 56 | 0 |
| Cant. Jesup, | - | 31 30 | 93 47 | |
| Baton Rouge, | - | 30 26 | 91 18 | |
| Cant. Clinch, | - | 30 24 | 87 14 | |
| St Augustine, | - | 29 50 | 81 27 | |
| Cant. Brooke, | - | 27 57 | 82 35 | |
| Mean, | - - | 38°10′ | 82°36′ | |

The general results of all the meteorological observations are given in three tables:—

The following table contains the temperature at $7^h$ A. M. $2^h$ P. M., and $9^h$ P. M.,—the mean annual temperature,—the maximum,—minimum and range on an average of *three* years.

## *General Annual Results for* 1823–4–5.

### Thermometer.

| Places of Observation. | Mean Temperature. vii. | ii. | ix. | Aggregate of mean temp. | Highest degree. | Lowest degree. | Range |
|---|---|---|---|---|---|---|---|
| Fort Brady, | 36.69 | 49.06 | 38.38 | 41.37 | 90 | —33 | 123 |
| Fort Snelling, | 39.96 | 52.34 | 42.70 | 45.00 | 96 | —29 | 125 |
| Fort Sullivan, | 38.26 | 49.51 | 39.66 | 42.44 | 94 | —19 | 113 |
| Fort Howard, | 37.81 | 52.98 | 42.71 | 44.50 | 100 | —38 | 138 |
| Fort Crawford, | 39.06 | 53.92 | 43.58 | 45.52 | 96 | —28 | 124 |
| Fort Wolcott, | 48.54 | 56.39 | 48.14 | 51.02 | 88 | — 1 | 89 |
| Council Bluffs, | 44.22 | 60.14 | 48.11 | 50.82 | 108 | —21 | 129 |
| Fort Columbus, | 48.37 | 59.77 | 50.34 | 52.82 | 104 | — 3 | 107 |
| Fort Mifflin, | 51.68 | 63.31 | 50.85 | 55.28 | 96 | 6 | 90 |
| Fort Severn, | 53.40 | 62.11 | 56.70 | 57.40 | 92 | 8 | 84 |
| Washington, | 52.23 | 62.18 | 55.65 | 56.56 | 95 | 10 | 85 |
| Fort Johnston, | 63.98 | 69.38 | 66.68 | 66.68 | 92 | 26 | 66 |
| Fort Moultrie, | 61.93 | 67.81 | 63.75 | 64.49 | 92 | 19 | 73 |
| Cant. Jesup, | 61.83 | 74.89 | 68.22 | 68.31 | 97 | 7 | 90 |
| Baton Rouge, | 62.87 | 74.54 | 66.82 | 68.07 | 99 | 18 | 81 |
| Cant. Clinch, | 64.43 | 74.12 | 67.77 | 68.77 | 95 | 11 | 84 |
| St. Augustine, | 70.94 | 74.46 | 71.29 | 72.23 | 94 | 42 | 52 |
| Cant. Brooke, | 68.64 | 79.05 | 69.42 | 72.37 | 92 | 40 | 52 |
| *Average of the several years,* 1822 | 52.25 | 63.47 | 55.48 | 57.06 | 108 | —29 | 137 |
| 1823 | 51.26 | 60.68 | 53.72 | 55.22 | 100 | —38 | 138 |
| 1824 | 51.27 | 61.22 | 53.90 | 55.56 | 96 | —33 | 129 |
| 1825 | 54.48 | 63.56 | 56.78 | 58.27 | 102 | —25 | 127 |
| Average, | 52.31 | 62.24 | 54.97 | 56.52 | 108 | —38 | 146 |

The following table shows the state of the winds, the whole numbers in each column being the number of days in the month of 30 days that the wind blows from any particular quarter.

## *General Annual Results for* 1823–4–5.

### WINDS.

| Places of Observation. | | N. Days. | N.W. Days. | N.E. Days. | E. Days. | S.E. Days. | S. Days. | S.W. Days. | W. Days. | Prevailing. |
|---|---|---|---|---|---|---|---|---|---|---|
| Fort Brady, | | 1.74 | 4.77 | 1.05 | 2.24 | 7.24 | 2.60 | 2.27 | 8.24 | W. |
| Fort Snelling, | | 2.88 | 7.13 | 2.33 | 1.16 | 4.02 | 3.52 | 6.05 | 3.24 | N.W. |
| Fort Sullivan, | | 3.26 | 6.89 | 2.04 | 2.08 | 0.79 | 7.02 | 3.68 | 4.77 | S. |
| Fort Howard, | | 0.70 | 0.70 | 11.52 | 0.19 | 0.08 | 0.39 | 16.04 | 0.78 | S.W. |
| Fort Crawford, | | 5.58 | 7.12 | 1.04 | 0.29 | 4.12 | 5.70 | 3.04 | 1.58 | N.W. |
| Fort Wolcott, | | 3.04 | 6.54 | 3.37 | 0.66 | 2.68 | 2.00 | 10.06 | 1.83 | S.W. |
| Council Bluffs, | | 5.89 | 4.52 | 2.12 | 1.83 | 4.02 | 7.39 | 3.06 | 1.60 | S. |
| Fort Columbus, | | 0.72 | 9.02 | 3.49 | 0.87 | 4.04 | 3.91 | 6.29 | 2.06 | N.W. |
| Fort Mifflin, | | 0.50 | 6.37 | 4.54 | 0.74 | 6.20 | 1.24 | 8.20 | 2.62 | S.W. |
| Fort Severn, | | 3.08 | 6.00 | 4.00 | 2.00 | 3.33 | 6.91 | 2.16 | 2.33 | S. |
| Washington, | | 2.62 | 7.47 | 4.97 | 1.05 | 3.19 | 2.66 | 7.63 | 0.74 | S.W. |
| Fort Johnston, | | 8.79 | 3.29 | 1.31 | 1.60 | 0.64 | 8.97 | 1.56 | 4.24 | S. |
| Fort Moultrie, | | 1.78 | 1.15 | 6.85 | 3.80 | 5.59 | 5.07 | 4.41 | 1.73 | N.E. |
| Cant. Jesup, | | 2.38 | 2.99 | 4.38 | 3.80 | 7.05 | 3.28 | 4.55 | 1.97 | S.E. |
| Baton Rouge, | | 4.58 | 3.00 | 2.50 | 2.67 | 5.00 | 4.84 | 4.75 | 3.08 | S.E. |
| Cant. Clinch, | | 2.05 | 4.10 | 4.13 | 1.47 | 7.11 | 2.05 | 8.67 | 0.80 | S.W. |
| St Augustine, | | 1.08 | 2.91 | 12.50 | 1.75 | 7.50 | 0.75 | 2.50 | 1.41 | N.E. |
| Cant. Brooke, | | 0.16 | 4.00 | 7.08 | 3.00 | 4.58 | 2.83 | 6.25 | 2.50 | N.E. |
| *Average of the several years,* | 1822 | 5.07 | 4.93 | 2.67 | 1.71 | 3.39 | 4.60 | 4.95 | 3.10 | N. |
| | 1823 | 3.15 | 3.85 | 4.84 | 1.65 | 4.10 | 3.19 | 7.22 | 2.29 | S.W. |
| | 1824 | 3.85 | 4.65 | 2.84 | 1.79 | 3.83 | 5.33 | 4.73 | 3.40 | S. |
| | 1825 | 3.23 | 4.81 | 4.72 | 1.45 | 5.52 | 2.79 | 3.09 | 3.24 | S.E. |
| Average, | | 3.82 | 4.56 | 3.77 | 1.65 | 4.21 | 3.98 | 5.00 | 3.01 | S.W. |

The following table shows the average state of the weather during all the years of observation, the numbers representing the days and decimals of a day in the months of 30 days that were *fair*, &c.

*General Annual Results for* 1823–4–5.

WEATHER.

| Places of Observation. | Fair. Days. | Cloudy. Days. | Rain. Days. | Snow. Days. | Prevailing. |
|---|---|---|---|---|---|
| Fort Brady, | 13.30 | 3.27 | 7.83 | 6.02 | Fair. |
| Fort Snelling, | 16.94 | 5.50 | 5.77 | 2.22 | Fair. |
| Fort Sullivan, | 17.91 | 9.39 | 2.31 | 0.81 | Fair. |
| Fort Howard, | 15.47 | 7.98 | 4.56 | 2.42 | Fair. |
| Fort Crawford, | 16.80 | 6.29 | 3.87 | 1.33 | Fair. |
| Fort Wolcott, | 15.31 | 8.16 | 5.94 | 1.02 | Fair. |
| Council Bluffs, | 19.68 | 6.54 | 2.95 | 1.25 | Fair. |
| Fort Columbus, | 20.41 | 3.56 | 5.47 | 0.98 | Fair. |
| Fort Mifflin, | 21.20 | 5.12 | 5.20 | 0.41 | Fair. |
| Fort Severn, | 19.67 | 4.50 | 5.08 | 1.17 | Fair. |
| Washington, | 17.30 | 6.05 | 6.44 | 0.63 | Fair. |
| Fort Johnston, | 16.87 | 7.60 | 5.85 | 0.12 | Fair. |
| Fort Moultrie, | 22.89 | 2.48 | 5.00 | 0.02 | Fair. |
| Cant. Jesup, | 18.63 | 4.49 | 7.25 | 0.05 | Fair. |
| Baton Rouge, | 20.16 | 4.08 | 6.16 | - | Fair. |
| Cant. Clinch, | 18.69 | 2.27 | 9.46 | - | Fair. |
| St Augustine, | 20.66 | 3.91 | 5.83 | - | Fair. |
| Cant. Brooke, | 18.16 | 3.91 | 8.33 | - | Fair. |
| *Average of the several years,* 1822 | 18.90 | 5.03 | 5.63 | 0.85 | Fair. |
| 1823 | 16.48 | 6.16 | 5.98 | 1.77 | Fair. |
| 1824 | 17.55 | 5.03 | 6.29 | 1.49 | Fair. |
| 1825 | 16.91 | 5.67 | 6.49 | 1.32 | Fair. |
| Average, | 17.46 | 5.47 | 6.10 | 1.36 | Fair. |

The thermometrical observations recorded in the preceding tables were made at three different hours of each day, namely, 7h A. M., 2h P. M., and 9h P. M, the hours recommended by Professor Dewey of Williamston, in the United States, giving, by taking their mean, the mean daily temperature throughout the year. According to the hourly meteorological observations made at Leith-Fort, (see this *Journal*, vol. v. No. ix. p. 18,) the mean of the hours 7, 2, and 9, selected by Professor Dewey, is about *three quarters of a degree* above the true mean of the day; and though the observations upon which Professor Dewey proceeded were made in America, yet, as they were not made for a whole year, we may be allowed to place more confidence in the Leith results; and for this reason to conclude that all the aggregate mean temperatures in the preceding table should be diminished by about ¾ths of a degree.

By examining the preceding observations, it appears *that at all the stations the time of the evening at which the mean temperature occurs is before* 9h P. M. *and after* 7h A. M.

If we compute the mean temperature of a point corresponding with the mean position of all the above stations by means of Dr Brewster's General Formula for the Western Hemisphere of the globe, we shall have

| | | |
|---|---|---|
| Mean temperature by Formula, | - | 54°80 |
| Do. observed, | - - | 56 52 |
| Difference, | - - | 1°72 |

The observed mean temperature ought, from what has been above stated, to be diminished about ¾ths of a degree; and it requires also to be increased, in order to reduce the mean temperature of the elevated stations to the level of the sea; but as the elevations of several of the stations are not known, it is out of our power to apply the requisite correction.

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## Art. XII.—*Thermometrical Observations made at Raiatea, one of the Society Islands, in* 1822. By the Rev. L. E. Threlkeld.*

The following series of very valuable observations were made in 1822, by the Rev. L. E. Threlkeld, one of the missionaries at Raiatea or Ulietea, one of the Society Islands. It is situated in west long. 151°30′, and south latitude 16°40′.

The tide at Raiatea, which rises about *two* feet, is never at any time affected by the moon, and is always highest at 12 o'clock.

Although the quantity of rain which fell in this island was not measured, yet the number of rainy days is marked in the Journal, and are as follows:—

| | | | | | |
|---|---|---|---|---|---|
| January, | 18 | May | 18 | September, | 20 |
| February, | 20 | June, | 13 | October, | 22 |
| March, | 20 | July, | 5† | November, | 25 |
| April, | 21 | August, | 15 | December, | 25 |
| | | | | Number of rainy days, | 222 |

* The Editor has been indebted for these observations to James Dunlop, Esq.

† From the 22d till the 31st of July no account of the rainy days was kept.

The following table shows the mean temperature of the different months of 1822, by morning, noon, and evening observations:

| 1822. | Morning. | Noon. | Evening. |
|---|---|---|---|
| January, - - | 74°.7 | 82°. | 79°.5 |
| February, - - | 79 .2 | 82 .6 | 80 .2 |
| March, - - | 79 | 83 .4 | 80 .3 |
| April, - - | 77 .3 | 82 .4 | 78 .6 |
| May, - - | 76 .6 | 80 .8 | 77 .8 |
| June, - - | 79 .3 | 79 .6 | 76 .3 |
| July, - - | 73 .8 | 78 .3 | 75 |
| August, - - | 75 .9 | 80 .1 | 77 .5 |
| September, - - | 75 .4 | 80 | 76 .9 |
| October, - - | 76 .1 | 80 .2 | 77 .5 |
| November, - - | 75 .6 | 81 | 76 |
| December, - - | 76 .3 | 81 .6 | 79 .7 |
| Mean, | 76°.6 | 81°.00 | 77°.94 |

Mean annual temperature for 1822 by the table, 78°51.

It is obvious, however, that, as there was no night observations to balance those made at noon, we must reject the noon observations, in order to obtain the correct mean temperature. We shall thus obtain,—

| | |
|---|---|
| Mean temperature for 1822, - - | 76°.77 |
| Mean temperature calculated by Dr Brewster's General formula, - - - | 76 .11 |
| Error of the formula, | 0°.66 |

The above result gives for the temperature of the equator 80°.14 differing only 0.3 from the measure obtained in No. xv. p. 67.

In the 10th Number of this *Journal*, p. 370, we have given the mean temperature of Hawai, one of the Sandwich Islands, situated nearly in the same longitude, viz. in 155½° (west long.,) and in a parallel of latitude a little more north than that of Raiatea is south of the equator, as ascertained by the American Missionaries in 1822. The mean temperature of Hawai was 75°.19, the temperature calculated by the Formula 74°.77, giving an error of only 0°.33. Hence we may conclude that the formula represents very accurately the mean temperature of that part of the globe.

ART. XIII.—*Notice on the Elastic Force of Vapour.* By RICHARD TREGASKIS, Esq. Communicated by the Author.

THE freezing point being zero, call the temperature and the force at any given distance above it — unity. Raise the temperature from that point, till the force be doubled, and it will be found that $\frac{1}{5}$th only is added to the temperature. Here the temperature is $1\frac{1}{5}$th; the force 2. And hence $1\frac{1}{5}$th, or 1,2 (not 14 reduced to 1.2, as printed on page 69 of the last Number,) is the ratio of temperature, 2 the ratio of force.

That this law continues in operation from 15 to 240 inches of mercury, appears from the following table:—

The force of steam at various temperatures in inches of mercury.

| By Experiment. | | | By Calculation. | | |
|---|---|---|---|---|---|
| Fahr. | Inches. | | Above Freezing. | Fahr. | Inches. |
| 182° | 15 | Betancourt, | 150° | 182° | 15 |
| | 15.86 | Dalton, | | | |
| 212 | 30 | Atmospheric pressure, | 180 | 212 | 30 |
| 248.5 | 60.40 | Ure, - | 216 | 248 | 60 |
| 290 | 120.15 | Ure, | 259.2 | 291.2 | 120 |
| 293 | 120 | Southern, | | | |
| 343.6 | 240 | Southern, - | 311.04 | 343.04 | 240 |

The experiments in Article X. of the last Number did not appear on the same page with the calculation. This circumstance, which made the comparison difficult, together with an error of the press noticed above, which rendered that part of the article obscure, will, it is hoped, be accepted as an apology for introducing the subject again.

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ART. XIV.—*Description of some remarkable Nebulæ and Clusters of Stars in the Southern Hemisphere, observed at Paramatta in New South Wales.** By JAMES DUNLOP, Esq.

THE following nebulæ and clusters of stars in the southern hemisphere were observed by me at my house in Paramatta,

* This is an abstract of Mr Dunlop's large and valuable Catalogue published in the *Phil. Trans.* 1828, p. 113. It is illustrated by seven large Plates, which it is impossible to copy into a *Journal.*

situated about 6″ of a degree south and about 1ˢ.78 of time east of the Brisbane Observatory. The observations were made in the open air, with an excellent nine-feet reflecting telescope, the clear aperture of the large mirror being nine inches. This telescope was occasionally fitted up as a meridian telescope, with a strong iron axis firmly attached to the lower side of the tube nearly opposite the cell of the large mirror, and the ends of the axis rested in brass Y's, which were screwed to blocks of wood let into the ground about 18 inches, and projecting about 4 inches above the ground; one end of the axis carried a brass semicircle divided into half degrees, and read off by a vernier to minutes. The position and index error of the instrument were ascertained by the passage of known stars. The eye end of the telescope was raised or lowered by a cord over a pulley attached to a strong wooden post let into the ground about two feet: with this apparatus I have observed a sweep of eight or ten degrees in breadth with very little deviation of the instrument from the plane of the meridian, and the tremor was very little even with a considerable magnifying power. I made drawings or representations of a great number of the nebulæ and clusters at the time of observation, several of which are annexed to this paper; and also very correct drawings of the Nebulæ major and minor, together with a representation of the milky nebulosity surrounding the star η Robur Caroli. The places of the small stars in the Nebulæ major and minor, and also those accompanying the η Robur Caroli, I ascertained by the mural circle in the year 1825, at which time I was preparing to commence a general survey of the southern hemisphere. These stars being laid down upon the chart, enabled me to delineate the nebulosity very accurately.

The nebulæ are arranged in the order of their south polar distances to the nearest minute for 1827, and in zones for each degree in the order of their right ascension. The column on the right hand shows the number of times the object has been observed.

The reductions and arrangement have been principally made since my return to Europe; and I trust this catalogue of the nebulæ will be found an acceptable addition to that knowledge which the Brisbane Observatory has been the means of putting the world in possession of, respecting that important and hitherto but little known portion of the heavens.

Mr Dunlop then proceeds to give his observations in detail on no fewer than 629 different nebulæ; but as it is impossible in a work like this to reprint so large a catalogue, we have selected the most curious and interesting nebulæ, and those which are most likely to attract the notice of the philosopher in his speculations on the construction of the heavens.

No. 18. R. Asc. $0^h$ $16^m$ $28^s$. S. Pol. Dist. 16° 59′.
47 Toucan, Bode.

This is a beautiful large round nebula, about 8′ diameter, very gradually condensed to the centre. This beautiful globe of light is easily resolvable into stars of a dusky colour. The compression to the centre is very great, and the stars are considerably scattered south preceding and north following.—

No. 62. R. Asc. $0^h$ $57^m$ $32^s$. S. Pol. Dist. 18° 15′.

A beautiful bright round nebula, about 4′ diameter, exceedingly condensed. This is a good representation of the 2d of the Connaissance des Tems in figure, colour, and distance; it is but a very little easier resolved, rather a brighter white, and perhaps more compact and globular. This is a beautiful globe of white light; resolvable: the stars are very little scattered.

No. 67. R. Asc. $12^h$ $11^m$ $4^s$. S. Pol. Dist. 18° 24′.

A star of the 6th magnitude, with a beautiful well-defined milky ray proceeding from it south following; the ray is conical, and the star appears in the point of the cone, and the broad or south following extremity is circular, or rounded off. The ray is about 7′ in length and nearly 2′ in breadth at the broadest part, near the southern extremity. With the sweeping power this appears like a star with a very faint milky ray south following, the ray gradually spreading in breadth from the star, and rounded off at the broader end. But with a higher power it is not a star with a ray, but a very faint nebula, and the star is not involved or connected with it: I should call it a very faint nebula of a long oval shape, the smaller end towards the star; this is easily resolvable into extremely minute points or stars, but I cannot discover the slightest indications of attraction or condensation towards any part of it. I certainly had not the least suspicion of this object being resolvable when I discovered it with the sweeping power, nor even when I examined it a second time; it is a beautiful object, of a uniform faint light.

No. 107. R. Asc. $5^h\ 52^m\ 20^s$. S. Pol. Dist. 19° 46′.

A very pretty double nebula, with a star in the preceding side of the largest, and a very small star in the south margin of the smallest nebula.

No. 142. R. Asc. $5^h\ 39^m\ 30^s$. S. Pol. Dist. 20° 45′.

30 Doradûs, Bode

Is a pretty large ill-defined nebula, of an irregular branched figure, with a pretty bright small star in the south side of the centre, which gives it the appearance of a nucleus. This is resolvable into very minute stars.

N.B. The 30 Doradûs is surrounded by a number of nebulæ of considerable magnitudes, nine or ten in number, with the 30 Doradûs in the centre.

No. 152. R. Asc. $5^h\ 43^m\ 50^s$. S. Pol. Dist. 20° 1′.

A cluster of six or seven small nebulæ, forming a square figure 5′ or 6′ diameter, with several minute stars mixt. This is a very pretty group of nebulæ.

No. 164. R. Asc. $12^h\ 49^m\ 0^s$. S. Pol. Dist. 20° 6′.

12 Muscæ, Bode.

This is a pretty bright round nebula, about 4′ diameter, moderately condensed to the centre. This, with the sweeping power, has the appearance of a globe of nebulous matter with very small stars in the north following margin. But with a power sufficient to resolve it, the globular appearance vanishes in a very considerable degree; and the brightest and most condensed part is to the preceding side of the centre, with the stars considerably scattered on the north following side. Resolvable into stars of mixt small magnitudes. A small nebula precedes this.

No. 175. R. Asc. $5^h\ 22^m\ 7^s$. S. Pol. Dist. 21° 50′.

A pretty large rather faint nebula, about 5′ diameter, irregular figure, partly resolvable into stars of mixt magnitudes. The nebulous matter has several seats of attraction, or rather it is a cluster of small nebulæ with strong nebulosity common to all.

No. 198. R. Asc. $6^h$ $6^m$ $27^s$ S. Pol. Dist. 21° 42′.

A pretty strong ray of nebula following a small star; but the small star is not involved. The ray is about 2′ long and 50″ broad, with a bright point or nucleus near the preceding extremity.

No. 266. R. Asc. $11^h$ $40^m$ $9^s$. S. Pol. Dist. 26° 8′.

A very small nebula, very bright immediately at the centre; the bright point is nearly equal in brightness to one of the minute stars north of the nebula. I do not think the bright point is a star, but a very highly condensed nucleus, surrounded by a faint chevelure, not more than 10″ diameter. Another very minute nebula precedes this.

No. 271. R. Asc. $11^h$ $11^m$ $36^s$. S. Pol. Dist. 27° 28′.

A rather bright nebula, about 2½′ or 3′ long and 1′ broad, in the form of a crescent, the convex side preceding; no condensation of the nebulous matter towards any point. This is easily resolvable into many stars of some considerable magnitude, arranged in pretty regular lines, with the nebula remaining, which is also resolvable into extremely minute stars. This is probably two clusters in the same line.

No. 278. R. Asc. $16^h$ $19^m$ $7^s$. S. Pol. Dist. 27° 18′.

A pretty well-defined small nebula, extending in the parallel of the equator, rather a little south preceding, and north following, about 1½′ long, and 25″ broad, with a star of the 11th or 12th magnitude in the centre. The nebula is nearly equally bright, and the star is in the centre.

No. 289. R. Asc. $11^h$ $29^m$ $20^s$. S. Pol. Dist. 29° 16′

A pretty large cluster of stars of mixt magnitudes, about 10′ diameter. The greater number of the stars are of a pale *white* colour. There is a *red* star near the preceding side; another of the same size and colour near the following side; another small *red* star near the centre; and a *yellow* star near the south following extremity, all in the cluster.

No. 295. R. Asc. $18^h$ $54^m$ $3^s$. S. Pol. Dist. 29° 45′.

A pretty large and very bright nebula, 5′ or 6′ diameter, irregular round figure, easily resolved into a cluster of small stars, exceedingly compressed at the centre. The bright part of the centre is occasioned by a group of stars of some considerable magnitude when compared with those of the nebula. I am inclined to think that this may be two clusters in the same line; the bright part is a little south of the centre of the large nebula.

No. 309. R. Asc. $10^h$ $38^m$. $0^s$. S. Pol. Dist. 31° 13′.
η Roboris Caroli, Bode.

Is a bright star of the 3d magnitude, surrounded by a multitude of small stars, and pretty strong nebulosity; very similar in its nature to that in Orion, but not so bright. The nebulosity is pretty strongly marked; that on the south side is very unequal in brightness, and the different portions of the nebulosity are completely detached, as represented in the figure. There is much nebulosity in this place, and very much extensive nebulosity throughout the Robur Caroli, which is also very rich in small stars.

No. 311. R. Asc. $12^h$ $50^m$ $30^s$. S. Pol. Dist. 31° 15′.

A very faint pretty large nebula, about 6′ or 8′ diameter, round figure, resolvable into very minute stars. Several stars of some considerable magnitude appear scattered among the minute stars of the nebula, but they are only the continuation of a branch of small stars which run over the place where the nebula is; the stars in the nebula are very gradually, but not much, compressed to the centre.

No. 332. R. Asc. $10^h$ $10^m$ $6^s$. S. Pol. Dist. 33° 57′.

A very faint ray of nebula, about 2′ broad, and 6′ or 7′ long, joining two small stars at the south following extremity, which are very slightly involved, but their lustre is not diminished from that of similar small stars in the field. The north extremity also joins a group of small stars, but they are not involved.

No. 357. R. Asc. $14^h$ $15^m$. $0^s$. S. Pol. Dist. 36° 17′.

A very extensive cluster of stars of mixed small magnitudes; the stars appear to be either congregating together in different parts of the cluster, or breaking up; there are several groups already formed, the whole cluster is composed of lines of stars, but no general attraction towards any particular point.

No. 366. R. Asc. $17^h$ $27^m$ $10^s$. S. Pol. Dist. 36° 25′.

A pretty large nebula, extended nearly in the parallel of the equator, brightest and broadest in the middle; a group of very small stars in the middle give it the appearance of a nucleus, but they are not connected with the nebula, but are similar to other small stars in this place, which are arranged in groups. The nebula is resolvable into stars.

No. 388. R. Asc. $13^h$ $36^m$ $0^s$. S. Pol. Dist. 39° 32′.

A bright exceedingly well-defined rather elliptical nebula, about 1′ diameter, exceedingly condensed almost to the very edge, and gradually a little brighter to the centre. This is about 6′ north of M Centauri.—I have strong suspicion that this is resolvable into stars.

No. 389. R. Asc. $15^h$ $16^m$ $34^s$. S. Pol. Dist. 39° 59′.

A very fine round pretty bright nebula, about 3′ diameter, gradually brighter towards the centre, and well-defined at the margin: this is resolvable. With a power of 260 it has a beautiful globular appearance. The stars are considerably scattered on the south side.

No. 408. R. Asc. $0^h$ $47^m$ $35^s$. S. Pol. Dist. 41° 38′.

A pretty large rather ill-defined nebula, of a round figure, with a bright point, or small nucleus near the centre; the nebula is extremely faint almost to the very centre. There is a star of the 8th or 9th magnitude near the south preceding side, but not involved.

No. 411. R. Asc. $12^h$ $55^m$ $30^s$. S. Pol. Dist. 41° 31′.

A beautiful long nebula, about 10′ long, and 2′ broad, forming an angle with the meridian, about 30° south preceding and north following; the brightest and broadest part is rather nearer the south preceding extremity than the centre, and it gradually diminishes in breadth and brightness towards the extremities, but the breadth is much better defined than the length. A small star near the north, and a smaller star near the south extremity, but neither of them is involved in the nebula. I have strong suspicions that this nebula is resolvable into stars, with very slight compression towards the centre. I have no doubt but it is resolvable. I can see the stars, they are merely points. This is north following the 1st ξ Centauri.

No. 440. R. Asc. 13ʰ 16ᵐ 0ˢ. S. Pol. Dist. 43° 26′.

ω Centauri (Bode)

Is a beautiful large bright round nebula, about 10′ or 12′ diameter, easily resolvable to the very centre; it is a beautiful globe of stars very gradually and moderately compressed to the centre; the stars are rather scattered preceding and following, and the greatest condensation is rather north of the centre; the stars are of slightly mixed magnitudes, of a white colour. This is the largest bright nebula in the southern hemisphere.

No. 446. R. Asc. 11ʰ 3ᵐ 55ˢ. S. Pol. Dist. 44° 21′.

A very minute star in the centre of a small round nebula, about 15″ diameter; this has very much the appearance of a small star surrounded by an atmosphere. There is a similar small star near the following margin, not involved.

No. 457. R. Asc. 17ʰ 23ᵐ 40ˢ. S. Pol. Dist. 45° 22′.

A beautiful round nebula, about 5′ diameter, with a bright round well-defined disc or nucleus, about 15″ diameter, exactly in the centre; this has the appearance of a planet surrounded by an extremely faint diluted atmosphere; there is a small star involved in the faint atmosphere; the atmosphere is at least 6′ diameter.

No. 473. R. Asc. 17ʰ 55ᵐ 14ˢ. S. Pol. Dist. 46° 22.

A very bright round highly condensed nebula, about 3′ diameter. I can resolve a considerable portion round the margin, but the compression is so great near the centre, that it would require a very high power, as well as light, to separate the stars; the stars are rather dusky.

No. 482. R. Asc. 13ʰ 14ᵐ 44ˢ. S. Pol. Dist. 47° 45′.

A very singular double nebula, about $2\frac{1}{2}'$ long and 1′ broad, a little unequal: there is a pretty bright small star in the south extremity of the southernmost of the two, resembling a bright nucleus: the northern and rather smaller nebula is faint in the middle, and has the appearance of a condensation of the nebulous matter near each extremity. These two nebulæ are completely distinct from each other, and no connection of the nebulous matters between them. There is a very minute star in the dark space between the preceding extremities of the nebula; they are extended in the parallel of the equator nearly.

No. 486. R. Asc. $18^h$ $39^m$ $20^s$. S. Pol. Dist. 47° 44′.

A very singular body resembling a star, with a very faint diluted atmosphere, 8″ or 10″ diameter; it is paler than a star of the same magnitude, and precedes a pretty bright star.

No. 501. R. Asc. $17^h$ $37^m$ $48^s$. S. Pol. Dist. 48° 41′.

Two very small stars, with a small nebula between them; both the stars are involved in the nebula, but the nebula is not in a line between the stars.

No. 507. R. Asc. $0^h$ $6^m$ $50^s$. S. Pol. Dist. 49° 50′.

A beautiful long nebula, about 25″ in length; position north preceding, and south following, a little brighter towards the middle, but extremely faint and diluted to the extremities. I see several minute points or stars in it, as it were through the nebula: the nebulous matter of the south extremity is extremely rare, and of a delicate bluish hue. This is a beautiful object.

No. 508. R. Asc. $5^h$ $7^m$ $0^s$. S. Pol. Dist. 49° 45′.

An exceedingly bright, round, well-defined nebula, about $1\frac{1}{2}'$ diameter, exceedingly condensed, almost to the very margin. This is the brightest small nebula that I have seen. I tried several magnifying powers on this beautiful globe; a considerable portion round the margin is resolvable, but the compression to the centre is so great, that I cannot reasonably expect to separate the stars. I compared this with the 68 Conn. des Tems, and this nebula greatly exceeds the 68 in condensation and brightness.

No. 564. R. Asc. $9^h$ $8^m$ $17^s$. S. Pol. Dist. 53° 53′.

A pretty large faint nebula of a round figure, 6′ or 8′ diameter; the nebulosity is faintly diffused to a considerable extent. There is a small nebula in the north preceding side, which is probably a condensation of the faint diffused nebulous matter; the large nebula is resolvable into stars with nebula remaining.

No. 573. R. Asc. $18^h$ $49^m$ $15^s$. S. Pol. Dist. 53° 10′.

A beautiful bright round nebula, about $3\frac{1}{2}'$ diameter, moderately and gradually condensed to the centre. This is resolvable. The moderate condensation, and the bluish colour of the stars which compose it, give it a very soft and pleasant appearance. This is rather difficult to resolve, although the condensation is not very great.

No. 588. R. Asc. $19^h\ 58^m\ 30^s$. S. Pol. Dist. 54° 7′.

A very curious nebula, very faint and well-defined, with an exceedingly bright point in the centre, resembling a small star surrounded by an atmosphere about 30″ diameter; the bright point is exactly in the centre, a bright star 12′ or 15′ south.

No. 611. R. Asc. $14^h\ 51^m\ 8^s$. S. Pol. Dist. 57° 39′.

A very singular body resembling a star with a burr. The light is equal to that of a star of the 7th and 8th magnitude, and the diameter is not sensibly larger, with various magnifying powers. This has the appearance of a bright nucleus, surrounded by a strong brush of light; and the nebulosity surrounding the bright point has not that softness which nebulæ in general possess. I consider this different from nebulæ in general.

No. 628. R. Asc. $13^h\ 15^m\ 3^s$. S. Pol. Dist. 61° 2′.
185 Centauri (Bode.)

Is a very beautiful round nebula, with an exceedingly bright well-defined planetary disk or nucleus, about 7″ or 8″ diameter, surrounded by a luminous atmosphere or chevelure, about 6′ diameter. The nebulous matter is rather a little brighter towards the edge of the planetary disk, but very slightly so. I can see several extremely minute points or stars in the chevelure, but I do not consider them as indications of its being resolvable, although I have no doubt it is composed of stars.

He next proceeds to give the following description of the famous Magellanic clouds under the name of Nebula Minor and Major.

The Nebula Minor, to the naked eye, has very much the appearance of a small cirrus-cloud; and through the telescope, it has very much the appearance of one of the brighter portions of the Milky Way, although it is not so rich in stars of all the variety of small magnitudes, with which the brighter parts of the Milky Way in general abound, and therefore it is probably a beautiful specimen of the nebulosity of which the remote portion of that magnificent zone is composed.

Its situation in the heavens is between $0^h$ 27′ and $1^h$ 6′ or 7′ in right ascension, and between 74° 30′ and 72° 53′ in south declination. Its position is oblique to the equator, south preceding and north following; and its form is nearly that of a parallelogram about two degrees long and fully one degree broad, and may be arranged according to its natural general appearance, into bright, faint, and very faint nebulosity. The bright nebula forms the south extremity and the preceding side, and is equal to the breadth of the nebula at the south end, and gradually diminishing in breadth and brightness till it terminates in an accumulation of the nebulous matter in the north extremity. The bright portion of the nebulous matter is not uniformly bright, but has something the appearance of small cumular clouds, although not very decidedly marked, and which I cannot well delineate. The faint nebula which is on the following side, is broad at the north extremity and gradually diminishing in breadth to where, with the other faint shade, it joins the following side of the brighter portion of the nebula, near the south extremity. The very faint shade is also on the following side, and extends from the northern to the southern extremity of the nebula, and is rather more strongly marked at what I would call its terminating border, than where it joins or blends with the faint shade; and I suspect it is faintly connected with a patch of faint nebula which follows at a little distance.

There are two pretty bright small nebulæ situated in the following margin of the bright shade, and a considerable number of faint nebulæ and accumulations of the nebulous matter variously situated throughout, and also in the patch which follows; but they are described in the general catalogue.

The figure of the Nebula Major is so irregular, and divided into so many parcels, that without the assistance of letters of reference it will be impossible for me to attempt a description. However, the appearance and construction of the different nebulæ which compose it, are more minutely described in the general catalogue. I will here only attempt to describe the apparent connection of one portion or branch of the nebulous matter with another. I find the existence of extensively diffused faint nebulosity throughout a great portion of this quarter of the heavens, from the Robur Caroli to the Nebula Major, and I can even trace its existence in the vicinity of Nebula Minor.

The Nebula Major is situated between $4^h$ 46′ and $6^h$ 3′ in right ascension, and between 66° 30′ and 71° 30′ of south declination; but the body or principal portion of the nebula is situated between $5^h$ 7′ and $5^h$ 40′ in right ascension, and between 69° and 71° of south declination, and is composed of very strong bright nebula, very rich in small nebulæ and clustering stars of all the variety of small magnitudes: I compared this portion of the nebula with Sobieski's Shield, which in this latitude is near the zenith. The observation says, "The Nebula Major very much resembles the brightness in Sobieski's Shield; it is scarcely so large, but I think it is equally bright." Another observation says, "The ridge or brighter portion of Nebula Major is more condensed than the Shield."

The bright ridge or body of the nebula is extended obliquely to the equator, north preceding and south following, and the following extremity breaks off rather suddenly, faint, decreasing in brightness in a south following direction to the distance of fully a degree and a half towards the star $\beta$, which is slightly involved in the narrow extremity: preceding the star marked $\gamma$, a considerable increase of the brightness of the nebulous matter takes place; another accumulation takes place at $\delta$ about 15′ diameter. There is a small star north with a small nebula preceding, but neither of them are involved in the accumulation of the nebulous matter. $\delta$ and $\varepsilon$ are connected by streams of unequal brightness, $\varepsilon$ is pretty large and is rich in small stars and nebulæ: opposite $\delta$ and $\varepsilon$, towards the principal body of the nebula, the nebulous matter is very faint and of unequal brightness; $\varepsilon$ is south following a beautiful group of nebulæ of various forms and magnitudes, on a ground of strong nebulosity common to all, with the 30 Doradûs (Bode) in the centre.

South of the 30 Doradûs a pretty bright accumulation of the nebulous matter takes place, extended, preceding and following, and is joined by pretty strong nebula to the arm $\varkappa$, which proceeds in a northerly direction from the body of the nebula; the bright star near the north extremity of the arm is not involved in the bright nebula. Between the arms $\varkappa$ and $\lambda$ the nebula is very faint, and the bright accumulations of the nebulous matter on the north side are all connected together by nebulosity of various brightness, and are connected to the main body by the arms $\varkappa$ and $\lambda$; and I strongly suspect the nebula at $\varphi$ is connected by very faint nebula with the group surrounding the 30 Doradûs. The accumulation of the nebulous matter at $\xi$ is connected with the preceding extremity of the body of the nebula, by nebula increasing in brightness towards the neck of the body, but I cannot say that the $\psi$ is connected with the $\xi$. Two arms proceed from the neck towards the south, which are connected by faint nebula between them, which gradually increases in brightness towards the junction of the arms; between the arm $\eta$ and the body, the nebulosity is faint, of various shades of brightness, and from the arms $\eta$ and $\nu$, to the head $\xi$, the nebulosity is of various degrees of brightness.

I have made a very good general representation of the various appearances of the Milky Way, from the Robur Caroli to where it crosses the zenith in Scorpio. This was generally made by the naked eye, except in particular places where I suspected an opening or separation of the nebulous matter, when I applied the telescope. However, the dark space on the east side of the Cross, or the black cloud as it is called, is very accurately laid down by the telescope; the darkness in this space is occasioned by a vacancy or want of stars; it contains only two or three of the 7th magnitude, and very few of the 8th or 9th magnitude. I may here remark that the Nebula Minor is not so bright as the Nebula Major.

Neither of the two nebulæ, Major and Minor, are at present in the place assigned to them by Lacaille; and it has been suspected that nebulous appearances change their form and also their situation. Yet, although the situation of these nebulæ, as given by Lacaille and compared with their present situation, would be favourable to such a surmise, still we must consider the dimensions of the instruments with which he made his observations, and make a reasonable allowance.

However, the 30 Doradûs is at present involved in pretty strong and pretty bright nebula, and is also situated very near the brightest part of the Nebula Major; and it would be singular if its relative situation was the same when Lacaille observed it as it at present is; that he should have assigned to it a place in the Dorado and not in the Nebula Major, to which, from its nature, it was not only nearly allied, but in which it was actually involved. This circumstance, it must be confessed, is favourable to the conjecture; and the 47 Toucani is similarly situated, with respect to distance, from the Nebula Minor, although it is not involved in nebulosity or connected with the nebula.

When reflecting on these circumstances, I was led to examine the present state of these nebulæ, and find that scarcely any nebulæ exist in a high state of condensation, and very few in a state of moderate condensation towards the centre. A considerable number appear a little brighter towards the centre, and several have minute bright points immediately at the centre. Others have small or very minute stars variously situated in them, but many of those bright points in or near the centre may be stars, for the Nebula Major in particular is very rich in small stars. But the greater number of the nebulæ appear only like condensations of the general nebulous matter, into faint nebulæ of various forms and magnitudes, generally not well-defined; and many of the larger nebulous appearances are resolvable into stars of mixed small magnitudes; and a great portion of the large cloud is resolvable into innumerable stars of all the variety of small magnitudes with strong nebula remaining, very similar to the brighter parts of the Milky Way. And whether the remaining nebulous appearance may not be occasioned by millions of stars disguised by their distance, is what I cannot say.

But a critical examination of these nebulæ would not only be a valuable treasure for the present generation to possess, but an invaluable inheritance for them to transmit to posterity. For it must be by the comparison of observations, made at distant periods of time, that we can draw any satisfactory conclusions concerning the breaking up or the greater condensation of the nebulous matter. It seems beyond a doubt that stars must assume a nebulous appearance when situated at immense distances; but whether all nebulous appearances are occasioned by stars, is a problem apparently beyond the reach of man to resolve, without the assistance of analogy, which ought not to be trusted too freely, especially with objects almost equally beyond the reach of our hands and telescopes. Several of the very faint and delicate nebulæ can be resolved into stars, and also many of the brighter nebulæ are composed of stars; but there are a greater number which have not yet been resolved or shown to consist of stars; and it is not improbable, that "shining matter may exist in a state different from that of the starry."

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ART. XV.—*Table of the Refractive Powers of several Bodies, according to the observations of J. F. W. Herschel, Esq. V. P. R. S. &c.* With remarks by the EDITOR.

IN his Treatise on Light, Mr Herschel has published a very copious table of refractive powers, compiled from the observations of preceding authors, and he has inserted in it various observations of his own, which, from the accuracy with which they were made, possess very great value. From the importance which is now beginning to be attached to the optical properties of minerals, as affording the most precise distinctive characters, both our optical and mineralogical readers will be glad to see these measures of Mr Herschel collected from the table in which they occur.

*Table of Mr Herschel's Measures of the Refractive Powers of several Bodies*.*

| | |
|---|---|
| Saturated aqueous solution of alum, - - | 1.356 |
| Alcohol (rectified spirits,) - - - | 1.372 |
| Muriatic acid (spec. grav. 1.134,) - - - | 1.392 |
| Sulphuric acid, - - - - | 1.430 |
| Oil of turpentine (common,) - - - | 1.486 |
| Oil of olives, - - - - - | 1.4705 |
| Nut oil (perhaps impure,) - - - | 1.490 |

* From his *Essay on Light*, §. 1116.

| | |
|---|---|
| Rochelle salt (mean green rays,) - - | 1.4985 |
| ——— (mean red,) - - - | 1.4929 |
| English plate glass (extreme red,) - - | 1.5133 |
| Crown glass, a prism by Dollond (extreme red,) | 1.526 |
| ——— another do. do. - | 1.5301 |
| Apophyllite (leucocyclite,) - - - | 1.5431 |
| Hyposulphate of lime (mean red,) - - | 1.561 |
| ——— (mean yellow green,) - | 1.566 |
| Flint glass, - - - - - | 1.578 |
| ——— a prism by Dollond - - - | 1.589 |
| ——— ——— (extreme red,) - | 1.585 |
| ——— a prism by Dollond (extreme red,) - | 1.601 |
| ——— do. marked "heavy" (extreme red) - | 1.602 |
| Hyposulphite of lime, least refraction, - - | 1.583 |
| ——— greatest refraction, - | 1.628 |
| ——— strontia, least refraction, - - | 1.608 |
| ——— greatest refraction, - | 1.651 |
| Sulphate of barytes, ordinary refraction (along the axis) for yellow green rays, - - - | 1.6460 |
| ——— another specimen do. red rays, | 1.6459 |
| ——— for yellow green rays, - | 1.6491 |
| Chloruret of sulphur, - - - - | 1.67 |
| Nitrate of bismuth, least refraction about - | 1.67 |
| ——— greatest ——— about - | 1.89 |
| Hyposulphite of soda and silver, least refraction, | 1.735 |
| ——— greatest do. - | 1.785 |
| Spinelle ruby, - - - - | 1.756 |
| Rubellite, - - - - - | 1.768 |
| Labrador hornblende, - - - - | 1.80 |
| Silicate of lead, atom to atom, - - | 2.123 |
| Nitrate of lead (bioxal, ? quadro-nitrate) or six-sided prisms, ordinary refraction, - - - | 2.322 |

At the end of the table from which the preceding measures are taken, Mr Herschel has made the following appropriate remarks.

"In casting our eyes down the foregoing table, we cannot but be struck with the looseness and vagueness of those results which refer to bodies whose chemical nature is in any respect determinate. The refractive indices assigned to the different oils, acids, &c. though no doubt accurately determined from the particular specimens under examination, are yet, as scientific data, deprived of most of their interest from the impossibility of stating precisely what *was* the substance examined. Most of the fixed oils are probably (as appears from the researches of Chevreul) compounds in very variable proportions of two distinct substances, a solid concrete matter (stearine,) and a liquid (elaine,) and it is presumable that no two specimens of the same oil agree in the proportions. This is probably, peculiarly the case with the *oil of anise-seed* *, which congeals almost entirely with a very moderate degree of cold. An accurate re-examination of the refractive and dispersive powers of natural bodies, of strictly determinate chemical composition, and identifiable nature, though doubtless a task of great labour and extent, would be a most valuable present to optical science."

At the end of the table of dispersive powers, which Mr Herschel gives from Dr Brewster's *Treatise on New Philosophical instruments*, he adds "respecting the results in this table, the remark applied to that of refractive indices may yet be more strongly urged. The whole stands in need of a radical reinvestigation."

Although we entirely agree with Mr Herschel in all these remarks, yet, as they are particularly applicable to our observations, which form the greater part of the tables referred to, we think it necessary to add the following explanations.

In order to obtain uniform measures of the refractive powers of oils and other fluids, it is absolutely necessary to determine their specific gravities, and the temperatures at which the observations are made. But even if we do this, we shall find that the same oil, especially if it is procured in small quantities, will give different results, even at the same temperature. The more volatile parts fly off, and the oil becomes inspissated, and has a higher refractive power. We have now

* As a proof of the correctness of this remark, I may observe, that the oil of anise-seed, whose refractive and dispersive power I measured, and which I have used in various optical inquiries, never congealed. That which I am using now, and which I consider pure, congeals entirely at 60° Fahr.—D. B.

before us oils purchased in 1810, and which have no resemblance to similar oils which are now obtained under the same name. Some of them, indeed, have deposited groups of crystals, and consequently they must have become almost new substances.

In the examination of gums, and such like hard solids, their refractive power depends on the degree of induration which they possess, and this will depend on the place where they have been kept; so that the same gum will give different results at different times.

In the case of minerals, every thing depends on the nature of the specimens which the observer can command. I have often been compelled to measure both refractive and dispersive powers with fragments not bigger than a pin's head, and with crystals that almost escaped unassisted vision. At other times, I have been obliged to work with specimens which I was not allowed to cut, and in this case, when the natural faces were imperfect, there was no resource but to take a mean of the inclinations of different parts of the faces, and a mean of the angle of deviation, or, what is sometimes better, to mask with an opaque cement all the imperfect portions of the surface, excepting those which had the best polish, and the most uniform inclination.

On other occasions, it was necessary to keep the crystal in its matrix, and to resort to the most troublesome methods of gaining a measure of its refractive or dispersive powers. All this labour, however, and none but those who have been exposed to it can form an idea of it, was not undergone to obtain merely a measure of refractive indices, or of dispersive actions, but for purposes much more important, and more interesting to the observer. This circumstance leads us to consider the various objects for which such measurements are taken.

1. When refractive or dispersive powers are measured to determine physical or chemical relations, numerical accuracy is of no importance. When Sir Isaac Newton, for example, deduced from his refractive indices of *camphor*, *olive oil*, *linseed oil*, *spirit of turpentine*, *amber*, and the *diamond*, his beautiful conclusion that the latter was probably an inflammable substance coagulated, the measures of the merest tyro would

have been sufficient authority for the conclusion. Had Sir Isaac made the index of diamond 2.000 in place of 2.439, and that of camphor 1.400 in place of 1.500, he would have arrived at the very same result.

2. When I concluded from my table of refractive powers, *that the refractive powers of the three simple inflammable substançes*, viz. DIAMOND, PHOSPHORUS, and SULPHUR, are in *the order of their inflammability*, I had no other results but a coarse measure of the influence of the two latter substances in altering the focal length of the object-glass of the microscope, (the influence being measured by the numbers 4.337 for sulphur, and 7.094 for phosphorus,) and these numbers were as good evidence of the general principle as if sulphur and phosphorus had been capable of being wrought into the purest transparent prisms, and had their refractive powers determined in relation to the fixed lines in their spectra.

3. In determining the relation between the index of refraction and the polarizing angle of bodies, the ordinary measures were quite sufficient for the purpose, and on their authority the law has been universally adopted.

4. When refractive and dispersive powers are measured to *discover* substances proper for achromatic telescopes and microscopes, a very rude measure is all that is necessary. When I found that sulphuret of carbon possessed most valuable properties, and when I recommended it as a fluid "which might yet be of incalculable service in the construction of optical instruments," I had taken only the ordinary measures of its action upon light; and the practical optician requires no better evidence of the suitableness of the fluid for the construction of fluid object-glasses.

5. When refractive and dispersive powers are required to enable the practical optician to calculate the curves for an achromatic combination, the greatest accuracy is required; but in such a case he durst not trust to the measurements of Newton, or Boscovich, or Dollond, or Wollaston, or Herschel, or even to those of Fraunhofer, the most accurate of all, because there is no possibility of his commanding the same materials with which their experiments were made. He has no alternative, therefore, but to measure with his own hands the

refractive and dispersive powers of the materials which he means to employ.

From these observations we have no hesitation in concluding, that the existing tables of refractive and dispersive powers, with all their imperfections and errors, are of great use in scientific researches. If they do not afford scientific data on which the philosopher may confidently rest, they furnish him with approximate results, and general indications; and are perhaps the more valuable to him, that they compel him to ascertain the properties of the materials themselves with which he works, or about which he reasons.

Now that mineralogy depends in a very great degree on the determination of the physical characters of the bodies which it embraces, we are on this account anxious to see new tables of refractive and dispersive powers; and we would strongly recommend the subject as one that would establish the reputation of any young philosopher who has the courage to devote himself to so laborious a task.

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## Art. XVI.—*Approximate Places of Double Stars in the Southern Hemisphere observed at Paramatta in New South Wales.* * By James Dunlop, Esq. In a Letter to Sir T. Macdougal Brisbane, K. C. B., F. R. S. Lond. and Ed.

Sir,

In presenting this list of double stars, it may be necessary for me to make some apology for its imperfect state, as regards the true apparent distance and position of a great many of the double stars, the situation of which it points out in the heavens.

You are aware that during your administration of the government of the colony of New South Wales, my time and attention were wholly devoted, in your employ, to the Paramatta observatory in the miscellaneous observations which occurred; and principally in observing the right ascensions and polar distances of the fixed stars, thereby collecting materials towards the formation of a catalogue of stars in that hemisphere (which mate-

* Abridged from the *Transactions of the Astronomical Society of London.* Read May 9, 1828.

rials have been presented by you to the Royal Society of London): and your departure from the colony alone prevented me from pursuing that branch further.

Finding myself in possession of reflecting telescopes, which I considered capable of adding considerably to our knowledge of the nebulæ and double stars in that portion of the heavens, I resolved to remain behind to prosecute my favourite pursuits, in collecting materials towards the formation of a catalogue of the nebulæ and double stars in that hemisphere, and any other object which might have attracted my attention.

The nebulæ being a primary object with me, I devoted the whole of the favourable weather in the absence of the moon to that department, and the moonlight, in general, was allotted to the observations of double stars; a portion only of which I have been able to subject to the various measurements necessary for the accurate determinations of their relative distances and positions.

In the case of the stars marked with an asterisk, their positions, distances, declinations, &c., are the result of micrometrical measurements with the 46-inch achromatic telescope mounted on the equatorial stand which you left with me: the micrometers were constructed by myself, consisting of a parallel line micrometer, the screws of which I bestowed great pains upon, and which I consider very excellent and uniform; also a double image micrometer on Amici's principle, which I sometimes used, particularly when the stars were nearly of equal magnitudes (I always found some uncertainty in the measurements, when the stars were of very unequal magnitudes): the position micrometer was made by Bancks, and belongs to the telescope.

In the case of those stars which are not marked with an asterisk, their positions and distances are only estimations while passing through the field of the 9-feet telescope: in the various sweeps, the right ascensions and declinations are also those which were indicated by the same instrument fitted up and described as a meridian telescope, in my paper on the nebulæ of the southern hemisphere.

I will only extend at length the observations of a few of the principal stars, merely to show the manner in which they have been conducted.

Trusting that my humble efforts will be of some service to science, I have the honour to be, Sir, your obedient servant,

James Dunlop.

R. Asc. $0^h$ $23^m$; Decl. 63° 56′ S.
1 and 2 β *Toucani*. Both of the 4th magnitude.
Both light yellow.
Angle of Position, 84° 5′ North Preceding.
Diff. of R. Ascension, 0″,607.
Diff. of Declination, 24″,865.

R. Ascen. $1^h$ $32^m$; Decl. 58° 18′ S.
100 *Phœnicis*. Double; 6th and 8th magnitudes.
Angle of Position, 17° 27′ South Following.
Distance, 15″,809.

R. Asc. $1^h$ $33^m$; Decl. 57° 4′ S.
6 *Eridani*. Double; both of the small 6th magnitude.
Angle of Position, 73° 6′.

A beautiful double star; both stars white; the preceding a little dusky. I cannot say which of the stars is the larger; perhaps the following, if there be any difference. The distance is about equal to one diameter of the following star, which I estimate at about $2\frac{1}{2}$ seconds.

R. Asc. $2^h$ $51^m$; Decl. 41° 0′ S.
θ *Eridani*. Double; 4.5 and 6th magnitudes.
Large white; small yellow.
Angle of Position, 1° 37′ North Following.
Distance, 10″,81.

R. Asc. $3^h$ $33^m$; Decl. 40° 55′ S.
184 *Eridani*. Double; 6th and 7th magnitudes.
Large white; small blue. Very pretty.
Angle of Position, 64° 55′ North Preceding.
Distance estimated at 4″.

R. Asc. $3^h$ $42^m$; Decl. 38° 10′ S.
207 *Eridani*. A beautiful double star; 5th and 5.6th magnitudes.
Both light yellow.
Angle of Position, 67° 48′ South Preceding.
Distance estimated at 7″.

R. Asc. $4^h$ $46^m$; Decl. 53° 46′ S.

*Pictoris.* Double; 6th and 7th magnitudes.

Large white; small blue.

Angle of Position, 30° 4′ North Following.

Distance, 12″,547.

Diff. of R. Ascension, 1″, 137.

Diff. of Declination, 8″,659.

R. Asc. $5^h$ $26^m$; Decl. 42° 26′ S.

26 *Pictoris.* Double; little unequal. Both of the small 6th magnitude.

Bluish white.

Angle of Position, 80° 7′ South Following.

Distance, 5″,534.

R. Asc. $7^h$ $31^m$; Decl. 26° 26′ S.

κ *Argûs.* Double; very nearly equal. 4th magnitude.

Both white.

Angle of Position, 45° 48′ North Preceding.

Distance, 8″,765.

N. B. Sometimes the stars appear sensibly unequal, and on other nights I cannot say which star is the larger.

R. Asc. $10^h$ $28^m$; Decl. 71° 13′ S.

Double; very nearly equal. 8th and 8th magnitudes.

Angle of Position, 41° 11′ South Preceding;

Distance, 3″,695.

R. Asc. $10^h$ $38^m$; Decl. 58° 43′ S.

η *Roboris Caroli.* Double; 3d and 10th magnitudes.

Angle of Position, 79° 2′ North Following;

Distance, 60″,20.

R. Asc. $11^h$ $24^m$; Decl. 28° 19′ S.

275 *Hydræ.* Double; very nearly equal. Both of the small 6th magnitude.

Large yellow; small blue.

Angle of Position, 61° 25′ North Following.

Distance, 9″,965.

Diff. of R. Ascension, 0″,20.

Diff. of Declination, 8″,252.

R. Asc. $12^h\ 16^m$; Decl. 62° 7′ S.
*α Crucis.* Triple; 2d, 2.3d, and 6th magnitudes.
Observations on the 2d and 2.3d magnitudes.
Both yellowish white; smaller rather pale.
Angle of Position, 24° 24′ South Following.
Distance, 5″,55.

N. B. *Castor* and *α Crucis* are double stars very similar to one another in point of magnitude, colour, and distance. The following comparison was made on the 26th March 1826, by the double image micrometer.

Distance *Castor*, 5″,375.
Distance *α Crucis*, 5″,292.

R. Asc. $12^h\ 16^m$; Decl. 62° 7′ S.
*α Crucis.* Double; 2d and 6th magnitudes.
Large white; small reddish yellow.
Angle of Position, 70° 0′ South Preceding.
Diff. of R. Ascension, $4^s$,45;
Diff. of Declination, 81″,473.

Mr Fallows mentions this star accompanying *α Crucis* as a star of the small 4th magnitude. I have never observed it for a star of more than the 6th, and frequently as a star of the 6.7th magnitude. I have never suspected it as a variable star.

*θ Pictoris.* R. Asc. $5^h\ 20^m$; Decl. 58° 28′ S.
5.6 and 6.7 m. L. yellow; S. bluish white.
Angle of position, 14° 4′ North Preceding.
Diff. of R. Ascension, 4″,19.
Diff. of Declination, 9″,055;
Distance, 38″,516.

*γ Crucis.* R. Asc. $12^h\ 21^m$; Decl. 56° 7′ S.
2 and 6.7 m. L. dusky red; S. pale.
Angle of Position, 46° 42′ North Following.
Diff. of R. Ascension, 7″,216;
Diff. of Declination, 70″,854.

*ο Crucis.* R. Asc. $12^h\ 44^m$; Decl. 56° 13′ S.
5 and 6 m. Both white.
Angle of Position, 79° 48′ North Following.
Diff. of R. Ascension, 1″,375;

Diff. of Declination, 34″,51;
Distance, 35,97.

k *Centauri.* R. Asc. 13$^h$ 42$^m$; Decl. 32° 9′ S.
5.6 and 8 m. L. white; S. blue.
Angle of Position, 30° 10′ South Following.
Diff. of R. Ascension, (time) 0″,57;
——————— (arc) 6″,97;
Diff. of Declination, 4″,425.

Y *Centauri.* R. Asc. 14$^h$ 10$^m$; Decl. 57° 40′ S.
5 and 8 m. L. yellow; S. pale.
Angle of Position, 70° 55′ South Following.
Diff. of R. Ascension, 0″,15;
Diff. of Declination, 9″,58;
Distance, 12″,789.

α *Centauri.* R. Asc. 14$^h$ 28$^m$; Decl. 60° 6′ S.
1 and 4 m. Both strong reddish yellow.
Angle of Position, 56° 49′ South Preceding.
Diff. of R. Ascension, 1″,783;
Diff. of Declination, 18″,788.

ζ *Lupi.* R. Asc. 14$^h$ 59$^m$; Decl. 51° 25′ S.
5 and 8 m. L. greenish yellow; S. pale.
Angle of Position, 20° 48′ North Preceding.
Diff. of R. Ascension, 7″,38 (time.)
——————— 64″,195 (arc.)
Diff. of Declination, 24″,47;
Distance, 68″,79.

κ *Lupi.* R. Asc. 15$^h$ 0$^m$; Decl. 48° 1′ S.
5 and 7 m. L. greenish yellow; S. reddish yellow.
Angle of Position, 55° 40′ South Following.
Diff. of R. Ascension, 1″,397;
——————— 16″,92;
Diff. of Declination, 22″,563;
Distance 28″,88.

μ *Lupi.* R. Asc. 15$^h$ 6$^m$; Decl. 47° 13′ S.
Angle of Position, 64° 36′ South Following.
Diff. of R. Ascension, 1″,50;

Diff. of R. Ascension, 18″,33 ;
Diff. of Declination, 14″613.

*ξ Lupi.* R. Asc. 15ʰ 46ᵐ ; Decl. 33° 30′ S.

A beautiful double star. Both of the small 6th magnitude; a little unequal. L. slightly yellow ; S. greenish.

Angle of Position, 40° 43′ North Following.
Diff. of R. Ascension, 0″,70 ;
——————— 9″,36 ;
Diff. of Declination, 7″,227 ;
On another night 6″,831.

*β Piscis Australis.* R. Asc. 22ʰ 21ᵐ ; Decl. 33° 14′ S.

Angle of Position, 82° 46′ South Following.
Diff. of Declination, 27″,68 ;
Distance, 35″,31.

*ψ Gruis.* R. Asc. 23ʰ 13ᵐ ; Decl. 54° 49′ S.

6 and 7 m. L. dusky ; S. blue.

Angle of Position, 58° 24′ South Preceding.
Diff. of Declination, 22″,73 ;
Distance, 27″,09.

*θ Phœnicis.* R. Asc. 23ʰ 30ᵐ ; Decl. 47° 36′ S.

6 and 6 m. ; very nearly equal. L. white ; S. bluish. Position preceding, in the parallel of the equator. Distance about 1½ diam. of the larger star.

*φ Sculptoris.* R. Asc. 23ʰ 46ᵐ ; Decl. 28° 26′ S.

Both of the small 6th magnitude ; a little unequal. Both bluish white.

Angle of Position, 0° 0′ exactly preceding.
Distance, 5″,031 4 obs.; Diff. 0″,75.

Nothing is more remarkable than the different colours of the stars as observed by Mr Dunlop. The following are some of the colours mentioned in the Catalogue.

| | |
|---|---|
| Uncommon red purple. | Blue. |
| Fine yellow. | Greenish. |
| Pale green. | White. |
| Dusky red. | |

Mr Dunlop's valuable memoir is then concluded with a detailed catalogue of 253 double stars.

**Art. XVII.**—*Account of an Experiment made on the composition of Oil of Cassia, to determine the cause of its high dispersive power,** *by J. W. F.* Herschel, *Esq. V. P. R. S. &c. &c.*

When the extraordinary dispersive power of *Oil of Cassia* was discovered by Dr Brewster, he made the following observation on it:

"The substances at the head of the table between the dispersive powers of 0.0128 and 0.400, (these numbers are values of $\frac{dR}{R-1}$) have never before been the subject of experiment, and present us with results of unexpected magnitude. *Chromate of lead, realgar, and phosphorus,* which are included within these limits, might, from their chemical properties, be supposed to possess a great degree of dispersion; but the *oil of cassia,* which exceeds even *phosphorus* in dispersive power, and stands far above every mineral or vegetable product, exerts a most surprising power in separating the extreme rays, *and indicates the existence of some ingredient which chemical analysis has not been able to detect.*" †

After the same author had discovered that *Sulphuret of Carbon* exceeded *oil of cassia* in refractive power, that of the former being 1.68, and that of the latter only 1.64; while oil of cassia exceeded the sulphuret in dispersive power, that of the former oil being 0.139, and that of the sulphuret 0.115, he remarks:—

"All other fluids are separated from these two in their optical properties by an immense interval; and hence we are of opinion, that oil of cassia will yet be found to consist of ingredients as remarkable as those which enter into the composition of sulphuret of carbon." ‡

As the *oil of cassia* possesses also the remarkable property of acting less powerfully upon green light than upon any other substance yet known, § it became very interesting to determine the principle to which such singular properties were owing.

* From his *Essay on Light,* § 1122.

† *Treatise on New Philosophical Instruments,* p. 310.

‡ *Edinburgh Transactions,* vol. vii. p. 288.

§ Id. vol. viii. p. 11.

This has been accomplished by Mr Herschel in a very interesting experiment, of which he has given the following account:—

"The following experiment would seem to point out the *hydrogen* of the latter oil *(oil of cassia)* as the principle to which its extraordinary dispersion is due, and is otherwise instructive, as exemplifying strongly the independence of the two powers *inter se.* A stream of chlorine was passed through oil of cassia till it refused to act any farther. The oil was at first greatly deepened in colour; but as the action proceeded, it changed to a much lighter ruddy yellow, which it retained till the action was complete, (and which in a few days changed to a fine rose red.) Copious fumes of muriatic acid gas were given off during the whole process, indicating the abstraction of abundance of hydrogen, and at length the oil was converted into a viscous mass, drawing out into long threads, having entirely lost its peculiar perfume, and acquired a pungent penetrating scent, an acrid astringent taste, totally unlike its former aromatic flavour. It was inflammable, though less than before, burning with a flame green at the edges, indicating the presence of chlorine. Its refractive power was very little diminished. A drop being placed in the angle of two glass plates, and close to it a drop of unaltered oil of cassia, the spectrum of a line of light was viewed *at once with the same eye* through both the media. They still formed a continuous line, the spectrum of the unaltered oil being more refracted by only about one-fourth the breadth of that of the *altered* specimen. But the dispersive power of the latter was most remarkably diminished, being brought below not only that of the unaltered oil, but even below that of flint glass. When the dispersion of the unaltered oil was corrected by flint-glass, that of the altered was found to be much more than corrected; and when the angle of the glass plates was such that the dispersion of the latter was just corrected by a prism of Dollond's 'heavy' flint, whose refracting angle = about 25°, the uncorrected spectrum of the former was about equal to that of the flint prism. The dispersion, then, had been diminished to half its former amount, while the refraction had suffered hardly any appreciable change.—*(October* 7, 1827.*)*

## Art. XVIII.—*Contributions to Physical Geography.*

### 1. *Account of the Eruptions of Mount Ætna.** By L. Simond.

It seems probable that in Homer's time Ætna was an extinct volcano, as Vesuvius continued to be to a much later period; for Homer, speaking of Ætna, says nothing of its fires.† Subsequently, however, Thucydides preserved the memory of three great eruptions, and Diodorus recorded another which had taken place in the first year of the 96th Olympiad. One hundred and twenty-two years before Christ, the earth shook and vomited fires even under the sea, and vessels perished near the coast of Sicily. In Cæsar's time a great eruption took place, perhaps two; as at his death, we find, the earth shook and the air was obscured. The eruption in the 44th year of our æra was recorded by Suetonius, only because it had made Caligula run away from Messina; and that of the year 812 was only remembered for a similar cause, no less a personage than Charlemagne having likewise been frightened.

In the intermediate time (the year 252) torrents of liquid fire running down the sides of Ætna turned away at the tomb of St Agatha, an indigenous female saint who the year before had suffered martyrdom on the spot. Possibly volcanic eruptions were as frequent as in modern times, but no one cared then about natural phenomena of any sort, unless connected with such great matters as the fright of an emperor or the glory of a saint.

Only two eruptions are recorded in the twelfth century, one in the thirteenth, two in the fourteenth, four in the fifteenth, and four in the sixteenth. During the last part of the fifteenth century and the first part of the sixteenth, a period of ninety years intervened without any. Twenty-two eruptions were recorded in the seventeenth century, thirty-two in the eighteenth, and in the few years that have elapsed of this present century already eight. Catania, shaken and more or less injured at

* Extracted from *A Tour in Italy and Sicily* in 1817-1818. Lond. 1828. P. 517, *et seq.*

† Yet Virgil exhibits them in all their terrific grandeur to the *Trojans* on their arrival in port.

> ———— horrificis juxta tonat Ætna ruinis
> Interdumque atram prorumpit ad æthera nubem,
> Turbine fumantem piceo et candente favilla
> Atollitque globos flammarum et sidera lambit, &c.—*Æn.* iii. 571.

every one of these convulsions of Ætna, was completely overturned or burnt down, and its inhabitants wholly or in part swallowed up, once in the twelfth century, and twice in the seventeenth.*

But during the memorable earthquake of 1783, which shook five hundred miles of country in a straight line through Sicily and Calabria, spreading over all Italy and a great part of Europe a fixed haze, which for many months neither wind nor rain could dispel, Catania suffered less in proportion than Messina. I have heard living witnesses describe the heaving up and down of the earth during that memorable earthquake, as resembling the motion of a carpet when the wind gets between it and the floor, and as a sort of undulation producing sea-sickness. The walls of buildings were not only thrown out of the perpendicular, but so shaken as to lean different ways at the same time, become totally disjointed, and fall to pieces. In the sylvan region of Ætna trees were seen bowing to one another, and the phenomena was attended with tremendous internal noises—*rimbombi e mugghiti*, as the Italian language finely expresses it,—and with occasional explosions as if the earth were breaking open: in fact, it did break open in many parts of Calabria, swallowing up villages and towns with all their inhabitants. The singular haze just mentioned might possibly have issued from those openings; meantime the great *spiraglio* (loop-hole or vent-hole) of Ætna (the crater at top,) remained closed,—a fact which may serve to account for the violence of the earthquakes.

It appears that more than one-third of these eruptions (fifteen out of forty-one,) took place in the months of February and March; a circumstance not unworthy of notice, for that period of the year is just after the rains of January; and it may be inferred, that rain water penetrating into the heart of the mountain, whence so very few springs are known to issue, serves to kindle its fires. Yet rain on the upper regions of Ætna is in winter always snow, and the rains on its base can alone penetrate; thence we may conclude the local place of the fire which rain water has an agency in kindling to be very low down.

* The last time (1693), at the moment when the houses of Catania were falling down and burying 18,000 people under their ruins, a tremendous eruption put a stop to the earthquake which had lasted some days, and was gradually increasing;—the summit of the mountain fell in.

It is a question here, whether the water of the sea also has an agency in this great phenomenon. Many of the eruptions have been attended with prodigious inundations down the sides of Ætna: these floods Recupero and other writers maintain to have been sea water thrown up by the volcano; and as a proof, it is alleged that shells have been deposited. But water thus raised from the deep through a fiery channel would have come out in the state of steam, and, instead of flowing down in torrents along the earth, would have gone up into the air and caused no inundation. The shells, too, calcined into lime and immediately dissolved by the water, would have wholly disappeared before they reached the mouth of the volcano. These great floods are very naturally explained by the melting of snow upwards of ten feet deep before a stream of lava. The water of the sea, though not thrown up, may still have an agency in kindling the fires of the volcano; and it certainly is a remarkable circumstance, that most volcanoes are situated near the sea or under it; yet too much water would soon extinguish the fire it had kindled, therefore the theory is in every way attended with great difficulties. The height, often immense, at which the craters of volcanos are found, is no argument against the great depth of their burning recesses; on the contrary, volcanic mountains being formed of ejected matters, their height is the measure of that depth. The simultaneous earthquakes in Calabria and Sicily just before great eruptions of Ætna, and the simultaneous eruptions of that volcano and Stromboli, scarcely leave any doubt of a communication existing under sea and land to Calabria, to the Lipari islands, and very probably to Vesuvius or farther.

The greatest part of the coast south-west of Ætna consists of lava which in times long anterior to all historical records ran down its sides. The dates of only two of the eruptions which produced the lava are known, that of the 96th Olympiad, and another, 122 years before Christ. Recupero estimates the quantity of volcanic matter ejected in the year 1669 alone (a memorable one indeed,) at ninety-four millions of cubic *passi*, (a *passo* is five feet,) equal to 11,750,000,000 cubic feet. Now that mass of solid matter would build nearly a dozen such cities as London, supposing it to consist of

208,000 houses, and each house to contain 5000 cubic feet of walls. This same eruption of 1669 destroyed the habitations of twenty-seven thousand people.

The region south of Ætna, extending towards Cape Pachino nearly one hundred miles, exhibits often to a great depth shelly calcareous strata alternating with what the Abbate Ferrara calls ancient lava, and the low grounds are full of marine and argillaceous deposits. The base of the mountain, as far as can be ascertained, is of the same nature. From all these facts the same learned writer infers, that his ancient lava is of submarine formation, the stupendous superstructure having been reared after Sicily had become dry land. This ancient lava, however, visible in many places, and particularly at La Motta, very near the volcano, is in fact basalt; a substance which, although it resembles lava, and probably was likewise once fluid through the agency of fire, differs too much, and especially by its abundance, to have the same origin and be of the same formation as lava.

Ætna, although situated nearly in the direction of the great chain of the Appennines, stands insulated. It is a truncated cone about ninety miles in circumference at the base and ten miles at top, * where there it is a level plain round the mouth of the volcano. That mouth in great eruptions occupies the whole plain, while at other times it is no bigger than a man's head, as I have heard it described here. Being the safety-valve of the boiler, it cannot be quite closed without dreadful consequences. In great eruptions there is certainly no possibility of approaching to ascertain the state of the plain ten miles in circumference just described; but as it is afterwards found to have undergone a total change, the cone upon it also being rebuilt often in another place, there can be no doubt that during an eruption this lid of the boiling caldron comes off entirely. When the activity of the fire begins to decline, the lava instead of boiling quite over swells no higher than the mouth of the crater, and there hardening quickly by its contact with the open air, forms a level surface or new plain like

* Ætna being only 10,200 feet, or nearly two miles in height, while at the base it is thirty miles in diameter, its ascent apparently steep is in reality very gradual.

that which before existed. A new cone is likewise soon formed round the comparatively small opening which remains, and through which stones and ashes are continually ejected. It always assumes a regular form, sloping inside and outside at an angle of about forty-five degrees. Its height at present is 1320 feet, its diameter at the base 2800 feet, the hollow inside 650 feet deep, and the inferior orifice there not more than 70 feet wide. At every great eruption this cone, which in England, in France, and over the greatest part of Europe, would be looked upon as a very good-sized mountain, falls back again into the fiery abyss from which it rose.

The total height of Ætna, cone included, taking the medium of various barometrical observations, and allowing a difference of $9\frac{1}{4}$ inches of mercury (French measure) between the sea-side and the top, is nearly 10,200 feet French measure. The difference of temperature between these two extreme points is about 40° of Fahrenheit. Although Ætna be fifteen or sixteen hundred feet above the line of perpetual snows, in this latitude (37° 51′), snow in summer is only found in a few sheltered places; especially in the great crater itself, where it remains throughout the year. The whole country is supplied with what is here deemed one of the necessaries of life from this natural ice-house.

The whole of Ætna, as far as it can be ascertained, consists of accumulated lava, scoriæ, and ashes, the analysis of which can alone throw some light on the nature of the substances operated upon by the subterranean fires. It has often been made; and the substances found to predominate are, I believe, silica and alumine.

### 2. *Account of the Large Chestnut of Mount Ætna.* By L. Simond.*

Leaving the *lettiga* and baggage to follow the direct road or path to La Nunziata, we went on horseback with a guide over the mountain to see the celebrated chestnut-tree, called *Castagno di Cento Cavalli*, because 100 horses might stand together under its shade. We rode ten hours for that purpose over rugged tracts of lava and precipices, requiring the

* From *Tour in Italy and Sicily*. Lond. 1828. Pp. 510, 513.

singular prudence and sure-footedness of our cattle to get through without accident. On the way we had occasion to observe melancholy traces of the earthquake of February last, particularly at the village of Zafarana, where the falling of the arched roof of the church crushed the curate and forty-one of his parishioners, only nine of whom were extricated alive; not a woman among the sufferers, for they had attended church in the morning, and the evening service had been performed on purpose for the men who had been out at work during the whole of that day. We saw a parcel of children playing with great glee among the ruins, and observed young women becomingly adjusting their black veils to please the living, already unmindful of the dead.

The lava of the great eruption of the first year of the 96th Olympiad, which formed the promontory of Aci in the sea, is still bare of soil, and without vegetation in many places, while that of 1669 is already covered with vines and fruit trees. The fact is, that compact lava is scarcely more liable to decomposition than any hard rock, and that scoriæ only are liable to decomposition; the lava of 1669 probably abounded with scoriæ. The promontory of Aci above mentioned, is 900 feet high, but far from being all formed by the lava of one eruption; the traces of as many as nine are observed one over the other, with argillaceous earth intervening.

The astonishing fertility of the soil all over the base of Ætna, and the luxuriant growth of all the plants, prepared us in some sort for the miracle of vegetation which we were about to behold; and when the *Castagno di Cento Cavalli* actually appeared before us, it seemed to make no very great figure, but on near inspection we were truly amazed.

Recupero says that he had the ground dug all round, and found a continuity of roots and even bark.

The present appearance is certainly that of a group of five large trees, one only of which is sound and covered with bark all round, while the others are decayed on the inward side, each of them appearing to be sections of a circumference smaller than the great one of 112 feet, which they all five with their intervals form together. Taken outside the bulging roots, that circumference might be reckoned at 180. The limbs, although vigorous and of great size, had lost their extremities, and upon the whole the mass of foliage bore no proportion to the stem or stems. This was not the only giant of the same family; for at the distance of 400 yards we saw two other chestnut-trees of vast size, and of greater beauty than the *Cento Cavalli.* One of them, consisting of two stems in close contact and from the same root, measured 24 feet in diameter, and was quite sound; the other measured 15 feet in diameter, but was entirely hollow, and presented within the singular appearance of several young stems, five or six inches in diameter, joining at top the hollow trunk, and looking like stalactites in a cavern. Probably when the inside of the tree, wholly decayed, had become vegetable earth, roots shot into it and down into the ground below; but in process of time that earth was washed away, and these internal roots exposed to the air, became so many stems, and ultimately young trees within the old one. Half a mile from these stood a fourth chestnut-tree, shattered above, but its stem quite sound, and that stem upwards of 70 feet in circumference. The soil in which all these trees grew was of a dark reddish brown or chocolate colour, very loose and penetrable. The fruit of the *Cento Cavalli* is rather smaller, and otherwise not quite so good as that of the other trees. This region of vegetable wonders is no less than 4000 feet above the sea.

### 3. *Account of the Falls of Niagara.*

"I had already seen some of the most celebrated works of nature in different parts of the globe; I had seen Ætna and Vesuvius; I had seen the Andes almost at their greatest elevation; Cape Horn, rugged and bleak, buffeted by the southern tempest; and, though last not least, I had seen the long swell of the Pacific; but nothing I had ever beheld or imagined could compare in grandeur with the falls of Niagara. My first sensation was that of exquisite delight at having before me the greatest wonder of the world. Strange as it may appear, this feeling was immediately succeeded by an irresistible melancholy. Had this not continued, it might perhaps have been attributed to the satiety incident to the complete gratification of 'hope long deferred;' but so far from diminishing, the more I gazed, the stronger and deeper the sentiment became. Yet this scene of sadness was strangely mingled with a kind of intoxicating fascination. Whether the phenomenon is peculiar to Niagara, I know not, but certain it is, that the spirits are affected and depressed in a singular manner by the magic influence of this stupendous and eternal fall. About five miles above the cataract the river expands to the dimensions of a lake, after which it gradually narrows. The Rapids commence at the upper extremity of Goat Island, which is half a mile in length, and divides the river at the point of precipitation into two unequal parts; the largest is distinguished by the several names of the Horseshoe, Crescent, and British Fall, from its semicircular form and contiguity to the Canadian shore. The smaller is named the American Fall. A portion of this fall is divided by a rock from Goat Island, and though here insignificant in appearance, would rank high among European cascades.

"The current runs about six miles an hour; but supposing it to be only five miles, the quantity which passes the falls in an hour is more than 85,000,000 tons avoirdupois; if we suppose it to be six, it will be more than 102,000,000; and in a day would exceed 2,400,000,000 tons.

"The next morning, with renewed delight, I beheld from my window the stupendous vision. The beams of the rising sun shed over it a variety of tints; a cloud of spray was ascending from the crescent; and as I viewed it from above, it appeared like the steam rising from the boiler of some monstrous engine. * * * * *

"This evening I went down with one of our party to view the cataract by moonlight. I took my favourite seat on the projecting rock, at a little distance from the brink of the fall, and gazed till every sense seemed absorbed in contemplation. Although the shades of the night increased the sublimity of the prospect, and 'deepened the murmur of the falling floods,' the moon in placid beauty shed her soft influence upon the mind, and mitigated the horrors of the scene. The thunders which bellowed from the abyss, and the loveliness of the falling element, which glittered like molten silver in the moonlight, seemed to complete the rare union of the beautiful with the sublime. * * * *

"Though earnestly dissuaded from the undertaking, I determined to employ the first fine morning in visiting the cavern beneath the fall. The guide recommended my companion and myself to set out as early as six o'clock, that we might have the advantage of the morning sun upon the waters. We came to the guide's house at the appointed hour, and disencumbered ourselves of such garments as we did not care to have wetted. Descending the circular ladder, we followed the course of the path running along the top of the *debris* of the precipice, which I have already described. Having pursued this tract for abouty eighty yards, in the course of which we were completely drenched, we found ourselves close to the cataract. Although enveloped in a cloud of spray, we could distinguish without difficulty the direction of our path and the nature of the cavern we were about to enter. Our guide warned us of the difficulty in respiration which we should encounter from the spray, and recommended us to look with exclusive attention to the security of our footing. Thus warned, we pushed forward, blown about and buffeted by the wind, stunned by the noise, and blinded by the spray; each successive gust penetrated us to the very bones with cold. Determined to proceed, we toiled and struggled on, and having followed the footsteps of the guide as far as was possible, consistently with safety, we sat down, and having collected our senses by degrees, the wonders of the cavern slowly developed themselves. It is impossible to describe the strange unnatural light reflected through its crystal wall, the roar of the waters, and the blasts of the hurricane, which perpetually rages in its recesses. We endured its fury a sufficient time to form a notion of the shape and dimensions of this dreadful place. The cavern was tolerably light, though the sun was unfortunately enveloped in clouds; his disc was invisible, but we could clearly distinguish his situation through the watery barrier. The fall of the cataract is nearly perpendicular; the bank, over which it is precipitated, is of concave form, owing to its upper stratum being composed of limestone and its base of soft slatestone, which has been eaten away by the constant attrition of the recoiling waters. The cavern is about one hundred and twenty feet in height, fifty in breadth, and three hundred in length; the entrance was completely invisible. By screaming in our ears, the guide contrived to explain to us that there was one more point which we might have reached had the wind been in any other direction; unluckily it blew full upon the sheet of the cataract, and drove it in, so as to dash upon the rock over which we must have passed. A few yards beyond this, the precipice becomes perpendicular, and blending with the water, forms the extremity of the cave. After a stay of nearly ten minutes in this most horrible purgatory, we gladly left it to its loathsome inhabitants, the eel and the water-snake, who crawl about its recesses in considerable numbers, and returned to the inn."—*De Roos' Personal Narrative.*

### 4. *Account of a Storm in the Desert.*

*Suez, February* 23, 1814.

After having travelled all the morning in the bed of the ancient canal that formerly connected the Red Sea with the Mediterranean, but without being able to discover a vestige of anything like masonry, or indication of the sluices by which its waters were said to have been regulated, we had lost, at noon, all traces of its course, though we continued our direction still northerly, inclining two or three points to the west, until we gained the site of the Bitter Lakes, as they were called by the ancients, and named the Salt Marshes in more modern maps. We traversed it in every direction, however, for a diameter of ten miles, having fleet trotting dromedaries beneath us, without finding the least portion of water, although it had evidently been the receptacle of an extensive lake, and was at this moment below the level of the sea at Suez. The soil here differs from all around it.

On leaving the last traces of the canal, we had entered upon a loose shifting sand; here we found a firm clay mixed with gravel, and perfectly dry, its surface encrusted over with a strong salt. On leaving the site of these now evaporated lakes, we entered upon a loose and shifting sand again, like that which Pliny describes when speaking of the roads from Pelusium across the sands of the desert; in which, he says, unless there be reeds stuck in the ground to point out the line of direction, the way could not be found, because the wind blows up the sand, and covers the footsteps.

The morning was delightful on our setting out, and promised us a fine day; but the light airs from the south soon increased to a gale, the sun became obscure, and as every hour brought us into a looser sand, it flew around us in such whirlwinds, with the sudden gusts that blew, that it was impossible to proceed.—We halted, therefore, for an hour, and took shelter under the lee of our beasts, who were themselves so terrified as to need fastening by the knees, and uttered, in their wailings, but a melancholy symphony.

I know not whether it was the novelty of the situation that gave it additional horrors, or whether the habit of magnifying evils to which we are unaccustomed, had increased its effect; but certain it is, that fifty gales of wind at sea appeared to me more easy to be encountered than one amongst those sands. It is impossible to imagine desolation more complete; we could see neither sun, earth, or sky; the plain at ten paces distance was absolutely imperceptible; our beasts, as well as ourselves, were so covered as to render breathing difficult; they hid their faces in the ground, and we could only uncover our own for a moment, to behold this chaos or mid-day darkness, and wait impatiently for its abatement. Alexander's journey to the temple of Jupiter Ammon, and the destruction of the Persian armies of Cambyses in the Lybian Desert, rose to my recollection with new impressions, made by the horror of the scene before me; while Addison's admirable lines, which I also remembered with peculiar force on this occasion, seemed to possess as much truth as beauty:—

> Lo! where our wide Numidian wastes extend,
> Sudden the impetuous hurricanes descend,
> Which through the air in circling eddies play,
> Tear up the sands, and sweep whole plains away.
> The helpless traveller, with wild surprise,
> Sees the dry desert all around him rise:
> And, smothered in the dusky whirlwind, dies.

The few hours we remained in this situation were passed in unbroken silence; every one was occupied with his own reflections, as if the reign of terror forbade communication. Its fury spent itself, like the storms of ocean, in sudden lulls and squalls; but it was not until the third or fourth interval that our fears were sufficiently conquered to address each other; nor shall I soon lose the recollection of the impressive manner in which that was done. "Allah kereem!" exclaimed the poor Bedouin, although habit had familiarized him with these resistless blasts. "Allah kereem!" repeated the Egyptians, with terrified solemnity; and both my servant and myself, as if by instinct, joined in the general exclamation. The bold imagery of the Eastern poets describing the Deity as avenging in his anger, and terrible in his wrath, riding upon the wings of the wind, and breathing his fury in the storm, must have been inspired by scenes like these.

It was now past sunset, and neither of us had yet broken our fast for the day; even the consoling pipe could not be lighted in the hurricane; and it was in vain to think of remaining in our present station, while the hope of finding some bush for shelter remained. We remounted, therefore, and departed. The young moon afforded us only a faint light, and all traces of the common road were completely obliterated; the stars were not even visible through so disturbed an atmosphere, and my compass was our only guide. The Arabs knew a spot near Sheick Amidid, where banks and trees were to be found, and, confiding in my direction for the course thither, we resumed our journey.

After a silent ride of five tedious hours, this garden of repose appeared in sight; and bleak and barren as it was, in truth, fatigue and apprehension gave it the charms of Eden. There we alighted, fed our weary animals, and, like sailors escaped from shipwreck, regaled in that delightful consciousness of security which is known only in the safety which succeeds to danger.—*Buckingham's Journal.*

## 5. *Burning Springs in America* *.

Springs of water charged with inflammable gas are quite common in the vicinity of Canandaigua, the capital of Ontario county, in the south-western part of the State of New York

* See this *Journal*, No. xv. p. 183.

Those at Bristol, ten miles S. W. of Canandaigua, are situated in a ravine on the west side of Bristol Hollow, about half a mile from the north Presbyterian Meeting-house. The ravine is formed in clay-slate, and a small brook runs through it. The gas rises through fissures of the slate from both the margin and bed of the brook. Where it rises through the water it is formed into bubbles, and flashes only when flame is applied; but where it rises directly from the rock, it burns with a steady and beautiful flame, which continues until extinguished by storms or by design.

The springs of Middlesex (twelve miles south from Canandaigua,) are from one to two miles south-west of the village of Rushville, along a tract nearly a mile in length, partly at the bottom of the valley called Federal Hollow, and partly at an elevation of forty or fifty feet on the south side of it.

These latter springs have been discovered within a few years, in a field which had long been cleared, and are very numerous. Their places are known by little hillocks a few feet in diameter and a few inches high, formed of a dark bituminous mould, which seems principally to have been deposited by the gas, and through which it finds its way to the surface in one or more currents. These currents of gas may be set on fire, and will burn with a steady flame.—In winter they form openings through the snow, and being set on fire, exhibit the novel and interesting phenomenon of a steady and lively flame in contact with nothing but snow. In very cold weather, it is said, tubes of ice are formed round these currents of gas (probably from the freezing of the water contained in it) which sometimes rises to the height of two or three feet, the gas issuing from the tops; the whole, when lighted in a still evening, presenting an appearance even more beautiful than the former.

Some time since, the proprietors of this field put into operation a plan for applying the gas to economical purposes. From a pit which was sunk in one of the hillocks, the gas is conducted through bored logs, to the kitchen of the dwelling, and rises through an aperture, a little more than half an inch in diameter in the door of a cooking stove. When inflamed, the mixture of gas and common air in the stove first explodes, and then the stream burns steadily. The heat evolved is considerable; so that even this small supply is said to be sufficient for cooking. In another part of the room a stream of the gas, from an orifice one-eighth of an inch in diameter, is kindled in the evening, and affords a light equal to three or four candles. The novelty of the spectacle attracts a concourse of visitors so great, that the proprietors have found it expedient to convert their dwelling into a public inn.

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ART. XIX.—*Meteorological Register for* 1828, *kept at Kinfauns Castle, the seat of the* RIGHT HONOURABLE LORD GRAY.

KINFAUNS Castle is situated in N. Lat. 56° 23′ 30″, and 140 feet above the level of the sea.

| 1828. | Morning, ¼ past 9. Mean height of | | Evening, ¼ past 8. Mean height of | |
|---|---|---|---|---|
| | Barom. | Ther. | Barom. | Ther. |
| January, | 29.674 | 41.258 | 29.700 | 40.968 |
| February, | 29.561 | 41.104 | 29.583 | 40.517 |
| March, | 29.645 | 44.774 | 29.629 | 43.484 |
| April, | 29.534 | 44.600 | 29.525 | 45.443 |
| May, | 29.695 | 55.355 | 29.691 | 50.968 |
| June, | 29.715 | 61.000 | 29.739 | 57.000 |
| July, | 29.499 | 62.710 | 29.505 | 58.967 |
| August, | 29.600 | 60.355 | 29.601 | 58.000 |
| September, | 29.732 | 57.267 | 29.736 | 55.167 |
| October, | 29.789 | 50.226 | 29.807 | 48.258 |
| November, | 29.615 | 46.433 | 29.606 | 45.533 |
| December, | 29.529 | 45.226 | 29.543 | 44.806 |
| Average of year, | 29.632 | 50.859 | 29.639 | 49.093 |

| | Mean Temp. by Six's. Ther. | Depth of Rain in Garden. | Number of days. Rain or snow. | Number of days. Fair. |
|---|---|---|---|---|
| January, | 41.613 | 3.40 | 14 | 17 |
| February, | 41.414 | 3.30 | 18 | 11 |
| March, | 44.355 | 1.00 | 5 | 26 |
| April, | 44.06 | 2.80 | 13 | 17 |

| | | | | |
|---|---|---|---|---|
| May, | 53.000 | 2.75 | 15 | 16 |
| June, | 58.567 | 1.90 | 9 | 21 |
| July, | 60.549 | 2.50 | 14 | 17 |
| August, | 59.710 | 4.50 | 13 | 18 |
| September, | 56.200 | 1.50 | 7 | 23 |
| October, | 49.613 | 2.00 | 8 | 23 |
| November, | 46.400 | 5.00 | 17 | 13 |
| December, | 44.806 | 3.00 | 15 | 16 |
| Average of year, | 50.219 | 33.65 | 148 | 218 |

ANNUAL RESULTS.

Morning.

| Barometer. Observations. | Wind. | | Thermometer. Wind. | |
|---|---|---|---|---|
| Highest, 29th Oct. | S. W. | 30.44 | 25th June, S. W, | 69° |
| Lowest, 21st March, | W. | 28.59 | 18th February, S. W. | 30° |

Evening.

| | | | | |
|---|---|---|---|---|
| Highest, 28th Oct. | S. W. | 30.48 | 22d June, S. W. - | 69° |
| Lowest, 21st March, | W. | 28.70 | 10th January, N. E. | 28° |

| Weather | Days. | Wind. | Times. |
|---|---|---|---|
| Fair, - - | 218 | N. and N. E. - | 44 |
| Rain or Snow, - | 148 | E. and S. E. - | 93 |
| | —— | S. and S. W. - | 146 |
| | 366 | W. and N. W. - | 83 |
| | | | —— |
| | | | 366 |

Extreme cold and heat by Six's Thermometer.

| | | |
|---|---|---|
| Coldest, 11th January, - | Wind, N. W. | 22 |
| Hottest, 29th June, - | do. S. W. | 78° |
| Mean Temperature for the year 1828, | | 50°219 |

| Results of 2 Rain Guages. | In. 100 |
|---|---|
| 1. Centre of Kinfauns Garden, about 20 feet above the level of the sea, - | 33.65 |
| 2. Square Tower, Kinfauns Castle, 140 feet, | 34.40 |

Art. XX.—*Account of a remarkable peculiarity in the Structure of Glauberite,* which has One Axis of Double Refraction for Violet, and Two Axes for Red Light.* By David Brewster, LL. D. F. R. S. L. & E.

In the optical and mineralogical classification of crystals which I published in the article Optics in the *Edinburgh Encyclopædia*, I have arranged Glauberite among those which have two axes of double refraction. The fragment which I used however, was so small and imperfect, that I could not measure the inclination of the resultant axes, or ascertain with any accuracy its action upon light. Mr William Nicol, Lecturer on Natural Philosophy, &c. and whose ingenuity is already well known, put into my hands two specimens of Glauberite, which he had skilfully prepared for showing its double system of polarised rings; and, by the use of these, I have been enabled to detect a very remarkable property in this mineral.

When examined by common polarised light, the tints of its rings are exceedingly anomalous, and we seek in vain for the two poles where the double refraction and polarisation generally disappear. The cause of this irregularity immediately shows itself, when we expose the crystal to homogeneous rays. In the Red rays, we observe the phenomena of two distinct axes, the inclination of the resultant axes being about 5°. This inclination gradually diminishes in the *orange*, *yellow*, and *green* rays, and in the *violet* the two poles coincide, exhibiting the system of rings round a single axis of double refraction. In all these cases, the character of the principal axis is *negative*.

When Mr Herschel discovered the very remarkable property in a specimen of Apophyllite, in virtue of which it exercised a negative influence over the red rays, a positive influence over the blue rays, and no influence at all over the yellow ones, I showed in a paper read before this Society, and printed in their *Transactions*,† that these apparently irreconcileable actions, related, as

* Abridged from the original paper read to the *Royal Society of Edinburgh*, January 9th, 1828, and which will appear in the *Transactions*, vol. xi. part ii. now in the press.—Ed.

† *Edinburgh Transactions*, vol. ix. p. 317.

they seemed to be, to a single axis of double refraction, could be calculated in the most rigorous manner, by supposing the crystal to have *three* positive axes at right angles to each other, each of which exercises a different dispersive action upon the differently coloured rays. This result, which is of considerable importance in the theory of double refraction, is strikingly confirmed by the phenomena of Glauberite, while these at the same time present us with a new and still less equivocal case of the composition of axes.

In the case of *Glauberite*, observation exhibits to us one *negative* axis A, which is the *single* axis for the violet light, and the *principal* axis for the *red* and the other less refrangible rays; and, at the same time, it presents to us a second axis B, which may be either *negative* or *positive*, but which must be 90° distant from A. If it is *negative*, it must be in a plane perpendicular to the plane passing through the two resultant axes for *red* light; and it must bear to A the ratio of the square of the sine of $2\frac{1}{2}$° (half the inclination of the resultant axes) to unity.* If it is *positive*, it must lie in the plane passing through the resultant axes, and it must bear to A the ratio of the square of the sine, to the square of the cosine of $2\frac{1}{2}$°. But whether it be *positive* or *negative*, it exercises no action whatever upon *violet* light, a supposition so absurd, that it cannot for a moment be received. Since the combination of axes, therefore, indicated by experiment for the *single* system of rings in *violet* light, and for the *double* system in the other rays, involves a physical absurdity, we must seek for a new combination, not liable to such an objection.

If we suppose that the axis A for violet light is the resultant of other axes, and that these other axes are two positive axes B and C at right angles to each other, and also to the apparent axis A, we shall obtain an explanation of all the phenomena. If the axes B, C, exercise the same action on the *violet* rays, they will produce a single *negative* axis at A for *violet* light, as given by observation; and if the relative intensities of their action upon red light are in the ratio of the square of

* See *Philosophical Transactions*, 1818, p. 237, &c.

the cosine of $2\frac{1}{2}°$ to unity, the intensity of the weakest gradually diminishing to *zero* for the rays between the *red* and the violet, then we can calculate, with mathematical precision, all the phenomena of double refraction and polarisation exhibited by *Glauberite*.

The structure of *Apophyllite* and *Glauberite*, therefore, furnish us with two unequivocal examples of minerals where the real axes of double refraction are not pointed out by observation. Their crystallographic structure does not indicate, with any certainty, the locality of the axes which we have now inferred from the laws of double refraction; but we have no doubt that the results of crystallography and optical structure will ultimately coincide, when our knowledge of the primitive and secondary forms of minerals shall have attained a higher degree of perfection.

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## Art. XXI.—*Account of the Single Lens Microscopes of Sapphire and Diamond, executed by Mr A. Pritchard, Optician, London.*

Although very successful attempts have been recently made in foreign countries to improve the microscope, particularly by Professor Amici of Modena, yet, notwithstanding the absolute discouragement of every species of science, whether theoretical or practical, this invaluable instrument has, in this country, undergone the most important improvements. For this great step in practical optics, England has been mainly indebted to the unwearied exertions of Dr Goring and Mr Pritchard.

With a liberality which nothing but the most ardent love of science would have prompted, and which was fortunately directed by optical knowledge, Dr Goring devoted his time and his fortune to the improvement of the microscope in all its forms. He was not content with speculative suggestions and improvements. He submitted every idea to the test of direct experiment, and was thus enabled to give to his contrivances that practical value, which is so often wanting in the inventions of theoretical men. We hope to be able to lay before our readers some account of the successive labours of Dr Goring, in the New Series of this *Journal*, which commences with the next

Number. In the meantime, we shall proceed to give an account of the single microscopes of sapphire and diamond, which have been so successfully executed by Mr Pritchard.

In the years 1810 and 1811, when Dr Brewster had determined the refractive and dispersive power of the gems, and found that some of them united very low dispersive with very high refractive powers, he pointed out the advantages of such an union of optical properties, for the construction of single microscopes. About ten years ago, Mr Peter Hill, an ingenious optician in Edinburgh, executed for him two single lenses of *ruby* and *garnet*, which were used both as single microscopes, and as the object-glasses of a compound microscope. Mr Sivright of Meggetland had also executed for him, we believe by the same artist, a single plano convex lens, of the colourless topaz of New Holland. Such were the attempts which had been made previous to the labours of Mr Pritchard, who has given the following account of them in the *Treatise on Optical Instruments*, published by the Society for the diffusion of Knowledge.

"Dr Brewster, in his *Treatise on New Philosophical Instruments*, speaking of single microscopes, says,—'We cannot expect any essential improvement in that instrument, unless from the discovery of some transparent substance, which, like the *diamond*, combines a high refractive power with a low power of dispersion.' This substance has subsequently been formed into lenses by Mr A. Pritchard, at the suggestion of Dr Goring, who caused Mr P. to commence the undertaking in June 1824. The first diamond lens was completed at the end of that year. The difficulty of working this substance into a perfect figure was subsequently overcome. Mr Pritchard finished the first diamond microscope in 1826; the focal distance of this magnifier, which is double convex, is about $\frac{1}{30}$th of an inch. Of the value and importance of the introduction of this brilliant substance for the formation of single microscopes, Dr Goring states, "I conceive *diamond lenses* to constitute the ultimatum of perfection in the single microscope.

"The principal advantages of employing this brilliant substance in the formation of microscopes, arise from the naturally high refractive power it possesses, whereby we can obtain lenses of any degree of magnifying power, and that with comparatively shallow curves; the indistinctness occasioned by the figure of the lens is thus greatly diminished, and the dispersion of colour in the substance being as low as that of water, renders the lens nearly achromatic."

The advantages arising from diamond, sapphire, and ruby lenses, will be at once seen from the following measures of their refractive powers, as established by Dr Brewster :—

| | Index of refraction. | Dispersive power. |
|---|---|---|
| Diamond, | 2.470 | 0.38 |
| Sapphire, | 1.780 | 0.26 |
| Ruby, | 1.779 | 0.26 |
| Plate glass, | 1.525 | 0.32 |

In this table the superiority of the *diamond* is very obvious; while it produces, in virtue of its low dispersive power, very little colour, its enormous refractive index enables the artist to produce a high magnifying power with very shallow curves.

The *sapphire* and the *ruby*, though they have not the same advantage as the diamond in giving the same magnifying power with as shallow curves, yet they have another valuable property in greater perfection than the diamond, namely, a very low dispersive power.

On the other hand, the *diamond* has again the superiority over the *sapphire* and *ruby* lenses by its generally *having no double refraction*, whereas the former have a considerable double refraction; and we presume Mr Pritchard found it absolutely necessary to make the axis of his sapphire lenses coincident with their axis of double refraction, which is parallel to the axis of the acute rhomboid in which these gems crystallize. But even if this is effected, the transmitted rays cannot all pass through the lens parallel to its axis, so that they must to a certain minute degree be separated into two pencils; but to what extent this will affect the performance of the lens as a microscope we do not yet know.

But though the diamond may be said to have no double refraction when perfectly crystallized, yet, in nine cases out of ten, Dr Brewster has discovered in it a doubly refracting structure. (See *Edinburgh Transactions*, vol. viii. p. 157, and *Edinburgh Philosophical Journal*, vol. iii. p. 98.) Mr Pritchard indeed has himself found some of the diamond lenses which he made, quite defective, giving something like a treble image. Hence it would be adviseable to manufacture diamond lenses only out of plates of diamond, through which it is easy to examine by polarized light its doubly refracting structure, and to reject all the plates in which there is the slightest tendency to this structure. If the diamond has not sufficiently flat surfaces to admit of this experiment being easily made, it should be examined when immersed in oil of cassia or sulphuret of carbon,—the fluids which approach nearest to it in refractive power.

Mr Pritchard mentions, that he has also "formed lenses of the other precious stones, but without any peculiar advantage, many of them producing two magnified images by double refraction." *Zircon*, *Essonite*, *Euclase*, and some others, would no doubt produce this effect to a great degree; but *Garnet*, *Pyrope*, *Spinelle*, and *Ruby* will not give double images. We have examined specimens of garnet, &c. so perfectly pure, that we would recommend strongly to Mr Pritchard to devote his attention to this substance. Its refractive index is 1.815 greater than that of sapphire, while its power of dispersion is 0.33 inferior to diamond, so that, from its having no double refraction, it unites the theoretical requisites for a perfect microscope in a greater degree than either diamond or sapphire. As the observation of colour is the least of all considerations, and is besides a very fallacious one in microscopic observations, the colour of the garnet cannot be regarded as a disadvantage. It is on the contrary an advantage, as it renders the microscope more achromatic by its absorption of the violet or most refrangible rays. But even if the observation of colour were material, we can determine it as clearly by a coloured as by a colourless lens. If, for example, the garnet lens shows an object or part of an object of a certain apparent colour, it is easy to determine the real colour by ascertaining what colour seen through the lens produces the apparent colour under consideration.

As it is now perfectly easy to illuminate microscopic objects with homogeneous light, we may set aside all consideration of the dispersive power of bodies, and employ for single lenses all substances that have a high refractive power, and no double refraction. Substances of this kind which are suitable for such a purpose, are

| | Index of Refraction. |
|---|---|
| Realgar, - | 2.549 |
| Blende, - | 2.260 |
| Glass of Antimony, | 2.216 for red rays. |

Glass of antimony will no doubt take a good polish. Blende will probably do the same; but realgar is perhaps too soft. Realgar is capable, however, of being melted, and we have no doubt that small transparent lenses of it could be moulded between small polished concave surfaces. We formed in this way a prism which enabled us to obtain a tolerably good measure of its refractive and dispersive power; so that there appears to be no practical difficulty in moulding it into very minute lenses. The realgar will retain its lustre, as we know by the prism now mentioned, which we have kept for sixteen years.

As the power of homogeneous illumination renders achromatic combinations of little use in microscopic observations, the perfection of the single microscope must depend on the degree to which we are able to remove the spherical aberration. Hence the radii of the single lenses should be as 6 to 1, and when they are of sufficient size, some of the contrivances for a diaphragm within the lens should be adopted.

Although we are not yet able to speak from our own observation of the excellence of Mr Pritchard's lenses, yet we are in possession of the most satisfactory evidence of their immense superiority to all single microscopes hitherto made, and of their equality to the most expensive Amician and achromatic instruments. Mr Pond, our able astronomer-royal, having procured one of Dr Goring's improved Amician microscopes, with metals of only *six-tenths* of an inch focus, and *three-tenths* of clear aperture, was desirous of comparing it with one of Mr Pritchard's sapphire lenses. He accordingly selected a plane convex sapphire lens of $\frac{1}{23}$th of an inch in focal length, and he found that, in every case, it exhibited all the most delicate test objects that could be seen with the reflecting microscope, and was otherwise equal to it in its performance. Since this comparison was made, Mr Pond has had two aplanatic microscopes made for him, the one by Mr Tulley, and the other by Mr Dollond, with *double triple* object-glasses, and both of these fine instruments, executed by the first artists in Europe, are equalled by the simple sapphire lens.

Our late distinguished countryman Dr Wollaston likewise compared the sapphire lens with these three instruments at the Royal Observatory. He also was perfectly satisfied that it was equal to these fine instruments; and he immediately ordered for his own use a set of the sapphire lenses.

Now since these three instruments with which the simple sapphire lens has been compared have no aberration of refrangibility, the reflecting microscope having necessarily none, and the other two having it completely corrected, while the sapphire lens has the disadvantage of all its uncorrected colour, and yet equals them, it is manifest that the sapphire lens *must surpass them completely, when it is put on the same footing in point of refrangibility, that is, when the objects are illuminated with homogeneous light.*

We would, therefore, strongly recommend it to Mr Pritchard, to turn his attention to the simplest method of obtaining homogeneous light, and to have the apparatus made to accompany his lenses. For opaque objects, coloured silks and paper produce a very fine effect, and from the vegetable world the most perfect homogeneous light may be obtained. In another paper we shall give an account of a series of experiments, which we have made on this subject with the flowers and leaves of plants in different stages of their growth; but we may mention, in the meantime, that the petals of the *scarlet lychnis* reflects at a certain stage of its growth a pure homogeneous red, upon which opaque objects are most beautifully seen.

There are two advantages of the diamond and sapphire lenses which we must not omit to mention. From their great hardness, they will never be scratched or injured by use like those made of glass; and from the same cause, the artist is enabled to burnish them into small flat plates of brass, which prevents the possibility of their being lost, and renders them capable of being cleaned without danger.

As Mr Pritchard is now executing for us one of his sapphire microscopes for the purpose of determining some delicate points in the structure of minerals, in which all our usual resources have failed, we hope to be soon able to speak of them from personal observation; but with such evidence in their favour as that of Dr Goring, Mr Pond, and Dr Wollaston, no farther recommendation is necessary; and we look forward with sanguine expectation to the discoveries which it will enable the naturalist to make respecting the structure and functions of organic bodies.

The perseverance and skill of Mr Pritchard in executing lenses of such refractory materials is beyond all praise, and we must make some demand upon the faith of our readers when we inform them that he can execute diamond lenses the *one hundredth part of an inch in focal length.* Such exertions and such success would, in other countries, have obtained the patronage of sovereigns, and the countenance of government; but England does not thus honour her scientific artists, and we therefore anxiously hope, that the great merits of Mr Pritchard will not be overlooked by that individual patronage which may still, for a brief period, preserve from exile the declining arts of our country.

We have been fortunate in obtaining the following list of prices at which Mr Pritchard is able to dispose of his sapphire and diamond lenses:—

| Focal length of sapphire lenses. | |
|---|---|
| From 1–10th to 1–30th of an inch, | L. 2, 2s. |
| From 1–30th to 1–60th of an inch, | L. 3, 3s. |
| From 1–60th to 1–80th of an inch, | L. 4, 4s. |
| From 1–80th to 1–100dth of an inch, | L. 5, 5s. |

Diamond lenses cost from ten to twenty guineas each.

We are glad to find, that Dr Goring and Mr Pritchard have published the First Number of a Work on the Microscope and its Objects, entitled "*The Natural History of several new living objects for the Microscope, conjoined with accurate descriptions of the Diamond, Sapphire, Aplanatic, and Amician Microscopes, &c. &c.*" It is to be had of Mr Pritchard, 18 Picket Street, Strand, London, and we may perhaps be able to lay before our readers some account of it in a subsequent article of this number.

ART. XXII.—*On the Defects of the Sympiesometer, as applied to the Measurement of Heights.* By JAMES D. FORBES, Esq. Communicated by the Author.

THE Sympiesometer is an instrument more attractive at first, perhaps, than in longer experience, and in its capability for expressing rather than receiving minute impressions. This will account in some measure for the very partial adoption of a contrivance, the excellency of the theory, and the ingenuity of the inventor of which all will admit. The principle indeed is by no means new, having been discussed by Hooke and others in the earlier *Philosophical Transactions ;* but Mr Adie has given it an elegance and an accuracy which its older projectors never anticipated.

The portable sympiesometer, notwithstanding its lightness, is not likely often to replace the barometer in the hands either of the practical man or the refined philosopher; and briefly for these reasons: It is as expensive and even more so than a plain mountain barometer. Though not nearly so liable to break as the mercurial tube by concussions, these will readily separate the oil, and sometimes render the instrument equally useless for the time, till it has undergone a rather hazardous operation. It must be kept in one position only,—a material objection, whereas a proper barometer may be travelled in any position. Though the space corresponding to an inch of mercury is far greater, the viscidity of the oil is so considerable, that it is impossible to read off the height to less than $\frac{1}{100}$ of an inch, and it is much to be doubted if the level of the oil be true to that quantity. A barometer of similar expence will be read off with secure accuracy to *one-fifth* of that space. Any barometer tolerably constructed will take its level in half a minute, but the sympiesometer will not merely require for the same purpose four or five minutes, as the inventor in his pamphlet states, but I mean to show that the time thus required may be *actually indefinite*, and to explain some weighty objections connected with this, which, if my observations do not deceive me, affect the instrument, so as to render it unfit in its present state for the measurement of heights, unless in peculiarly favourable circumstances. *

The experiments from which I expect to deduce these results were made by me so far back as 1825: † having been led by some previous observations to doubt the speedy accommodation of the instrument to the condition of the air, as stated by Mr Adie in his small work which accompanies the sympiesometer, I resolved to institute a series of observations on the subject upon the same spot of which I had already obtained the approximate height, and by taking the indications at short successive intervals, to discover in how long a time the sympiesometer might in all cases be considered to have taken its final level, which is the most important practical question in the use of an instrument. It was with much vexation that I found, after many trials, that this time seemed quite indefinite, and often appeared as if it would never arrive, as even after hanging an hour, the oscillation continued. I threw the observations aside as hopeless; and it was only at a later period that I saw some chance of drawing inferences from them which might explain the anomaly they disclose, and now, after nearly four years, I give them to the world in hopes of exciting farther inquiry on the subject, and to suggest, or at least point out, the mode of discovering a cure for the defect.

It will be proper, first, to explain what I conceive to be the great fault of the instrument, and then endeavour to substantiate it by the detail of my observations. It will readily be admitted that the cylindrical receptacle at the top of the instrument, which we may suppose on an average to be 2 inches long and $\frac{1}{3}$ in diameter, which is filled with the most diffuse known fluid, hydrogen gas, must be incomparably sooner affected by any change of temperature than the large bulb of a thermometer, intended to have degrees of great size, and which ex-

* Besides these objections, a very important one has been established by a very complete set of experiments, recorded in the *Edinburgh Encyclopædia*, Art. *Meteorology*, p. 173, that a gradual absorption of the gas by the oil takes place, raising the indications of the instrument.

† I must here acknowledge the important assistance which I received in the prosecution of these experiments from my brother Mr C. Forbes.

poses a cylinder of mercury, the most dense fluid discovered, of perhaps an inch long and $\frac{1}{4}$ in diameter. This we apprehend will be readily admitted; and it is equally incontrovertible, that the accuracy of the sympiesometer fundamentally depends on the precision of the correction for changes of temperature, elegantly performed by a sliding scale. Whence, if the atmosphere be in a variable condition, and we shall find that at almost all times it is sufficiently so to produce an effect, the thermometer, from its less sensibility than the magazine of hydrogen, which is the important part of the instrument, (the oil acting merely as an index), will show a temperature more or less different from that required for the true correction, which will therefore be erroneously made. Suppose the temperature of the air sinking, (for in the case of heights the instrument, at one station at least, may be presumed to be in the open air,) the instrument itself will have parted with a minute quantity of caloric before the thermometer. The scale therefore depending on the latter will be pushed lower down than if the true temperature had been indicated, wherefore the oil will stand opposite a higher point on the sliding scale, which is divided into inches of mercury, and a logarithimic line of fathoms, than indicates the actual pressure of the atmosphere. Conversely, if the temperature be rising, the pressure indicated will be too small.

If this source of error was ever thought of, probably it was considered too minute to be sensible. We must therefore endeavour to substantiate it by experiments, in detailing which, I would premise, that, as far as they go, I put perfect confidence in their accuracy, though I could wish some additional observations had been made, both under circumstances considerably different, and in repetition of the observations on returning to the first station; though the latter precaution we shall find will little affect the general conclusions.

The upper station, which we shall designate by A, was the room in which the sympiesometer usually hung in Colinton House, at 399 feet above the mean level of the sea. The lower one, B, was on the bank of the Water of Leith, in a deep valley, which offered a very fit locality for barometric experiments. Its level below station A I ascertained with the nicest accuracy, by levelling with a theodolite by Troughton, to be 141.1 feet. From a mean of some single observations made with the sympiesometer in the spring of the same year, I obtained nearly a similar result. The observations now to be detailed were made in the height of summer, and their great discrepancy in some cases from the real height indicate, I fear, some more fundamental want of compensation than in the mere horary variations of temperature. Without regarding the order of dates, we shall commence with the most irregular sets of observations, and go on to those more accordant with the result by levelling, and more accurate in themselves. The mode employed was, after making the observation at the higher station, to proceed as quickly as possible to the other, and after the cork which closes the cistern of oil had been open generally from two to four minutes, the register commences, and was continued every five minutes for an hour, with the purpose of discovering the ultimate time required for the self-adjustment of the instrument. We shall arrange them in tables according to each day's observations, and make our remarks on each. The height of the sympiesometer is given in inches, and also in fathoms, as marked on the scale, and the column of Diff. indicates the difference of level in fathoms indicated between the two stations, but which of course requires the usual thermometric correction for the temperature of the air, as in measurements by the barometer.

TABLE I.—*Aug. 2d*, 1825.

| No. | Stat. | Hour, P.M. | Therm. | Sympiesometer. Inches. | Fath. | Diff. |
|---|---|---|---|---|---|---|
| 1 | A | $6^h\ 20'$ | 69.0 | 29.18 | 263 | — |
| 2 | B | 6 .30 | 62.8 | 29.37 | 233 | —30 |
| 3 | — | 6 .35 | 62.3 | 29.41 | 228 | 35 |
| 4 | — | 6 .40 | 61.4 | 29.41 | 228 | 35 |
| 5 | — | 6 .45 | 60.9 | 29.41 | 228 | 35 |
| 6 | — | 6 .50 | 60.6 | 29.42 | 227 | 36 |
| 7 | — | 6 .55 | 60.2 | 29.42 | 227 | 36 |
| 8 | — | 7 .00 | 59.9 | 29.42 | 226 | 37 |
| 9 | — | 7 .05 | 60.2 | 29.46 | 222 | 41 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | B | 7h.10′ | 60.8 | 29.48 | 218 | 45 |
| 11 | — | 7 .15 | 60.1 | 29.45 | 223 | 40 |
| 12 | — | 7 .20 | 59.9 | 29.44 | 224 | 39 |
| 13 | — | 7 .25 | 60.3 | 29.46 | 221 | 42 |
| 14 | — | 7 .30 | 60.3 | 29.46 | 221 | 42 |

This is the worst set of observations I have obtained, and in many respects they are unsatisfactory. We may see, however, that the general disposition of the thermometer to fall is, as by our hypothesis, accompanied with a uniform rise of the sympiesometer, interrupted by the stationary aspect, which during a rise is equivalent to a descent in Obs. 6 to 8, which is succeeded and accounted for by the rise of the thermometer in Obs. 8 to 10, as it is obvious that the thermometer upon our supposition will only indicate the change after its effect has been manifested in the gaseous column. The only other instance of a fall of the sympiesometer is between Obs. 10 and 12, and which is equally promptly accounted for by the rise of the thermometer at Obs. 13. The column of differences is far too great, since when corrected for temperature the height ought to be only 23.52 fathoms. The positive height, however, is not our present subject of examination. I will only observe farther, that there are 10° between the temperature of the two stations; and if there be any *constant* defect of compensation, the error would be, as we have shown, in making the height too great.

Table II.—*June 21st*, 1825.

| No. | Stat. | Hour, P.M. | Therm. | Sympiesometer. Inches. | Fath. | Diff. |
|---|---|---|---|---|---|---|
| 15 | A | 3h.10′ | —— | 29.46 | 221 | — |
| 16 | B | 3 .30 | 55.1 | 29.55 | 208 | —13 |
| 17 | — | 3 .35 | 54.3 | 29.65 | 196 | 25 |
| 18 | — | 3 .40 | 54.6 | 29.70 | 186 | 35 |
| 19 | — | 3 .45 | 53.8 | 29.72 | 185 | 36 |
| 20 | — | 3 .50 | 53.6 | 29.72 | 185 | 36 |
| 21 | — | 3 .55 | 53.6 | 29.73 | 183 | 38 |
| 22 | — | 4 .00 | 53.8 | 29.74 | 180 | 41 |
| 23 | — | 4 .05 | 53.8 | 29.74 | 180 | 41 |
| 24 | — | 4 .10 | 53.2 | 29.74 | 180 | 41 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 25 | B | 4h.15′ | 52.8 | 29.74 | 180 | 41 |
| 26 | — | 4 .20 | 52.4 | 29.70 | 185 | 36 |
| 27 | — | 4 .25 | 52.3 | 29.74 | 182 | 39 |
| 28 | — | 4 .30 | 52.4 | 29.74 | 181 | 40 |

This, which is one of the worst sets, must be imputed, like the last, to those unaccountable uncertainties which affect barometric measurements, particularly in cases like this, where the height is small, and one of the stations in a ravine liable to accidental changes of temperature and partial currents of air. But the inconsistency of the indications between spaces of five minutes is the point we have to remark, and the general character of the series amply confirms the assumption with which we set out. The *fall* of the thermometer is continuous until the last observation, when it rises 0°.1, and we notice an equally regular *rise* in the column of differences till the last three observations, when it is very clear the atmosphere had been influenced by some agencies contrary to the decline of the diurnal temperature, which, though not indicated by the mass of mercury till Obs. 28, had begun at Obs. 26 to influence the magazine of hydrogen. Such a series as the one before us shows how perplexing an instrument the sympiesometer must sometimes be, since in this case, even after the tedious delay of an hour, we should have the greatest difficulty in selecting the height most to be depended on.

The following I consider a very important series.

Table III.—*July* 19*th* (?) 1825.

| No. | Stat. | Hour, P. M. | Therm. | Sympiesometer. Inches. | Sympiesometer. Fath. | Diff. |
|---|---|---|---|---|---|---|
| 29 | A | 2h40′ | 70.6 | 29.81 | 170 | — |
| 30 | B | 3 .00 | 66.4 | 29.96 | 148 | —22 |
| 31 | — | 3 .05 | 66.4 | 30.00 | 143 | 27 |
| 32 | — | 3 .10 | 66.5 | 30.00 | 143 | 27 |
| 33 | — | 3 .15 | 66.5 | 30.02 | 141 | 29 |
| 34 | — | 3 .20 | 66.3 | 29.96 | 149 | 21 |
| 35 | — | 3 .25 | 66.4 | 29.99 | 144 | 26 |
| 36 | — | 3 .30 | 65.7 | 30.00 | 143 | 27 |
| 37 | — | 3 .35 | 65.2 | 30.01 | 142 | 28 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 38 | — | 3h.40′ | 66.5 | 30.06 | 135 | 35 |
| 39 | — | 3 .45 | 66.2 | 30.02 | 140 | 30 |
| 40 | — | 3 .50 | 66.0 | 30.00 | 143 | 27 |
| 41 | — | 3 .55 | 65.9 | 30.01 | 142 | 28 |
| 42 | — | 4 .00 | 66.2 | 30.04 | 138 | 32 |

It is clear from our explanation of the irregularities of the sympiesometer that the *cause* (viz. any change of temperature) must be indicated by the thermometer *after* the irregularity has been observed, since the explanation is founded on the inaptitude of the thermometer to receive speedily slight impressions. In the two former tables, where the temperature uniformly declined, the sympiesometer uniformly rose; and here, where the thermometer undergoing irregular changes, and being nearly as high at the end as at first, the sympiesometer exhibits similar irregular movements. A little attention to Table 3 will show that the changes incident to the indicated height are *succeeded* shortly by such changes in the thermometer, as, according to our hypothesis, form an explanation of them. Thus the rise of .02 inches at Obs. 32 and 33, is succeeded by a fall of 0°.2 at Obs. 34, and the fall of the oil at Obs. 34 had been caused by an evanescent current of air, producing at Obs. 35 a minute rise of the thermometer. The continuous rise of the oil in Obs. 35 to 37 is satisfactorily accounted for by the considerable fall of the temperature from 66.4 to 65.2 in the same observations; nor can we doubt that the thermometric rise of 1°.3 in the succeeding observations was accidental from the approach of the body of the observer to *the thermometer only*, since it descends immediately after, and since the problematical rise of the instrument is readily explained by the partial heating of the thermometer. Had it not been for this obviously accidental heating, the oil, instead of declining, would in all probability have risen steadily, till Obs. 39, accompanied with the descending temperature, indicated by the thermometer in Obs. 39 to 41, where a rise is again exhibited which had already affected the oil at Obs. 40. The rise of the oil in the two last observations is to be imputed to another descent of temperature not indicated when the observation ceased.

TABLE IV.—*July 5th*, 1825.

| No. | Stat. | Hour, P. M. | Therm. | Sympiesometer. Inches. | Fath. | Diff. |
|---|---|---|---|---|---|---|
| 43 | A | $4^h$ 00′ | —— | 29.78 | 175 | — |
| 44 | B | 4 .05 | 63.8 | 29.86 | 164 | —11 |
| 45 | — | 4 .10 | 64.3 | 29,69 | 188 | +13 |
| 46 | — | 4 .15 | 62.8 | 29.83 | 168 | — 7 |
| 47 | — | 4 .20 | 62.3 | 29.92 | 156 | 19 |
| 48 | — | 4 .25 | 62.6 | 30.00 | 144 | 31 |
| 49 | — | 4 .30 | 61.6 | 30.00 | 144 | 31 |
| 50 | — | 4 .35 | 61.4 | 30.00 | 144 | 31 |
| 51 | — | 4 .40 | 61.0 | 29.97 | 146 | 29 |
| 52 | — | 4 .45 | 60.4 | 29.95 | 150 | 25 |
| 53 | — | 4 .50 | 60.3 | 29.97 | 146 | 29 |
| 54 | — | 4 .55 | 60.2 | 29.96 | 148 | 27 |
| 55 | — | 5 .00 | 60.0 | 29.96 | 149 | 26 |

From this series we can hardly draw conclusions either for or against the theory we propose; the first part being favourable to it, and the latter observations exhibiting the unusual concurrence of the descending thermometer with descending oil. We would notice the extraneous motion at Obs. 45, as being certainly occasioned by the accidental contact of the person of the observer with the instrument, which raising the mercury 0°.5, had imparted a much larger portion of caloric to the hydrogen gas, and caused the descent of the oil to a great extent. The temporary rise of the thermometer at Obs. 48 seems to have given the turn to the oil, which becomes stationary, and afterwards descends without apparent cause. It is remarkable that the last three or four observations give the height much more nearly than when the instrument stood for ten minutes together at 30.00 inches.

TABLE V.—*July 4th*, 1825.

| No. | Stat. | Hour, P. M. | Therm. | Sympiesometer. Inches. | Fath. | Diff. |
|---|---|---|---|---|---|---|
| 56 | A | $6^h$ 40′ | 65.8 | 29.78 | 185 | — |
| 57 | B | 6 .45 | 63.8 | 29.88 | 160 | —25 |
| 58 | — | 6 .50 | 61.2 | 29.90 | 158 | 27 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 59 | B | 6h.55′ | 60.2 | 29.90 | 158 | 27 |
| 60 | — | 7 .00 | 59.7 | 29.92 | 154 | 31 |
| 61 | — | 7 .05 | 59.3 | 29.92 | 154 | 31 |
| 62 | — | 7 .10 | 59.4 | 29.94 | 152 | 33 |
| 63 | — | 7 .15 | 59.3 | 29.94 | 152 | 33 |
| 64 | — | 7 .20 | 58.8 | 29.92 | 154 | 31 |
| 65 | — | 7 .25 | 58.7 | 29.94 | 152 | 33 |
| 66 | — | 7 .30 | 58.9 | 29.95 | 150 | 35 |
| 67 | — | 7 .35 | 58.6 | 29.95 | 150 | 35 |
| 68 | — | 7 .40 | 58.3 | 29.95 | 130 | 35 |

This table seems peculiarly fitted to verify our hypothesis, and, if taken singly, would be no insufficient proof of its correctness. The general tendency of the sympiesometer is to rise, and of the thermometer to sink, but their minuter oscillations prove more closely their connection. The fall of the latter is steady, accompanied by the ascent of the former, till Obs. 60, where the stationary condition of the oil is *succeeded* by an evanescent rise of 0°.1 in Obs. 62. The subsequent descent of .02 in the oil is perfectly accounted for by the almost stationary condition of the thermometer at Obs. 65, and its rise of 0°.2 at Obs. 66. When its renewed gradual descent continues to raise the sympiesometer, or render it motionless till the conclusion of the series: the positive height indicated is much too great.

TABLE VI.—*July 20th*, 1825.

| No. | Stat. | Hour P.M. | Therm. | Sympiesometer. Inches. | Fath. | Diff. |
|---|---|---|---|---|---|---|
| 69 | A | 3h 55′ | 69.5 | 29.79 | 174 | — |
| 70 | B | 4 .02 | 66.0 | 29.80 | 172 | — 2 |
| 71 | — | 4 .05 | 64.4 | 29.84 | 166 | 8 |
| 72 | — | 4 .10 | 63.3 | 29.98 | 148 | 26 |
| 73 | — | 4 .15 | 62.8 | 30.02 | 139 | 35 |
| 74 | — | 4 .20 | 62.8 | 30.02 | 139 | 35 |
| 75 | — | 4 .25 | 62.6 | 30.02 | 139 | 35 |
| 76 | — | 4 .30 | 62.4 | 30.02 | 139 | 35 |
| 77 | — | 4 .35 | 62.4 | 30.03 | 138 | 36 |
| 78 | — | 4 .40 | 62.0 | 30.02 | 140 | 34 |
| 79 | — | 4 .45 | 62.6 | 30.02 | 140 | 34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 80 | B | $4^h.50'$ | 62.6 | 30.02 | 139 | 35 |
| 81 | — | 4 .55 | 62.6 | 30.02 | 139 | 35 |
| 82 | — | 5 .00 | 62.4 | 30.02 | 140 | 34 |

After watching the sympiesometer in its most fluctuating state, it is pleasing to find, in a series like the one before us, that in its remarkable steadiness, which is greater than I ever observed, our supposition is completely backed by the uniformity of temperature very singular for such a time of day. The cistern was opened at the instant of the first observation at the lower station, and after two more observations, it seems to have acquired the temperature of the air, which continued for 45′ with an extreme variation of only 0°.8, which occurred but in one instance. We may therefore easily account for the extraordinary unity of the columns of the sympiesometer, though it is not so easy to explain why the height is so much greater than it ought to be; but that is not to our present purpose. The only variation which breaks the column of inches between Obs. 72 and 82, is of .01 at Obs 77, and is immediately succeeded and accounted for by a sudden fall of 0°.4 of the thermometer, which is actually *double of any fall of the thermometer* within the same limits. This seems to prove to demonstration the accuracy of our explanation.

TABLE VII.—*July 30th*, 1825.

| No. | Stat. | Hour P.M. | Therm. | Sympiesometer. Inches. | Sympiesometer. Fath. | Diff. |
|---|---|---|---|---|---|---|
| 83 | A | $2^h.35'$ | 73.1 | 29.46 | 222 | — |
| 84 | B | 2 .40 | 77.2 | 29.50 | 216 | — 6 |
| 85 | — | 2 .45 | 77.4 | 29.54 | 208 | 14 |
| 86 | — | 2 .50 | 76.1 | 29.55 | 207 | 15 |
| 87 | — | 2 .55 | 76.2 | 29.60 | 200 | 22 |
| 88 | — | 3 .00 | 75.6 | 29.61 | 199 | 23 |
| 89 | — | 3 .05 | 75.0 | 29.61 | 199 | 23 |
| 90 | — | 3 .10 | 75.0 | 29.60 | 201 | 21 |
| 91 | — | 3 .15 | 74.8 | 29.59 | 202 | 20 |
| 92 | — | 3 .20 | 74.1 | 29.60 | 201 | 21 |
| 93 | — | 3 .25 | 74.1 | 29.60 | 200 | 22 |
| 94 | — | 3 .30 | 74.3 | 29.61 | 198 | 24 |
| 95 | — | 3 .35 | 74.5 | 29.63 | 196 | 26 |

This table I have placed the last of the series, because the heights it indicates are pretty regular, and approach to the true altitude far nearer than any of the others; and it is well worthy of observation, that it appears to be the only instance of the temperature of the lower station being equal to or greater than that of the upper. This surely indicates some permanent want of compensation of temperature. In this set the thermometer generally falls, and the sympiesometer generally ascends to the conclusion of the observations. Some small fluctuations not exceeding one or two hundredths of an inch occur, and the oscillations of the thermometer, contrary to the diurnal decline of temperature, do not exceed 0°.2 between any two observations.

I shall conclude these experiments by giving the results of one of a very simple nature, in which the instrument was removed from station A to one about a fathom lower (D,) an apartment partly under ground, and with a pretty free exposure to the changes of external temperature, it will serve to confirm our former results. The instrument was ascertained to be exactly at the same height some time after its return to station A. The column Diff. in the following table merely indicates the successive differences of the height of the sympiesometer.

Table VIII.—*June 18th*, 1825.

| No. | Stat. | Hour P. M. | Therm. | Sympiesometer. | Diff. |
|---|---|---|---|---|---|
| 96 | A | $2^h\ 40'$ | 67.6 | 29.695 | — |
| 97 | D | 2 .45 | 65.1 | 29.60 | — |
| 98 | — | 2 .50 | 64.6 | 29.69 | +09 |
| 99 | — | 2 .55 | 63.3 | 29.71 | +02 |
| 100 | — | 3 .00 | 63.1 | 29.74 | +03 |
| 101 | — | 3 .05 | 62.4 | 29.74 | 00 |
| 102 | — | 3 .10 | 62.4 | 29.75 | +01 |
| 103 | — | 3 .15 | 62.4 | 29.77 | +02 |
| 104 | — | 3 .20 | 62.0 | 29.75 | —02 |
| 105 | — | 3 .25 | 62.0 | 29.75 | 00 |
| 106 | — | 3 .30 | 61.4 | 29.74 | —01 |
| 107 | — | 3 .40 | 62.0 | 29.74 | 00 |
| 108 | — | 3 .45 | 61.6 | 29.72 | —02 |
| 109 | — | 3 .50 | 61.6 | 29.74 | +02 |

| | | | | | |
|---|---|---|---|---|---|
| 110 | D | $3^h.55'$ | 61.3 | 29.72 | —02 |
| 111 | — | 4 .00 | 61.4 | 29.74 | +02 |

From Obs. 97 to 105, the thermometer falls, and the sympiesometer, with one exception, uniformly rises. The fall of .01 at Obs. 106 is caused by a change indicated by the fall of no less than 0°.6 of the thermometer at the next observation. The descent of the oil between Obs. 107 and 108 is succeeded in Obs. 109 by a stationary thermometer, which in the course of falling is equivalent to an initial rise. The ascent of the oil in Obs. 109 is followed by the descent of mercury in Obs. 110, and the renewed fall of the former in Obs. 110 is produced by the cause which is indicated in the contrary motion of the mercury in Obs. 111, so that this curious oscillation is preserved five times; the motion of the sympiesometer always preceding that of the thermometer, as it ought to do according to theory.

Regarding the very erroneous results of height which many of the preceding tables give, I own I feel it difficult to give an explanation, more especially as several trials I made in spring agreed far better with the actual height, when the differences of the attached thermometer were of course greater My experiments are too limited to draw positive conclusions on this point, which is not the one I aim at; and I shall content myself with noticing two possible sources of error. That the instrument (which I believe is graduated wholly experimentally) may not have been subjected to sufficient degrees of heat, which in these experiments was so considerable; and that the situation of the experiment was such as to render it trying to barometric measurement, being a ravine where probably very various currents prevail, particularly in warm weather. I hope at a future time to continue my experiments on the use of the sympiesometer, and in the meantime to excite some attention to the subject.

I promised, before concluding, to give some hints for the removal of the defect I suspected, and as my paper is now longer than I intended, I shall do so in a few sentences. Since the the main point is, that the thermometer should indicate the actual temperature of the hydrogen gas, I should recommend that the bulb be actually inserted in the magazine which contains it, and the stem being turned down, should run parallel to the instrument, the degrees running downwards, which is actually the direction they assume on the lower scale upon which that of inches and fathoms slide. Farther, though this I think would nearly obviate the evil, the bulb of the mercurial thermometer might advantageously be made much smaller, and a very minute but *flattened* bore applied. Thus the degrees would be rendered smaller; but if they were only half their present size, the accuracy, I am convinced, would be advantageously transferred from the minuteness of the adjustment of the scale to the certainty that that adjustment, as nearly as it could be made, would be in its principle correct. A nice eye would discern the tenth of a degree if aided by skilful graduation, though no larger than half what they are at present, and a lens might even be provided. The magazine of hydrogen should also be more defended than at present from the influence of the breath of the observer; and even were the position of the thermometer not to be altered, the seclusion of the gaseous bulb from the more immediate action of atmospheric changes, would be advantageous, by rendering it more similar in condition to the mercury. Other precautions will doubtless occur to practical men, for the remedy of the defect I have endeavoured to prove, if my deductions be correct.

In conclusion, I have only to observe, that my animadversions of course apply to the sympiesometer merely as used in the measurement of heights; as a marine barometer, its superiority in accuracy and utility, as well as convenience, seems fully established.

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## Art. XXIII.—*On the influence of Light on the motions of Infusoria.* By R. E. Grant, M. D., F. R. S. E., F. L. S., Professor of Zoology and Comparative Anatomy in the University of London. Communicated by the Author.

Many animals appear sensible to the impression of light which have obviously no distinct organs of vision, and some even which exhibit no trace of a nervous system are notwithstanding perceptibly influenced by that agent. *Actiniæ* placed alive in basons of sea water I have observed to move slowly along the sides of the vessels till they reached the most shaded situation, where they generally remained stationary, and they appear to shun the light in their native element. I have often verified the observations of Trembley on the fondness of the *Hydræ* for light. When placed in a glass jar with pure water, they quickly betake themselves to the illuminated side of the vessel, and collect in that situation. In their natural abode they show their partiality to light by approaching to the surface of the water, where they are generally found adhering to the stalks of floating *Lemnæ*. When we watch the motions of *Medusæ* floating in the sea, we generally observe them change their direction as they approach the surface, and direct their course downward before any part of their body has come into contact with the atmosphere. From seeing this often take place where the water was quite still, I have been induced to believe that the delicate transparent texture of the animal was sensible to the blaze of the sun's light as it approached the surface. I have elsewhere remarked that even the ova of some zoophytes preferred to attach themselves to the shaded parts of the vessels in which they were placed. From the soft gelatinous texture of such beings, indeed, it seems natural to expect that an agent impinging on them with such velocity and in so great a quantity as the rays of light, and which penetrates their whole substance, should be able to affect them in some manner, were it only with impressions of touch. And the examination of the localities and the particular positions habitually assumed by the lowest species of fixed and nerveless animals, where the temperature and pressure do not vary, lead us to conclude that their physical distribution is principally determined by the intensity of light.

From the minuteness of the *Infusoria* and their transparent colourless texture, and also from the manner in which they are generally examined, in watch-glasses under the microscope, the influence of light on their motions has probably escaped notice. The motions are most easily observed in those which have a perceptible magnitude with some degree of opacity and a lively colour, as the *Furcocerca viridis* of Lam. (*Cercaria* *viridis* of Muller and Bruguiere), which is perceptible to the naked eye, and has a bright grass-green colour. This animalcule is found in the summer season in stagnant pools of fresh water, where it forms a thin green film on the surface. It was observed by Muller in this situation in the fresh water pools of Denmark, and it is found in the same situation in stagnant pools near London. Muller observed that when these animalcules were placed in a vessel of water, they collected at the margin, and died by the evaporation of the water, leaving a thin green film on the side of the vessel. In the month of August last I observed a light-green film on the south side of a small pool of stagnant fresh water near London; it covered detached portions of the surface and extended over more than twenty square feet. As it did not appear to the naked eye to be produced by the green leaves of any plant, I placed a small portion of the film in water under a pocket microscope and observed that the whole green matter detached itself into separate lively animalcules with a tapering bifurcated tail, and corresponding exactly with the figures and descriptions of the *Cercaria viridis*, given by Muller in his *Animalc. Infus.* (tab. 19, fig. 6—13), and by Bruguiere in the *Encyc. Meth.* (pl. 9, fig. 6—13). Lamarck has made a distinct genus, *Furcocerca*, of those *Cercariæ* of Muller which, like the present species, have a bifurcated tail.

The water containing these minute animalcules was placed in a shallow crystal vessel near a window that I might observe their motions and appearance. Under the microscope they exhibited a granular or vesicular texture, but presented none of those spots which Muller mistook for eyes in some other species of *Cercariæ*. After remaining about two hours I observed my green animalcules all accumulated at the surface of the water on one side of the vessel, and nearly left dry on the shallow margin by the rapid evaporation of the water. Thinking that some slight inclination of the vessel to one side might have caused them thus to accumulate at one part of the margin, I turned that part slowly to the opposite side, added a small supply of water, and agitated slightly with the water the animalcules which had nearly perished by the evaporation. On inspecting them a few hours afterwards I found them all again accumulated at one side of the surface of the water, and as it happened both times to be the side next the window where they were collected, I suspected that, like the *Hydræ*, they might have been attracted to that side by the influence of the light. I now removed the vessel to the opposite side of the window, that the light might reach it by a different direction, and in about an hour I found that they had again collected precisely on the part of the margin nearest to the light. The vessel was afterwards placed at various distances from the window, and in various directions with regard to it, and in more than twenty successive trials, I found the animalcules invariably betake themselves to the most illuminated point of the margin. On turning the vessel gently round from the window, I could observe the animalcules with a pocket lens bound forward almost in a straight line to the light, after slowly detaching themselves from the side where they had previously accumulated. When they are swimming dispersed through the water, they seem to have disappeared, being almost invisible to the naked eye when thus separated, and exhibiting an intense green colour only when collected closely together.

The presence of eyes in such animals has been ridiculed by later naturalists, as implying the existence of an optic nerve, a centre of nervous energy, and a general complicated organization, which are contradicted by microscopic inspection. The motions of *Infusoria* are by many believed to be automatic, and Lamarck conceives them to result merely from the action of various imponderable fluids pervading all bodies. Distinct organs of vision belong only to those animals which require to modify the light, so as to produce images of distant objects, to enable them to shun their foes, to select their proper food, or to provide for the continuance of their race, and are not met with in the *Infusoria*, *Zoophyta*, or *Radiata*. It is interesting, however, to observe, that an agent so extensively diffused over nature as light has an obvious and powerful influence on the motions of the *Furcocerca viridis*, an animalcule which exhibits nearly the simplest known form of animal organization.

Art. XXIV.—*Further observations on the Generation of the Virgularia mirabilis.* By R. E. Grant, M. D., F. R. S. E., F. L. S., Professor of Zoology and Comparative Anatomy in the University of London. Communicated by the Author.

In a former notice regarding the structure of the *Virgularia mirabilis*, Lam. (*Edinburgh Journal of Science*, vol. vii. p. 332,) I observed that the small round white ova are seen, in spring, ranged in a double transverse row under each of the lateral fleshy expansions, and that when mature they probably pass out through the bodies of the polypi, as in some other nearly allied zoophytes. This conclusion, founded on analogy, I had an opportunity of confirming by observing the process of generation in this animal in April last. Specimens were brought me alive to Edinburgh from the same part of the Frith of Forth with those of the preceding year, and by carefully supplying them with pure sea water they were preserved in a healthy condition for several weeks in long glass tubes, that I might more closely examine them with a lens without in the least disturbing their motions. The white ova under the pinnæ, close to the stem, were of considerable size, and caused the fleshy substance to project at these parts like small external vesicles. I had the satisfaction, however, to observe the ova advance slowly upwards into the bodies of the polypi which compose the whole substance of the pinnæ, and during this passage they acquired a yellowish white colour, a more regular spherical form, and a greater size. As they approached the base of the stomach they appeared to enjoy more freedom, and on examining them in this situation with a lens, through the sides of the glass tubes, I could distinctly perceive the ova in the same restless state as I had observed the red ova in the polypi of the *Lobularia digitata.* They obviously contracted themselves in different directions, they changed their positions, and sometimes they appeared as if revolving round their own axis. On escaping from the body they exhibited the same slow spontaneous motions as in the *Lobularia.* It is interesting to observe this singular law regarding the generation of zoophytes thus gradually extended by the cautious observation of individual facts.

A very remarkable *lusus naturæ* of this animal was brought me along with the other specimens. It measured nineteen inches in length, and had lost the central calcareous stem of its upper half. The lower half of the animal had the usual structure and a healthy appearance, but the portion which had lost the axis was cylindrical and smooth like a worm, with a clavate termination, and without the slightest appearance of pinnæ or polypi on any part. The pinnæ of the healthy portion diminish gradually in size from the middle to near the commencement of the smooth vermiform half, which was equally alive with the other, though very differently formed. This remarkable specimen of the *Virgularia mirabilis* is preserved in the Zoological Museum of the University of London.

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## Art. XXV.—ZOOLOGICAL COLLECTIONS.

### 1. *Observations on the Mantis Tribe, or that of the Leaf Insects.** By Dr Adam.

Of all the insect tribes in India that of the Leaf Insects is the most remarkable for external form. According to the latest classification, this tribe has been divided into the two families of the *Mantida* and *Phasmida*, founded on a difference in the structure of the foot or leg; this member in the former being raptorious, is provided with a sharp claw, and a hollow on the leg and thigh, and a double series of spurs, for the better securing its prey; and in the latter, being destitute of any such peculiarity. Dr Adam calls two of the specimens laid before the Committee *Gongylodes*, as they appear to correspond closely with the description and figure of that species in the latest entomological works. This insect, when alive and fresh, presents a striking resemblance to a blade of grass, differing in colour according to the season, being green and succulent in the rains, and in the dry weather, so much like a withered straw, that they can with difficulty be distinguished. On first beholding this insect, during the hot winds in the upper provinces, Dr Adam could hardly be convinced that it was not straw, and part of the same long and dry grass on which it rested. A slight movement of the head, however, like that of the house lizard, on the wall, when watching its prey, satisfied him that it was a living object, and on removing grass and all to his hut for examination, he was both surprised and amused at the extraordinary powers which the insect developed. Clinging close to the upright straw which was fixed on the table,

* Read at a meeting of the Physical Committee of the Asiatic Society of Calcutta.

the animal lay in wait for its prey, with no less design than would be exhibited by a cat or a tiger, and if an unlucky fly happened to alight in his neighbourhood, there was hardly left to it a chance of escape. He projects rapidly his armed paw, and, with unerring aim transfixing his victim, lodges it in the toothed hollow of the thigh, destined for its reception. After the fly is in his power, no time is lost in devouring it, commencing with the trunk, and in a few minutes swallowing the whole, the head and wings constituting the finishing morsel. In this manner he would destroy at a meal five or six large flies, which, in point of bulk, nearly doubled his own body.

On viewing the structure of the fore-limb of this insect, it seems impossible to imagine any thing more perfectly contrived for the end in view. The limb itself so strong and muscular, provided with a claw at its extremity, likewise strong, horny, and sharp as a needle, and the groove in the last joints, with the double row of teeth or spurs on the margin, corresponding and locking closely into each other, like the fangs of the alligator, altogether constitute an apparatus for seizing and securing its prey, which, in so small a creature, cannot but excite admiration. By means of these formidable weapons, the insect not only becomes destructive to others, but is employed to attack its own species ; and in China, we are told, fighting the mantis forms as much the favourite amusement of boys, who carry them about in cages for the purpose, as cock-fighting in England, or among the inhabitants of the Eastern Islands.

2. *Account of a Singular Species of Mollusca from the Coast of Ceylon.**
By JAMES CALDER, Esq.

The specimen of this animal presented to the Society was sent to Mr Calder by Captain White, commanding the ship Sherborn, who gives the following account of the manner in which it was procured by him :— While passing Ceylon, he says, a boat came off, in which was this curious sea-animal. We had never seen any thing of the kind before, and the natives appeared to have a great dread of them, as they gave an account of the large ones, on being touched, possessing the power to destroy the use of a man's arm. It lives on the weeds which grow on the rocks, and is frequently found on the Coast of Ceylon. It is observed, that, from several circumstances in its anatomical structure, the species would appear to rank among the *Asterias ;* but it differs materially in other respects from the species described by systematic writers, and presents a peculiarity of external form that does not belong to any of the Mollusca, as far as his acquaintance with this order extends. It is, however, chiefly interesting from the reported power it possesses, as alluded to by Captain White, of benumbing or destroying the ability of a person's hand touching it, resembling in this point the *Torpedo Raia*, and *Gymnotus electricus*. It seems strange, however, that no mention should have been made of an animal of this description by any of the authors who have written on Ceylon and its natural productions. The subject is deserving of further inquiry, and, should the native account be confirmed, we shall have obtained a most interesting addition to our zoological knowledge in the animal now under consideration.

* Read at a meeting of the Asiatic Society, June 13, 1828.

3. *Experiments on the effects produced by dividing the semicircular canals in the Ears of Birds.* By M. Flourens.

At the meeting of the Academy of Sciences of Paris on the 15th September last, an interesting report was presented by MM. Portal, Cuvier, and Dumeril, on the experiments of M. Flourens, relative to the effects produced by dividing the semicircular canals of the ear in birds. This physiologist had already ascertained that the membrane of the tympanum might be removed without affecting hearing; that taking the *stapes* out of the groove which forms the *fenestra ovalis* weakens sensation; and that the destruction of the pulp of the interior of the vestibule annihilates it. These results might to a certain extent have been anticipated; but experiments on the semicircular canals produced effects altogether unexpected. Their section did not appear to weaken the sensibility to sounds, but only to render it painful; while the movements of the animal occasioned by the separation of the parts struck M. Flourens with surprise. He had formerly, in November 1824, announced this fact with regard to the horizontal canals, and subsequent experiments on the others have led to new results. The semicircular canals in the ear of birds, being protected merely by a thin osseous plate, are surrounded by a slight covering of cellular substance, or by openings which communicate with the cavity of the tympanum. One of the three adheres to the internal wall of the cranium; the two others approach more to the external wall, and, crossing one another, one goes in a horizontal plane from right to left, the other in a vertical direction forwards and backwards. The experiments of M. Flourens were upon these three canals. The section of the horizontal canal constantly produces a motion of the head from right to left, and *vice versa;* and when the two horizontal canals are divided, this motion becomes so rapid and impetuous, that the animal loses its balance, and rolls over and over without the power of raising itself. If the semicircular vertical external canals be cut, a violent motion upwards and downwards takes place; the animal does not turn round, or roll over and over, but falls, often in spite of exertions to the contrary, on its back; and lastly, the section of the semicircular vertical internal canals produces violent motions upwards and downwards, but the animal in this case always falls forward on its bill and tumbles round in that direction. These motions cease when the bird remains at rest; but as soon as it attempts to change its place they are renewed, and flight or walking is rendered totally impracticable. The section of all these canals induces violent and surprising motions of the head in every direction. These phenomena do not take place on simple destruction of the osseous envelope of the canals, unless the membranous canal and the pulp with which it is filled be also divided.

An extraordinary circumstance attending these experiments is, that the involuntary motions do not prevent the healing up of the wound, the animal from feeding as usual, and even getting fat. Still however the motions are continued, and M. Flourens has seen pigeons upon which he had operated, and afterwards fed with care, for many months, and even upwards of a year, fall into the peculiar motions and tumblings corresponding to the divided canal, whenever they attempted to change their position.

In other respects the birds exercised all their functions, hearing and seeing, eating and drinking as usual.

M. Flourens repeated his experiments in presence of MM. Cuvier and Dumeril, with the same results; and however surprising and inexplicable they may be, there seems no doubt of the facts as stated.—*Revue Encyclopédique*, Sept. 1828. Pp. 781—784.

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## Art. XXVI.—HISTORY OF MECHANICAL INVENTIONS AND OF PROCESSES AND MATERIALS USED IN THE FINE AND USEFUL ARTS.

### 1. *Description of a Differential Barometer.* By the late W. Hyde Wollaston, M. D. F. R. S.

This instrument is capable of measuring, with considerable accuracy, extremely small differences of barometric pressure. It was originally contrived with the view of determining the force of ascent of heated air in chimneys of different kinds; but as its construction admits of any assignable degree of sensibility being given to it, it is susceptible of application to many other purposes of more extensive utility. A glass tube, of which the internal diameter is at least a quarter of an inch, being bent in the middle into the form of an inverted syphon, with the legs parallel to each other, is cemented at each of its open extremities into the bottom of a separate cistern, about two inches in diameter. One of these cisterns is closed on all sides, excepting where a small horizontal pipe opens from it laterally at its upper part; while the other cistern remains open. The lower portion of the glass tube is filled with water or other fluid, to the height of two or three inches; while the remaining parts of the tube, together with the cistern, to the depth of about half an inch, are filled with oil; care being taken to bring the surfaces of water in both legs to the same level, by equalising the pressure of the incumbent columns of oil. If the horizontal pipe be applied to the key-hole of door, or any similar perforation in a partition between portions of the atmosphere in which the pressures are unequal, the fluid in the corresponding half of the instrument will be depressed, while it is raised in the opposite one, until the excess of weight in the column that is elevated will just balance the external force resulting from the inequality of atmospheric pressure upon the surface of oil in both cisterns. This, however, is equal only to the difference between the weight of the column of water pressing on one side, and that of an equal column of oil which occupies the same length of tube on the other side; this difference depending upon the relative specific gravities of the two fluids, will, in the case of olive oil and water, be about one-eleventh of the weight of the column of water elevated. But the sensibility of the instrument might be increased at pleasure, by mixing with the water a greater or less quantity of alcohol, by which the excess of its specific gravity over that of the oil may be reduced to one-twentieth, one thirtieth, or any other assignable proportion. The instrument may be converted into an areometer, by closing both the cisterns, and by applying to the upper part of each a trumpet-mouthed aperture, opening laterally.

2. *Account of a method of measuring the resistance of fluids to bodies passing through them.* By JAMES WALKER, Esq. F. R. S. Edin.

As it has been demonstrated that the resistance from friction to a carriage upon a road or rail-road is the same at all velocities, Mr Walker was desirous of ascertaining the strain upon a boat when moving at different velocities, This experiment was made in the middle of the East India Import Dock, (1410 feet long, 560 wide, 924 deep,) so that there was no resistance from the sides or bottom of the dock. A spring weighing machine was fixed near the bow of the boat, the dial laid horizontally so as to be easily seen by a person on board; one end of a line ⅝ of an inch in diameter was attached to the back of the spring, the other end was carried ashore and attached to a rock or barrel, 3 feet in diameter, the frame of which was firmly fixed in the ground, and the handles of sufficient length for the necessary number of men to turn the barrel. The velocities were calculated from the time of passing through 176 yards, or $\frac{1}{10}$ of a mile, but to obtain uniform velocity, the boat was at each experiment drawn over twice the length, and the 176 yards taken in the middle of the distance by two marks upon the line. The line between the two marks coming to the edge of the dock was carefully noted by a person stationed there for the purpose. Three persons at least were on board the boat, one to read off the strain shown upon the dial every 2 seconds; one to write them down, and a third to steady the boat. An exact uniformity of motion by the men at the handles was obtained by a little practice, by means of a pendulum varying in length (as a quick or slow motion was required), hung up in sight of the men, by the oscillations of which they regulated the revolution of the handles. The weights marked by the index of the dial measured only the resistances to the boat. The following were the results obtained with a full built boat loaded with 2 tons 2 cwt. exclusive of the men. The length of the boat on the surface of the water was 18½ feet, its breadth 6 feet, its depth of immersion 2 feet, the whole depth of the boat being 3 feet, leaving one foot above water, the greatest immersed cross section 9 feet.

TABLE I.

| | No. of seconds in passing 176 yards. | Velocity per hour in Miles. | Observed resistance, or strain in lbs. on Dial. | Calculated resistance, No. 5 being the standard. |
|---|---|---|---|---|
| 1 | 124 | 2.903 | 15.75 | 15.04 |
| 2 | 85 | 4.235 | 39.50 | 32.01 |
| 3 | 146 | 2.465 | 10.00 | 10.85 |
| 4 | 140 | 2.571 | 11.00 | 11.80 |
| 5 | 145 | 2.483 | 11.00 | 11.00 stand. |
| 6 | 140 | 2.571 | 12.00 | 11.80 |
| 7 | 120 | 3.000 | 14.00 | 16.06 |
| 8 | 120 | 3.000 | 14.00 | 16.06 |

The average resistance of Nos. 7, 8, and 10, (low velocities) is 9.41 lbs. and the corresponding velocity 2.529 miles. The average of Nos. 1 and 2 (high velocities) is 42.59 lbs. and the velocity per hour 4.529 miles. The calculated resistance in these cases would be

For low velocities 22.04 instead of 28.07
— high ——— 38.11 ——— 42.59

Mr Walker also made experiments with a light boat 28 feet long, and on a Thames wherry.

In almost every experiment the resistance showed an increase, amounting to the square of the velocity; but where the velocity was considerable, the resistance followed a still higher ratio, and this in open water. In narrow canals the increase must be considerably greater. The excess above the square, is ascribed in a great measure to the raising of the water at the bow in high velocities, and to the depression at the stern.

If with a speed of 2½ miles per hour, 30 tons upon a canal be equal to 7½ upon a level rail-road, a speed of five miles per hour, would, upon the principle of the square, bring the rail-road and canal to an equality; whereas the above results makes the *two modes of conveyance equal considerably under four miles per hour, and gives the railway the decided preference at all higher velocities.*

The following tables will show at once the comparative merits of canal and railway conveyance.

| Land Experiments. | | Water Experiments. |
|---|---|---|
| Velocity per hour, | 2 miles | 2 miles |
| Distance passed over, | 2 miles | 2 miles |
| Power of engine required, | 1 horse | 1 horse |
| Time occupied, | 1 hour | 1 hour |
| Mechanic power expended, | 1 | 1 |
| Velocity per hour, | 4 miles | 4 miles |
| Distance passed over, | 2 miles | 2 miles |
| Power of engine required, | 2 horse | 8 horse by theory, more by experiment. |
| Time occupied, | ½ hour | ½ hour |
| Mechanic power expended, | 1 hour | 4 by theory, more by experiment. |

In these experiments the resistance per superficial foot was only 1,22, whereas in Bossut's experiments it was 1.854. The cause of this does not well appear; but we have no doubt of the great accuracy of Mr Walker, and his method is obviously superior to those hitherto used. As he promises to continue the subject, we may expect soon to call the attention of our mechanical readers to new and important results. In the present state of our commerce and manufactures, we consider the main result of Mr Walker's paper, viz. the great superiority of land over water carriage, as a matter of national interest. A fuller account of Mr Walker's experiments will be found in the *Phil. Trans.* for 1828, p. 15—22.

3. *On the permanent increase of Bulk in Cast-Iron by successive heatings.* By JAMES PRINSEP, Esq. Assay Master of the Mint at Benares.

In a former paper on Mechanical Inventions in No. xvii. p. 168, we noticed the highly important experiments of Mr Prinsep on high temperatures. In the course of these experiments he discovered the very remarkable fact, that *cast-iron acquires a permanent increase of bulk by each successive heating.* This point is determined by measuring the cubic extent of an iron retort, as ascertained by the weight of pure mercury which it contained at the temperature of 80°. The actual contents were as follows:—

| | | |
|---|---|---|
| Before the first experiment, | | 9.13 cubic inches. |
| After the first fire, | - | 9.64 ——— |
| After three fires, | - | 10.16 ——— |

But what is more remarkable still, *the augmentation of the bulk of the retort exceeds the dilatation due to the temperature to which it was exposed.* For as iron expands 0.0105 by 180° of Fahrenheit, the increase of bulk upon 10 cubic inches should be $0.105 \times 3 = 0.315$ at 1800° of Fahrenheit, or even the melting heat of silver. Hence we may conclude that the dilatation of iron is not equable, a result formerly obtained by Messrs Dulong and Petit.

4. *Description of a Sounding-Board in Attercliffe Church,* invented by the Rev. John Blackburn, Minister of Attercliffe-cum-Darnall, Sheffield. (From the *Phil. Trans.* 1828, p. 361.)

This sounding board is represented in Plate II. fig, 9, 10. The material is pine wood, the surface is concave, and is generated by half a revolution of one branch of a parabola on its axis.

| | |
|---|---|
| The distance from the focus to the vertex is | = 2 feet |
| The length of the abscissa is | = 4 feet |
| The length of the ordinate to the axis | $\sqrt{32}$ feet |
| | = nearly 5.7 |
| | = Rad. of outer circle. |

The axis is inclined forward to the plane of the floor, see Fig. 10, at an angle ACD of about 10 or 15 degrees, and elevated so that the speaker's mouth may be in the focus.

A small curvilineal section is taken away on each side from beneath, that the view of the preacher from the north and south galleries may not be interrupted; whence the outer semicircle is imperfect.

This, however, gives an appearance that is not inelegant, and the outer edge being ornamented with crockets and leaves, and with a pinnacle at the highest point, and the concave surface being painted in imitation of a ground oak canopy, the effect of the whole is pleasing to the eye.

A curtain is suspended from the lower edge of the canopy for about 18 inches on each side.

1. By means of this erection the volume of sound is increased in a very considerable ratio, (perhaps as 5 : 1), and is thrown powerfully, as well as distinctly, to the most distant parts of the church; so that whereas formerly the difficulty of hearing an intelligible sound was very great, now that difficulty is effectually removed. *e. g.*

The preacher was scarcely audible even in the pews near the pulpit, and not at all in those more remote: he may now be heard in every part, and nowhere more distinctly than in the west gallery, or under it, on the ground floor.

2. It should seem that the voice is reflected in a direction parallel to the axis; for let A stand in the pulpit, and B stand first in the west gallery, opposite to the pulpit, and then in the side galleries; though B is much

nearer to A in the latter case than in the former, he can yet hear with decided advantage when opposite to A (*i. e.* at the greater distance from him.)

The side galleries appear to be benefited rather by the increased volume of sound, and by the secondary vibrations excited in a lateral direction.

3. It appears also that vibrations, proceeding from a distant point and moving in the direction of the axis, are reflected from the parabolic surface towards the focus. For let A stand in the pulpit, as before, and B in a distant point opposite to it, A can then converse with B in a whisper; whilst C standing at an intermediate point, cannot at all distinguish the words spoken by B; he can, however, hear what is said by A. Also, if B at a distance, opposite to the sounding board speaks, whilst A places one ear on the focus of the parabola, and one ear towards B, the effect produced is that of a voice close to the ear, and in a direction the reverse of that from which it really proceeds.

4. The converse of this also appears true from the following experiment. Let B remain in the situation last supposed, and let A place his face towards the parabolic surface, and his back towards B; let A now speak, having his mouth in the situation of the focus, and he will be heard as distinctly as when his face was turned towards B.

5. If the mouth of the speaker is placed much within or without, above or below the focus, the effect is proportionally diminished.

6. While the figure of the canopy remained perfect, the effect was more complete; perhaps it might be improved if constructed longer, or in other words if continued farther; but the distance of the focus S to the vertex A, fig. 10, which regulates the curve must depend on the supposed situation of the speaker, which will vary with the diameter of the pulpit.

Fig. 10 represents a section of the parabolic sounding-board, which is shown by the line A P B. The axis of the parabola A C is inclined as shown on the figure, to the horizon. The mouth of the speaker would be about the focus S. If S *p*, S P are the directions of the sound incident upon the board, *p q*, P Q will be its direction after reflexion.

### 5. *Account of a Process for producing a beautiful Blue Colour.* By M. Braconnot.

Six parts of sulphate of copper were dissolved in a small quantity of water; also, six parts of white arsenic with eight parts of potash of commerce, were boiled in water until no further quantity of carbonic acid was disengaged. This hot solution was gradually mixed with the first, continually agitating until effervescence ceased. An abundant dull yellowish green precipitate was formed. About three parts of acetic acid were then added, or such a quantity that a slight excess was sensible to the smell. Gradually the precipitate diminished in volume, and in some hours a slightly crystalline powder was deposited at the bottom of an entirely colourless solution. The fluid was poured off as soon as possible; and the powder, washed with plenty of water to remove the last portions of arsenic, was then of a brilliant blue colour.

Care must be taken not to add to the cupreous solution an excess of arseniate of potash, as it causes waste of the acetic acid afterwards added, as the latter must be in excess. In repeating the process in the large way, an arseniate of potash, prepared with eight parts of oxide of arsenic, instead of six, was used, and the result was very successful. M. Braconnot thinks that probably a slight variation of the proportions he has given may be found advantageous; but, in the meantime, considers it right to give the best process he is able for the preparation of a colour so beautiful, and which may be very useful in the arts.

### 6. *Account of the Process for making Ultramarine.*

M. Gruinet of Thoulouse has succeeded in forming this valuable pigment; and our able correspondent, Professor Gmelin of Tubingen, has also discovered a process for making it, which is given in the *Ann. de Chim.* for April.

Prepare hydrate of silica and hydrate of alumina; the former is obtained by fusing well powdered quartz with four times its weight of carbonate of potash, dissolving the fused mass in water, and precipitating by muriatic acid Hydrate of alumina is procured by precipitating a solution of alum with ammonia. These two earths are to be carefully washed with distilled water. After this, the quantity of dry earth remaining is to be ascertained, by heating to redness a certain quantity of the moist precipitates. The hydrate of silica which I employed in my experiments, contained in 100 parts 56, and the hydrate of alumina 3.24 parts of anhydrous earth.

Dissolve afterwards, with the assistance of heat, as much of this hydrate of silica as a solution of caustic soda is capable of taking up, and determine the quantity dissolved. Take then for 72 parts of the latter (anhydrous silica) a quantity of hydrate of alumina, which contains 70 of anhydrous alumina: it is to be added to the solution of silica, and the mixture is to be evaporated, with constant stirring, until a moist powder only remains.

This combination of silica, alumina, and soda, is the base of the ultramarine, which is to be coloured by sulphuret of sodium, and this is effected in the following manner:—Put into a Hessian crucible, provided with a good cover, a mixture of two parts of sulphur, and one part of anhydrous carbonate of soda; it is to be gradually heated, until, at a moderate red heat, the mass is well fused. This mixture is then to be projected, in very small quantities at a time, into the middle of the fused mass. As soon as the effervescence occasioned by the vapour of water ceases, a fresh portion is to be thrown in. Having kept the crucible moderately red-hot for an hour, it is to be taken from the fire and permitted to cool. It now contains ultramarine, mixed with sulphuret in excess, which is to be separated by water. If there be sulphur in excess, it is to be expelled by a moderate heat. If the whole of the ultramarine be not equally coloured, the finer parts may be separated, after having reduced them to a very fine powder, by washing with water.

### 7. *Inventions for Sharpening Blades of Knives.*

In 1827, Mr Felton took a patent for a method of sharpening edge-tools by means of two ground steel cylinders, which acted like files. Their edges were drawn backward and forward in the angle formed between the two cylindrical files. The working surfaces are a succession of small cylinders with openings between (bosses and recesses,) and the surfaces of the bosses are exposed, or cut, or scribed round circularly, like the files called floats, which present so many cutting or file edges, against which the knife is pressed when drawn backwards and forwards.

Another patent has been taken out in May 1828 by Mr F. Westley, for a similar apparatus, which is a decided copy of the principle of Mr Felton's invention, without being an improvement. It may, however, be cheaper, and more easily made. It consists of four pairs of straight bars of steel, with file edges, each pair being placed like a St Andrew's cross, and at the same acute angle. The knife is then drawn between them as in Mr Felton's contrivance. The inclination of the bars may be varied with a screw.

Another method of effecting the same purpose has been invented by Mr Blake of Sheffield. A series of file-edged bars are connected together by an axle passing through their centres, so that they can be set at any angle, and fastened by a screw.

We have no doubt that a better contrivance than any of them would be to use two ground surfaces of variable curvature, (parabolic, for example,) so that various inclinations of the cutting surfaces could be obtained by merely making the one revolve round upon the other.

8. *Description of the Pneumatic Spoon.* Invented by Mr Gibson.

This truly ingenious and useful invention has been very properly rewarded by the Society of Arts with the Isis Medal. It is shown in Plate II. Fig. 11, and has a lid L, opening round the joint, *a b*. Its handle H is a tube, the extremity of which E, is a circular disc, upon which the operator puts his thumb. The fluid is introduced at the lid L; and when the lid L is shut, and the thumb placed upon E, the spoon may be held in any position, without the fluid falling out. Hence it is especially valuable in administering food or medicine when the patient is in bed. When the spoon is inserted in the mouth, the food or medicine falls out of the spoon by withdrawing the thumb from E.

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## Art. XXVII.—ANALYSIS OF SCIENTIFIC BOOKS AND MEMOIRS.

*The Natural History of several New, Popular, and Diverting Living Objects for the Microscope, with the phenomena presented by them under observation, &c. &c. Conjoined with accurate Descriptions of the latest improvements in the Diamond, Sapphire, Aplanatic, and Amician Microscopes; and instructions for managing them, &c. &c. To which is added a Tract on the newly discovered Test Objects. Illustrated by very highly finished Coloured Engravings, from drawings of the actual Living Subjects.* By C. R. Goring, M. D. and Andrew Pritchard. No. I. Lond. Feb. 1829. Pp. 32. 2 8vo. Coloured Plates.

In a preceding article of this number (p. 327) we have already had occasion to give an account of the labours of Dr Goring and Mr Pritchard relative to the improvement of the microscope. Impressed as we are with the high importance of this branch of science, and with the great value of the improvements which these gentlemen have introduced, we naturally looked forward with the most sanguine expectations to the publication of the present work. We knew well that both its authors were peculiarly fitted for executing in a superior manner particular departments of such an extensive undertaking; but we were unable to anticipate how Dr Goring would execute the drawings of microscopic objects, or how Mr Pritchard would discharge the functions of the naturalist. This information, however, is amply supplied by the first number of the work; and we have no hesitation in stating it as our opinion, that Dr Goring and Mr Pritchard have both accomplished these difficult tasks with the greatest success.

The first number, now before us, commences with an exordium or preface, written in Dr Goring's peculiar but forcible style, and vindicating microscopic science from the sarcasms of ignorant and presumptuous pretenders. The first chapter, which is also from the pen of Dr Goring, contains *practical remarks on Microscopes for viewing and drawing Aquatic Larvæ, &c.* The other two chapters of the number, which are written by Mr Pritchard, are entitled, 1. *On the Larva and Pupa of a straw-coloured plumed Culex or Gnat*; and 2. *On the Larva and Chrysalis of the Ephemera marginalis.* The coloured drawings by Dr Goring, by which these two chapters are illustrated, are executed in such a masterly manner, that they will themselves bear to be seen by the microscope, and they cannot fail to impress the observer with the conviction, that they are correct portraits of the living animals.

The description of the larva and pupa of the plumed gnat will be interesting to the naturalist.

"The transformation," says Mr Pritchard, "of this animal from the larva to the pupa is one of the most singular and wonderful changes that can be conceived; and under the microscope presents to the admirer of nature a most curious and interesting spectacle. Although the whole operation is under the immediate inspection of the observer, yet so complete is the change, that its former organization can scarcely be recognized in its new state of existence.

"If we now compare the different parts of the larva with the pupa, we remark a very striking change in the tail, which, in the previous state of being, was composed of 22 beautifully plumed branches; while, in the latter, it is converted into two fine membranous tissues ramified. This change appears the more remarkable, as not the slightest resemblance can be discovered between them; nor can any vestiges of the former tail be found in the water. The partial disappearance of the shell-like bodies is another curious circumstance. The two lower of them, it may be conjectured, go to form the new tail, for if the number of joints be counted from the head, the new tail will be found appended to that joint which was nearest them in the larva state. The two small horns which form the white plumed antennæ of this species of gnat, when in its perfect state, are discernible in the larva folded up under the skin near the head. The alimentary canal appears nearly to vanish in the pupa, as in that state there is no necessity for it, the insect then entirely abstaining from food; while, near this canal, the two intestinal blood-vessels seen in the larva have now become more distinct, and are supplied with several anastomosing branches.

"During the latter part of the day on which the drawing was taken, the rudiments of the legs of the perfect insect might be seen, folded within that part which appears to be the head of the pupa; and several of the globules had vanished, those remaining longest that were situated nearest the head. It may be necessary to observe, that the head of the pupa floats just under the surface of the water; and the insect, in this state, is nearly upright in that fluid, while the larva rests its belly or sides at the bottom of the pond or vessel in which it is kept.

"The circuitous manner in which the Creator appears to form this species of gnat, and many other of His smaller productions, is truly wonderful. Other creatures are formed directly either from the egg or the maternal womb. As, however, the Deity does nothing in vain, it may be presumed that He must have had in view some important object in the preliminary steps through which these beings have to pass, as from the *egg* to the *larva, chrysalis,* and perfect insect; and, however low these minutiae of nature may be held in the estimation of the unthinking mass of mankind, this most elaborate proceeding renders it not improbable that they may be deemed by Him the choicest and most exquisite of His productions. These mysterious creative operations of nature, as detected and unravelled by microscopes, are surely grand and capital subjects for observations. I should pity the spirit of the man who scorned to be amused by inspecting these marvellous metamorphoses, and disdained to be informed of the manner in which they are effected."

From this specimen of Mr Pritchard's description, which is here seen to great disadvantage from the want of the figures, the reader will form an idea of the manner in which this part of the work will be executed.

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## Art. XXVIII.—PROCEEDINGS OF SOCIETIES.

### 1. *Proceedings of the Royal Society of Edinburgh.*

*December* 15, 1828.—The following communication was read: "Observations on the Movements of the Molecules of Organized Bodies. By Dr Brewster, F. R. SS. L. and E.

*January* 5, 1829.—The following Gentlemen were admitted ordinary Members:—

Andrew Skene, Esq.

R. C. Colyar, Esq.

The following communications were read:—

1. Biographical notice of the late Sir J. E. Smith, P. L. S. with an estimate of the character and influence of his botanical labours, by the Rev. E. B. Ramsay, B. A. F. R. S. E. and F. A. S. Scot.

2. Account of a great luminous arch as seen at Plymouth. By G. Harvey, Esq. F. R. SS. L. and E.

3. A letter from Dr Thomson describing a spontaneous emission of inflammable gas at Redly, seven miles N. E. of Glasgow.

*January* 19. 1. Remarks on Glauchoma, by J. Howship, Esq. Member of the Royal College of Surgeons. Communicated by Dr Knox.

2. Notice regarding a female Orang-outang sent from Singapore to Calcutta to be kept with a male one in the possession of G. Swinton, Esq. F. R. S. E.

*February* 2. 1. On the composition of Blende, by T. Thomson, M. D. F. R. SS., L. and E. Professor of Chemistry, Glasgow.

2. Comparative experiments on different Dew point instruments, with a description of one on an improved construction, by Mr J. Adie. Mr Adie's improved instrument was exhibited.

*February* 16.—On the size of the brain and the proportion of its parts, as affected by age, sex, or sexual mutilation. By Sir William Hamilton, Bart.

*March* 2.—The following candidates were admitted Fellows of the Society :—

William Gibson-Craig, Esq.
Charles Fergusson, Esq. younger of Kilkerran.
James Ewing, Esq. LL. D. Glasgow.
Duncan Macneill, Esq. Sheriff-depute of Perth.
Reverend J. Sinclair, A. M. Pemb. Coll. Ox.
Arthur Connell, Esq.
Reverend J. Sheepshanks, A. M.
James Hope Vere, Esq. of Craigiehall.

The following communications were read :—

1. Notice of an experiment relative to the supposed spontaneous Motions of Bodies suspended in Fluids, by Dr Brewster.

2. Notice regarding the Miners' Compass, and its application in underground surveys, by R. Bald, Esq. Civil Engineer.

3. Notice concerning an autograph MS. by Sir I. Newton, found among the papers of Dr D. Gregory, formerly Sav. Prof. of Astr, Oxford, by Dr J. C. Gregory.

### 2. *Proceedings of the Society for the Encouragement of the Useful Arts in Scotland.*

*March* 19, 1828.—Messrs George and James Nasmyth exhibited and described a section model of the Steam Engine, constructed by them for the purpose of explaining the principle and construction of that machine.

Messrs Nasmyth also exhibited, in action, an improved high Pressure Steam Engine constructed by them.

Drawings of a Steam Carriage capable of carrying six persons were submitted to the Society, together with proposals for erecting the same by subscription. By Messrs G. and J. Nasmyth.

*April* 2.—Notice of a machine for the use of boot and shoe-makers, invented by Mr James Dowie, boot and shoemaker, Register Street, and Mr Alexander Black, surveyor, Calton Street, Edinburgh, was read to to the Society. The machine was exhibited in its full size ; and a handsome model of it was also exhibited, and was presented to the Society along with the notice descriptive of its uses; and a plan of a work-shop fitted up in the most approved manner with these machines. By Mr JAMES DOWIE.

Mr ALEXANDER NASMYTH exhibited and described a model of an improved gate for agricultural and ornamental purposes.

Mr JAMES NASMYTH exhibited and described a model of a method of protecting chimney cans from the effect of wind.

Messrs G. and J. NASMYTH exhibited some experiments relative to the cause of the coldness of high pressure steam when issuing from a small aperture.

Mr ROBISON exhibited some beautiful and delicate specimens of drill turning.

Mr JOHN MILNE, architect, teacher of mechanical and architectural drawing, Edinburgh, was elected an Associate Member.

*April* 22.—The following communications were made and models exhibited, viz.

Drawings on a large scale of the great steam engine erected at Stoneyhill in 1827, by Messrs CLAUD GIRDWOOD, & Co. for draining the coal mines of Sir John Hope of Craighall Bart. both in section and in perspective, and intended to be engraved by subscription, were exhibited to the Society. By Mr JOHN MILNE.

A section drawing, and model of a double piston valve, proposed to be substituted for the slide valve, particularly in working *models* of the steam engine, whereby their cost will be greatly reduced and the waste of steam prevented, were exhibited by Mr JAMES KILPATRICK, Edinburgh.

An Attwood's machine, *without* friction rollers, constructed byMr Dunn, optician, by which the application of friction rollers to that machine was said to be unnecessary for even very delicate experiments, and the cost of the instrument greatly reduced, was exhibited by Mr DUNN.

The following Gentlemen were elected Members:

*Ordinary.*

Charles M'Laren, Esq.
James Greig Junior, Esq. W. S.
John Craig, Esq.
John G. Kinnear, Esq.

*May* 7.—A new instrument for procuring an instantaneous light, invented by Mr JOHN NAPIER, joiner, South Richmond Street, Edinburgh, was exhibited and described.

Mr JOHN MILNE exhibited his drawings of the steam engine at Stoneyhill, and read a description of them, which is intended to be published along with the drawings.

ADAM G. ELLIS, Esq. W. S. was admitted an Ordinary Member.

*Dec.* 3.—The following communications were made:

A description of an Apparatus for sweeping Chimneys, invented by the Rev. GEORGE TOUGH, Ayton Manse, was read, whereby the use of climbing boys is rendered unnecessary.

A description of a clock pendulum, in which the impulse is received directly from the swing wheel, without the intervention of either fork or verge, invented by Mr ALEXANDER DOIG, watchmaker Musselburgh, was read, and a working model exhibited.

The following gentlemen were elected Members:

*Ordinary.*

Thomas Grainger, Esq. civil engineer, Edinburgh.

Robert Fraser, Esq. Newington, Edinburgh.

*Associate.*

James Smith, Esq. Deanstoun.

*Dec.* 17.—Mr ALEXANDER DOIG explained the nature and uses of his clock pendulum without verge or fork, and again exhibited his working model of it.

CAPTAIN MACONOCHIE, R. N. exhibited and described very fully models of a Steam Tug and Flat Boat, on new principles and construction, invented by him.

Mr W. H. LIZARS read a letter from Mr Alexander Cowan, papermaker, Penicuick, sending him some specimens of *paper* made by him at the request of Mr Lizars, from the masses of stuff from Nepaul, sent from India by George Swinton, Esq. and exhibited to the Society *(in mass)* upon the 5th of March last. Mr Lizars exhibited and presented to the Society the specimens of this paper, which is of a bladdery kind, and does not take a good impression from a copperplate. Mr Lizars also exhibited and presented to the Society a specimen of copperplate printing on a piece of *Cobbett's Indian corn paper,* which had been sent him by Mr Cowan. The Indian corn paper takes rather a good impression from copperplate.

Mr JOHN MILNE was transferred from the list of associate to that of Ordinary Members.

*January* 7, 1829.—A description of a clock pendulum, which receives the impulse directly from the swing wheel without the intervention of fork or crutch, invented by Mr DAVID WHITELAW, watchmaker, 16, Princes Street, Edinburgh, was read, and the pendulum exhibited in action.

Mr EDWARD SANG read a paper regarding a new phenomenon discovered in Iceland spar. Numerous specimens were exhibited in illustration.

*January* 21.—Mr JAMES GRÆME, W. S., was admitted an Ordinary Member.

CAPTAIN MACONOCHIE, R. N., read a paper on steam-towing, demonstrative of its application to *General,* but more particularly to *Mercantile,* navigation ; and exhibited models in illustration, which he presented to the Society.

A model of a door alarum by Mr JAMES FORBES, Old Meldrum, was next exhibited to the meeting, and a description of it read.

*February* 4.—Mr JOHN MILLER, civil-engineer, was elected an Ordinary Member.

A new hydrometer, invented by the late Mr Lunan of Aberdeen, was communicated by Mr JOHN ARMSTRONG, and exhibited and explained by Mr ADIE.

A description of a new door alarum, invented by Mr ROBERT FRASER, Jeweller, Princes Street, was read, and a model exhibited and explained by the inventor.

Mr WHITELAW submitted an enlarged description of his pendulum without fork or verge, which was read.

*February* 18.—Mr JOHN ARMSTRONG, Lauriston Place, was admitted an Ordinary Member.

Mr JOHN ADIE read a paper on a new construction of a Dew Point Instrument, accompanied with a comparative table of observations made by it, and by others previously in use.

A model of the Rev. GEORGE TOUGH's apparatus for sweeping chimneys, whereby the use of climbing boys is rendered unnecessary, was exhibited, and presented to the Society by the inventor.

*March* 4.—Mr GALBRAITH exhibited to the Society a Turnip Extractor, invented by Mr WILLIAM HUME of Greenlaw, and explained the manner of its application for extracting turnips from the throats of cattle.

Mr DUNN read a paper on the escape of steam from the aperture of a boiler, in reference to an experiment of Clement. Mr Dunn's experiments seemed to show in a very satisfactory manner, that no real danger can arise from the singular adhesion of a circular disc to an aperture from which a fluid is issuing.

### 3. *Proceedings of the Cambridge Philosophical Society.*

*December* 8, 1828.—The Rev. Professor Farish, Vice-President, being in the chair, a communication was read to the society by the Rev. JOHN WARREN of Jesus College, stating the coincidence of the views respecting the Algebraic Quantities commonly called *Impossible Roots* or *Imaginary Quantities*, contained in his "*Treatise on the Geometrical representation of the Square Roots of Negative Quantities*," with those independently arrived at by M. Mourey, in his work entitled "*La vraie Theorie des Quantités Negatives et des Quantites pretendues Imaginaires*," published at Paris during the present year: and giving from these views a proof, extracted from the work of M. Mourey, that *every equation has as many roots as it has dimensions.*

A communication was likewise read by Dr THACKERAY, respecting a young woman in the neighbourhood of Cambridge, who was stated to have lived without food or the least reduction in the weight of the body, since the beginning of October.

The reading of Mr CHALLIS's paper was also concluded, "on the extension to the satellites, of Bode's law of the distances of the primary planets." The existence of the law in this case having been proved, it was inferred that the distances may be approximately expressed in the following manner:—

| | |
|---|---|
| For the Planets | $4,\ 4+3,\ 4+3\times 2$, &c. |
| For Jupiter's satellites | $7,\ 7+4,\ 7+4\times 2\frac{1}{2}$, &c. |
| For Saturn's satellites | $4,\ 4+1,\ 4+1\times 2$, &c. |
| For Uranus's satellites | $3,\ 3+1,\ 3+1\times 1\frac{1}{2}$, &c. |

It was likewise concluded from this law, that there can be no planet nearer the sun than Mercury; and no satellite nearer the several primaries, than the nearest of those, in each system which have been discovered. The deviations from the law were also examined, and it was stated to be probably established that these depend on the masses and mutual actions of the revolving bodies.

After the meeting, the Rev. L. JENYNS gave an account, illustrated by drawings, of the comparative anatomy of birds and mammalia, and of several remarkable particulars respecting the former class of animals.

*March* 2, 1829.—The very Rev. the Dean of Ely in the chair. A memoir by PIERCE MORTON, Esq of Trinity College, was read, "on the focus of a conic section," in which the author pointed out the solid construction from which that point is derived.

The reading of a paper by PROFESSOR WHEWELL was also begun, "on the application of mathematical reasoning to some of the theories of Political Economy," in which the author maintained, that, so far as that science is founded on definitions and axioms, the shortest and most certain method of deducing its results is by the assistance of mathematical process.

After the meeting, Professor Whewell gave an account of some of the contrivances which have been employed in the use of the dipping needle, and exhibited one of a construction in some respects new.

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## ART. XXIX.—SCIENTIFIC INTELLIGENCE.

### I. NATURAL PHILOSOPHY.

#### ASTRONOMY.

1. *Mr Dunlop's Observations on Encke's Comet.*—Mr Dunlop discovered at Makerston the celebrated comet of Encke, on the 26th of October. His first observation gave its place about 16″ or 18″ of time greater in right ascension, and about *one* minute farther north than its place in the Ephemeris. Several observations which he made in November, and which he has reduced, give nearly the same differences, and the observation of December 7th, gives its place about 20″ greater in right ascension, and fully one minute from the north in declination than the calculated place. Since the beginning of December it has been decreasing in brightness; but it is considerably higher than it was in 1822. Mr Dunlop measured the diameter of the chevelure on the 7th December, and found it about five minutes. About the end of November he thinks it would be about six minutes. The nebulous form is not round but rather fan-shaped, with the condensation of the nebulous matter near the point or apparent lower extremity.

#### OPTICS.

2. *Supernumerary Rainbows.*—In our last *Number*, p. 163, we committed a strange oversight in stating that the supernumerary colours had not before been seen in the secondary or outer bow. We have ourselves mentioned them in the article Optics, in the *Edinburgh Encyclopædia*, as seen by M. Dicquemarre, and also Dr Young's explanation, which connects the phenomenon with that of the colours of thin plates, (*Nat. Phil.* vol. i. p. 470,) applies to both.

ACOUSTICS.

3. *Velocity of Sound in the Arctic Regions by Captain Parry's observations.*—In a valuable paper by Professor Moll of Utrecht, (*Phil. Trans.* 1828, p. 103.) containing a reduction of Captain Parry's experiments on the velocity of Sound at Port Bowen, the following table of results is given:—

| | Velocity of sound in inches. |
|---|---|
| Captain Parry and Lieutenant Foster, | 333.15 |
| Do. another series, - - - | 333.71 |
| Do. another series, - - - | 332.85 |
| Professor Moll and Von Beck, - | 332.05 |
| M. Stampfer and Myrbach in Germany, | 333.25 |
| Messrs Arago, Mathieu, and Biot in France, | 331.05 |
| M. Benzenberg, Germany, - - | 333.70 |
| MM. Epinoza and Bauza in Chili, - | 356.14 |
| Dr O. Gregory in England, - - | 335.14 |
| French Academicians, - - | 332.93 |

ELECTRICITY.

4. *On the influence of Electricity on the emanation of Odours.*—In a late number of the *Antologia* of Florence, M. William Libri has announced the following curious fact. "When a continued current of electricity traverses an odoriferous body, camphor, for example, the odour of this body becomes weaker and weaker, and finally disappears entirely. When this happens, remove the body from all electrical influence, and put it in communication with the ground, and it will continue without odour for some time. The camphor will afterwards recover its properties gradually but slowly." It would appear from a note in the *Ann. de Chim.* that difficulties have occurred in the repetition of this experiment.

GALVANISM.

5. *M. Becquerel on the temperature of conducting wires.*—M. Becquerel has discovered that *the temperature of a conducting wire communicating with the two poles of a pile, increases from each of its extremities, and constantly reaches its maximum in the middle of the wire.*

METEOROLOGY.

6. *Mass of Meteoric Iron found in France.*—On the 13th October, M. Hericart de Thury read to the Institute a notice of a mass of meteoric iron existing at Caille, in the department of the Var. In August last, Mr Brard sent from Fréjus a specimen of the mass in question, with respect to the origin of which he did not decide. The examination made by the author caused him to suspect that it might be meteoric iron, and he therefore wrote to M. Brard, to beg that he would go to the place, in order to determine the nature of the mountain on which it was discovered; to examine the mass of supposed meteoric iron; and to collect from the inhabitants all the information which they could give him. The following is extracted from the account given by Mr Brard:—The mass of iron which

had been for two years placed at the door of the church at Caille, has been in that village about 150 years. It was discovered in the mountains of Audehert, a league off, and was drawn by four oxen into a court or garden in the village, where it seems to have been forgotten; but an inhabitant having inclosed it in a wall, it was claimed as an object held in some veneration; the wall was pulled down by the authorities, and the enormous mass was deposited in the principal street of the village, from which it was removed to the spot which it now occupies.

The form of the mass is very irregular; its external colour blackish brown, with a shade of lead colour; it is shining, but occasionally spotted with yellow rust; its internal colour is whiter than that of common iron. It weighs about 1000 or 1200 pounds.

The mountain in which this mass was found is of considerable altitude, and similar to those which surround it; there are no appearances of iron works having ever existed in the neighbourhood.

This iron has the crystalline appearance which marks its meteoric origin, and Mr Laugier has found that it contains nickel.

Application has been made for its removal to Paris, and this has probably been already accomplished.

It was reported in the village, that two smaller masses were found with it, which were used for making horses' shoes, nails, &c. It was also proposed to heat this mass, and thus divide it, and apply it to the same purposes; fortunately for the interests of science, the greatness of the mass prevented the intended destruction.—*Le Globe, Phil. Mag.*

At the sitting of the Academy of Sciences of the 17th November, the minister of the interior announced, that, at the request of the academy, he had destined the sum of 610 francs for the purchase of the above mass of meteoric iron, and for its transport to the Museum of Natural History.

## II. CHEMISTRY.

7. *Diamonds made artificially in France*—On the 10th November M. Arago communicated a note from M. Cagnard de Latour, in which this philosopher announces *that he has succeeded in crystallizing carbon to form the diamond*, by methods different from those of M. Gannal, and that a sealed packet deposited in the secretariat in 1824 contains the details of his first processes.

M. Arago announces that he knows another person who has arrived at similar results; and M. Gay-Lussac declares, that M. Gannal spoke to him more than eight years ago of his attempt.

At the meeting of the Institute of 17th November M. Thenard gave an account of his examination of the products obtained by M. Cagnard de Latour in his crystallization of carbon. Such of the crystals as have no colour scratch quartz, but they are scratched by diamond. They do not burn; and an accurate analysis has proved that they are not carbon, but a silicate. We trust that an equally careful examination will be made of the diamonds of M. Gannal, and those of the persons, more than one, whom M. Arago mentions as having obtained similar products.

8. *Melting point of Silver and its alloys with Gold.*—Mr Prinsep of Benares, in a very able paper on the measurement of high temperatures, has given the following average results, which are of great importance:—

| | |
|---|---|
| Full red heat, - - | 1200° Fahr. |
| Orange heat, - - | 1650 |
| Silver melting, - - | 1830 |
| Silver with one-tenth gold, | 1920 |
| Silver with one-tenth gold, | 2050 |

Mr Wedgewood made the melting point of silver so high as 4717° and Mr Daniell 2233°.

## III. NATURAL HISTORY.

### MINERALOGY.

9. *Specimen of Chalcedony with a large Fluid Cavity.*—A foreign dealer in minerals has sent us a drawing of a very curious specimen of common blue chalcedony, having in it a cavity half full of a " limpid fluid not unlike to water." The specimen has been ground and polished all round the cavity, so as to leave a crust of chalcedony about one-tenth of an inch thick. The external dimensions of the specimen are *two inches* long by *one inch* broad, so that the length of the cavity is at least *one inch and seven-tenths*. The price asked for this specimen is *thirty guineas*. If the fluid is water, it is not worth the tenth part of that sum; but if it is, which is not probable, one of the new fluids discovered in topaz, the specimen would be invaluable.

10. *Analysis of Radiolite.* By Professor HUNEFELD.

| | | |
|---|---|---|
| Silica, - - | 41.88 | |
| Alumina, - - | 23.79 | |
| Soda, - - | 14.07 | |
| Potash, - - | 1.01 | |
| Water, - - | 10.00 | |
| Oxide of iron, - - | 0.91 | |
| Carbonate of lime, - | 2.50 | |
| Matrix, - - | 5.50 | |
| | | 99.66 |

11. *Analysis of Iron Sinter from Freiberg.* By M. K. KERSTEN.

| | | |
|---|---|---|
| Arsenic acid, - - | 30.25 | |
| Oxide of iron, - - | 40.45 | |
| Water, - - | 28.50 | |
| | | 99.20 |

12. *Analysis of Datholite from the Harz.* By Dr DU MENIL.

| | | |
|---|---|---|
| Lime, - - | 35.59 | |
| Silica, - - | 38.51 | |
| Boracic acid, - - | 21.34 | |
| Water, - - | 4.60 | |
| | | 100.04 |

13. ***Analysis of Marmolite from New Jersey.*** By Mr Thomas Steel, a Pupil of Dr Thomson's.

| | | |
|---|---|---|
| Silica, - - | 41.256 | |
| Magnesia, - - | 41.720 | |
| Alumina, - - | 1.000 | |
| Peroxide of iron, - | 0.400 | |
| Water, - - | 17.680 | |
| | | 102.056 |

Hence Dr Thomson considers it a hydrous sesquisilicate of magnesia, or a variety of the precious serpentine or picrolite of Haussmann. Mr Nuttal, the discoverer of the mineral, found no alumina, and made the silica and the magnesia 36 and 46.

14. ***Analysis of Bismuth blende of Breithaupt.*** By Professor Hunefeld.

| | | |
|---|---|---|
| Carbonate of bismuth, - | 58.8 | |
| Arsenic acid, - - | 2.2 | |
| Silica, - - - | 23.8 | |
| Arseniate of cobalt, copper and iron, | 5.9 | |
| Matrix, - - - | 9.1 | |
| | | 99.8 |

15. ***Analysis of Leelite.*** By Mr R. Mitchell, a Pupil of Dr Thomson's.

| | Mr Mitchell. | | Dr Clark. | |
|---|---|---|---|---|
| Silica, - | 81.91 | | 75.0 | |
| Alumina, | 6.55 | | 22.0 | |
| Protoxide of iron, | 6.42 | | —— | |
| Potash, - | 8.88 | | —— | |
| Manganese, | —— | | 2.5 | |
| Water, - | —— | | 0.5 | |
| | | 103.76 | | 100 |

Hence it consists of 2 atoms octosilicate of alumina, 1 atom octosilicate of iron, and 1 atom octosilicate of potash.

GEOLOGY.

16. *Conclusion of the General Summary of the Geology of India.* By James Calder, Esq. From p. 184 of this volume.—"At Bancora," says Mr Calder," the calcareous concretion called *kunkur* begins to cover the surface of the granite and mica schists. Thence we pass on to the great coal field that occupies both sides of the river Dummoda. The boundaries of this formation have not yet been accurately ascertained; to the southward we trace its associating rocks (sandstone and shales) to within a few miles of Rogonauthpore, reposing on granite. About forty miles north by east from that place, we come to the first colliery ever opened in India. The late Mr Jones, an enterprizing and laborious engineer, had the merit of commencing these works in 1815, at a place called Rany Gunge, on the left bank of the Dummoda. It is described as the N. W. coal district of Bengal. Mr Jones observed the line of bearing for sixty-five miles in one direction, its breadth towards Bancora (on the S. W. side) being not more than eleven or twelve miles from the river; and he conjectures that the same coal formation, crossing the valley of the Ganges near Cutwa, unites with that of Sylhet and Cachar, which he denominates the N. E. coal district, and from which abundant specimens of coal have been produced.

An accurate survey of these extensive and valuable deposits seems to be called for, by obvious considerations of the most important public advantage.

" The principal rocks that compose this formation are varieties of sandstone, clay slates, and shales, with occasional dikes and veins of trap and green-stone ; the shale immediately covering the coal abounds with vegetable impressions, and some animal organic remains ; amongst these Dr Voysey distinguished a *phytolithus*, a *calamite, lycopodium*, and one specimen of a gigantic species of *paletta*. The shale passes into clay-slate, above which succeeds a soft, but gritty, micaceous yellowish-grey sandstone, here and there becoming indurated and slaty. This forms the surface rock all over the coal district, rising into low round-topped hills and undulated grounds. On the coal pits, (three in number), which have yet been sunk to a depth of only eighty-eight feet, seven seams of coal have been met with, one of which exceeds nine feet in thickness ; the quality of the coal has proved excellent, resembling the Sunderland coal, but leaving a larger proportion of cinders and ashes.

" Proceeding northward and westward from Bancora and the Dummoda river, the road to Benares passes over granitic rocks, of which the ranges of hills on the left, and the whole country as far as the Soane, and round Skeergatty and Gya, is probably composed. On approaching the Soane river, crossing the hills behind Sasseram, sandstone begins to appear, and continues to be the surface rock, with probably only one considerable interval all the way to Agra, forming, as before noticed, the southern barrier of the valley of the Ganges and Jumna. That interval occurs in the low lands of Bundlecund, where the remarkable isolated hills, forming ridges running S. W. and N. E., are all granitic, the high lands being covered with sandy stones. This brings us back to the rocky plains of Hindoostan, and to the last of the three principal mountain ranges first alluded to ; viz. the Vindya Zone, which,crossing the continent from east to west, may be said to unite the northern extremities of the two great ranges already described, which terminate in nearly the same parallel of latitude, forming, as it were, the base of the triangle that elevates the table-land of the peninsula. The Vindya belt, yielding little in classical character to the Himalaya, intersects the heart of the country, and is distinctly traceable, even in our very imperfect maps, running south 75° west, from the point called the Ramgurh hills towards Guzerat. This great zone has numerous divisions, and a multitude of names, almost every district giving a change of denomination ; but to the eye of a geologist, who considers things on an extended scale, there is a parallelism in the disjoined parts, and a general connection and dependence on the central range. The substrata prove this fact, for in every case they preserve a parallelism to it. The great surface formations of Central India and the Deccan are granite, sandstone, and the overlying rocks, the latter exceeding in their extent those of any other country. The basaltic trap formation extends northward all over Malwa and Saugor, Sohagpore, and Omercantoe ; thence, proceeding southward by Nagpore, it sweeps the western confines of Hydrabad, nearly to the 15th parallel of latitude, and, bending to N. W., connects with the sea near Fort Victoria, as already noticed, composing the shores of the Concan northward, all the way to the mouth of the Nerbudda, covering an area of at least 200,000 square miles. It overlies sandstone in the district of Sagur, and hence it may be inferred, that a portion of it, at least, is posterior to sandstone. It possesses the common property of trap rocks in general, viz. that of changing the nature of every other rock which comes in contact with it; and in the district of Sagur it is always associated with an earthy lime-stone, which seems to have undergone calcination, exhibiting strongly the marks of the agency of heat. According to Capt. Franklin, the sandstone deposits are so very regular, both in their disposition and geological character, that they cannot be mistaken; their general parallelism to the horizon, and their saliferous nature, appear to him to identify them with the new red sandstone of England; whilst the red marle and its superincumbent variegated or mottled variety (called by Werner *bunter-sand-stein*), together with the deposits of lias limestone, place the matter beyond all doubt. In using the term 'new red sandstone,' however, it must be understood, as it is in England, to comprise all that series of beds which intervenes between the *lias* and *magnesian* limestones; admitting which, he concludes with confidence, that the waterfalls of the Bundachel hills of Bundlecund, which are the lowest steps of the Vindya range, will afford a series of formation corresponding perfectly with those of England, where the lias formation has been thoroughly studied, from its connection with the coal measures.

" On the western side of India it is, as we have seen, covered by overlying rocks, as at Sagur; it appears, however, flanking the large primitive branch, which runs to Odeypore, on the side of Guzerat, and to the north it sweeps into the desert to an unknown extent. The paper in the *London Geological Transactions*, proves this fact, even if we had not the more substantial evidence of rock-salt, which is there produced in abundance.

" The next of the great surface rocks of Central India is large-grained granite, frequently passing into gneiss, generally composed of quartz, flesh-coloured felspar, a little brown or black mica, and hornblende. It varies, however, in appearance, and also in the proportion of its constituents.

" With regard to the rocks of more recent formation than sandstone, India is peculiarly barren; but this circumstance, above all others, renders its geology interesting, if it be in reality so. Whence, says Mr Calder, does such a remarkable distinction proceed? The reply may comprehend a solution of the most important phenomena of the science.

" The lias formation is, as yet, known only from Capt. Franklin's researches. He has found it in Bundlecund *in situ*, reposing on red marle, or new red sandstone, and its geological character is, in all respects, so distinct that it cannot be mistaken. He thinks he has identified it by its characteristic organic fossil,—the gryphite,—by stems of fern and fossil wood; and, moreover, the lime made from it possesses the peculiar property of the species, and its finer varieties have been found to answer for lithography. He entertains no doubt of the existence of this formation, nor of its proving two main points: first, that the sandstones on which it reposes is the red marle, or new red stone of the English school; and second, that, with the exception perhaps of trap, and the concretionary formations, it is the most recent hitherto discovered in India; for Capt. Franklin has subsequently traversed the range at the foot of which it extends, and has found no traces of an oolitic formation, and thinks it obvious, that, if such a formation does exist in India, it ought to be found there.

" Common kunkur, on analysis, is found to contain the elements of oolite and chalk. May not this concretionary formation, therefore, which seems peculiar to India, be the remains of what, under different circumstances, might have become (as in England) regular oolitic strata? Capt. Franklin observes, that these irregular beds of kunkur, which are found following every water-course, and forming its banks, have all the appearance of having been deposited under circumstances peculiarly unfavourable to regularity; and it may be asked to what agency, but that of running and turbulent water, can such appearance be satisfactorily ascribed?

" With regard to organic remains (the most interesting of all the branches of geological science), it is to be feared that India is not likely to prove a productive field. The coal strata, when public spirit and enterprize shall excavate them, will probably afford other varieties of vegetables and fishes, besides those already mentioned; and the lias limestone may contain specimens of the sauri tribe; but hitherto, the most striking feature in Indian geology is the almost total absence of organic remains in the stratified rocks, and in the diluvial soil.

" Silicified wood has been found in the diluvium of Calcutta and Jubbulpore; but bones of animals have never yet, we believe, been discovered, either in diluvium or in stratified rocks; in this branch, however, the extensive deposits of fossil bones recently discovered in Ava, apparently antediluvian, and, perhaps, the yet unexplored caverns in the limestone strata of Sylhet, Cachar, and Assam, promise a fruitful field for future researches.

" Mr Calder concludes his observations by introducing a view of the system of Indian geology adopted by the late Dr Voysey, as communicated in some of his last letters to his lamented friend Dr Abel; and, as they contain almost the only record he has left us of the general conclusions to which his philosophic mind came, and it is desirable to preserve every ray of light from so valuable a source, to guide our future research, the following extracts are transcribed verbatim from his letters.

" On the 1st of August 1823 he writes as follows:—' It may appear rather presumptuous in me to attempt a sketch of Indian geology after so short a residence, particularly when you recollect that Smith's map of English geology took him twenty years to complete. There is, however, this remarkable difference between the two countries, that in India, instead of twenty different formations, as in England, there are only four, viz. the granitic, the sandstone, the clay-slate, the trap, the diluvial. All of these have subordinate rocks: but they are never found in any of the other formations, and they all occupy a vast extent of surface.'

" In a subsequent letter, of the 8th September 1823, he gives the following synopsis of Indian geology, between the parallels of 27° and 28° north latitude, viz.: ' The geology of India may be divided into four formations each of which possessing characteristics in common, which strongly mark their contemporaniety.

"'1. The granitic rocks include—*granite,* to which is subordinate cubic quartz-rock, greenstone, in veins and beds; *gneiss,* to which is subordinate hornblende slate, crystalline limestone, crystalline dolomite, mica-slate chlorite, talc-slate, and quartz-rock.

"'2. The schistose rocks include *sandstone,* crystalline, conglomerate and cemented, which passes into *clay-slate,* calcareous clay-slate, and calcareous-slate, to which are subordinate, *flinty slate, diamond breccia,* and *coal measures.*

"'3. The basaltic, or overlying, and intruding rocks, include *basalt, wacken, amygdaloid, iron-clay* or *lacterite,* which is sometimes directly superimposed on *granite* and *gneiss.*

"'4. The diluvian lands or plains, black soil from the debris of trap rocks. Diluvium of the Doab, and plains of the Ganges, including the beds of calcareous conglomerate, or kunkur.'

"He then proceeds.—'I am convinced that very few additions will be made to my synopsis. There is nothing in India resembling the oolite, the chalk, or the London clay. Up to the present period, I am inclined to think that both the granite and gneiss of India are contemporaneous, as they are perpetually passing into each other, and have the same subordinate rocks; I think it probable they owe their difference of structure to a different mode of consolidation. At present, also, I am disposed to think that the stratified rocks are the oldest in point of time; but I will not anticipate: the antique history of India and geology are intimately connected in the history of the trap rocks, as exemplified in the tradition of towns having been overwhelmed by showers of black mud. Lately reading an account of Sclotthiem's discovery of human bones, he says that they were always calcined, and deprived of their animal gluten. Does he mean to say that they had lost their carbonic acid? Do you think that if India was inhabited before the deluge, there would not have been some remains of animals in its vast and numerous diluvial plains? It has been a favourite speculation with some philosophers that the aborigines of India, the Goands (who differ most remarkably in their manners and customs from the Hindoos,) escaped from the waters of the deluge on the high mountains in the interior. There appears to me to be a great resemblance in the animal and vegetable productions all over India. I do not think that I have seen any thing which you have not got in the vicinity of Calcutta.'

"In another letter, dated 22d February 1824, he says:—'I am making a barometrical section and geological sketch of the country as I proceed, and shall have, by the time I reach Calcutta, made a great addition to the geological map of India. I have been struck, during my travels in India, by the great sameness of the productions, that is to say, of the same soil. If I were told such is the soil of A, I think I could tell exactly the mode of cultivation, the grain or produce, the fauna and the sylva. This is, no doubt, owing to the fewness of the formations and their great extent. Ever since I left Sumbhulpoor I have been travelling on gneiss, which passes into granite with the usual trap veins of that formation in India; also into mica-schist, containing beds and veins of hornblende-rock and hornblende-schist and quartz rock; the mica-schist passes into chlorite-schist."
—*Cal. Gov. Gaz.*

17. *M. Raspail's Discovery respecting Belemnites.*—M. Raspail has lately announced to the Institute, that, after a careful study of 250 Belemnites collected in the mountains of Provence, he has discovered that Belemnites are not the shells of animals, as geologists generally think, but that they *are cutaneous appendages belonging* to marine animals, allied to the *Echinodermata,* but which are now extinct.

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## Art. XXX.—LIST OF PATENTS GRANTED IN SCOTLAND SINCE DECEMBER 6, 1828.

33. December 6. For an Improvement in the Manufacture of Buttons and in the Machinery or Apparatus for Manufacturing the same. To Thomas Tyndall, county of Warwick.

34. December 12. For an Improvement in the making of Alum. To William Strachan, county of Denbigh.

35. December 24. For certain Improvements in Distillation. To Robert Stein, county of Middlesex.

36. December 24. For a Method or principle or an apparatus for Raising Water or other Fluids. To Anton Bernhard, county of Middlesex.

1. 1829. January 19. For an Improvement in the Construction of Ships' cable and hawser chains. To John Hawks, county of Middlesex.

2. January 26. For an Improvement or Improvements on Bits. To Valentine Llanos, county of Middlesex.

3. February 26. For certain Improvements in the construction of Steam Engines and Steam Generators or Boilers. To Samuel Clegg, county of Lancaster.

4. March 5. For certain Improvements in Machinery to be used in Navigation, applicable to the Propelling of Ships and other Floating Bodies, &c. To Charles Harsleben, county of Middlesex.

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## Art. XXXI.—CELESTIAL PHENOMENA,

*From April 1st, to July 1st, 1829. Adapted to the Meridian of Greenwich, Apparent Time, excepting the Eclipses of Jupiter's Satellites which are given in Mean Time.*

N. B.—The day begins at noon, and the conjunctions of the Moon and Stars are given in Right scension.

APRIL.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 2 | | | ☿ ☌ ☉ ♒ |
| 3 | | | | The sun will be eclipsed invisible at Greenwich. The conjunction is at 10h 21¼′ in long. $0^s$ 13° 53¾′. ☽'s lat. 35¼′ S. The Sun will be centrally eclipsed on the meridian at $9^h$ 56½′ in W. Long. 149° 6⅛′, and S. Lat. 32° 15′. |
| 3 | 10 | 21 | | ● New Moon. |
| 7 | 4 | 50 | 49 | ☽ ☌ Aldeb. ☽ 54′ N. |
| 8 | 13 | 17 | 52 | Em. III. Sat. ♃ |
| 8 | 14 | 12 | 20 | Im. II. Sat. ♃ |
| 9 | 13 | 6 | 43 | Im. I. Sat. ♃ |
| 9 | 16 | | | ♂ ☌ A ♉ |
| 10 | 14 | 7 | | ☽ First Quarter. |
| 12 | 6 | 11 | 58 | ☽ ☌ 2 κ ♋ ☽ 43′ N. |
| 13 | 13 | 59 | 43 | ☽ ☌ π ♌ ☽ 30′ N. |
| 15 | 14 | 54 | | Im. III. Sat. ♃ |
| 15 | 20 | | | ♀ ☌ ζ ♓ |
| 16 | 15 | 0 | 25 | Im. I. Sat. ♃ |
| 16 | 23 | | | ♂ ☌ 2 κ ♉ |
| 17 | 13 | 45 | | ♄ □ ☉ |

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 18 | 18 | 22 | | ○ Full Moon. |
| 19 | 21 | 7 | | ☉ enters ♉ |
| 22 | 18 | | | ♀ ☌ • ♓ |
| 26 | 2 | 55 | | ☾ Last Quarter. |
| 26 | 8 | 30 | | ♅ □ ☉ |
| 27 | 1 | | | ☿ ☌ • ♓ |

MAY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 15 | 8 | 34 | ☽ ☌ • ♓ ☽ 45′ S. |
| 2 | 13 | 16 | 39 | Im. I. Sat. ♃ |
| 2 | 19 | 57 | | ● New Moon. |
| 3 | 11 | 8 | 23 | Im. II. Sat. ♃ |
| 4 | 0 | | | ☿ ☌ ♀ |
| 4 | 9 | 20 | 52 | ☽ ☌ 1 δ ♉ ☽ 24′ S. |
| 4 | 9 | 50 | 21 | ☽ ☌ 2 δ ♉ ☽ 16′ S. |
| 4 | 14 | 51 | 17 | ☽ ☌ Aldeb. ☽ 58′ N. |
| 7 | 13 | 45 | | ☿ Sup. ☌ ☉ |
| 9 | 13 | 59 | 32 | ☽ ☌ 2 α ♋ ☽ 51′ N. |
| 9 | 15 | 10 | 40 | Im. I. Sat. ♃ |
| 10 | 7 | 36 | | ☽ First Quarter. |
| 10 | 11 | 39 | 57 | ☽ ☌ • ♌ ☽ 7′ N. |
| 10 | 13 | 41 | 49 | Im. II. Sat. ♃ |
| 11 | | | | ♅ Stationary. |
| 14 | 0 | | | ☿ ☌ A ♉ |
| 16 | 0 | | | ♂ ☌ 132 ♉ |
| 16 | 9 | | | ☿ 2 α ♉ |
| 18 | 7 | 31 | 23 | ☽ ☌ θ ♎ ☽ 30′ N. |
| 18 | 7 | 48 | | ○ Full Moon. |
| 18 | 11 | 33 | 19 | Im. I. Sat. ♃ |
| 20 | 8 | 15 | | ♀ Sup. ☌ ☉ |
| 20 | 21 | 31 | | ☉ enters ♊ |
| 21 | 10 | 45 | 6 | Im. III. Sat. ♃ |
| 25 | 8 | 19 | | ☾ Last Quarter. |
| 25 | 13 | 27 | 35 | Im. I. Sat. ♃ |
| 26 | 14 | | | ☿ ☌ 132 ♉ |
| 28 | 9 | 2 | 38 | ☽ ☌ ζ ♓ ☽ 52′ S. |
| 28 | 14 | 43 | 16 | Im. III. Sat. ♃ |

JUNE.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 5 | 49 | | ● New Moon. |
| 3 | 12 | 0 | 4 | Em. I. Sat. ♃ |
| 4 | 8 | | | ♂ ☌ • ♊ |
| 4 | 12 | | | ☿ ☌ • ♊ |
| 4 | 13 | 6 | 42 | Em. II. Sat. ♃ |
| 4 | 17 | | | ☿ ☌ ♂ |
| 6 | 14 | 52 | 43 | ☽ ☌ ξ ♌ ☽ 27′ S. |
| 7 | 5 | 22 | 52 | ☽ ☌ π ♌ ☽ 51′ N. |
| 9 | 1 | 23 | | ☽ First Quarter. |
| 10 | 2 | | | ♀ ☌ 132 ♉ |
| 10 | 13 | 54 | 37 | Em. I. Sat. ♃ |
| 11 | 9 | 21 | 29 | ☽ ☌ θ ♍ ☽ 47′ S. |
| 13 | 20 | | | ☿ ☌ δ ♊ |
| 14 | 7 | 46 | 38 | ☽ ☌ γ ♎ ☽ 39′ S. |
| 15 | 8 | 18 | 31 | ☽ ☌ φ Oph. ☽ 47′ S. |
| 16 | 18 | 15 | | ○ Full Moon. |
| 17 | 5 | | | ♂ ☌ δ ♊ |
| 19 | 7 | 10 | 13 | ☽ ☌ β ♑ ☽ 11′ S. |
| 19 | 10 | 17 | 56 | Em. I. Sat. ♃ |
| 20 | 9 | | | ♀ ☌ • ♊ |
| 21 | 6 | 8 | | ☉ enters ♋ |
| 21 | 8 | 3 | 52 | ☽ ☌ θ ♒ ☽ 1′ S. |
| 22 | | | | ☿ Stationary. |
| 23 | 12 | 57 | | ☾ Last Quarter. |
| 24 | 14 | 28 | 6 | ☽ ☌ ζ ♓ ☽ 65′ S. |
| 26 | 12 | 12 | 43 | Em. I. Sat. ♃ |
| 27 | 6 | | | ♀ ☌ δ ♊ |
| 28 | 7 | 9 | 10 | ☽ ☌ Aldeb. ☽ 57′ N. |
| 29 | 10 | 8 | 12 | Em. II Sat. ♃ |
| 30 | 16 | 45 | | ● New Moon. |

*Times of the Planets passing the Meridian.*

APRIL.

| | Mercury. | | Venus | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | h. | ′ | h | ′ | h | ′ | h | ′ | h | ′ | h | ′ |
| 1 | 22 | 24 | 23 | 16 | 2 | 48 | 10 | 12 | 7 | 15 | 19 | 48 |
| 7 | 22 | 32 | 23 | 21 | 2 | 43 | 15 | 49 | 6 | 53 | 19 | 27 |
| 13 | 22 | 43 | 23 | 26 | 2 | 38 | 15 | 27 | 6 | 32 | 19 | 6 |
| 19 | 22 | 57 | 23 | 32 | 2 | 33 | 15 | 3 | 6 | 11 | 18 | 43 |
| 25 | 23 | 14 | 23 | 37 | 2 | 27 | 14 | 39 | 5 | 49 | 18 | 22 |

MAY.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 | 36 | 23 | 42 | 2 | 22 | 14 | 14 | 5 | 28 | 17 | 59 |
| 7 | 24 | 2 | 23 | 48 | 2 | 16 | 13 | 49 | 5 | 7 | 17 | 36 |
| 13 | 0 | 26 | 23 | 54 | 2 | 10 | 13 | 23 | 4 | 45 | 17 | 13 |
| 19 | 0 | 55 | 0 | 0 | 2 | 3 | 12 | 56 | 4 | 23 | 16 | 49 |
| 25 | 1 | 19 | 0 | 5 | 1 | 56 | 12 | 29 | 4 | 2 | 16 | 26 |

JUNE.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 38 | 0 | 13 | 1 | 48 | 11 | 57 | 3 | 36 | 15 | 56 |
| 7 | 1 | 45 | 0 | 21 | 1 | 40 | 11 | 29 | 3 | 14 | 15 | 37 |
| 13 | 1 | 42 | 0 | 28 | 1 | 32 | 11 | 1 | 2 | 52 | 15 | 8 |
| 19 | 1 | 28 | 0 | 35 | 1 | 24 | 10 | 33 | 2 | 30 | 14 | 37 |
| 25 | 1 | 2 | 0 | 45 | 1 | 16 | 10 | 6 | 2 | 8 | 14 | 18 |

*Declination of the Planets.*

APRIL.

| D. | Mercury. ° ′ | Venus. ° ′ | Mars. ° ′ | Jupiter. ° ′ | Saturn. ° ′ | Georgian. ° ′ |
|---|---|---|---|---|---|---|
| 1 | 8 6 S. | 1 55 S. | 19 49N. | 21 51 S. | 21 12N. | 19 25 S. |
| 7 | 5 28 | 1 3N. | 20 47 | 21 50 | 21 11 | 19 22 |
| 13 | 2 4 S. | 4 1 | 21 39 | 21 49 | 21 10 | 19 20 |
| 19 | 2 0N. | 6 56 | 22 24 | 21 47 | 21 8 | 19 18 |
| 25 | 6 37 | 9 45 | 23 3 | 21 45 | 21 5 | 19 17 |
| MAY. | | | | | | |
| 1 | 11 35N. | 12 26N. | 23 35N. | 21 41 S. | 21 1N. | 19 17 |
| 7 | 16 33 | 14 57 | 23 59 | 21 37 | 20 57 | 19 17 |
| 13 | 20 52 | 17 15 | 24 17 | 21 33 | 20 52 | 19 18 |
| 19 | 23 55 | 19 16 | 24 27 | 21 28 | 20 46 | 19 18 |
| 25 | 25 25 | 20 59 | 24 30 | 21 22 | 20 40 | 19 19 |
| JUNE. | | | | | | |
| 1 | 25 29N. | 22 33N. | 24 25N. | 21 15 S. | 20 32N. | 19 20 S. |
| 7 | 24 30 | 23 29 | 24 13 | 21 9 | 20 24 | 19 22 |
| 13 | 22 57 | 24 0 | 23 54 | 21 4 | 20 16 | 19 24 |
| 19 | 21 13 | 24 5 | 23 28 | 20 58 | 20 7 | 19 27 |
| 25 | 19 37 | 23 45 | 22 56 | 20 53 | 19 57 | 19 29 |

The preceding numbers will enable any person to find the positions of the planets, to lay them down upon a celestial globe, and to determine their times of rising and setting.

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Art. XXXII.—*Summary of Meteorological Observations made at Kendal in December* 1828, *and January and February* 1829. By Mr Samuel Marshall. Communicated by the Author.

*State of the Barometer, Thermometer, &c. in Kendal for December* 1828.

| | Inches. |
|---|---|
| **Barometer.** | |
| Maximum on the 14th, - - - | 30.27 |
| Minimum on the 7th, - - - - | 28.99 |
| Mean height, - - - - - | 29.64 |
| **Thermometer.** | |
| Maximum on the 13th and 14th, - - - | 52.5° |
| Minimum on the 9th, - - - - | 31° |
| Mean height, - - - - - - | 44.20° |

Quantity of rain, 9.226 inches.
Number of rainy days, 25.
Prevalent wind, west.

In this month, as in the last, there have been but *two* nights of frost, the thermometer never having been, but in those instances, at or below the freezing point. It is rarely found that the mean temperature of December is upwards of 44°. A greater quantity of rain has fallen in this month than in any preceding one in the year, and yet, though the weather has been with little variation rainy, the barometer has varied less than is often the case when the weather is more variable. The wind has been in the west for 17 days, and rain has generally accompanied it. For the rest of the month winds have prevailed from the S.W. and S. excepting one day, but we have had occasional currents from other points of the compass, though of short duration.

*January.*

| Barometer. | Inches. |
|---|---|
| Maximum on the 7th, - - - | 30.06 |
| Minimum on the 26th, - - - | 28.83 |
| Mean height, - - | 29.68 |

| Thermometer. | |
|---|---|
| Maximum on the 1st, - - - - | 47° |
| Minimum on the 20th, - - - - | 18.5° |
| Mean height, - - - - - | 32.18° |

Quantity of rain, 0.747 inch.
Number of rainy days, 3.
Prevalent wind, north.

This has been a remarkably fine winter month. No rain fell from the 4th to the 28th, and though during that period we had some snow, this was confined chiefly to the 23d, 24th, and 25th. On the 26th was a thaw, and on the 27th, .090 inch of water was taken by the guage, which was the melted snow that had fallen the three preceding days. The barometer has been very variable. A corona was observed several times round the moon, but no halo. Neither has Aurora Borealis been observed during the month, (though frequent attention has been paid to the subject,) excepting on the evening of the 2d, when it was very bright. The three days on which rain was taken were the 1st, 4th and 28th. Since the 2d, the nights have mostly been frosty, and sometimes the greater part of the days. There has not been registered in Kendal, for the last seven years so small quantity of rain in January.

*February.*

| Barometer. | Inches. |
|---|---|
| Maximum on the 2d, - - - | 30.33 |
| Minimum on the 21st - - - | 29.10 |
| Mean height. - - - | 29.88 |

| Thermometer. | |
|---|---|
| Maximum on the 13th and 16th, - - | 50° |
| Minimum on the 3d, - - - - - | 23° |
| Mean height, - - - - - | 38.08° |

Quantity of rain, 1.234 inch
Number of rainy days, 11.
Prevalent wind, west.

There has been much less frost in this month than in the last, and yet there has been but little rain, though the weather has been mostly cloudy. In January and February last year there were 32 rainy days, and 10.817 inches of rain were taken, but in those months in the present year there have been but 14 rainy days, and 1.981 inch of rain. The barometer has been mostly high, and the mean for the month is greater than that of any month in the last year. Both this and the last month have been colder than the corresponding ones in 1828. The wind has been prevalent in the west for 15 days.

## ART. XXXIII.—REGISTER OF THE BAROMETER, THERMOMETER, AND RAIN-GAGE, *kept at Canaan Cottage.* By ALEX. ADIE, Esq. F.R.S. Edin.

THE Observations contained in the following Register were made at Canaan Cottage, the residence of Mr Adie, by means of very nice instruments, constructed by himself. Canaan Cottage is situated about 1½ mile to the south of Edinburgh Castle, about 3 miles from the sea at Leith, and about ¼ of a mile N. of the west end of Blackford Hill. The ridge of Braid Hills is about 1 mile to the south, and the Pentland Hills about 4 miles to the west of south. The height of the instruments is 300 feet above high water-mark at Leith. The morning and evening observations were made about 10 A.M. and 10 P.M.

### DECEMBER 1828.

| D. of Week. | Day of Month. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| M | 1 | 40 | 36 | 38 | 34 | 42 | 38 | 30.00 | 30.05 | |
| T. | 2 | 40 | 49 | 44.5 | 35 | 49 | 42 | 29.85 | 29.37 | |
| W. | 3 | 48 | 47 | 47.5 | 41 | 50 | 45.5 | 29.53 | 29.55 | .12 |
| T. | 4 | 47 | 50 | 48.5 | 44 | 50 | 47 | 29.78 | 29.87 | |
| F. | 5 | 49 | 47 | 48 | 41 | 49 | 45 | 29.75 | 29.77 | |
| S. | 6 | 50 | 49 | 49.5 | 46 | 51 | 48.5 | 29.40 | 29.10 | |
| S. | 7 | 50 | 37 | 43.5 | 39 | 51 | 45 | 28.95 | 29.17 | .10 |
| M. | 8 | 43 | 37 | 40 | 36 | 42 | 39 | 28.76 | 28.93 | |
| T. | 9 | 37 | 40 | 38.5 | 33 | 40 | 36.5 | 29.21 | 29.43 | .29 |
| W. | 10 | 40 | 50 | 45 | 37 | 50 | 43.5 | 29.62 | 29.23 | |
| T. | 11 | 45 | 48 | 46.5 | 40 | 49 | 44.5 | 29.55 | 29.72 | |
| F. | 12 | 52 | 57 | 54.5 | 40 | 57 | 48.5 | 29.72 | 29.72 | |
| S. | 13 | 47 | 45 | 46 | 47 | 50 | 48.5 | 30.05 | 30.25 | |
| S. | 14 | 47 | 45 | 46 | 43 | 49 | 46 | 30.20 | 30.17 | |
| M. | 15 | 46 | 44 | 45 | 40 | 47 | 43.5 | 29.95 | 29.85 | .10 |
| T. | 16 | 50 | 50 | 50 | 37 | 50 | 43.5 | 29.45 | 29.12 | |
| W. | 17 | 45 | 45 | 45 | 40 | 49 | 44.5 | 29.15 | 29.05 | |
| T. | 18 | 42 | 39 | 40.5 | 40 | 49 | 44.5 | 28.95 | 28.89 | .30 |
| F. | 19 | 44 | 43 | 43.5 | 38 | 44 | 41 | 29.16 | 29.37 | .19 |
| S. | 20 | 52 | 53 | 52.5 | 42 | 54 | 48 | 29.50 | 29.33 | .10 |
| S. | 21 | 48 | 44 | 46 | 45 | 50 | 47.5 | 29.45 | 29.69 | .20 |
| M. | 22 | 44 | 45 | 44.5 | 42 | 45 | 43.5 | 29.52 | 29.53 | .30 |
| T. | 23 | 42 | 42 | 42 | 35 | 42 | 38.5 | 29.50 | 29.42 | |
| W. | 24 | 45 | 44 | 44·5 | 41 | 46 | 43·5 | 29.15 | 29.07 | |
| T. | 25 | 40 | 38 | 39 | 38 | 44 | 41 | 29.06 | 29.08 | |
| F. | 26 | 40 | 40 | 40 | 32 | 42 | 37 | 29.14 | 29.20 | |
| S. | 27 | 40 | 37 | 38.5 | 37 | 43 | 40 | 29.36 | 29.46 | .20 |
| S. | 28 | 40 | 39 | 39.5 | 34 | 41 | 37.5 | 29.59 | 29.81 | |
| M. | 29 | 48 | 49 | 48.5 | 32 | 50 | 41 | 29.87 | 29.73 | |
| T. | 30 | 50 | 51 | 50.5 | 46 | 51 | 48.5 | 29.65 | 29.48 | .03 |
| W. | 31 | 45 | 38 | 41.5 | 37 | 49 | 43 | 29 50 | 23.38 | .25 |
| | Sum, | 1396 | 1378 | 1387 | 1212 | 1475 | 1343.5 | 914.45 | 913.79 | 2.18 |
| | Mean. | 45.03 | 44.45 | 44.74 | 39.42 | 47.26 | 43.34 | 29.498 | 29.477 | |

### JANUARY 1829.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| T. | 1 | 40 | 38 | 39 | 37 | 44 | 40.5 | 29.48 | 29.59 | |
| F. | 2 | 40 | 34 | 37 | 33 | 41 | 37 | 29.73 | 29.70 | |
| S. | 3 | 37 | 39 | 38 | 31 | 39 | 35 | 29.73 | 29.60 | |
| S. | 4 | 37 | 34 | 35.5 | 31 | 39 | 35 | 29.45 | 29.55 | .10 |
| M. | 5 | 38 | 35 | 36.5 | 31 | 40 | 35.5 | 29.81 | 29.89 | |
| T. | 6 | 35 | 33 | 34 | 29 | 40 | 34.5 | 29.95 | 29.98 | |
| W. | 7 | 33 | 32 | 32.5 | 30 | 34 | 32 | 29.95 | 29.91 | |
| T. | 8 | 33 | 32 | 32.5 | 28 | 36 | 32 | 29.83 | 29.78 | |
| F. | 9 | 33 | 36 | 34.5 | 29 | 36 | 32.5 | 29.73 | 29.53 | .18 |
| S. | 10 | 35 | 34 | 34.5 | 38 | 36 | 37 | 29.62 | 29.62 | .45 |
| S. | 11 | 34 | 35 | 34.5 | 32 | 36 | 34 | 29.71 | 29.92 | .11 |
| M. | 12 | 35 | 36 | 35.5 | 30 | 37 | 33.5 | 30.06 | 30.08 | |
| T. | 13 | 35 | 33 | 34 | 34 | 37 | 35.5 | 30.15 | 30.02 | |
| W. | 14 | 32 | 35 | 33.5 | 27 | 36 | 31.5 | 29.92 | 29.78 | |
| T. | 15 | 35 | 34 | 34.5 | 33 | 37 | 35 | 29.62 | 29.46 | |
| F. | 16 | 34 | 32 | 33 | 32 | 37 | 34.5 | 29.47 | 29.50 | |
| S. | 17 | 33 | 30 | 31.5 | 30 | 34 | 32 | 29.62 | 29.73 | |
| S. | 18 | 30 | 25 | 27.5 | 26 | 34 | 30 | 29.76 | 29.83 | |
| M. | 19 | 28 | 25 | 26.5 | 21 | 34 | 27.5 | 29.92 | 29.93 | |
| T. | 20 | 28 | 23 | 25.5 | 20 | 32 | 26 | 29.88 | 29.19 | |
| W. | 21 | 27 | 24 | 25.5 | 18 | 31 | 24.5 | 29.74 | 29.63 | |
| T. | 22 | 26 | 27 | 26.5 | 15 | 30 | 22.5 | 29.61 | 29.57 | |
| F. | 23 | 31 | 19 | 25 | 24 | 32 | 28 | 29.55 | 29.62 | |
| S. | 24 | 27 | 24 | 25.5 | 16 | 31 | 23.5 | 29·59 | 29.53 | .07 |
| S. | 25 | 28 | 21 | 21.5 | 15 | 33 | 24 | 29.43 | 29.18 | |
| M. | 26 | 31 | 36 | 33.5 | 17 | 36 | 26.5 | 28.85 | 28.73 | .40 |
| T. | 27 | 37 | 38 | 37.5 | 24 | 39 | 31.5 | 28.89 | 29.07 | .57 |
| W. | 28 | 36 | 37 | 36.5 | 34 | 37 | 35.5 | 29.32 | 29.39 | .48 |
| T. | 29 | 37 | 36 | 36.5 | 33 | 39 | 36 | 29.42 | 29.42 | .11 |
| F. | 30 | 37 | 37 | 37 | 33 | 39 | 36 | 29.53 | 29.84 | .02 |
| S. | 31 | 38 | 34 | 36 | 33 | 39 | 36 | 30.08 | 30.17 | |
| | | 1040 | 988 | 1014 | 864 | 1125 | 994.5 | 919.40 | 918.74 | 2.39 |
| | | 33.55 | 31.87 | 32.71 | 27.87 | 36.29 | 32.08 | 29·658 | 29.637 | |

### FEBRUARY 1829.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| S. | 1 | 34 | 31 | 32.5 | 29 | 36 | 32.5 | 30.20 | 30.19 | |
| M. | 2 | 35 | 35 | 35 | 30 | 38 | 34 | 30.22 | 30.22 | |
| T. | 3 | 38 | 42 | 40 | 33 | 42 | 37.5 | 30.18 | 30.15 | |
| W. | 4 | 45 | 45 | 45 | 40 | 46 | 43 | 30.07 | 29.92 | .05 |
| T. | 5 | 46 | 43 | 44.5 | 42 | 46 | 44 | 30.07 | 30.04 | |
| F. | 6 | 47 | 44 | 45.5 | 40 | 50 | 45 | 30.03 | 29.93 | |
| S. | 7 | 47 | 40 | 43.5 | 41 | 52 | 46.5 | 29.90 | 30.05 | |
| S. | 8 | 44 | 37 | 40.5 | 35 | 45 | 40 | 30·20 | 30.17 | |
| M. | 9 | 45 | 41 | 43 | 31 | 45 | 38 | 30.15 | 30.12 | |
| T. | 10 | 45 | 45 | 45 | 35 | 47 | 41 | 30.10 | 30.07 | .18 |
| W. | 11 | 46 | 48 | 47 | 42 | 50 | 46 | 30.05 | 30.00 | |
| T. | 12 | 50 | 40 | 45 | 44 | 51 | 47.5 | 30.00 | 29.97 | |
| F. | 13 | 44 | 42 | 43 | 36 | 49 | 42.5 | 29.90 | 29.80 | |
| S. | 14 | 45 | 46 | 45.5 | 39 | 49 | 44 | 29.72 | 29.58 | |
| S | 15 | 45 | 45 | 45 | 45 | 49 | 47 | 29.62 | 29.63 | .27 |
| M. | 16 | 35 | 36 | 35.5 | 34 | 39 | 36.5 | 29.63 | 29.53 | .49 |
| T. | 17 | 35 | 29 | 32 | 32 | 37 | 34.5 | 29.68 | 29.75 | |
| W. | 18 | 34 | 34 | 34 | 21 | 32 | 28 | 29.67 | 29.50 | |
| T. | 19 | 36 | 37 | 36.5 | 32 | 37 | 34.5 | 29.33 | 29.23 | .20 |
| F. | 20 | 42 | 41 | 41.5 | 32 | 48 | 40 | 29.23 | 29.17 | |
| S. | 21 | 41 | 40 | 40.5 | 36 | 43 | 39.5 | 29.07 | 29.10 | |
| S. | 22 | 37 | 32 | 34.5 | 35 | 41 | 38 | 29.27 | 29.33 | |
| M. | 23 | 33 | 32 | 32.5 | 23 | 39 | 31 | 29.31 | 29.25 | |
| T. | 24 | 32 | 31 | 31.5 | 26 | 38 | 32 | 29.37 | 29.58 | .16 |
| W. | 25 | 33 | 28 | 30.5 | 25 | 40 | 32.5 | 29.73 | 29.92 | |
| T. | 26 | 36 | 37 | 36.5 | 27 | 37 | 32 | 29.77 | 29.62 | .26 |
| F. | 27 | 43 | 32 | 37.5 | 32 | 46 | 39 | 29 88 | 30.01 | |
| S. | 28 | 43 | 38 | 40.5 | 31 | 48 | 39.5 | 30.00 | 29.97 | |
| | | 1136 | 1071 | 1103.5 | 951 | 1220 | 1085.5 | 834.35 | 833.78 | 1.61 |
| | | 40.57 | 38.25 | 39.41 | 33.96 | 43.57 | 38.77 | 29.798 | 29.778 | |

# INDEX TO VOL. X.

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# DESCRIPTION OF PLATES IN VOL. X.



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