# THE
# LONDON AND EDINBURGH
# PHILOSOPHICAL MAGAZINE
# AND
# JOURNAL OF SCIENCE.

---

CONDUCTED BY

SIR DAVID BREWSTER, K.H. LL.D. F.R.S. L. & E. &c.
RICHARD TAYLOR, F.S.A. L.S. G.S. Astr. S. &c.
AND
RICHARD PHILLIPS, F.R.S. L. & E. F.G.S. &c.

---

"Nec aranearum sane textus ideo melior quia ex se fila gignunt, nec noster vilior quia ex alienis libamus ut apes." Just. Lips. *Monit. Polit.* lib. i. cap. 1.

---

VOL. III.

NEW AND UNITED SERIES OF THE PHILOSOPHICAL MAGAZINE
AND JOURNAL OF SCIENCE.

JULY—DECEMBER, 1833.

---

*LONDON:*

PRINTED BY RICHARD TAYLOR, RED LION COURT, FLEET STREET,
*Printer to the University of London.*

SOLD BY LONGMAN, REES, ORME, BROWN, GREEN, AND LONGMAN; CADELL;
BALDWIN AND CRADOCK; SHERWOOD, GILBERT, AND PIPER; SIMPKIN
AND MARSHALL; AND S. HIGHLEY, LONDON:—BY ADAM
BLACK, EDINBURGH; SMITH AND SON, GLASGOW;
HODGES AND M'ARTHUR, DUBLIN;
AND G. G. BENNIS, PARIS.


ALERE FLAMMAM
B.

# TABLE OF CONTENTS.

## NUMBER XIII.—JULY.

Page

## NUMBER XV.—SEPTEMBER.

---

## NUMBER XVI.—OCTOBER.

## NUMBER XVII.—NOVEMBER.

## NUMBER XVIII.—DECEMBER.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

*JULY* 1833.

## I. *Observations on the Circumstances producing Ignition in Charcoal in Atmospheric Temperatures.* By Mr. William Hadfield*.

THE spontaneous combustion of charcoal under certain circumstances has been long observed, though it has not excited the attention which it merits; nor would it now, perhaps, have possessed much general interest, had it not been for the serious consequences which may result from its occurrence in some situations. As large quantities of charcoal are used in gunpowder manufactories and in other works, its spontaneous combustion in such places would manifestly endanger, not only much property, but a number of lives. The subject is, therefore, worthy of attention; since, if the cause could be assigned, the danger might be averted.

Engaged during 25 years in a manufactory where charcoal is produced, I have had many opportunities of observing the phænomenon; and I have been induced, by the suggestions of a number of my friends, to lay the amount of my own experience before this Society.

Though I am aware that a very interesting article on the subject was, in January last, published by Col. Aubert in the *Bulletin des Sciences Militaires*, I shall abstain from any further notice of it; since I wish to confine my present paper to the result of my own observation and experiments.

---

* Read before a Meeting of the Literary and Philosophical Society of Manchester, on November 4, 1831; and now communicated by the Author.

If 20 or 30 cwt. of charcoal, in a state of minute division, be put together in a heap and left undisturbed, spontaneous combustion generally ensues. The fact has been long known; but no investigation, with the exception of that to which I have referred, has, to my knowledge, been instituted.

Spontaneous combustion does not often take place in what the manufacturers call *round charcoal*; that is to say, in fragments of considerable size; unless when large quantities are laid together, under which circumstances it is not very unusual. In this case the phænomenon is generally ascribed by the makers to the charcoal not having been sufficiently cooled after its production. This reason is, no doubt, sometimes, but not always, correct. On the contrary, I have known charcoal, which has been freely exposed to the atmosphere for several days, enter into a state of ignition, when, though closely watched, it presented in the interval no appearance of the kind.

In one case charcoal was loaded in Manchester, and conveyed by a cart to a distance of twenty miles. No combustion appeared during the loading, nor could the carter, though he carefully examined, perceive any indication of it, when, at 11 o'clock, he left it for the night. At 5 o'clock on the following morning, however, he was called up to save his cart, which he found on fire and nearly consumed.

This charcoal had been made three days before the accident. Care had been taken that it should be sufficiently cool before it was loaded, as a similar event had previously occurred to the same parties, who ascribed it to the charcoal being too new, when, as they conceived, fire lurked in it unextinguished.

These two instances may, I should think, be accounted for in the following manner:—

When large quantities of charcoal, as in the first example, are laid together, it is evident that the lower parts must be exposed to pressure, and, by the motion of the cart, to friction from the parts above; in this way, therefore, a portion of the charcoal is pulverized, forming a compact mass at the bottom, where it enters into spontaneous combustion.

In the second instance, pressure and friction had still greater influence. The carter, while he was loading, beat down the charcoal with a large hammer, to force it into a smaller compass. Conveyed for twenty miles in a cart, the pieces would rub against each other, and the finer parts would be shaken to a compact mass; and possibly the friction might, in this case particularly, produce a degree of heat which might promote the ignition.

Before I proceed to an account of my own direct experiments, I will describe here another instance of spontaneous combustion which occurred casually. About 2000 lbs. weight of charcoal were loaded at Cornbrook, in the cart of Messrs. Williamson and Co., powder-manufacturers of Fernelee, near Buxton. The charcoal had been made several days before, and had lain freely exposed to the open air. No indications of combustion could be perceived. After being taken out of the cart at Fernelee, it was left for the night, and the next day finely pulverized as a preparation for making gunpowder. It was then thrown into a heap; and no appearance of a tendency to ignite ensued. This was on the Saturday evening; and on Sunday, the building which contained it was observed to be on fire. The fire must have commenced with the charcoal, as every other source of heat was carefully excluded, on account of the gunpowder manufactory.

These, and a number of other accidents which have arisen from the same cause, united with the opportunities which I have possessed as a manufacturer of charcoal, have led me to take particular interest in the subject.

Colonel Aubert's paper, which I have already alluded to, and an abridged translation of which appeared in Dr. Brewster's Journal for April last (1831)*, placed the subject in so striking a point of view, that I came to the determination of making, for my own satisfaction, a few experiments, which I shall proceed to describe.

*Exp.* 1.—120 pounds of charcoal, slightly pulverized, were put into a flour-barrel, and a leaden tube, of an inch and a half in diameter and 14 inches long, inserted in the middle, to hold a thermometer. The temperature of the charcoal when put into the barrel was 60°. In two days the charcoal acquired a temperature of 74°; from that time the temperature gradually diminished until, in two days more, it was reduced again to 60°,—the temperature of the surrounding atmosphere. This charcoal was rather old, having been made several weeks, and afterwards freely exposed to the open air.

*Exp.* 2.—120 pounds of fresh charcoal, pulverized as before, were put into the vessel used in the preceding experiment. The charcoal was then at 70°, and the surrounding air at 62°. In 24 hours it had acquired a temperature of 90°; in 36 hours, of 110°; and in 48 hours, of 120°: from this time the temperature fell; and in 48 hours more it was down to 70°, as at the commencement.

---

* An abstract of Col. Aubert's paper was also given in Phil. Mag. and Annals. N.S. vol. ix. p. 148.—Edit.

*Exp.* 3.—The same quantity of charcoal was taken as in the foregoing experiments: it was quite fresh, and ground into coarse powder. In 36 hours the temperature was 130°; it then gradually declined to 70°, when the experiment was given up.

From the preceding experiments I was satisfied that spontaneous combustion would not take place in so small a quantity. I therefore determined to make the experiment upon a larger scale.

*Exp.* 4.—10 cwt. of new charcoal was finely ground, and put into a hogshead, with a thermometer placed, as before, in a leaden pipe. Several holes were bored in the sides of the hogshead to admit the air. The charcoal when ground was 65°; and particular care was taken in examining the charcoal, to see that it was free from ignition. It was put into the hogshead at about 10 o'clock in the morning, at night its temperature had risen to 90°; the following morning to 150°; and in the afternoon of the second day the thermometer stood at 180°.

I was surprised to find at this time that combustion had taken place at about five or six inches from the surface, and about the same distance from the leaden pipe which contained the thermometer, though the temperature, as indicated by the thermometer, was only 180° or 190°.

It may perhaps be proper to remark, that the combustion always takes place *near* to the surface; or, if small charcoal be laid against a wall, the combustion generally begins either at the surface, or close to the wall.

On the 13th of October 1831, small charcoal was thrown into a heap, which covered about 10 feet square, was about 4 feet deep, and contained from two to three tons in weight. In three days the temperature had increased to 90°, though it was at first only 57°, being the same as that of the air. On the 19th it was 150°; and on the 20th combustion had occurred in several places. Water was thrown upon it; and the fire was, to all appearance, effectually extinguished; yet on the 21st it was again observed to be burning in different parts; and it continued to burn until it was removed and formed into smaller heaps.

The last experiment was the most satisfactory one which has ever come under my notice. The charcoal had been made for at least ten or twelve days before it was put together; and had been lying, during the interval, in small heaps freely exposed in the open air.

I am not aware that any experiment has been made to ascertain the effect of an exposure of the charcoal to pure oxygen gas. A bell-glass, of the capacity of two quarts, was filled with oxygen gas previously freed from carbonic acid by washing with lime-water. In this vessel was placed a glass dish, containing an ounce of finely pulverized charcoal. The charcoal was left to stand in the oxygen for 24 hours; and at the expiration of that time no trace of carbonic acid was to be found on passing the remaining gas through lime-water.

This experiment was three times performed in the same manner, and with precisely the same result.

I have here given a brief and simple statement of the observations and experiments which I have yet made upon this curious and interesting subject. The spontaneous combustion of charcoal is, I apprehend, now fully established; and I have endeavoured, to the best of my ability, to determine some of the circumstances under which it takes place. I have abstained from any theoretical speculations; contented, for the present, to have related the facts which experiments alone have elicited. If in future any new facts should present themselves, I shall be happy to submit them to the Society.

## II. *On the Muscular Structure and Functions of the Capsule of the Crystalline Lens and Ciliary Zone. By Mr.* THOMAS SMITH, *Surgeon, Fochabers*[*].

HAVING found by observations on the eyes of the three principal classes of animals, that the capsule of the crystalline lens, and the radiated circle of the hyaloid membrane to which it is attached, are endowed with a fibrous structure and contractile property which admirably fit them for changing the figure of the lens, by rendering it more or less spherical; and that the optical phænomena attending the accommodation of the eye to different distances, as well as certain changes which the lens itself is found to undergo, correspond in a singularly happy manner with those which ought to result from the functional action of the capsule as the organ of adjustment,—I venture, in compliance with the advice of some intelligent friends to whom my observations have been submitted, to offer an account of them for publication; for though the induction from the phænomena is not in certain respects so complete as I have been anxious to make it, yet I trust it may be found sufficiently so to vindicate me from the charge of presumption in directing into this new channel the attention of persons better qualified than I can pretend to be, to carry it to perfection.

The extreme transparency of the capsule of the lens in its sound state renders its structure difficult to be ascertained by

---

[*] Communicated by the Author.

direct ocular observation. Certain peculiarities, however, which have not been mentioned by anatomical writers, are sufficiently distinct to be seen by the help of the microscope, or even with the naked eye, in a favourable light. If the whole vitreous humour, and lens imbedded in it, are taken out of the eyeball, by cautiously separating the hyaloid membrane from its connexions with the parts around the iris, the lens in its capsule is seen surrounded by a beautiful radiated circle or zone, which has been generally but erroneously described as merely the marks left by the ciliary processes on the hyaloid membrane. Even the celebrated Cuvier speaks of it as nothing more. Dr. Knox of Edinburgh corrects this mistake. The zone around the capsule exhibits, he says, "a very complicated structure. On that part of the hyaloid membrane on which the ciliary processes rest, we find an equal number of folds or laminæ, which projecting outwards, are dove-tailed, as it were, with the ciliary processes. These membranous folds are vascular, the vessels pass in great numbers from the ciliary processes to them, and these vessels, together with the dove-tailing of the two sets of processes, form, as every anatomist ought to know, the bond of union between the choroid and hyaloid membranes, which otherwise would have no connexion with each other*." The radii, which are here termed *membranous folds*, unite together in a circular ring around and close to the capsule, and even seem to spread over the circumference of the capsule itself, giving it a notched appearance, noticed by M. Cloquet, and forming a pretty broad belt all round the capsule. To the naked eye, the radii of the zone, when washed free from the black paint which generally adheres to them, the ring in which they unite, and the belt which I have described as surrounding the capsule, have a remarkable resemblance to the muscular fibre of the haddock or of the whiting; and when they are viewed through a powerful microscope, the fibrous structure is seen in the most distinct manner *along* the ridges of the radii and *across* the ring and belt.

If we divide the eyeball of any of the larger quadrupeds into two nearly equal parts, by a section of the sclerotic coat and vitreous humour parallel to the plane of the iris, and invert the section containing the lens, that body will be seen through the remaining part of the vitreous humour surrounded by a radiated circle, consisting of the zone of the hyaloid membrane above mentioned in conjunction with the ciliary processes of the choroid coat, and forming what has been termed the ciliary body,—the following particulars respecting which deserve at-

---

* Vide Translation of Cloquet's Anatomy, p. 552.

tention. It consists of about 80 larger radii or ridges regularly arranged around the capsule, and pointing to the centre of the lens, but terminating abruptly where they touch the capsule. These ridges swell out and assume a bulging appearance towards their middle, from whence they divide both ways into more slender ramifications. Of these smaller branches, those which proceed to the capsule anastomose together branch to branch of the contiguous larger ridges, so as to support or act upon, equally, almost every point of the circumference of the capsule. Those branches that go out in the opposite direction are nearly twice as numerous; and as they lay hold of the retina, they must support or act upon it, because the ciliary ligament which binds the ciliary body to the sclerotic coat is situate directly behind the bulging part of the radii. The breadth of the ciliary ligament is never equal to that of the ciliary body, consequently part of the ramifications of each ridge must be loose both ways; so that whatever be the function of the radii, the ciliary ligament must be the fulcrum or point of support on which the action of the smaller ramifications bears, both ways.

Reflecting on these circumstances, (the force of which the reader will better understand by examining the parts with his own eyes,) and on the fibrous structure and fleshy appearance of the ridges of the zone and belt surrounding the capsule,—the muscularity of these parts appeared to me highly probable, particularly when the elegant regularity of their arrangement and their constancy in all classes of animals, even where no ciliary processes were to be found, were taken into view; together with the manifest provision made by nature to supply them plentifully with fresh blood, contrary to what is found in parts whose office is merely ligamentous.

Unwilling, however, to depend on such evidence alone, I endeavoured to find a method by which muscular fibre might be distinguished from other tissues, for which, as in the present instance, it might be mistaken. The description given by such physiological writers as I had access to, of the changes produced on some of the animal tissues by boiling water, suggested to my mind an experimental inquiry with that agent, from which I was enabled to deduce the test I was in search of. The general results of the inquiry were;—that all animal tissue that was certainly muscular contracted in the direction of the fibre, when immersed in boiling water: all tissue that was certainly tendinous or ligamentous contracted in the direction of the fibre, but more largely. By the contraction, muscle lost about one third, tendon more than one half its length. All purely membranous envelopes, such as the peritoneum, pericardium, &c. contracted like tendon, but in all directions. All muscular tissue, from being transparent before immersion in boiling water, became opake and white after it. The transparency of the muscular fibre of clear-blooded animals, such as the *cod*, *whiting*, &c. is obvious; and in red-blooded animals the transparency of the fibre permits the colour of the blood to be seen through it. Tendon or ligament, from being white and glistening, became semitransparent and yellowish in boiling water; and purely membranous tissues, whose office is akin to that of ligament, remained transparent after immersion in boiling water, as they were before it.—From these facts I have ventured to deduce the following test, by which the muscularity of *transparent animal tissue* may, if the principle appears well founded, be tried.

*Test.*—Immerse in water boiling hot the transparent part of animal tissue to be tried: If it contract about one third part of its length and become opake and white, it is *muscular:* if it does not contract, it is not muscular, though it become white: if it contract more than one third, and remain transparent, it is of a ligamentous nature.

The late Dr. Young, it will be remembered, taught that the crystalline lens consisted of a muscular and tendinous structure arranged in concentric layers and intermixed with a gelatinous substance, and that by the action of the muscular parts of the layers the convexity of the lens was adapted to the different distances of objects. The entire want of communication between the lens and capsule by means of nerves and blood-vessels, on which anatomical writers appear to be agreed, is a strong objection to Dr. Young's hypothesis,—not to mention the perfect fluidity of the fœtal lens, so very unlike any other muscular or tendinous part at the same period. But to remove all doubt I plunged the lens, deprived of its capsule, in boiling water. If Dr. Young's opinion were correct, the lens, from the contraction of both the muscular and tendinous parts of each coat, ought to have become much more spherical, and we should have been able, on separating the intervening coagulum of gelatinous substance, to obtain a succession of thin transparent tendinous layers, surrounded by the muscles attached to it, made white by the boiling water. But in numberless instances which I tried, the lens was not found to undergo the smallest appreciable increase of sphericity. It became opake and white, but continued of the same diameter and thickness after immersion in boiling water as it was before. It therefore is not muscular.

A very different result was obtained when the lens, *covered by its capsule*, was immersed in the same manner. The lens of a cow, with its capsule around it, measured in diameter 0·7 inch, in thickness 0·5 inch, before immersion. After it had lain in boiling water till it became quite opake and white, it measured on being taken out 0·65 inch in diameter, and 0·55 inch in thickness. In losing in diameter and gaining in thickness, the lens of course acquired a greater degree of sphericity. The alteration in this respect, indeed, was so remarkable, that a gentleman of science,—to whom I showed the two lenses of the same animal after they had been immersed in boiling water, the one with, the other without the capsule,—pronounced without hesitation, that they must have belonged to very different animals. The following Table shows the effects of immersion on the lens of a variety of animals taken at random from a very great number of experiments which I made at different times; and I can faithfully assure the reader that I have not, in all the trials I have made, met with a single exception to the principle which it exhibits.

| Name of Animal. | Measurements of the Crystalline, in Parts of an Inch. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | With the Capsule on it. | | | | Without the Capsule. | | | |
| | Before Immersion. | | After Immersion. | | Before Immersion. | | After Immersion. | |
| | Diameter. | Thickness. | Diameter. | Thickness. | Diameter. | Thickness. | Diameter. | Thickness. |
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. |
| Ox | 0·74 | 0·5 | 0·7 | 0·54 | 0·745 | 0·49 | 0·745 | 0·49 |
| Stag | 0·70 | 0·5 | 0·64 | 0·54 | 0·71 | 0·49 | 0·71 | 0·49 |
| Sheep | 0·60 | 0·42 | 0·55 | 0·48 | 0·61 | 0·41 | 0·61 | 0·41 |
| Pig | 0·41 | 0·32 | 0·39 | 0·36 | 0·43 | 0·31 | 0·43 | 0·31 |
| Roe | 0·39 | 0·28 | 0·37 | 0·32 | 0·39 | 0·28 | 0·39 | 0·28 |
| Rabbit | 0·36 | 0·26 | 0·34 | 0·29 | 0·38 | 0·25 | 0·38 | 0·25 |
| Rat | 0·20 | 0·16 | 0·18 | 0·18 | 0·20 | 0·16 | 0·20 | 0·16 |
| Domestic Fowl | 0·26 | 0·13 | 0·2 | 0·15 | 0·28 | 0·12 | 0·28 | 0·12 |
| Codling | 0·42 | 0·39 | 0·415 | 0·415 | 0·42 | 0·39 | 0·42 | 0·39 |
| Herring | 0·26 | 0·22 | 0·24 | 0·24 | 0·26 | 0·22 | 0·26 | 0·22 |
| Whiting | 0·265 | 0·24 | 0·26 | 0·255 | 0·27 | 0·24 | 0·27 | 0·24 |
| Flounder | 0·200 | 0·18 | 0·19 | 0·19 | 0·20 | 0·18 | 0·20 | 0·18 |

From this Table it is obvious that the change of sphericity produced by immersing the lens in boiling water is due to a contractile power in the capsule alone. By measuring the breadth of the capsular belt above mentioned before and after the immersion, I found that it was rendered narrower as well as shorter by a boiling heat; and as the *transverse* circumference of the lens in its capsule was, as nearly as I could determine, the same before and after immersion, this proves the important fact that the contraction of the transverse fibres of the belt is compensated for by an expansion of the elastic membrane constituting the rest of the capsule. In order to try to what class of tissue the capsular belt and radii surrounding it belonged, I removed the lens from the capsule, and immersed the capsule attached to the radiated zone, along with the whole vitreous humour, in boiling water. The *belt* contracted both in length and breadth, and became white; the anterior part within the belt became white, but did not contract; the posterior part within the belt remained transparent. The radii of the hyaloid zone contracted, and became white. These radii, therefore, and the belt around the capsule exhibit the properties of muscular tissue.

Assuming the muscularity of the capsule and hyaloid zone as declared by the test, it remains to try whether such a structure in action is capable of performing the function of adjustment, as it is found to be performed, in the perfect eye.

The function of the muscular belt around the capsule is made sufficiently evident by its effects on the figure of the lens when plunged in boiling water; but the function of the radii of the zone around the capsule can only be understood by attending to the fixed points towards which their contraction must carry their extremities. I have stated above, that these fixed points correspond to the position of the ciliary ligament. Hence the contraction of that part of each of the radii that lies between the capsule and the ligament must draw the circumference of the capsule towards the ligament, and increase the diameter of the lens. The function of the radii, therefore, is antagonist to that of the belt.

As a sense of straining or effort is experienced when the eye is adapted for a considerable length of time, either to very near or very distant objects, followed by a sense of fatigue, it would appear that there is a middle point, to which the convexity of the lens is naturally adapted, and that the adjustment of the eye to nearer or more distant objects is made by a functional exertion. If the adjustment to near objects is made by contraction of the capsule, and to distant objects by contraction of the radii, I find by a calculation founded on optical principles, that the changes of curvature of both surfaces of the lens, easily made by these means, fully account for a range of distinct vision equal to that which the young and healthy eye actually commands. What increases the probability that the adjustment of the eye to different distances is really effected by these means, is, that the accommodation made in this way is attended with no change of the optical centre of the eye; whereas it can be demonstrated that by every other method that has been proposed, a change in the position of the optical centre, and consequently an apparent motion of stationary objects, must occur during the act of adjustment to different distances. Sir David Brewster* employs this argument successfully against the hypothesis that the eyeball is lengthened, or the convexity of the cornea increased, to accommodate the eye to near objects. It is of equal force against the supposition that the lens is drawn forward by any means; for this would move the centre of the lens, and consequently the optical centre of the eye, forward,—an occurrence which the apparent stability of stationary objects out of the axis of vision during the adjustment, disproves beyond any doubt.

In attempting to ascertain the seat and mechanism of a hidden function, as this is, it appears incumbent upon us not only to show, as I have endeavoured to do, that a structure exists which is capable of performing the function; but also to prove that the physical effects which the action of that mechanism ought to produce, are actually produced in the living body, in connexion with the exercise of the function itself. If this can be done in the present case, all that the most cautious and rigorous induction can demand, will, I venture to hope, be fulfilled.

In its natural state the crystalline lens appears to be a thin gelatinous fluid, with a refractive power of about 1·377; for I have repeatedly found it wholly so in the eye of the fœtus. It is condensable even to solidity without destroying its transparency, and its refractive power keeps pace with its density, as may be proved by suffering the fluid part of it to condense by drying in a hollow prism made with two plates of glass.

Now, if the capsule is the organ of adjustment, the lens, from its condensability, ought to exhibit the following effects of the capsular function:—

1st. The contraction of the capsule ought, by pressing upon its contents, to render them denser towards the centre than towards the surface. For if the lens is a sphere consisting of concentric layers or shells of equal thickness, it is obvious that the pressure of the capsule, being propagated from the surface to the centre, is equal over the whole of each layer. But as the layers towards the centre occupy less space than those which are towards the surface, the pressure on equal portions must increase in the same proportion towards the centre; consequently the central parts must in the course of time be rendered denser by the reiterated action of the function, pressing equal portions in the inverse duplicate ratio of the distance from the centre.

2nd. The more spherical the lens is, the denser, *cæteris paribus*, ought its nucleus to be. For in a perfectly spherical

---

* See Lardner's Cyclopædia, Article Optics, p. 301.

lens, the whole pressure of the capsule is sustained by a single central particle. But in a flat lens the same pressure is sustained by a number of particles occupying an extended space. If the force of pressure is the same in all lenses, the density, at the centre of a flat lens, ought to be the same as it is found to be at the same distance from the surface of a spherical lens.

3rd. The more the eye has been employed in surveying near objects, the harder ought its central nucleus to be. Hence the central density ought to increase with the age of the animal; and it should be found, *cæteris paribus*, harder in individuals that are much employed in near vision than in those of a contrary habit. Even short-sightedness may, in some instances, be expected as the consequence of long intense adaptation to near objects.

4th. The hardest part of the crystalline ought to be in the centre of pressure. This is an evident and important corollary of the theory; and as the convexity of the two surfaces of the lens is seldom or never equal, the position of the hardest point of the nucleus will furnish an excellent test of its truth. If the capsule is the organ of adjustment, the distance of the hardest point from the anterior surface will be to its distance from the posterior, as the radius of curvature of the former is to the radius of curvature of the latter. For there the centre of pressure of the two surfaces must be.

5th. The indurated nucleus of the unadjusted lens ought to be more spherical than the soft external part. For when the central parts have gained that degree of firmness and consistence that enables them to retain any figure given to them, the figure which they will assume will obviously be determined by the figure of the contracted capsule adapting the eye to the nearest distance. If the external soft parts are sufficiently abundant, this will enable the capsule to adapt the eye to distant objects by moulding the soft parts, while the indurated nucleus retains the convexity given to it by the contracted capsule. This therefore will furnish another important test by which the truth of the theory may be tried; for no other cause that I am aware of could produce the same effect.

It now remains to ascertain, by examination of the lens itself, whether or not its structure and appearances correspond with the theory in these respects.

1st. The greater density of the crystalline at the centre than at the surface has long been known, and is universally acknowledged by physiologists. Sir David Brewster demonstrates in an elegant manner its gradual increase of density from the surface to the centre. Upon exposing a recent human crystalline lens to polarized light, he found it depolarize four faint sectors of light considerably below the white of the first order; "thus indicating a positive doubly refracting structure, like a sphere of glass rapidly cooled, and increasing in density towards the centre."

2nd. The celebrated Cuvier, in his Lectures on Comparative Anatomy, mentions as a general fact that the nucleus is hardest in those lenses that are most convex. My own observations on the lenses of quadrupeds, birds and fishes, confirm this fact in its fullest extent. The greatest hardness of the nucleus of the ox is not greater than the hardness of the lens of the cod half way between the surface and the centre; and very flat lenses, such as those of fowls in general, are scarcely more dense at the centre than those of the cod very near the surface. These appearances are in strict accordance with the theory; but surely they do not correspond with those which might be expected if the lens were a solid organized for the express purpose of correcting the spherical aberration of light. The fact I have stated above, that I had found the very young fœtal lens entirely fluid, and of the same refractive power as the soft or fluid external part of the maternal lens, together with the universally soft state of young lenses,—strongly impress on my mind a conviction that the substance of the lens is a secretion of a peculiar fluid; and what has been termed the *liquor Morgagni* is probably this fluid recently secreted. This impression is greatly strengthened by the account of experiments made by Messieurs Cocteau and Le Roy d'Etiolle, and published in the *Journal de Physiologie* for January 1827. These gentlemen performed the operation of extraction on many rabbits, cats, and dogs; and they found that in most instances, though not in all, the capsule, examined at the end of four or six weeks, contained a new body, of a lenticular form, and approaching in consistence to that of the extracted lens. In one of these experiments they allowed the animal, a rabbit, to live six months after the operation. "The crystalline capsules were then found perfectly transparent without a visible cicatrix; and they contained each a lens of the same volume and consistence as those extracted. For the sake of greater certainty, they were immersed in hot water, when they became opake, hard and friable like ordinary lenses; the sole difference being, that the disposition in brilliant plates was evident only on the outer layers." This fact shows the importance of preserving the capsule in the operation for cataract when it is not diseased, and completely disarms any objection that may be urged against our theory from some individuals having been known to have the power of adjusting the eye to different distances, after the lens had been extracted by an operation.

3rd. All anatomists agree that in young eyes the lens is entirely soft and pulpy; whereas in old eyes, which of course have been often adjusted to near objects, it is firmer, and has a hard nucleus at the centre. In the fœtal calf and lamb I have found the whole lens so fluid that it formed the capsule into the figure of a globule. In very young calves, lambs and rabbits, after birth, the consistence was firmer, but still pulpy throughout; but in old cows, sheep, &c. the central part constituted a nucleus hard or firm enough to retain any form given to it. In this respect, therefore, observation also agrees with the theory.

4th. The position of the hardest part of the crystalline, ascertained by observation on the lenses of oxen, sheep, deer, rabbits, pigs, &c. agrees also in the most correct manner with the theory. I made this observation several years ago with considerable surprise, and long before the slightest idea of its cause had entered into my mind. Wishing to divide the lens into two equal sections in the direction of the axis, without deranging the curvatures of its surfaces, I applied the edges of two sharp scalpels to the opposite faces of the lens, and holding the blades in the same plane pressed them gently together along the axis till they met, which they did of course, in the hardest point. By a memorandum, taken at the time, the distance of this point was 0·28 inch from the anterior, and 0·22 inch from the posterior surface. The lens was that of a cow, its diameter being 0·7 inch, its thickness 0·5 inch. By measurements taken with the utmost care, the radius of curvature of the anterior surface was 0·5 inch, the radius of the posterior surface 0·39 inch. By the theory, I have shown that the centre of pressure, and consequently the hardest point of the nucleus, ought to be so situate, that its distance from the anterior surface may be to its distance from the posterior, as the radius of curvature of the former is to that of the latter. But 28 is to 22 as 50 to 39 very nearly. In short, in all animals that have the anterior surface of the lens flatter than the posterior, which I have been able to examine carefully, I have found the hardest part of the lens nearer to the posterior than the anterior surface. But in the roe, in the lens of which I found the anterior surface the most convex, I found the hardest point nearer to it than to the posterior surface. In this respect, therefore, the theory is strongly supported by observation. The lenses of the cod and most other fishes are so nearly spherical, that the relative position of the hardest point is difficult to be determined by the method I have mentioned. I regret that it is not in my power to try the question by means of polarized light; for it would be highly interesting to know whether the want of symmetry of structure of the crystalline lens of fishes, observed by Sir David Brewster on exposing it in different positions to polarized light, was owing to the hardest or densest part lying nearer to the more convex surface than to the other, and whether the ratio of the difference could be found in that way.

5th. The figure of the nucleus corresponds admirably with the theory, and if carefully attended to it may enable the intelligent observer, who has full opportunities of examining the human lens, to ascertain, by comparing the whole lens and its nucleus in different eyes, the degree of sphericity which the functional contraction of the capsule can produce. Haller is the only author that I know of, who has noticed the greater sphericity of the nucleus than of the whole lens. That distinguished physiologist mentions having found the nucleus of the badger quite spherical, though the whole lens itself was not so*. Notwithstanding the silence of other authors, the fact is very evident, and may be easily demonstrated as follows:—Deprive the lens of its capsule and plunge it in boiling water: when it has become opake and firm, take it out of the water and divide it into two equal parts, without deranging its curvatures, by a section along the axis. The greater sphericity of the nucleus than of the whole lens will then appear in the most distinct manner; for the change it undergoes in boiling water produces no sensible effect on its convexity.

It is an interesting fact, that the figure which the whole lens acquires by contraction of the capsule in boiling water, is almost or altogether the same as that of the nucleus in its natural state. In the lenses of several old cows, I have observed a very remarkable circumstance. When I first observed that the ratio of the diameter to the thickness of the whole lens in its natural state, was different from the ratio of the diameter to the thickness of the nucleus, I examined a great number of lenses for the sake of ascertaining whether the fact was universal or only accidental. The result was, that the central part of the nucleus was always decidedly more spherical than the whole lens; but in some old lenses, I observed that the external laminæ of the nucleus approached nearer and nearer to the figure of the whole lens; from which it follows, that in advanced age, the force by which the figure of the nucleus is determined, is, *cæteris paribus*, less than in youth. This fact,

---

* *Physiologia*, lib. xvi. sect. 2.

therefore, is important in connexion with the well known decrease of the power of adjustment observed to occur in old age.

Having thus endeavoured to deduce, in the best manner I have been able with the limited means in my power, a knowledge of the functions of the capsule of the lens from its structure and from the phænomena, I shall conclude with a summary of the results to which the induction appears to lead.

1st. The lens of animals, in its original state, consists of a peculiar gelatinous fluid, which admits of being moulded into various degrees of sphericity, and condensed towards the centre by the functional action of its capsule.

2nd. The capsule of the lens is provided, around its circumference, with a muscular belt, by the contraction of which the two surfaces of the lens are made more convex, and the eye adapted to near objects.

3rd. The radiated zone, to which the capsule is firmly attached all round, is provided with a muscular structure, by the contraction of which, and simultaneous relaxation of the capsular belt, the figure of the lens is flattened, and the eye adapted to distant objects.

---

## III. *Experiment on the Electro-magnetism of Metalliferous Veins made in a Copper Mine in Ireland. By Mr.* THOMAS PETHERICK.

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

THE following experiment, illustrative of the electro-magnetic properties of metalliferous veins, so ably developed by Mr. R. W. Fox, you will probably deem worthy of insertion in your Journal; not only from its being the first of the kind made in Ireland, but from the different character of the veins of the mine in which it was made, from those of the mines in the West of England, to which, I apprehend, the experiments made on this interesting subject have till now been confined.

The Connoree copper-mine, to which this notice refers, is situated near the summit of the Cronebane mountain, in the county of Wicklow. The mountain consists principally of compact clay-slate, and the metallic veins that occur in this and other mines on the same range appear to be of contemporaneous formation; the veins being interstratified with the laminæ composing the rock, and conformable with it in dip and direction. Immense masses of granite appear on the surface; but none of that rock is observable *in situ* nearer than about Glenmalur, eight or ten miles to the westward; where the interesting phænomenon is observable of regular alternations of granite and mica slate.

The lode on which the experiment was made is very large, and appears to be more distinctly defined than most of the others. It consists principally of clay and soft clay-slate and friable quartz, through which the ores (chiefly gray copper-ore with some mundic, and a small portion of yellow copper-ore,) traverse in various directions in thick ribs and bunches, the continuous direction of which I could not satisfactorily ascertain. The experiment was made on this lode in a level about 25 fathoms from the surface, driven about 8 fathoms in a south-west direction from the shaft. The galvanometer being fixed in the level about 4 fathoms in that direction from the shaft, the end of one wire was placed against the ore ground in the "end" or extremity of the level about 4 fathoms further in the same direction, the other end of it being placed in the western receptacle of the instrument. The end of another wire was placed against a mass of ore near the shaft; and on inserting the opposite extremity of it in the eastern receptacle, it had the effect of repelling the north end of the needle towards the west, showing the wire in the western receptacle to be negative, and the other of course positive. The oscillations of the needle reached about 18°.

I am, Gentlemen, yours, &c.

Peupellick, near Lostwithiel,
Jan. 25, 1833.

THO. PETHERICK.

---

## IV. *On the Electro-magnetism of Veins of Copper-Ore in Cornwall. By Mr.* JOHN BENNETTS.

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

SINCE the discovery of electrical currents in the mines of Cornwall, by Mr. R. W. Fox, the galvanometer has been applied to veins in various copper-mines with more or less effect.

In my experiments the electro-galvanic action has borne some proportion to the quantity of copper-ore in those parts of the vein with which the wires of the galvanometer have been brought into contact.

When the vein produces but little copper-ore, I have found but little action; but my experiments have not been sufficiently numerous to lay down a rule as to the relation existing between the intensity of electrical action and the quantity of the ores in the vein.

But a series of electro-galvanic experiments on metalliferous veins is greatly to be desired; and to show my willingness to contribute, I beg leave to annex the following Experiment:—

At Wheal Vyvyan Mine near Helston in this county, in the present month, I applied one wire of the galvanometer to a productive part of the vein 20 fathoms below the adit; the other wire to the same vein 10 fathoms below this level,—thus leaving 60 feet in depth between the plates connecting the wires with the vein. The action on the magnetic needle was considerable; it passed over an arc of 15 degrees, the lower part of the vein being negative to the upper part.

There are some peculiarities in the formation of this lode or vein which are not unworthy of the attention of the geologist. It is in some places 20 feet wide in granite strata. A great part of the vein is also composed of granite mixed with quartz and fluor. The more productive part of the vein is from 3 to 6 feet in width, and composed of arsenical pyrites, fluor, yellow sulphuret of copper, and tin; the tin and copper being so intimately mixed in the same stone, as not to be separated without being first pulverized, roasted, and washed; the proportion of copper to tin in the vein stones being as 5 to 1 in weight. The lode underlies north, about 4 feet in a fathom, and its direction is east and west.

Perranarwothall, near Truro,
April 10, 1833.

JOHN BENNETTS.

---

## V. *On certain Experiments in Magneto-electricity and Electro-magnetism.* *By* P. M.

*To the Editors of the Philosophical Magazine and Journal.*

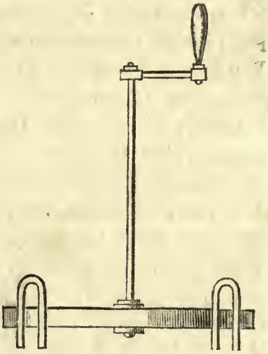
Gentlemen,

IT is within these few days that I read by accident in your Journal the letter I sent to Mr. Faraday; and I feel much obliged to him for the kind manner in which he noticed it*. The same experiment has with equal success been performed in France by a single powerful magnet: those that I made use of were of the smallest description, yet the wire was of considerable length. Shortly after I sent that letter, I made a considerable improvement in the apparatus, by connecting a soft iron ring to the wire, which became momentarily a magnet, and in its turn reacted on the wire, and caused a very considerable increase of power. The wire when coiled round the first lifter, before proceeding to the second was wound a considerable

---

* See Lond. and Edinb. Phil. Mag. and Journal, vol. i. p. 161.—EDIT.

number of times round the iron ring, on a space equal to the distance between those lifters; then continuing its course round the second iron, it was again brought round the ring to the third lifter, and so on; the turns of the helix round this ring were of course all in one direction. I took the whole apparatus asunder at this time, with a view of making another alteration (that occurred to me) when my attention should be directed, at a leisure hour, to another branch of the same subject; and from that day have not put the machine together, or tried any further experiments that way. There is a circumstance connected with electro-magnetism, or I should say, in the making of temporary magnets by means of electricity, which has been overlooked as yet, but which is beautifully explained by this momentary action which has been discovered by Mr. Faraday: I mean, in the case when a weight is suspended to one of these magnets, and the current of electricity suddenly reversed, the poles of the magnet are changed, yet the weight will not fall off; this fact is well known: but what follows, I believe, is not,—That at that moment, and but for a moment, it will lift a considerably greater weight than what it could keep suspended without this reversal of the poles, and which is caused by the momentary reaction and action of the magnet and wires. The magnet I made, which was but small, would lift a weight for a moment from the distance of half an inch, which it would not keep suspended if there was a bit of wood $\frac{1}{4}$ of an inch thick between it and the weight.



In the sketch given of the wheel in my former paper there was an error; as the board on which the lifters was fastened, was parallel to the wheel, and the magnets were made fast in the wheel as here shown, in a direction perpendicular to that board.

Dublin, March 13, 1833.

---

In the hurry of writing the above letter, I fear I have not sufficiently explained the nature of the last experiment described in it. As it is difficult to perform the experiment satisfactorily when the magnet and weights are in contact (although it is shown by the weight not falling off when the poles are reversed, when yet the weight is actually separated and falls a small distance), it is contrived, by performing this experiment at a small distance from contact, satisfactorily to show the difference of power. Observe what weight the magnet is capable of raising from a small distance; say $\frac{1}{2}$ an inch,—and vary the distance until by a few trials you find what is the exact distance it lifts the given weight at the moment the poles are reversed, and that it will not have power to lift more. Now keep the weight this exact distance from the magnet by means of a bit of glass or wood placed between; the weight must now be considerably reduced before it can be suspended at this distance from the magnet when the poles are stationary, and the difference of weight will show the power of the magnet under both circumstances.

Dublin, March 16, 1833. P. M.

---

## VI. *On the Modulus of Elasticity of Gold. By* B. Bevan, *Esq.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

SINCE my former communication on this subject, I have procured a prismatic bar of gold of the standard quality used in British coinage, and have found the modulus of elasticity in one direction to be 12,226,000 pounds, and in the other direction 11,955,000,—the mean of the two is 12,110,500 pounds; from which the height of the modulus will be found about 1,480,000 feet. The additional height of the modulus of coinage gold above that of pure gold is less than I expected; it agrees, however, very nearly with the calculated modulus, as deduced from the proportioned modulus of gold and its alloy. This result suggests an important inquiry on the properties of alloys in general, and is deserving of the attention of the experimentalist. This inquiry led me to the modulus of copper: this metal is given in the Supplement to the *Encyclopædia Britannica* 5,700,000 feet, which I find upon examination to be erroneous: upon whose authority it is quoted I am not aware. My experiments, repeated with considerable care, give 4,380,000 feet, or nearly three times the height of that of gold. Investigations of the law that governs combinations of different metals may be readily tried with various proportions of zinc and lead,—two metals of easy fusibility, and of great difference of elasticity. Compositions of lead and tin may also be employed for this purpose.

I am, Gentlemen, yours truly,

B. Bevan.

## VII. *Report of a Lecture on the Chemistry of Geology, delivered at one of the Evening Meetings at the University of London**, *by* Edward Turner, *M.D. F.R.S. L. & E., Sec. G.S.*†

THE lecturer began by explaining that under the title "Chemistry of Geology," he included all those geological phænomena to the elucidation of which chemical principles were applicable. The subject, he said, was one of great extent. He might proceed to consider the affinities which operated in forming the crystalline rocks of the non-fossiliferous series, — to develope the several theories by which it is attempted to account for volcanic action, — to show by what means the soft materials of aqueous deposites were converted into solid rocks,—to trace the effects of heat in modifying the appearance and nature of previously consolidated masses,—to endeavour to explain the origin of mineral waters,—and speculate on the obscure subject of the formation of veins. But he would not then venture to discuss any of those topics, the rather as some of them were then under investigation. He meant to confine his remarks to two parts of the subject: First, to the causes which give rise to the degradation of rocks, thereby providing the materials for new by the destruction of pre-existing geological formations; and, secondly, to the production, by means of aqueous solution, of siliceous and other deposites which were commonly regarded as insoluble. He would touch cursorily on the former, chiefly with a view to facilitate the comprehension of the latter.

I. *Disintegration of Rocks.* — The principal agents concerned in the degradation of rocks might, it was said, be conveniently arranged under three heads:—

1. Mechanical agents; such as rain, rivers, and torrents, or, generally, water in motion.—This subject, the lecturer said, did not require comment on that occasion, as it was not only familiar to geologists, but foreign to the plan of his lecture.

2. The alternate congelation and liquefaction of water.—In all situations liable to alternate frost and thaw, this was a most fertile source of destruction to rocks.

Water, insinuating itself into fissures or between the strata of rocks, and congealing there, tore asunder the firmest masses by the immensely expansive force which water exerts in freezing, kept together the disjointed parts, as by cement, while it

---

* See Lond. and Edinb. Phil. Mag. for June, page 479.

† The interest as well as the length of this report have induced us to prefer giving it its present place, to inserting it in our "Proceedings of Learned Societies."—Edit.

remained solid, and on thawing left them to fall asunder by the mere force of gravity. This was perhaps the most influential cause of the vast ruin daily witnessed in the valleys of Switzerland, and in all countries where high mountain chains are intersected by deep narrow gorges, bounded by bare, precipitous, and irregularly fissured escarpments. By the operation of the same cause buildings were defaced and destroyed. When water froze within the cavities of porous stones, the particles were frequently more or less disunited from each other, and crumbled to dust at the first thaw. Building materials differed in their destructibility by frost. The compact tenacious sandstone of Edinburgh suffered little; while some of the handsome colleges of Oxford gave melancholy proof of the injury which it might occasion in the more porous and less tenacious oolite of that county. The lecturer observed, that a scientific knowledge of the cause of such decay had led to the suggestion of a ready mode of estimating the durability, as far as frost was concerned, of different building materials. The freezing of water was a process of crystallization attended, as in most other cases, with forcible increase of volume. The crystallization of salts was a similar phænomenon, and gave rise to a similar effect. When a stone was dipped into a saline solution, and then suspended in the air to dry, the crystallization of the salt produced a certain amount of injury; and the effect due to one operation might be multiplied to any extent by repetition of the same process. The experiment of a few days might thus be made to imitate the effect of numerous winters, and the relative durability of different materials be ascertained prior to their selection for building. The salt most applicable to such purposes was found to be sulphate of soda*.

3. *Chemical Action.*—The affinities which principally contribute to affect the integrity of rocks were stated to be those of water and carbonic acid for potash and soda, and that of oxygen for iron. The changes referred to were frequent in felspathic rocks, and were exemplified in a very striking manner in the formation of porcelain clay from granite and other allied rocks rich in felspar. All granitic regions presented examples of this nature, and in none were they more remarkable than in Cornwall and Auvergne. It was probable that the long-continued action of pure water might produce decomposition; but the effect of its affinity for the alkalies of the rock was materially aided by that of carbonic acid for the same bases. This was shown by the increased decomposing power of water when charged with carbonic acid, and by the action

---

* M. Brard in *Ann. de Chim. et de Phys.,* vol. xxxviii. p. 160.

of moist carbonic acid gas on granite, as exemplified in the volcanic districts of Auvergne. Basaltic rocks were likewise prone to decomposition, partly in consequence of containing felspar, and partly from the protoxide of iron of the augite or hornblende which enters into their composition. The passage of the iron into a higher degree of oxidation was due to atmospheric oxygen applied in a liquid state to the rock through the medium of water. It was probable that carbonic acid likewise co-operated;—that, as in the rusting of iron, a carbonate of the protoxide was first generated, which subsequently passed into the hydrated peroxide of iron.

The rocks in which these changes occurred, underwent a total alteration both in their mechanical state and in chemical constitution. Their tenacity was so entirely destroyed, that the slightest force, a shower or the breeze, sufficed to overcome the cohesion of their particles. The alkali of the felspar was entirely washed away, and an earthy mixture, combined with water, remained. The ochreous tint of decomposed basalt and greenstone sufficiently indicated that their iron had passed into a higher state of oxidation; but felspar often left a perfectly white earth, the small portions of iron and manganese contained in the original rock having been removed, probably in the state of carbonate, during the progress of disintegration. These changes constituted one of the great sources of the alkalies present in springs and in the soil; and the alkaline matter of the nitrates of potash and soda, generated so abundantly in parts of India and America, had probably the same origin. They likewise accounted for the connexion observed between the agricultural character of the soil of certain districts, and the rocks from which it was derived. The decomposition of granitic rocks led to deposites of clay and sand, which were too entirely free from each other and from lime to be suitable for the growth of plants; while the earth derived from most basaltic rocks was an intimate mixture of argillaceous, siliceous, and calcareous matter, in proportions peculiarly favourable to vegetation.

II. *Deposites from Aqueous Solution of Substances commonly considered insoluble.*—The lecturer next discussed the second branch of his subject, referring more especially to siliceous depositions; such as flint, calcedony, and rock crystal. Many circumstances, he remarked, proved the fact that silica very frequently existed in solution. Mineral waters, he said, commonly contained silica:—chemists, indeed, frequently overlooked it in their analyses; but when carefully sought for, it might in most instances be detected. It was constantly contained in the sap of certain plants, if not in all. For it was shown by the late Sir H. Davy that silex is contained in grass, and in the epidermis of reeds, corn, canes, and of hollow plants in general. The existence of silex in the sap of the bamboo was not only attested by its flinty epidermis, but by the siliceous concretions called *tabasheer*. Similar evidence was afforded by some fossils, which contained silex in such a form as to indicate that it was deposited from a solution. In proof of his position the lecturer exhibited samples of shells having their form preserved in silex, some beautiful specimens of silicified coral, and a suite of chalk flints which displayed the structure of sponges and other zoophytes. For the opportunity of exhibiting such specimens he was indebted to the indulgence of the President and Council of the Geological Society. Traces of organization might by careful examination be so frequently detected in chalk flints, that he was disposed to the opinion of those geologists who considered flints in general as zoophytes fossilized by silica. The lecturer next adverted to the formation of calcedony, and showed specimens which, though found in igneous rocks, had their aqueous origin clearly established by the stalactitic form which they possessed. Similar masses of calcedony existed in some flints, and passed into the substance of flint by insensible gradations. The hollow balls of crystals, called geodes, afforded similar testimony, by presenting both calcedony and rock crystal under circumstances indicative of pre-existing solution.

The fact being established,—that siliceous minerals are frequently formed from aqueous solution, the lecturer went on to state the principles by which he thought the solution of siliceous matter, and its subsequent deposition, might be explained. The first observation he would make related to the meaning of the term *insoluble*. Chemists, he said, apply it to substances which are not found to lose an appreciable weight when subjected to the action of water. It was not affirmed that absolutely nothing was dissolved in such cases, but that the quantities were too small to be appreciated. This was true even of one of the most insoluble substances known to chemists; namely, sulphate of baryta. But though the weight of such bodies was not perceptibly diminished by trials conducted in the laboratory, during a short interval of time, and with small quantities of water, the effect of the same operation, as performed on the great scale in the mineral kingdom, during hundreds and thousands of years, and with unlimited quantities of the menstruum, might be, and doubtless was, very different. It was not necessary, however, to have recourse to this mode of reasoning. Substances, he said, which are inappreciably soluble in one state, may be freely dissolved in another. Silex in the finest powder may be boiled in water without perceptible solution; but if presented to that solvent while in the *nascent* state, it was freely dissolved. Substances in the act of being formed from their elements, or of separating from previously existing combinations, do not possess that force of aggregation which properly belongs to them, and in such states of transition they have a peculiar aptitude to combine with other bodies. This property is observed more or less in all bodies; but silica offers one of the most striking illustrations of it. Siliceous earth, in its nascent state, is freely soluble in water and in various acid and saline solutions, which do not perceptibly dissolve ordinary flint, however finely it may be pulverized; and the alkalies and alkaline carbonates, which dissolve silex even in its solid condition, take it up while nascent in far greater quantity. Now in the decomposition of felspathic rocks, which had been referred to in the first part of the lecture expressly with a view to that subject, the silex was exposed to the united action of water and alkali at the moment of passing from the state of combination which constitutes felspar, and would be expected to be freely dissolved. That it was so, might be proved by a comparative view of the constitution of porcelain clay and felspar. He would represent their composition, he said, by a formula expressive of the number of equivalents of each element; though in doing so, he did not mean to assert that porcelain clay was strictly an atomic compound. Thus,

Felspar. Porcelain Clay.

$$(\dot{\mathrm{Po}} + 3\,\dot{\mathrm{Si}}) + (\underline{\dddot{\mathrm{Al}}} + 9\,\dot{\mathrm{Si}}); \qquad (\underline{\dddot{\mathrm{Al}}} + 3\tfrac{1}{2}\,\dot{\mathrm{Si}}).$$

The lecturer stated that the porcelain clay referred to, was a sample from Villarica, which he had analysed during the course of the winter. Besides aluminous and siliceous earth, it contained 21·3 per cent. of water. Mr. Rogers of Philadelphia had obligingly analysed for him some porcelain clay from the vicinity of Mont Dor in Auvergne, which had a similar constitution. Berthier and Rose had likewise analysed porcelain clay from other localities, and each found the ratio of the two earths to be nearly 2 equivalents of alumina to 3 of silica. Its constitution accordingly appeared subject to very slight variation. The formulæ showed that every 2 equivalents of alumina, present in porcelain clay along with 3½ of silica, corresponded in the original felspar, from which it was derived, to 12 equivalents of silica and 1 of potash.

Hence the quantity of silica carried off in solution was enormous.

The lecturer then went on to explain how it happened that silica, existing in solution, was deposited so as to constitute minerals. One obvious principle, he stated, was the molecular attraction which exists between similar particles of matter, as was proved by facts without number. Its existence was attested by the globular form assumed by water, oil, mercury, and other liquids;—by the separation from one another of salts in crystallizing out of mixed solutions;—by the formation of crystals during the slow deposition of vapour, as when camphor was subliming slowly in a glass bottle, the particles attaching themselves to one another rather than spreading uniformly over the surface on which they collect;—and by the tendency of like molecules to get together and cohere while intermixed with a mass of dissimilar matter rendered liquid by heat, as when particles of titanium, diffused in a furnace through a mass of iron, seek out each other and form regular crystals, or when minerals crystallize out of melted lava or basalt. So from solutions of silex, whether strong or dilute, the particles are disposed to adhere together whenever they cease to remain in solution.

Another principle applicable to this question, was the following: Whenever substances, insoluble in their ordinary state, were dissolved by the force of favourable circumstances, such solutions were very prone to decomposition. They formed instances of peculiarly unstable equilibrium. The slightest disturbing causes,—as agitation, change of temperature, or the affinity, though slight, of some other body for the solvent,—would in such cases put an end to the solution. Illustrative examples of this principle were afforded by solutions of tin, titanium, and peroxide of iron in a neutral state. He might probably quote albuminous solutions as an instance from the animal kingdom. Water cooled carefully below its usual point of congelation, and saturated solutions of Glauber's salt, were liquids in which a similar instability of equilibrium was conspicuous. The lecturer, in illustration, here showed two solutions of Glauber's salt:—he explained that the mere pressure of the atmosphere on removing the cork, or the slightest agitation, often caused such solutions to become solid; and that when these failed, the introduction of a solid body, especially a crystal of Glauber's salt, or of any substance having even a feeble affinity for the salt or its solvent,—such as a globule of air or carbonic acid gas,—generally determined immediate crystallization. The solutions on the lecture-table retained their form after removal of the cork and after gentle agitation: one of them instantly became solid on the introduction of a glass tube; and the other bore the introduction of the tube, but crystallized instantly when a globule of air from the lungs was blown through the tube. The principle elucidated by these facts was, he said, directly applicable to his argument. A solution of silica oozing slowly into the cavities of a porous or cellular rock, might yield a deposite as a consequence of evaporation, of a slight affinity between the silica and some substance with which it accidentally came into contact, or of the solvent power of an alkali which had contributed to its solution being lessened by passing from the state of a simple carbonate to that of a bicarbonate, or by entering into some other mode of combination. The siliceous matter, being once solid, would most probably be insoluble in the menstruum by which it had been originally dissolved, and in that state would promote the increase of the deposite by its molecular attraction for the silex still remaining in solution. In this manner might cavities of considerable size be gradually filled up with calcedony, flint, or rock crystal. It was difficult, he said, to indicate the precise circumstances which determined the form assumed by the silex; but it was probable, agreeably to the laws of crystallization, that the development of regular crystals was owing to the extremely slow progress of the same process which, when less slow, might cause the deposite to be amorphous. In the formation of calcedony and flint it was most likely, as Brongniart supposed, that the silica, as in operations in the laboratory, was deposited in a gelatinous form, hardening gradually by evaporation and the cohesive attraction of its particles. The regularly disposed lines which were so beautifully displayed in some varieties of calcedony, seemed owing to successive deposition,—one layer succeeding another, each assuming the form and irregularities of the preceding, and differing in tint according to the absence or presence of small varying quantities of foreign matter, such as iron and manganese. In the case of flint it was necessary, he said, to account for that remarkable tendency which silica possessed, to occupy the place of organic matter, as exemplified by the specimens of flint, silicified wood, and coral, on the lecture-table. This phænomenon the lecturer thought might be explained on the principles which had been developed that evening. Siliceous solutions, infiltrating through organic masses in progress of decay, might readily be decomposed by the affinity of gases or other compounds generated during slow putrefaction, either for the silica itself, or for its solvent. In either case a deposite of silex would result. Consistently with this view, it was well known that flints contained traces of bitumen or some similar substance of organic origin. To it the dark colour of flints was owing, and to its destruction the whiteness of roasted and bleached flints was attributable.

The lecturer, in conclusion, briefly referred to the formation of some other minerals. He explained that the production of crystals of selenite, celestine, and heavy spar, obviously resulted in many cases from the sulphuric acid arising, one while from burned sulphur in volcanic districts, and at another from oxidizing pyrites, acting upon contiguous masses containing lime, strontia, and baryta. He showed a specimen of red oxide of iron possessed of a stalactitic form decisive of aqueous origin; and oxide of manganese, he said, sometimes occurred in a similar state. He considered such specimens to have been originally deposited in the state of carbonates, out of solutions of carbonic acid, and to have been subsequently still further oxidized,—a change which he illustrated by a specimen of carbonate of manganese kindly given to him by Mr. Phillips, in which the progress of conversion was distinctly exhibited. He also suggested a possible explanation of the origin of the pyrites so often found in fossil shells imbedded in clay which abounds in nodular pyrites. It had been observed that sulphates undergo gradual decomposition by the action of organic matter; and he thought it therefore far from improbable that sulphate of iron, generated from oxidized pyrites, might by the deoxidizing agency of animal remains be reconverted into sulphuret.

## VIII. *Contributions to the Geology of Northumberland and Durham. By* N. J. WINCH, *Esq. G.S. & A.L.S.*[*]

MINERS and geologists at all conversant with the great coal-field of Northumberland and Durham, are acquainted with the vein generally called the Main or Ninety-fathom Dyke, which traverses the district in a south-westerly direction, dividing it into two unequal portions, and which is only recurred to here as a guide to the situations of the coal mines whose sections form the subject, and are the chief value, of the following paper. This dyke may be seen to advantage both in the cliffs and intersecting the rocks on the sea-shore a little to the north of Cullercoates, from whence it passes by Whitley Quarry to Earsdon, Backworth, Killingworth, Gosforth, Denton Hall; by the north corner of the field east of West Den-

---

[*] Communicated by the Author. [The reader of these contributions should consult the map of Northumberland and Durham, in the First Series of the Transactions of the Geological Society, vol. iv. Plate I.—AUTHOR.]

ton House; crosses the river Tyne in the direction of Ryton Church, and proceeds to the south-west of Greenside and Leadgate, into the encrinal or mountain limestone district. The rocky strata to the north of this fissure are depressed to a considerable depth; but it is only at Gosforth, Killingworth, and Montague main collieries, that, to use the miners' phrase, the dyke has been *proved.* At the former of these collieries, (see Section, No. I.) its inclination or hade, and the depth to which the coal-measures have been thrown down by it, have been fully ascertained.

In the second edition of Mr. Westgarth Forster's Section, at page 72, is this note: — " The Great Stublick Dyke here mentioned, runs in a direction nearly east and west, and may be traced for a considerable distance on its line of bearing; viz. from Stublick Syke westward to Cupola Bridge, where it crosses the Allen Water; from thence over Whitfield Ridge to the river Tyne, a little below Eals Bridge; thence to the south of Hartley Bourn and Tynedale Fell collieries. It has an immense throw down to the northward, but the precise distance cannot be exactly ascertained; it must however be very considerable, *as it throws down the lower part of the Newcastle coal series in the districts through which it passes.* There is some reason to suppose it identical with the Ninety-fathom Dyke which dislocates the coal-measures near Tynemouth Castle." (See page 28.) From the preceding observations it appears, that previous to the year 1821, Mr. W. Forster was aware that the coal seams worked at Stublick and in its vicinity were the lower beds of the Newcastle coal-field, which are not interstratified with the encrinal limestone (see Sections of these mines in the First Series of the Geological Transactions, vol. iv. page 70.), and suspected that the Stublick Dyke was a continuation of the Ninety-fathom Dyke, by the depression on the north side of which the Newcastle coal-field was thus extended much further to the westward than it otherwise would have been.

Let us now return to the eastern extremity of this dyke on the sea-coast of Northumberland. At Whitley near Cullercoates, a narrow stripe of magnesian limestone detached from its formation, owing to the depression occasioned by the fissure, has long been the site of extensive quarries; but it was only during the course of 1831, that, on the ground being opened at a fresh place, Mr. Fryer of Whitley House observed an irregular, though thick bed of sulphate of barytes interposed between the surface-soil and the limestone. This heavy spar, upon close examination, he found to consist of minute brittle crystals aggregated together, of a white colour, but occasionally tinged yellow by ochre. Imbedded in the mass, large rhomboidal crystals, similar to the Dufton spar, of a pale azure blue, were detected: these, however, were of rare occurrence. That sulphate of barytes once covered the limestone at the old quarries is evident from patches left on the cliffs not worked away, but which being far out of reach, were mistaken for the remains of a bed of white limestone. Botryoidal heavy spar, of a flesh-red colour, was some years since found in the interstices of the rough partially crystalline magnesian limestone at Man Haven, on the coast of Durham near Whitburn, by the Rev. Mr. Abbs; but I believe that an extensive bed, in places exceeding ten feet thick, is a new feature of this formation. Casts of shells and one impression of a fish, I hear, have been found in the Whitley Quarries; and small brilliant crystals of blend I have seen in the dyke, on the sea-shore, where the soft yellow sandstone, first described as underlying the magnesian limestone, appears in the cliffs on the north side of the dyke at Cullercoates; and after passing under the village of Whitley, may be seen at its northern extremity in a small well, a little to the north of the place where it was detected by Mr. Fryer.

Section, No. 1.—*An Account of the Strata sunk through at Gosforth Colliery, Northumberland, finished 27th October* 1827.

| No. of Strata. | | East Pit. | | | West Pit. | | |
|---|---|---|---|---|---|---|---|
| | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
| | Brown stony clay .. .. .. .. .. .. .. | 7 | 1 | 10 | 7 | 1 | 4 |
| 1 | Gray seggar clay, or thill .. .. .. .. .. .. | 0 | 4 | 0 | 0 | 4 | 0 |
| 2<br>3 | Gray metal stone mixed with gray post in East Pit . .. .. .. .. .. .. .. .. | 4 | 1 | 0 | 2 | 5 | 7 |
| | Black metal.. .. .. .. .. .. .. .. .. .. | 0 | 3 | 0 | 0 | 3 | 0 |
| 4 | *Coal* .. .. .. .. .. .. .. .. .. .. .. | 0 | 0 | 9 | 0 | 0 | 11 |
| 5 | Thill scared with black slate near the bottom | 1 | 1 | 0 | 1 | 3 | 9 |
| 6 | Gray metal stone with post girdles .. .. .. | 1 | 5 | 10 | 1 | 5 | 1 |
| 7<br>8 | Brown post, which grew whitish towards the bottom .. .. .. .. .. .. .. .. .. | 2 | 2 | 10 | 2 | 2 | 7 |
| | Gray metal with scamy post girdles.. .. .. | 1 | 0 | 6 | 1 | 2 | 0 |
| 9 | Blue metal .. .. .. .. .. .. .. ... .. | 0 | 2 | 1 | 0 | 2 | 0 |
| 10 | *Coal* . .. .. .. .. .. .. .. .. .. .. .. | 0 | 0 | 6 | 0 | 0 | 4 |
| 11 | Thill .. .. .. .. .. .. .. .. .. .. .. | 0 | 2 | 1 | 0 | 2 | 1 |
| 12 | Gray metal stone.. .. .. .. .. .. .. .. | 0 | 3 | 2 | 0 | 3 | 1 |
| 13 | Gray scamy post .. .. .. .. .. .. .. .. | 0 | 3 | 6 | 0 | 3 | 6 |
| 14 | Black metal .. .. .. .. .. .. .. .. .. | 0 | 0 | 6 | 0 | 0 | 6 |
| 15 | Gray post .. .. .. .. .. .. .. .. .. | 1 | 0 | 8 | 0 | 5 | 10 |
| 16 | Gray shivery post . .. .. .. .. .. .. .. | 0 | 2 | 9 | 0 | 3 | 0 |
| 17 | Black stone .. .. .. .. .. .. .. .. .. | 3 | 1 | 8 | 3 | 3 | 11 |
| 18 | *Coal* .. .. .. .. .. .. .. .. .. .. .. | 0 | 1 | 0 | 0 | 1 | 0 |
| 19 | Thill .. .. .. .. .. .. .. .. .. .. .. | 0 | 0 | 8 | 0 | 1 | 0 |
| 20 | Main post .. .. .. .. .. .. .. .. .. | 7 | 4 | 8 | 7 | 4 | 10 |
| 21 | Post, in blocks, being high main coal waste .. | 0 | 4 | 0 | 0 | 4 | 0 |
| 22 | Carried forward ... ... | 35 | 0 | 0 | 34 | 3 | 4 |

| No. of Strata. | | East Pit. | | | West Pit. | | |
|---|---|---|---|---|---|---|---|
| | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
| | Brought forward.—Depth from soil to thill of high main coal | 35 | 0 | 0 | 34 | 3 | 4 |
| 23 | Thill, very little disturbed | 0 | 0 | 6 | 0 | 0 | 6 |
| 24 | *Coal* (coarse) being *ground coal* of main coal seam | 0 | 2 | 3 | 0 | 2 | 3 |
| 25 | Thill | 0 | 3 | 0 | 0 | 3 | 0 |
| 26 | Gray metal and gray metal stone with water | 4 | 0 | 10 | 4 | 1 | 7 |
| 27 | Black metal | 0 | 0 | 6 | 0 | 0 | 5 |
| 28 | Gray metal | 0 | 5 | 1 | 0 | 4 | 7 |
| 29 | *Coal* (the metal *coal*) | 0 | 1 | 5 | 0 | 1 | 5 |
| 30 | Thill | 0 | 2 | 3 | 0 | 2 | 2 |
| 31 | Gray metal | 0 | 2 | 0 | 0 | 2 | 0 |
| 32 | Gray scamy post with water near the top | 1 | 1 | 4 | 1 | 0 | 6 |
| 33 | Black metal with a little water near the bottom | 1 | 3 | 2 | 1 | 3 | 6 |
| 34 | Gray post with a little water | 0 | 2 | 4 | 0 | 2 | 10 |
| 35 | Black metal | 0 | 0 | 5 | 0 | 0 | 8 |
| 36 | *Coal* (*stone coal*) | 0 | 1 | 4 | 0 | 1 | 5 |
| 37 | Thill | 0 | 0 | 8 | 0 | 0 | 9 |
| 38 | Dark gray post | 0 | 3 | 4 | 0 | 4 | 0 |
| 39 | Black metal | 0 | 0 | 6 | 0 | 0 | 7 |
| 40 | White post; but which was brown for 2 feet near bottom | 1 | 3 | 4 | 1 | 2 | 7 |
| 41 | Mixture of black metal and coal | 0 | 0 | 2 | 0 | 0 | 3 |
| 42 | Gray metal | 0 | 1 | 1 | 0 | 1 | 0 |
| 43 | White post | 0 | 2 | 10 | 0 | 2 | 10 |
| 44 | Gray metal and metal stone | 2 | 5 | 4 | 2 | 5 | 9 |
| 45 | Black metal | 0 | 0 | 4 | 0 | 0 | 4 |
| 46 | *East Pit. WestPit.*<br>*Coal* 0 10 / 0 10<br>Band of gray metal 1 0 / 0 11<br>*Coal* 0 5 / 0 5 | 0 | 2 | 3 | 0 | 2 | 2 |
| 47 | Thill | 0 | 1 | 10 | 0 | 2 | 0 |
| 48 | Dark gray post mixed with blue metal | 1 | 4 | 0 | 1 | 3 | 5 |
| 49 | Strong white post with a little water | 3 | 2 | 7 | 3 | 3 | 4 |
| 50 | *Coal* (coarse) 1 3½ / 1 3<br>Band of hard gray metal 1 0 / 1 0<br>*Coal* (coarse) 0 10½ / 0 11<br>yard *coal* | 0 | 3 | 2 | 0 | 3 | 2 |
| 51 | Hard gray and dark brown metal stone scared with post | 0 | 5 | 9 | 0 | 5 | 9 |
| 52 | Black metal | 0 | 3 | 8 | 0 | 3 | 8 |
| 53 | *Coal* (slaty coal) | 0 | 0 | 2 | 0 | 0 | 3 |
| 54 | Thill | 0 | 0 | 8 | 0 | 0 | 8 |
| 55 | Gray metal stone | 0 | 3 | 10 | 0 | 3 | 10 |
| 56 | Gray metal and gray post girdles intermixed with bands of ironstone | 2 | 3 | 2 | 2 | 4 | 2 |
| 57 | Gray metal with balls of ironstone | 1 | 5 | 2 | 1 | 4 | 1 |
| 58 | *Coal* 1 8 / 1 8<br>Black slate mixed with coal & water 0 2 / 0 2<br>*Coal* 0 8 / 0 8<br>Bensham seam | 0 | 2 | 6 | 0 | 2 | 6 |
| 59 | Dark gray metal stone or thill | 0 | 1 | 6 | 0 | 1 | 11 |
| 60 | Gray post intermixed scantily with layers of black metal | 14 | 1 | 0 | 13 | 0 | 10 |
| 61 | Dark gray metal stone with a few post girdles | 5 | 2 | 5 | 6 | 1 | 11 |
| | Carried forward | 84 | 3 | 8 | 84 | 1 | 11 |

| No. of Strata. | | East Pit. | | | West Pit. | | |
|---|---|---|---|---|---|---|---|
| | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
| | Brought forward ... ... ... | 84 | 3 | 8 | 84 | 1 | 11 |
| 62 | Black metal ... ... ... ... ... ... ... | 0 | 2 | 0 | 0 | 0 | 2 |
| 63 | *East Pit. West Pit.*<br>*Coal* ... ... ... 1 0½ 1 0½ fine<br>Gray metal stone band 0 1½ 0 1½ quarter<br>*Coal* ... ... ... 1 0 1 0½ coal | 0 | 2 | 2 | 0 | 2 | 2 |
| 64 | Gray metal and gray metal stone with post girdles ... ... ... ... ... ... ... | 3 | 0 | 3 | 3 | 0 | 3 |
| 65 | Coarse slaty *coal* ... ... ... ... ... ... | 0 | 0 | 8 | 0 | 0 | 8 |
| 66 | Gray metal and gray metal stone with post girdles ... ... ... ... ... ... ... | 8 | 2 | 10 | 8 | 2 | 2 |
| 67 | Black metal ... ... ... ... ... ... ... | 0 | 1 | 5 | 0 | 2 | 1 |
| 68 | Coal, very tender (supposed *low main*) ... ... | 0 | 0 | 8 | 0 | 0 | 8 |
| 69 | Gray metal stone ... ... ... ... ... ... | 5 | 4 | 9 | 5 | 2 | 6 |
| 70 | Greenish post (very hard) ... ... ... ... | 15 | 0 | 10 | 15 | 3 | 1 |
| 71 | Blue metal mixed with dark-coloured post ... | 0 | 0 | 6 | 0 | 0 | 6 |
| 72 | White post ... ... ... ... ... ... ... | 3 | 4 | 10 | 3 | 1 | 7 |
| 73 | Blue metal ... ... ... ... ... ... ... | 1 | 3 | 1 | 1 | 5 | 5 |
| 74 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 2 | 0 | 0 | 1 |
| 75 | Blue and black metal ... ... ... ... ... ... | 0 | 3 | 9 | 0 | 3 | 10 |
| 76 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 3 | 0 | 0 | 3 |
| 77 | Slaty blue metal ... ... ... ... ... ... | 0 | 2 | 0 | 0 | 1 | 10 |
| 78 | Post girdles with metal partings ... ... ... | 1 | 2 | 2 | 0 | 5 | 11 |
| 79 | Blue metal ... ... ... ... ... ... ... | 0 | 4 | 0 | 0 | 4 | 0 |
| 80 | *Coal* (Beaumont seam) ... ... ... ... ... | 0 | 1 | 10 | 0 | 1 | 5 |
| 81 | Blue metal stone with occasional thin post girdles ... ... ... ... ... ... ... | 1 | 0 | 3 | 0 | 5 | 5 |
| 82 | White post ... ... ... ... ... ... ... | 0 | 5 | 0 | 1 | 3 | 8 |
| 83 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 11 | 0 | 0 | 11 |
| 84 | Blue metal and blue metal stone ... ... ... | 0 | 4 | 6 | 0 | 4 | 6 |
| 85 | White post ... ... ... ... ... ... ... | 0 | 2 | 0½ | 0 | 2 | 5 |
| 86 | Blue metal and blue metal stone ... ... ... | 1 | 1 | 2 | 1 | 0 | 5½ |
| 87 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 3½ | 0 | 0 | 3½ |
| 88 | Soft gray post with metal layers ... ... ... | 2 | 2 | 8 | 2 | 2 | 6 |
| 89 | Hard white post ... ... ... ... ... ... | 1 | 2 | 0 | 1 | 2 | 11 |
| 90 | *Coal*, very soft and coarse ... ... ... ... | 0 | 1 | 1 | 0 | 1 | 0 |
| 91 | Thilly gray metal ... ... ... ... ... ... | 0 | 2 | 0 | 0 | 1 | 6 |
| 92 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 8 | 0 | 0 | 8 |
| 93 | Dark gray or blue metal and metal stone ... | 2 | 3 | 0 | 2 | 3 | 0 |
| 94 | White post ... ... ... ... ... ... ... | 1 | 5 | 9 | 2 | 0 | 3 |
| 95 | *Coal*, tender ... ... ... ... ... ... ... | 0 | 0 | 2 | 0 | 0 | 2½ |
| 96 | Thill ... ... ... ... ... ... ... ... ... ... | 0 | 2 | 7 | 0 | 2 | 8 |
| 97 | *Coal*, very coarse and slaty ... ... ... ... | 0 | 0 | 5 | 0 | 0 | 5½ |
| 98 | Blue metal and blue metal stone ... ... ... | 1 | 4 | 1 | 1 | 3 | 6 |
| 99 | *Coal* (Denton low main) ... ... ... ... ... | 0 | 2 | 8 | 0 | 2 | 8 |
| 100 | Thill, which grew into a metal stone as sinking advanced ... ... ... ... ... | 1 | 2 | 11 | 1 | 2 | 10½ |
| 101 | *Coal*, very coarse ... ... ... ... ... ... | 0 | 0 | 5½ | 0 | 0 | 5½ |
| 102 | Gray metal stone with post girdles near the bottom ... ... ... ... ... ... ... | 1 | 0 | 9½ | 1 | 0 | 5 |
| 103 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 1 | 0 | 0 | 1 |
| 104 | Gray metal stone with post girdles ... ... | 1 | 0 | 5 | 1 | 0 | 11 |
| 105 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 1 | 1 | 0 | 1 | 2 |
| | Carried forward ... ... | 146 | 3 | 0 | 146 | 1 | 5 |

| No. of Strata. | | East Pit. | | | West Pit. | | |
|---|---|---|---|---|---|---|---|
| | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
| | Brought foward ... ... | 146 | 3 | 0 | 146 | 1 | 5 |
| 106 | Gray metal stone ... ... ... ... ... ... | 3 | 0 | 5 | 2 | 5 | 3 |
| 107 | Hard white post ... ... ... ... ... ... | 3 | 5 | 0 | 4 | 0 | 6 |
| 108 | Dark blue metal ... ... ... ... ... ... | 0 | 3 | 2 | 0 | 3 | 5½ |
| 109 | Gray shivery post with metal partings near the bottom ... ... ... ... ... ... | 1 | 0 | 4 | 1 | 0 | 4 |
| 110 | Dark blue metal ... ... ... ... ... ... | 0 | 2 | 6 | 0 | 2 | 6 |
| 111 | *East Pit. West Pit.*<br>*Coal* ... 1 5 — 1 5<br>Brown band 0 2½ — 0 2½<br>*Coal* ... 0 7 — 0 7<br>Probably the Denton *low main* ... | 0 | 2 | 2½ | 0 | 2 | 2½ |
| 112 | Gray metal stone ... .. ... ... ... ... | 0 | 5 | 2 | 0 | 5 | 10 |
| 113 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 1 | 0 | 0 | 1 |
| 114 | Gray metal ... ... ... ... ... ... ... | 0 | 3 | 6½ | 0 | 3 | 10 |
| 115 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 3 | 0 | 0 | 3 |
| 116 | Gray shivery post with metal partings ... ... | 1 | 3 | 4 | 1 | 2 | 4 |
| 117 | Gray metal ... ... ... ... ... ... ... | 0 | 3 | 6 | 0 | 3 | 5 |
| 118 | *Coal* ... ... ... ... ... ... ... ... ... | 0 | 0 | 1 | 0 | 0 | 1 |
| 119 | Gray metal ... ... ... ... ... ... ... | 0 | 2 | 2 | 0 | 2 | 2 |
| 120 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 8 | 0 | 0 | 8 |
| 121 | Gray metal ... ... ... ... ... ... ... | 0 | 3 | 9 | 0 | 3 | 3½ |
| 122 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 7 | 0 | 0 | 7½ |
| 123 | Dark gray metal and metal stone ... ... ... | 1 | 0 | 9 | 0 | 5 | 4 |
| 124 | *East Pit. West Pit.*<br>*Coal* ... 1 11 — 2 1<br>Brown band 0 8 — 0 6½<br>*Coal* ... 1 5 — 1 4½<br>... ... ... | 0 | 4 | 0 | 0 | 4 | 0 |
| 125 | Gray metal ... ... ... ... ... ... ... | 0 | 5 | 1½ | 0 | 4 | 11½ |
| 126 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 3½ | 0 | 0 | 3½ |
| 127 | Gray metal ... ... ... ... ... ... ... | 0 | 1 | 11 | 0 | 2 | 1 |
| 128 | White post ... ... ... ... ... ... ... | 7 | 2 | 8 | 7 | 3 | 1 |
| 129 | Blue metal ... ... ... ... ... ... ... | 0 | 2 | 0 | 0 | 2 | 1 |
| 130 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 1 | 3 | 0 | 1 | 3 |
| 131 | Blue and gray metal stone with post girdles ... | 2 | 4 | 3 | 2 | 4 | 8 |
| 132 | White post mixed with whin ... ... ... ... | 6 | 1 | 6 | 5 | 5 | 11 |
| 133 | Blue metal ... ... ... ... ... ... ... | 0 | 5 | 0 | 1 | 0 | 0 |
| 134 | *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 3 | 0 | 0 | 3 |
| | Depth to sole of *main* drifts ... ... ... | 181 | 2 | 9 | 181 | 0 | 2 |
| 135 | Hard blue metal stone and post girdles ... ... | 2 | 1 | 10 | | | |
| 136 | White post ... ... ... ... ... ... ... | 3 | 3 | 5 | | | |
| 137 | *East Pit.*<br>*Coal* ... ... ... ... ... ... ... 0 9<br>Soft thilly brown metal ... ... 0 7<br>*Coal* ... ... ... ... ... ... ... 0 8<br>... | 0 | 2 | 0 | | | |
| 138 | Black slaty metal ... ... ... ... ... ... | 0 | 0 | 3 | | | |
| 139 | Gray metal stone ... ... ... ... ... ... | 0 | 0 | 9 | | | |
| 140 | Gray post ... ... ... ... ... ... ... ... | 0 | 0 | 9 | | | |
| 141 | In gray metal stone ... ... ... ... ... ... | 0 | 3 | 0 | | | |
| | Total depth ... ... | 188 | 2 | 9 | 181 | 0 | 2 |

Gosforth colliery is situated about seven miles and a half west from the sea-coast at Cullercoates, and two miles north of Newcastle. The section of this mine is peculiarly interesting in a geological point of view; not only from the great number of strata passed through, but owing to the shafts, by which the coal was won, being sunk on the south side of the main dyke, and the coal obtained by a drift driven due north through it. This mode of coming at the coal, I believe, was adopted for the purpose of avoiding the water supposed to be accumulated in the rents and fissures in the strata towards the north, while the coal-field on the south side of the dyke was known to have been drained, by the Heaton and other engines, to the dip of the Gosforth mine. The true inclination of the dyke, and the depth to which the strata have been depressed by it, have never been so accurately ascertained as at this place; and the following particulars, obtained on the spot, are to be relied upon. The distance of the West Pit to the south brow of the dyke is three hundred and fifty yards. The breadth of the fissure, which is filled with soft blue metal (argillaceous shale), having irregular pieces of white post (hard sandstone) imbedded in it, is four feet. The fissure hades towards the north at an angle of 37°, and ranges nearly from east to west. For the first three hundred yards from the pit, the strata rise at a pretty uniform and moderate rate towards the north; they then begin to bend down, and continue to dip gently close up to the fissure.—The following is the section of the beds where they come in contact with the south side of the dyke.

| | Feet. | Inches. |
|---|---|---|
| White post next the roof | 1 | 0 |
| Blue metal | 0 | 5 |
| Coal | 0 | 9 |
| Thill (fire-clay) | 2 | 0 |
| Coal | 0 | 2 |
| Thill | 3 | 5 |
| The height of the drift | 7 | 9 |

Immediately on the north side of the fissure the following beds presented themselves:—

| | Feet. | Inches. |
|---|---|---|
| Coal at the top of the drift | 3 | 3 |
| Thill | 0 | 8 |
| White post | 3 | 6 |
| The height of the drift | 7 | 5 |

The high main coal was first cut at the distance of five hundred and eighty-four yards from the pit, and it was here found rising to the north at the rate of nine inches in a yard, or an angle of 14° with the horizon. The strata are here thrown down to the north not less than one hundred and sixty fathoms. The depression at Montague main colliery, three miles and a half to the westward, was, several years ago, calculated at ninety fathoms (See sections in the Geological Transactions, First Series, vol. iv. pp. 34 and 36.)

[To be continued.]

## IX. *On a Method of obtaining Homogeneous Light of great Intensity.* *By* H. F. Talbot, *Esq. M.P. F.R.S.*[*]

As it is a desideratum[†] in optical science to procure *perfectly* homogeneous light of sufficient brightness for many important experiments, I am glad to be able to communicate a method which in a satisfactory manner supplies that deficiency.

It is only requisite to place a lump of common salt upon the wick of a spirit-lamp, and *to direct a stream of oxygen gas* from a blowpipe upon the salt. The light emitted is quite homogeneous, and of dazzling brightness. If instead of common salt we use the various salts of strontian, barytes, &c. we obtain the well-known coloured flames, which are characteristic of those substances, with far more brilliancy than by any other method with which I am acquainted.

## X. *Reviews, and Notices respecting New Books.*

*The Alphabet of Scientific Chemistry for the use of Beginners.* By James Rennie, M.A. Professor of Zoology in King's College, London, &c.

We shall not enter into a minute examination of this work, but offer a few observations, which may preserve the public from being led to suppose, that because the author is Professor of Zoology in King's College, he is competent to write on the subject of Chemistry.

In page 76, in treating of nitric acid, a gas is mentioned which we never heard of before; it is called *nitric gas.* Now if this term has any meaning, it must be nitric *acid* gas; but unluckily this acid does not exist in the aëriform state. Further on, it is stated that this nitric gas combines with oxygen to form nitrous acid;—of course for nitric gas, we must read nitric *oxide* gas; indeed a note serves to correct this blunder of the text.

After speaking of the nitric and nitrous acids, the author says, that "with smaller proportions of oxygen, two other acids are formed, the hyponitric, and the hyponitrous acids." No such acid as the hypo-

---

[*] Communicated by the Author.

[†] See the following remarks by Professor Airy, in the Philosophical Magazine for January last, p. 29:—"I have made no experiments here with homogeneous light, and I know that, on account of its extreme faintness, *however obtained*, little confidence can be placed in results," &c. &c.

Also, at p. 164, Professor Airy says that it is well-known "how faint is light of any reasonable degree of homogeneity."

nitric is known; we have then "nitrous gas, popularly laughing gas." Now nitrous gas means nitric oxide gas; and if Prof. Rennie will attempt to breathe it, he will probably term it in the next edition, *choking gas*, if he should survive the experiment. We are further instructed, that this nitrous gas may be prepared "by exposing *liquid* nitric oxide for some days to the action of iron filings." This is the first time we have heard of the liquefaction of nitric oxide gas. Mr. Faraday failed in the attempt to render it fluid. In p. 77 the "laughing gas" is again called nitrous gas.

In page 78 we learn that arsenious acid "is sweet, a circumstance which has occasioned cases of poisoning, by children mistaking it for white sugar." Dr. Christison assures us that he and several of his scientific friends (Prof. Rennie of course not present,) all agreed "that it had hardly any taste at all,—perhaps towards the close a very faint sweetish taste."*

In p. 85 we have a new description of sulpho-salts. "The compounds, to which Berzelius has given the name of sulpho-salts, have a metallic base, combined with a double proportion of sulphuric acid;" and in a note it is stated that compounds containing this proportion of sulphuric acid are called "double sulphurets." Here is "confusion worse confounded:" first, sulpho-salts do not contain sulphuric acid at all; secondly, if they did contain a double portion of it they would not be double sulphurets, but bisulphates. Orpiment, we are informed, is a compound "of sulphuric acid and arsenic;" it contains no sulphuric acid; but if it "be dissolved in solution of potass, the oxygen of a portion of the potass unites with the arsenic, forming arsenious acid," &c. Now if the arsenic were combined with sulphuric acid, it must be already in the state of oxide or arsenious acid, and consequently would not take oxygen from the potash to become so.

In page 145 we have a tissue of blunders: it is asserted that if in a salt "the acid was in excess, the term *super, hyper*, or *per* was placed before it, as *per*sulphate of mercury." The term *per* has no relation to the quantity of acid in a salt, but indicates the quantity of oxygen in its base; persulphate of mercury means not supersulphate of the protoxide of mercury, but sulphate of the peroxide. Once more; "when the acid was deficient, and the base in excess, the term *sub* or *hypo* was placed before it, as *sub*sulphate of potass." No such salt as subsulphate of potash is known, nor (we believe) was ever supposed to exist. Again; the term *hypo* was never employed as described, it designates the relative proportion of oxygen in the acid of a salt, but has nothing to do with the quantity of the acid; *hypo*sulphate of potash means a compound of hyposulphuric acid and potash, not the Professor's imaginary subsulphate. More yet; "what was formerly termed *per*sulphate of potass, is now *bi*sulphate of potass"; *per*sulphate of potass was never used to express bisulphate; it means a sulphate of the peroxide of potassium, which cannot be formed, and the term has therefore never been employed at all.

These are a few of the blunders in this miserable abortion.

---

* See Phil. Mag. and Annals, N.S. vol. viii. p. 277.

# XI. *Proceedings of Learned Societies.*

## ROYAL SOCIETY.

IN our last Number we gave a list of the papers read before the Royal Society from the 13th of December 1832 to the 2nd of May 1833, both inclusive; and we now give abstracts of some of those papers.

1832. Dec. 13.—A paper was read, entitled, "On the extensive atmosphere of Mars." In a Letter to His Royal Highness the President. By Sir James South, Knt. F.R.S.

In this paper the author gives an account of a further observation which corroborates the conclusion he had stated in a former communication "On the extensive atmosphere of Mars*," namely, that no indication now existed of any atmosphere being attached to that planet. A star retained its light blue colour, and its full brilliancy and comparative steadiness, till the very instant of its occultation by Mars. At its emersion it was seen nearly dichotomized. The author concludes, that either some physical change has occurred in the atmosphere of that planet, or that the observations of Cassini and of Roemer were inaccurate.

A paper was also read, entitled, "On the Law which connects the various Magneto-electric Phænomena lately discovered by Dr. Faraday." By the Rev. William Ritchie, LL.D. F.R.S. Professor of Natural and Experimental Philosophy in the Royal Institution of Great Britain, and Professor of Natural Philosophy and Astronomy in the University of London.

The general principle from which the author deduces the law in question, is that of the equality of action and reaction. The application of this principle to electro-magnetism, he thinks, may be thus expressed:—since a current of voltaic electricity can, in certain circumstances, induce magnetism, magnets will, in similar circumstances, induce similar voltaic currents. He gives an account of several experiments in confirmation of the universality of this law.

A paper was then read, entitled, "An Account of an extraordinary Meteor seen at Malvern, November 12, 1832." By W. Addison, Esq. F.L.S. Communicated by W. G. Maton, M.D. V.P.R.S.

The author beheld, from the Malvern Hills, a constant succession of meteors, of various degrees of magnitude and brilliancy. The smaller ones were like those commonly called shooting stars, and left behind them, for a moment, a train of pale yellowish light. Others were much more brilliant, and notwithstanding the bright moonshine threw a strong glare upon every object: they always commenced as a small luminous point, rapidly increasing in size and splendour, shooting with great swiftness over a considerable arc, and then, suddenly disappearing, left behind them a long train of very vivid white light, which slowly changed into a pale yellow. The author witnessed this scene for upwards of an hour, although it was still going on when he

---

* An abstract of this paper was given in Phil. Mag. and Annals, N. S., vol. x. p. 300.

left it. At one time he counted forty-eight of these meteors during the interval of five minutes.

Dec. 20.—A paper was read, entitled, "On certain properties of Vapour." By the Rev. Dionysius Lardner, LL.D. F.R.S.

It has been generally supposed, that if a certain volume of aqueous vapour, contained in a vessel that was incapable of transmitting heat, were compressed by an exterior force into a space sufficiently small, a part of it would be restored to the liquid state. The author considers this assumption to be at variance with the doctrine of latent heat, and inconsistent with the results deduced from the experiments which have established that the absolute quantities of heat necessary to convert a given weight of water into steam, under all pressures, are sensibly equal. It follows, from this principle, that steam raised from water, under any pressure whatever, admits of indefinite compression and expansion, without returning to the liquid state. The effect of its compression will be to evolve heat and raise the temperature; that of its expansion, to absorb heat and lower the temperature: but in every state of density it will have exactly that temperature which it would have were it immediately raised from water under the pressure which it has acquired by compression or expansion. The only cause of the restoration of vapour to the liquid form is the abstraction of heat from it; and this cause will be equally operative, whatever may be the state of the vapour with respect to density: but compression alone, without such abstraction of redundant heat, can never convert any portion of vapour into a liquid. In accordance with these views, the author regards the permanent gases as vapours, containing a large quantity of redundant heat.

1833. Jan. 17.—The reading of Mr. Faraday's paper, entitled, "Experimental Researches on Electricity, Third Series," was resumed and concluded.

The object of the inquiries of which an account is given in the present paper, is to establish the identity of the electricities derived from different sources. The author was induced to investigate this subject, because doubts have been frequently expressed as to the accuracy of some experiments from which the identity of the common and voltaic electricities is inferred: and distinctions have been drawn between them, as if they were different forms and modifications of one common power. In order to examine the question in all its bearings, he arranges the phænomena under two general heads; namely, those arising from electricity in a state of equilibrium, or *tension,* as it has been called; and those which are the consequence of its *motion,* when that equilibrium has been destroyed. The visible effects of electricity of tension are attractions or repulsions at sensible distances; those of electricity in motion are the evolution of heat, the production of magnetism, chemical decompositions, physiological changes, and, lastly, the evolution of light in the form of a spark. The author proves, by experiments, that every one of these phænomena takes place from the operation either of ordinary or of voltaic electricity; the degree in which they are produced depending on the different circumstances of quantity, of intensity, and of velocity, attendant on the different modes in which electricity has been excited and supplied. Thus no difference was found to exist in the mode in which a Leyden battery charged with ordinary electricity, and a voltaic battery, were discharged, when the comparison was made by means of fine points, nicely arranged and approximated, either through air of the ordinary temperature, or through heated air, such as the flame of a spirit-lamp, interposed between the points.

By the term *current*, the author designates any progressive change, of whatever nature it may be, in the electric state, whether consisting in the motion of one electric fluid in a particular direction, or of two fluids in contrary directions: and by the term *arrangement*, he understands a local adjustment of particles, or fluids, or forces, not progressive.

By *ordinary electricity*, he understands that which can be obtained from the common electrical machine, or from the atmosphere, or by pressure, or cleavage of crystals, or similar mechanical operations; its character being that of great intensity, and the exertion of attractive and repulsive forces, not merely at small but also at considerable distances. The parallel between voltaic and ordinary electricity is then pursued by the production of evidence that those attractions and repulsions, which were thought to characterize the latter, are exhibited also by the former; and that, on the other hand, ordinary electricity, when in motion, gives rise to an increase of temperature, to magnetic phænomena, to chemical decompositions, to physiological impressions, and to luminous appearances, precisely of the same kind as those which had been supposed to be the peculiar effects of voltaic electricity. The experiments of Mr. Colladon, which seemed to show that a stream of common electricity has power to produce the deflexion of a magnet,—a conclusion which has hitherto rested on the single testimony of that experimentalist,—have been repeated and extended by Mr. Faraday, who completely confirms their accuracy, and the truth of the result that had been obtained from them. The author succeeded in making common electricity assume more of the characters of voltaic electricity, by availing himself of the retarding power of bad conductors interposed in the electric circuit. In this way he easily succeeded in obtaining the same decisive evidence of chemical action by common electricity as Dr. Wollaston had done in his experiment. But Mr. Faraday considers the experiment in which water is decomposed by this power, as affording no proof of electro-chemical agency; because, as Dr. Wollaston had pointed out, both oxygen and hydrogen are evolved at each of the points of the interrupted circuit, and not separately at the respective poles. The author regards the amount of electro-chemical decomposition as being proportional, not to the *intensity*, but to the *quantity* of electricity transmitted. It is not effected by electricity passed from the machine in sparks, although these tend to decompose water into its constituent elements. Some experiments of Bonijol on the decomposition of water by atmospherical electricity, are commented on by the author, who considers them as analogous to the experiment of Dr. Wollaston already referred to. Mr. Faraday also makes some remarks upon Mr. Barry's paper in the Philosophical Transactions for 1831, and suggests doubts of the soundness of the inferences he draws from his experiments*.

The author then proceeds to examine the electrical phænomena elicited by magneto-electricity, and shows that, as far as they have been observed, they coincide with those of voltaic electricity, and, consequently, are referrible to the same agency. The only effects that have not yet been obtained are chemical decompositions. The quantities of thermo-electricity that can be elicited in ordinary cases are too small to produce any effects but those of magnetism, and also muscular contractions in the limbs of frogs. The animal electricity of the torpedo produces most of the effects of voltaic electricity, excepting the evolution of heat and light. The general conclusion deduced by the author from these researches is, that electricity, whatever be its source, is perfectly identical in its nature.

In the concluding chapter of the present paper, the author endeavours to establish some relation by measure between common and voltaic electricity. He shows, by experiment, that whenever the same *absolute quantity* of electricity, whatever be its *intensity*, passes through the galvanometer, the deflecting force exerted upon the magnetic needle is invariably the same. Hence this deflecting force may be taken as the measure of the absolute quantity of transmitted electricity; a principle which establishes the value of the galvanometer as an instrument of measurement in all cases of electricity in motion. The power of chemical decomposition he finds to be also directly as the quantity of transmitted electricity.

Feb. 7.—A paper was read, entitled, "On the relation which subsists between the Nervous and Muscular Systems in the more perfect Animals, and the nature of the Influence by which it is maintained." By A. P. W. Philip, M.D., F.R.S. L.& E.

The author, after referring to his former papers which have at different times been read to the Royal Society, and published in their Transactions, is led to view the brain and spinal marrow as the only active parts of the nervous system; the nerves, whether belonging to the class of cerebral or ganglionic, together with their plexuses and ganglions, serving only as the means of conveying and combining the various parts of the former organs, and therefore being passive with reference to their functions. This view of the subject is directly opposed to that which has been adopted by many physiologists, who consider these ganglions as the sources, and not the mere vehicles, of nervous influence. In order to determine this point, the author made the following experiment on an animal that had been pithed so as to destroy its sensibility, while the action of the heart continued. Under these circumstances, he applied mechanical irritation, and also various chemical agents, to the ganglions and plexuses of the ganglionic nerves, and found that the heart continued to beat with the same regularity as before, and with the same frequency of pulsation. From these and other observations, the author concludes that the ganglionic system of nerves, with their plexuses and ganglions, performs the office of combining the influence of every part of the brain

---

* An abstract of Mr. Barry's paper appeared in Phil. Mag. and Annals, N.S. vol. ix. p. 357.

and spinal marrow, and of bestowing it on the muscles of involuntary motion, these muscles being subservient to those functions of life which require that combined influence; that the manner in which the influence of these organs affects the muscular fibre is not essentially different from that of other stimulants and sedatives; and that this influence is not an agent peculiar to the nervous system, but is capable of existing elsewhere, and is consequently not a vital power, properly so called; a conclusion which appears to him to be confirmed from the circumstance that galvanism is capable of performing all its functions. Hence he infers that the brain and spinal marrow, far from bestowing on the muscular fibre its peculiar power, only supplies an inanimate agent, which, like all other such agents, capable of affecting it, acts on it either as a stimulant or sedative, according to the degree in which it is applied, and is identical with the galvanic influence.

Feb. 14.—A paper was read, entitled, "On the Existence of four distinct Hearts, having regular Pulsations, connected with the Lymphatic System, in certain Amphibious Animals." By John Müller, M.D., Professor of Physiology in the University of Bonn. Communicated by Leonard Horner, Esq., F.R.S.

The author had long ago observed, that, in frogs, there exists, immediately under the skin, large spaces containing lymph, whence it can be readily collected by making incisions through the skin. These receptacles for lymph are larger in the frog than in the other amphibia: but all the animals of this class appear, from the observations of the author, to be also provided with remarkable pulsating organs, which propel the lymph in the lymphatic vessels, in the same way as the heart propels the blood circulating in the arterial system. In the frog, two of these lymphatic hearts are situated behind the joint of the hip, and immediately underneath the skin. Their contractions are performed with regularity, and may be seen through the skin; but they are not synchronous either with the motions of the heart, or with those of the lungs, and they continue after the removal of the heart, and even after the dismemberment of the animal. The pulsations of these two organs on the right and left side are not performed at the same time, but often alternate at irregular intervals.

The author proceeds to trace the connexions of these cavities with the lymphatic vessels in the neighbourhood, and with one another: and it appears from his researches, that the lymph of the hinder extremities, as well as that of the posterior part of the abdomen, is conveyed by means of these hearts into the trunk of the crural veins. He also gives a description of the posterior part of the venous system of the frog, noticing particularly the large transverse anastomosis between the sciatic and the crural veins, which joins the anterior median vein of the abdomen, and conducts the blood partly into the vena portæ, and partly into the renal veins.

Professor Müller has likewise discovered two anterior lymphatic hearts in the frog; a discovery to which he was led by some observations of Dr. Marshall Hall, who stated that he had seen in that animal an artery pulsate after the removal of the heart. These anterior lymphatic hearts lie on each side upon the great transverse process of the third vertebra, immediately under the posterior end of the scapula, and they are nearly as large as the posterior hearts. They receive the lymph of the anterior parts of the body, and probably also that of the intestinal canal, in order to transmit it into contiguous veins, which pour their contents into the jugular vein. The author has discovered similar organs in the toad, the salamander, and the green lizard; and is of opinion that they exist in all the amphibia.

## GEOLOGICAL SOCIETY.

[*President's Address, concluded from p.* 475.]

General Geology and Physical Geography.—Geologists have long felt that a period would arrive, when every geographer would seek to obtain a competent acquaintance with what may be termed the anatomy of his subject; and it is therefore gratifying to remark, that the past year has been prolific in works explanatory of the intimate association of geology with the physical geography of Great Britain.

England.—The encouragement which, at the suggestion of Colonel Colby, the Board of Ordnance has afforded to all the surveyors who, during their labours in the field, have kept a register of the mineral changes accompanying variations of outline in the land, is now producing the happiest results.

Mr. Wright has already given us ample proof of this, in the geological delineation of a tract of country around Ludlow, which, from repeated personal examination, I can testify to be a model of accuracy.

Mr. Maclauchlan, another of our Fellows, attached to the Ordnance Survey, has with equal success illuminated a much larger surface of the Ordnance maps, comprehending the Forest of Dean, and the central parts of Herefordshire. His details respecting the rich coal-field in the Forest of Dean are of singular value, being derived from the observations of so experienced a miner as Mr. Mushett.

Our Society has further been most advantageously connected with the Ordnance Survey, by the appointment of Mr. De la Beche to affix geological colours to the maps of Devonshire, and portions of Somerset, Dorset, and Cornwall. From our acquaintance with the skill of this geologist, and from his long practice in the districts which he has undertaken to represent, it is certain that he will furnish many striking examples of the value of well-defined physical features, in enabling the geologist to explain the relation of the present outline of the land to ancient subterranean movements.

The adoption of a fixed scale of colours by all English geologists is still an essential desideratum in this department; and I am happy to have it in my power to state, that a systematic arrangement will shortly be submitted to you, after it has undergone the supervision of our Council, and shall have met with the approval of the Board of Ordnance. This scale, being founded on the principle of employing such colours only as are fixed and distinct from each other, has been suggested by our valued member Mr. Chantrey, who, by this highly useful appropriation of his leisure moments, has augmented those claims upon our gratitude which he had established by many acts of good fellowship, and the devotion of his time and talents to our cause.

Through the early investigations of William Smith, the oolitic series was divided into sub-formations; and, by the subsequent adoption of these subdivisions by Conybeare, their provincial names have become classic throughout Europe, and have served to commemorate the discernment of him who first taught us to identify strata by their organic remains.

At the last anniversary it was announced that, with entire confidence in his qualifications, your Council had fixed upon Mr. Lonsdale to commence a task, the prosecution of which they conceived to be strictly consonant to the spirit of the bequest of the lamented Wollaston; by which we are endowed with the means of rewarding those who enlarge the circle of geological knowledge. Mr. Lonsdale has presented us with the result of his labours, having laid down upon maps of the Ordnance Survey the range of different members of the oolite, from the neighbourhood of Bath, where he had previously developed their relations, to the southern limits of Warwickshire and Oxfordshire. The success attendant upon this undertaking has already been made apparent in the maps, sections, and remarks of our Curator. By these you will perceive he has already demonstrated that the upper shale and marl-stone of the lias, which are only visible as mere beds in the neighbourhood of Bath, swell out rapidly in their north-eastern course, and soon assume the same characters which Mr. Phillips has assigned to them in Yorkshire. He next establishes that the whole of the fine-grained white oolite in the escarpment of the Cotteswold Hills, although lithologically undistinguishable from the great oolite of Bath, is only an expansion of the inferior oolite. It is then made apparent that the Fuller's earth disappears entirely to the north of Gloucestershire; and the highest degree of interest is added to these groups, by determining, for the first time, the true position of the Stonesfield slate, which he shows to be the base of the great oolite; thus removing it from the geological horizon, in which, from the obscure sections at Stonesfield, it had before been placed. Such are a few of the evidences of the good already derived from the revision of this series of our formations by a geologist like Mr. Lonsdale, who, to the eye of an unerring observer, adds the rare qualifications of a thorough acquaintance with specific distinctions in organic remains.

But the value of such a work is not to be measured by reference to English geology alone; for, if it be now ascertained that the oolitic groups are made up of members which inosculate with each other, expanding to vast thicknesses, or thinning out entirely, within the limited range of two counties; and that even its principal formations cannot be followed into Yorkshire, still less to Brora and the Hebrides, without exhibiting great changes in their mineral and fossil contents; we can scarcely hope to identify each subordinate member of our own country with the subdivisions of the series on the continent of Europe. I willingly express this opinion, although it may seem to be slightly at variance with a surmise I ventured to advance last year respecting the age of the lithographic stone of Solenhofen. That comparison was intended simply to afford the English geologist an approximate idea of the age of a rock, which, by some of my countrymen, had been considered as of tertiary origin, by others, as belonging to the greensand; so that if my rough estimate should prove less accurate than that of a distinguished Prussian [*], who has since compared it with the coral rag, I shall still feel satisfied in having first pointed out to the English inquirer, that the Solenhofen slate is a member of the Jurassic or oolitic system, and that, from the general similarity of many of the organic remains, such as Pterodactyli, Crustaceæ, and certain plants, it is probably the equivalent of the Stonesfield slate, or one of the central and slaty members of this complex series. On a broad scale, however, I feel persuaded, that a simple division into "*upper*" and "*lower*" oolitic systems is the full extent to which we can bring continental and British formations of this age under comparison.

To Dr. Fitton we are indebted for his "Notes on the Progress of Geology," in which the relative merits of the founders of the science in England are well put forth; and also for his "Geological Sketch of the Vicinity of Hastings," a most valuable addition to those local monographs which contribute so largely to the diffusion of precise information. I rejoice to see this powerful geologist once more before us as an author, and still more when it is announced, in this last useful work, that a series of figures, including all the undescribed species of the shells of the Wealden formations, will appear in the volume of the Geological Transactions now in the press, with a comprehensive Memoir upon the formations between the chalk and the oolites, the publication of which has been so loudly called for by foreign and native geologists.

The results of my own observations during the last two summers are about to be offered to you, in a detailed description of the upper fossiliferous grauwacke, and its relations to the overlying deposits, with descriptions of the intrusive rocks by which the series has been penetrated. The zone examined, comprehends the western parts of Shropshire and Herefordshire, and passing to the south-west, through Radnor and the wildest tracts of Brecknockshire, terminates in the mouth of the Towey in Caermarthenshire. As considerable spaces within this zone have not yet been laid down for publication in the Ordnance map, it is obvious that without the extraordinary aid, which has been so cheerfully afforded me by Capt. Robe, and other officers of His Majesty's Map-office, and also by that excellent field surveyor Mr. Budgin, little progress could have been made in the performance of a work, which, when completed, will I trust meet with your approbation [†].

---

[*] Von Buch.

[†] This memoir owes the most valuable portion of its zoological illustrations to the Rev. T. Lewis of Aymestrey. Colonel Wingfield, Dr. Dugard, the Rev. I. Rocke, Mr. Jones, and Dr. Lloyd, have also contributed to throw light on the structure of their respective neighbourhoods in Shropshire. The last gentleman has been fortunate enough to discover the remains of Trilobites in the old red sandstone.

In the communication explanatory of these coloured maps, I hope to prove that the old red sandstone, with few exceptions, passes down into, and is conformable to, those rocks, to which we have been accustomed to apply the term "Transition;" and that, throughout great areas, the old red sandstone is equally conformable to the overlying carboniferous limestone as to the underlying grauwacke;—that the fossiliferous grauwacke is divided into a number of large natural formations or groups, charged with a variety of organic remains, for the most part undescribed. In tracing the lines of disturbance which have affected these deposits, flexures upon a gigantic scale will be pointed out, whereby the old red sandstone has been thrown into basins of elevation, and, by a reversed inclination, extended to the westward, far within the escarpment of the grauwacke; and these lines of disturbance and elevation will then be delineated, and their relation traced to ridges of intrusive rocks.

Whatever merit these observations may possess, they cannot but derive value from being linked with the contemporaneous investigations of Professor Sedgwick, amid the adjoining regions of grauwacke, slate, and older rocks of the Welsh mountains.

This will become evident when the Professor shall exhibit to you the directions of those extensive anticlinal and synclinal lines which he has determined with much personal labour, though unaided by good geographical data. It will then be shown by him at what periods igneous action has been in operation within these older rocks; whilst it will be my province to point out how these outbursts have been succeeded, on the eastern frontiers of the principality, by other linear, submarine eruptions, and to describe the effects produced by them upon the different sedimentary strata.

These results must, however, only be viewed as the first attempts, on the part of Professor Sedgwick and myself, to reduce to chronological order a vast succession of ancient deposits, which have hitherto been much neglected in this country, on account, as we may suppose, of the alleged obscurity of their organic remains, and still more, perhaps, in consequence of their altered condition, due to the numerous convulsions to which they have been subjected.

IRELAND.—We have been favoured with two communications upon the geological structure of parts of the North of Ireland, illustrated by excellent maps, constructed by the authors. In one of these, Mr. A. Bryce, of Belfast, describes the north-eastern portion of Antrim, in which he points out a much larger extent of mica schist than had been noticed by former observers. These primary rocks are succeeded, in ascending order, by ancient red conglomerates, partial carboniferous deposits, new red sandstone, lias, greensand, and chalk. He mentions porphyry as only associated with the older red sandstone; and basalt, as overlying the chalk, all the important peculiarities of which have been so well detailed by Conybeare and Buckland.

The other Memoir upon Ireland is from the pen of Archdeacon Verschoyle, and is much more comprehensive, describing the north-west coast of Mayo and Sligo. The accompanying map is of considerable value, the geographical features having been obtained from the Ordnance surveyors; chiefly, I believe, through the intervention of Capt. Portlock, R.E.

The Archdeacon shows that this region has for its mineralogical axis a mountainous range of mica schist, and other primary rocks, the overlying deposits consisting of partial conglomerates, succeeded by the carboniferous limestone and unproductive coal measures,—the former containing, as in many parts of England, a lower limestone shale and an oolitic limestone. In describing the rocks of intrusive character, this author is to be much commended for having traced, with precision, the course of no less than eleven basaltic dykes, within a zone of eleven miles in breadth; which are parallel to each other, trending nearly W. to E., and striking through all the rocks of the district—one of them being observable for the distance of 60 to 70 miles.

With such works as these before us, we may feel assured that the day is not far distant, when a manual of the structure of the whole of our sister kingdom may be compiled. This useful work will doubtless be achieved by the efforts of the members of the new Geological Society of Ireland, who in the mean time will, it is hoped, extend their discoveries to Galway, and such tracts as have not been examined by Weaver, Griffiths, and other good observers.

ROCKS OF IGNEOUS ORIGIN.—Two of our Foreign Members have, in the past year, favoured us with communications, both of which relate to igneous action.

Signor Monticelli, of Naples, has noticed, in one of the largest and most ancient currents of Vesuvius, called La Scala, that besides the appearances of regular stratification which the lava possesses, as formerly observed by Breislac, it presents, when still more deeply cut into, a curvilinear arrangement, proving that these masses have been formed in concentric layers around an elliptical nucleus.

Professor Necker of Geneva, reviving and extending an ingenious hypothesis of Dr. Boué, has led the way in attempting to bring under a general law the relation of metalliferous veins and deposits to those crystalline rocks which, by the great majority of modern geologists, are considered to have been produced by fire.

Humboldt had indeed already expressed his belief that the mines on the flanks of the Oural, being associated with porphyritic and granitoid rocks, have resulted from former volcanic agency; and Professor Necker now cites many additional authorities, to show similar juxta-positions in other parts of the world. Whether the doctrine of sublimation, suggested by the author as the best explanation of this problem, can be sustained, is very doubtful; since the case which first led him to a contemplation of these general views,—a deposition of specular iron on the surface of a stream of Vesuvian lava, is one which, having taken place under the terrestrial atmosphere, may have been due to a cause which could scarcely have been co-existent with submarine or deeply-seated subterranean phænomena. Such difficulties, however, instead of checking, ought rather to stimulate us to pursue with vigour this animating train of inquiry, by gathering together data responding to the queries of M. Necker, and by pointing out with equal fidelity all those districts which come within the application of his theory, as well as those great metalliferous tracts, in which as yet no trace of contiguous, unstratified rock has been observed. Why are we to shrink from the supposition, that in this, as in the production of other phænomena, nature may not have employed various means, when it is known that a distinguished French chemist *, imitating her energies, has succeeded in producing simple minerals by the direct union of their constituents. If, therefore, the ingenuity of a second Hall should demonstrate the very manner in which volcanic forces, under great pressure, may have produced effects analogous to those of sublimation beneath the common atmosphere, there are still wide fields for experiment. For who can venture to expound all the possible effects of those changes depending upon the laws of electro-magnetism, which must have been evolved by the varied actions of the elements, brought into play during those movements by which the land and sea have changed their places?

In the mean time, the Essay of M. Necker must be regarded as an excellent stimulant to research; and judging from my own limited experience, and particularly from facts observed in the mining districts of the west of Shropshire during the last summer, I should infer, that England will not be found deficient in phænomena amply corroborative of the views of Humboldt, Boué, and Necker.—Mr. Henwood has long been engaged in an inquiry, the objects of which cannot be too much commended; and you have already heard the result of a considerable number of his most laborious investigations. It would appear from these that he has already ascertained that the phænomena of the mineral veins of Cornwall, do not come under those general laws to which they have been referred by the native miners. As, however, his labours are still in progress, it would be premature to speak of the consequences to which they point, before the whole of them are given to the public.

I am here naturally led to speak of a work upon the Geology of Cornwall, by Dr. Boase, composed of two parts, the former of which contains most instructive and valuable detail, collected with indefatigable industry, and is a most important addition to our previous knowledge of the structure of that portion of our island. The Second Part, though supported by arguments conducted with skill, and tending consistently to one leading object, is directly opposed to the opinions of nearly all modern geologists. Dr. Boase differs from previous observers, who conceived that certain granitic veins which ramify through the slates have been injected into the latter; and supposes, since many of these veins are made up of the same ingredients as the surrounding slate, that the whole is of common and contemporaneous origin, the veins being merely crystalline segregations. Now, without denying the existence of many contemporaneous and segregated veins in Cornwall as in other countries, surely no one can at this day resist the accumulated mass of evidence adduced by Allan, Sedgwick,

---

* Berthier.

Dechen, Oeynhausen, and a host of geologists, which indicates the posterior intrusion of such veins as branch upwards from large bodies of granite, and ramify in thin filaments through the overlying killas. If, however, granitic veins be formed by segregation, and if the masses of schist within a granite vein are but portions of that vein under a different state of development, by what happy accident, we would ask, do the angles of the entangled fragments accord with each other, or with those of the wall of the vein itself? Concretions with some approximation to regular forms, may have separated themselves chemically from mineral masses to which they are subordinate: but no mode of chemical action can offer us an intelligible explanation of the angular fragments of killas imbedded in the granite veins of Trewavas Head and other parts of Cornwall. They can be explained rationally only on the supposition of the mechanical protrusion of the vein itself into the mass of the pre-existing slate-rock. But Dr. Boase extends the horizon of his speculations: he will not even concede that the dykes of porphyry and elvan in Cornwall afford any proofs of igneous origin or of subsequent intrusion; and rising with his favourite hypothesis into hostility to every operation of fire, he at length avows himself sceptical as to the volcanic origin of all trappæan rocks. Whatever may be the value of the arguments applied to Cornwall, they must be seriously weakened by a mode of reasoning which compels the author to deny the existence of phænomena which may really be considered as mathematically demonstrated, and which are now registered among the fixed principles of the science. If Cornwall does not offer clear proofs of the igneous origin of any of its rocks to the eye of Dr. Boase, why does he not seek to verify or reject his theoretical inductions by an appeal to countries where the evidences are clearer? Let him visit Scotland, and inspect all those appearances of intrusive granite, which have long since been recorded by the approving testimonies of Hutton, Hall, Playfair, and Seymour; and let him follow MacCulloch through the Hebrides, and then inform us whether he has not been led to a modification of his views. But if these evidences should not produce the expected result, I would urge him to travel into central France, where in one limited district is seen a succession of epochs of igneous intensity, from the oldest trappæan rocks to modern basaltic lavas, demonstrating that all these have originated in a succession of similar volcanic causes. Notwithstanding, however, the discrepancy between the views of Dr. Boase and those of most modern observers, I repeat that his work being the result of long-continued examination, is well worthy of your study from the valuable facts which it presents.

In the mean time, permit me to notice how the evidences of former volcanic agencies have lately been operating upon the minds of observers in distant parts of the world. In a recent work by Messrs. Jackson and Alger upon the Geology and Mineralogy of Nova Scotia, the authors acknowledge that in the commencement of their survey they were biassed in favour of the Wernerian theory; but when they met with repeated instances of sedimentary deposits, suddenly altered and rendered crystalline, and of vegetable remains charred when in contact with trappæan rocks; and when they also found these latter rocks possessing all the intrusive characters assigned to them in Europe,—they became satisfied of the insufficiency of the aqueous system, and upon conviction, embraced the igneous theory as affording the only satisfactory solution of such phænomena.

The student who seeks for further evidence upon this subject, may advantageously consult the Synopsis lately published by Professor Leonhardt of Heidelberg, in which many of the well-authenticated phænomena attesting the effects of igneous action have been grouped in so clear a manner as to leave no escape from the inferences upon which I have been insisting.

Colonel Sykes, after a long residence in Hindostan, has presented us with a circumstantial account of the structure of the Deccan or hilly region of the Peninsula to the east of Bombay. This tract, it appears, is very similar to the other extremity of the vast trap region which was described by Major Franklin, being exclusively composed of trappæan rocks, which offer many varieties in mineral composition. These rocks rise in tabular forms from low terraces upon the coast, until they attain heights from 4000 to 6000 feet in the interior: the profound chasms by which they are fissured are occupied by the rivers, and their hardest and loftiest protuberances afford those strong natural defences of the natives, known to Europeans under the name of Hill Forts. In these step-like table-lands are the remnants of volcanic outbursts of successive periods, presenting further analogies to known igneous productions in dykes of columnar basalt which have been injected vertically through the horizontal currents. According to the observations of Colonel Sykes and of his precursors Capt. Dangerfield and Dr. Voysey, these igneous phænomena extend over 250,000 square miles; so that the mind is almost lost in the contemplation of their grandeur: unfortunately, the relative age of these eruptions must remain for the present undetermined, no vestiges of secondary or tertiary formations having been detected within the region described.

Although that interesting small tract of extinct volcanos the "Eifel," had been partially made known to the English reader by Dr. Daubeny and Mr. Poulett Scrope, an adequate knowledge of it could be obtained only by consulting the works of several German writers*. Our learned associate Dr. Hibbert has now presented us with an account of the same district, under the title of "History of the Extinct Volcanoes of the Basin of Neuwied," to complete which he has devoted two years of assiduous, personal exertion. In recommending this volume to your study, I may express my regret that the author should not have first distinctly laid before us a clear view of the mineral constitution and physical features of the district, and after-

---

* While these pages are passing through the press, I learn that Professor Hoffmann, having, on his return from Sicily, studied the relations of the marble of Carrara, has communicated to the Academy at Berlin his opinion, that this marble is of the age of the oolitic series (Jura or Alpine limestone), and has been changed by igneous operations similar to those which altered the chalk of Antrim, the lias limestone of Skye, &c. &c.

wards have deduced therefrom his ingenious theoretical views;—the more so, as his inferences are interwoven with theories of the earth, which, whether in respect to parallelism and consequent synchronism of mountain-chains, or their divergence and necessary diversity of age, are still subjects of contention among leading geologists.

Dr. Hibbert has, however, done essential service in delineating the topography and true features of this disturbed region. He has further laboured hard to impress upon us a conception of those vivid images which he has established in his own mind, as the true landscapes which this district and its environs must have successively offered to view, as well in the various periods of volcanic eruption and violence, as in those of quiescence, during which lacustrine, estuary, and terrestrial accumulations were formed. In accounting for the production of trachyte, which is so intimately connected with these ancient lake-craters, he has direct recourse to the analogies of modern volcanos, and also attempts the reconstruction of those more recent currents of basaltic lava, of which there are now left such imperfect evidences. If Dr. Hibbert has succeeded in proving the relative age of the outbursts of the various volcanic products of the Eifel from trachyte to the most modern basaltic ejections, he has accomplished a task from which his precursors have shrunk; their great difficulty consisting in the comparative absence or obscurity of all strata of secondary or tertiary age, which, if they contained distinct evidences in their organic remains, might have been deemed true historical records. In Auvergne and in the Cantal, where no such deficiencies exist, but where, on the contrary, the sedimentary strata have been elevated into mountain-masses teeming with the remains of organic life; the precise relative periods at which the intensity of volcanic action has been renewed, or suspended, is demonstrable by alternate dislocations and regularities of the associated strata. But in the Eifel, if we except the fossils of that very ancient group of rocks the grauwacke, the evidences to be gathered from organic remains in the subsequent epochs are deplorably deficient, being merely observable in thin patches of brown coal and tertiary clay, a few only of which are connected with the volcanic phænomena of this district.

That brown coal is associated with tertiary deposits of various ages is well known to those who have explored Germany and the flanks of the Alps; and the greater part of this mineral in the basin of the Lower Rhine has been referred to an early period in the tertiary series. This subject has recently been freed from much of its obscurity by the observations of our valued fellow-labourer Mr. Leonard Horner, on the Geology of the Environs of Bonn*. From this very able Memoir we learn, that notwithstanding the difficulty of assigning a precise geological age to this deposit, on account of the almost entire absence of shelly remains, yet from the imbedded fishes, frogs, and plants, which though essentially differing

---

* M. Mitscherlich is also, I am rejoiced to learn, now engaged in writing a Memoir upon this district.

from, bear a strong analogy to existing species, the brown coal of the Rhine is probably of the age of the lacustrine limestone of Aix en Provence.

Mr. Horner further throws new light upon the period of the trachytic and basaltic eruptions of the Sieben-gebirge, which, like many volcanic hills in central France, he supposes to have burst forth from beneath an ancient lake; and whilst he indicates that this ridge has been elevated posterior to the formation of the associated brown coal, he shows that one of the lake-craters on the opposite bank of the Rhine, the Rodderberg, was formed during a more recent period, probably contemporaneous with the accumulation of the loess or loamy alluvium.

We are here naturally led to reflect upon that exciting theoretical question concerning craters of elevation, which now divides the geologists of France and Germany. In France, De Beaumont, Dufrénoy, and others, contend for the establishment of the views of Von Buch and Humboldt, which refer the crateriform cavities to simple expansion of the earth's crust, caused by intumescence from within; whilst Cordier and Constant Prevost maintain that all these ancient cones and craters present in their structure a direct analogy to the products of modern volcanic agency, and have been similarly formed.

M. Constant Prevost is preparing an account of his late voyage in the Mediterranean, by which he hopes to convince us, that all the most ancient geological phænomena, of igneous characters, can alone be rationally explained by an appeal to existing evidences, thus harmonizing in his speculative views with our countryman Mr. Lyell, who, from an examination of the same districts, had before arrived at similar conclusions, and who had been among the first to combat the theory of elevation craters as applied to the Cantal and Mont D'Or*. I must for a second time allude to the forthcoming volume of this author, in which you will find descriptions of those interesting tracts, the Eifel, and of Olot in Catalonia, coupled with an abundance of striking and original observations respecting the volcanic ejections of Etna, which absolutely demonstrate, that many of our older trappæan currents must have had a similar origin.

In concluding this review of works illustrative of volcanic phænomena, I announce with delight that our secretary Dr. Turner, in cooperation with Mr. De la Beche, has commenced a series of experiments to determine the effects of heat upon various rocks, both crystalline and sedimentary, for the purpose of elucidating the modes in which some may have been formed, and others altered. The inquiry will afterwards be extended to the production of simple minerals, and will also lead to the repetition of some of the experiments of Sir J. Hall, in a field nearly abandoned in Great Britain since his successful career, although France and Germany have to boast of the important discoveries of Berthier and of Mitscherlich.

Having adverted to those works, of the past year, which may be conveniently classed under separate scientific heads, I will now briefly

---

* Principles of Geology, vol. i. p. 386, &c.

allude to a few Memoirs relating to foreign countries, which possess a general character, and yet bear upon our own Proceedings.

Spain and Portugal.—We have hitherto acquired but limited knowledge of the geology of Spain and Portugal. In anticipation of further information from Colonel Silvertop, who has lately revisited the southern provinces, and a promised Memoir of Capt. Cook, R.N. we have before us the first geological sketch, which has been attempted, of the general structure of the Peninsula from the pen of Professor Hausmann, in a work entitled "Hispaniæ de Constitutione Geognosticâ," which, founded on the personal examination of its eloquent author, conveys a very clear idea of the simplicity of structure which characterizes a large portion of that country.

Mr. D. Sharpe has read before this Society an account of parts of Portugal. He acquaints us that the rocks around Oporto consist of granite succeeded by gneiss and mica schist, which are overlaid by conglomerates containing anthracite, and by blue clay. Between Oporto and Lisbon he points out trappæan rocks and an ancient secondary sandstone overlaid by a limestone with belemnites. The estuary of the Tagus is stated to exhibit on its shores a tertiary series separable into three divisions. The lowest of these is a fossiliferous blue clay; the intermediate and most extensive group is made up of sand and arenaceous limestone, which, judging from their fossil contents, are probably of the Sub-Apennine age. Organic remains have not yet been observed in the uppermost group, although we may incline to the belief, that in a country so convulsed by earthquakes within the term of history, these superficial beds of sand may prove of the same age as the youngest shelly deposits which have been raised upon the shores of the Mediterranean Sea.

British Colonies.—I expressed, on a former occasion, the hope that our East Indian possessions might soon be rendered more interesting to us by an exposition of their geological relations, and particularly by descriptions of the carbonaceous and other deposits of the Peninsula. We have in the mean time received an account of the structure of Pulo Pinang, and its adjacent islets, drawn up by Dr. Ward, an able and zealous naturalist, at the suggestion of the East India Company's Resident, Mr. Kenneth Murchison. Although we may regret that the Malayan Archipelago offers no other than primary rocks, here and there covered with their disintegrated materials, we must hold up as highly worthy of imitation that good spirit which prompted the Resident to take all the means at his disposal to obtain for us this amount of natural knowledge; as it is obvious, that similar efforts on the part of the chief officers in our numerous distant colonies would prove of inappreciable value. And here I would point your attention to the short "Instructions for Young Geologists," which were prepared for distribution in the colonies; and I would request you in circulating these Instructions, to urge upon your friends in the West Indies the real service they may perform by sending home suites of specimens, to afford us the means of instituting a comparison between the silicified zoophytes of those parts, and the existing corals of the adjoining seas.

Continental Writers.—The Discourse of the President of this

Society must, from its brevity, be chiefly devoted to the review of the discoveries and proceedings of the English school; for so numerous are the European observers, that a volume would scarcely suffice to elucidate their annual productions. In this place, therefore, I can simply allude to a few of those writings which, from their comprehensive nature, will best acquaint you with the recent pursuits of our coadjutors in various parts of the continent.

M. Boué, in his "Considérations générales sur la Nature et l'Origine des Terrains de l'Europe," brings into discussion every great general and theoretical question, with reference to the origin of each formation, in the tone which peculiarly marks the present developpment of the science. To the enlightened Reports of the Geological Society of France, by the same learned author, I have made honourable allusion on a former occasion; and I have now to notice the last Report upon the progress of geology in France, by M. Desnoyers, where the subjects that have occupied geologists are treated of under distinct heads, in each of which the various matters are synthetically grouped, their connexion clearly pointed out, and their cumulative bearing on the science admirably stated. In short, this Report of M. Desnoyers is conclusive evidence of the advantages which have already flowed from the establishment of the Geological Society of France, in giving a full view of the practical labours of all the geologists of that country, whose works without such an organ of communication would not have been understood or duly appreciated by the scientific world.

The unabated vigour of research which animates the geologists of Prussia, is the natural effect of the examples of Humboldt and Von Buch. Although your attention has already been drawn to several individuals of this nation, whose discoveries had reference to the topics contained in this address, a work of deep utility still remains unnoticed, in the German translation of the Manual of Mr. De la Beche, by M. Von Dechen, who in thus communicating to his countrymen the essence of the practical geology of England, with which he is so thoroughly acquainted, has further transfused through this volume all the spirit and knowledge of the modern school of Germany.

It is deeply to be regretted, that England is so ill supplied with information of the proceedings of the geologists of Italy. In announcing that we may soon look for the appearance of a map of the southern flanks of the Alps, embracing all the sub-alpine regions, delineated by three such competent geologists as the Marquis Pareto of Genoa, M. Cristoforis of Milan, and M. Pasini of Schio, I may briefly remind you, that the land which was the cradle of geology, still contains within it men endowed with the intelligence and enterprise requisite to complete those illustrations, which are essential accompaniments of the present condition of the science*.

---

* I have abstained, on this occasion, from noticing a recent Memoir of M. Pasini, in which, supporting the theory of the Count Marzari Pencati, and opposing the views of Von Buch, Boué, De Beaumont, and others, who contend for the elevation of the secondary limestone of the Alps, he controverts a sketch of my own upon the "*Relations of the Tertiary* to the Se-

United States.—Though this be not the occasion on which I may dilate upon the productions and discoveries of our foreign contemporaries in Germany, Italy, and France, still I may offer a few brief remarks on the strides which have been recently made by our coadjutors in the Western hemisphere, connected as they are with us by community of origin and language.

In the United States of America our science, cultivated upon true principles, rises steadily in public estimation. A Geological Society is formed at Philadelphia, which commencing energetically in the collection of specimens, and inviting descriptive sections from all parts of Pennsylvania, shows how effectually the intelligence and public spirit of this State have been drawn to our subject,—an effect chiefly due to the writings and lectures of our zealous Associate, Mr. Featherstonhaugh.

Another of our Fellows, Mr. R. C. Taylor, has begun to apply his acquaintance with English geology, in describing a large bituminous coal-field on the flank of the Alleghany Mountains, which seems to bear a striking resemblance to the carboniferous districts of Great Britain.

To Dr. Haerlam, already known by his valuable contributions to the works of Cuvier, we owe several important recent additions to fossil zoology.

Dr. Morton, Corresponding Secretary of the Academy of Sciences of Philadelphia, who had illustrated the organic remains of the ferruginous sandstone of Pennsylvania, has also formed an instructive and rich collection of the tertiary shells of that State, which have met with an excellent expositor in Mr. Conrad. The First Number of a work, long desired by every European geologist, has just appeared, entitled "Fossil Shells of the Tertiary Formations of North America," by this author; and I may confidently recommend it as a most instructive performance, the continuation of which will at length enable us to speculate with confidence upon one important class of the deposits of that vast continent. Some inaccuracies of comparison seem to be owing to the author's unacquaintance with those conchological distinctions which have been so very recently applied to the tertiary groups by Desnoyers, Lyell, and Deshayes. Without entering upon the nature of the vast alluvial and diluvial accumulations of North America, which upon minute and careful examination will probably be found to offer all the subdivisions they are capable of in Europe,

---

condary Rocks in the neighbourhood of Bassano."—(Phil. Mag. and Ann. vol. v. June 1829.) At some future day I may point out the extent to which M. Pasini has misunderstood the facts I have explained; probably from his rigorous interpretation of a hastily drawn section. This slight sketch was simply intended to show, that within a *very limited* district on the southern flank of the Alps, the tertiary strata were highly inclined in conformity with the scaglia or chalk, as clearly exhibited in the bed of the Brenta. Of the dolomite of that region, it was not my intention to have spoken; and I regret that the few words relating to the disrupted masses of that rock in the defiles of the Brenta should have been thought worthy of so much criticism on the part of the ingenious author.

I must remark, that in the triple classification of the tertiary formations, the author errs in supposing that the shells of our crag, which he identifies with his upper marine, are all of existing species; it being ascertained that the crag contains only about 45 per cent. of shells identical with those now living.

Nor can the middle tertiary formation of Mr. Conrad be positively identified with the "calcaire grossier," until we are supplied with lists of the relative numbers of the existing and extinct species. The lower tertiary formation, it is evident, cannot be classed with the "argile plastique" of M. Brongniart, upon the test of lignite alone; since that substance is no longer deemed characteristic of one particular period, but occurs in tertiary groups of all ages: in truth, the plastic clay occupies no longer a place in the list of European formations, being simply the occasional substratum of certain tertiary basins, in many of which it is inseparable from the overlying clay. These errors of comparison and geological classification are, however, quite excusable on the part of a naturalist, who strives to arrange his subject after models he has been taught to consider classical, but which inevitably have partaken of such defects as characterize the broad generalizations of the early geologists of all countries. Such defects are, however, of little moment, and can soon be obviated. The high merits of the undertaking of Mr. Conrad are to be found in an accurate delineation of the organic remains, and in his faithful account of the manner in which the strata containing them have succeeded to each other. By his description we now learn, for the first time, that the whole line of coast of North America has been elevated after the creation of existing mollusca, and that the highest or youngest of these fossil groups is spread over a zone of land of 150 miles in breadth! Judging from the information before us in the first fasciculus of this interesting work, it may be inferred that these upper shelly sands and marls are synchronous with those modern elevated groups in the Mediterranean, by some geologists termed Quaternary, which Mr. Lyell classes in the group of newer Pliocene. I have now to express my hope that Mr. Conrad may meet with such encouragement, that he may complete not only the illustration of these younger and tertiary shells, but succeed also in his laudable ambition of describing the remains of the secondary and older formations of North America.

That geology is pursued with vigour in other States of the Union, we have abundant proof in the Journal of Professor Silliman.

Professor Hitchcock has published a well-digested and circumstantial Report upon the Mineral Structure of Massachusetts, accompanied by an illustrative map. That part of the work which shows the value of an acquaintance with mineral masses in their application to the agriculture and commerce of the State, has alone appeared; but the materials, therein collected, bear testimony to so much ability and research, that some good geological induction may be looked for in the second volume.

This author will, however, pardon me if I suggest some caution in the identification of those great tracts of red sandstone in America with the *new* red sandstone of England; since it is obvious that in countries where the coal measures are wanting, it is difficult to arrive at safe conclusions. We now begin to perceive, that even in England strata of similar red colours reappear at intervals throughout the descending order, from the base of the lias to vast depths within the grauwacke series. Still less is a red sandstone to be identified with the new red sandstone by the presence of salt; since it is now demonstrated that this substance occurs in formations of all ages, from the youngest tertiary to the oldest transition rocks.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—We may now revert to the consideration of the general state of our native geology. Connected, as our progress must be, with the advancement of other branches of science, I am sure you will unite with me in rejoicing that so much success attended the second assembly of the British Association, held last year at Oxford. The cordial reception its Members met with from that distinguished University, has been the means of making known its objects, and advancing its interests; and its continued success is secured by the invitation of the sister University to hold the ensuing meeting at Cambridge.

A volume about to appear, containing the original Reports read at Oxford, will sustain the high reputation of their respective authors; and the cultivators of our science will gladly see that the recent progress and present state of geology found an able and eloquent expositor in our Vice-President Mr. Conybeare.

I would further request your attention to the numerous important queries, suggested by the Geological Committee of this body, which will explain how intimately its objects are connected with our own. If, indeed, it be essential to our progress to secure the zealous cooperation of our friends in other departments of science, where can we so well make known our wants, where can we better gather data for the extension of our inquiries, or where find so good a solution of our difficulties, as in a general Congress, which embodies men of distinction from all parts of the British Isles?

But to you, Gentlemen, it is needless to expatiate on such obvious advantages; for already by your hearty cooperation you have striven to uphold the merits of the British Association for the Advancement of Science. So highly indeed have these efforts been valued, that this great Institution has done honour to us, in selecting for their last and their succeeding Presidents the geological leader of each University,—men already enshrined in the hearts of all whom I now address.

GEOLOGICAL DESIDERATA.—The amount of geological labours performed in Great Britain within the past year, indicates, I hope, a continuance of exertion as vigorous as that of any former year; but notwithstanding the good ends which have been realized, I feel that there still remains a duty for me to perform before I quit this chair, by placing before you a few of the essential desiderata at home, which must be supplied before we shall have completed the sketch of the geological structure of the whole kingdom.

Much as has been written upon parts of Scotland, no comprehensive work has yet appeared in the English language descriptive of the whole of that country; although Dr. Boué and Professor Necker have long since explained to their countrymen the general relations of its rocks. It must be granted that the northern portion of Scotland has received more than its fair proportion of attention; for besides the eminent geologists of the school of Hutton, who sought in it for the proofs of the truth of the theory of their master, the crystalline and trappæan rocks of those parts have met with ample and able commentators in Jameson, Allan, Mackenzie, Hibbert, MacCulloch, and other living authors; the nature of its sedimentary deposits has been partly recorded in your Transactions by Professor Sedgwick and myself. In the central and southern division of Scotland, however, and in the coal-fields particularly, we yet require many descriptions of large tracts, and some general work, which, embracing all the country between the borders of England and the rise of the Grampian chain, shall inform us whether the regular coal-measures are based upon mountain limestone, or descend, as it is stated they do, in northern Northumberland and in Berwickshire, into the old red sandstone.

The Reverend Dr. Fleming has, I learn, obtained a clear knowledge of the complicated and disturbed coal-field of Fifeshire, and has extended his researches to the south-eastern flanks of the Grampians: we may, therefore, look with confidence to the result of his observations, while we express our wishes that this able naturalist may further have it in his power to describe the relations of the great trappæan range of the Ochills.

If, however, we are led to anticipate some correct views of the northern edges of this great vale, we shall still be strikingly deficient in data concerning its southern division. Although Nithsdale has been described by Mr. Monteith, the older chain of the Lead Hills, and all the surrounding groups of the transition series, still require much detailed examination. Let us, therefore, hope that Professor Jameson, who has laboured to such good effect in the department of the unstratified and trappæan rocks, may, by his own efforts, and those of his pupils, fill up these blanks in the secondary geology of his native country.

It is not, however, on the north side of the Tweed alone that deficiencies exist. The English side of the Scottish border calls equally for exploration; since we are still without any good account of the porphyritic ridges of the Cheviots, although we may, I believe, expect one from the pen of Mr. Culley.

In England and Wales the difficulties attending the development of the oldest sedimentary formations are, as you have seen, fast vanishing; thanks to Professor Sedgwick, who, having fairly grappled with this obscure yet indispensable branch of our subject, will shortly lay before you the final results of many years of anxious labour. I have endeavoured to extend, in the ascending order, these labours of my friend, into the younger and more fossiliferous tracts upon the borders of Wales,—to point out the formations into which they are divided,—and to connect these with the old red sandstone and overlying deposits. To the termination of this work I look with pleasure in the ensuing summer.

If we turn from these hitherto neglected western regions and transport ourselves to the eastern shores, who does not perceive that we are there without any complete history of the crag and younger deposits ? The works of Mr. R. C. Taylor and others, though excellent in their respective districts, are not of general application ; and ingenious as are the views of Professor Lyell, they are only drawn from those parts of the coast which have fallen under his own observation.

Let me, therefore, entreat you to wipe away this imperfection from our system, and to endeavour to establish demarcations as clear as our fellow-labourers in France have done for the deposits of this age, by working out the whole extent of the crag, and the precise nature of its upper limits : also by showing the relative ages of gravel beds with existing species of shells, and the numerous lacustrine and terrestrial accumulations which abound along our east coast, from the north bank of the Humber to the mouth of the Thames.

The most essential, however, of all our scientific wants is a perfect history of the coal-fields ; for, connected as these are with the existence of England as a manufacturing nation, the call for information upon this point cannot be too frequently repeated, nor its importance too warmly inculcated.

Some addition to our knowledge of carboniferous tracts has recently been made by that excellent geologist Mr. J. Phillips, in a short Memoir upon the Ganister, or Lower Coal-field of Yorkshire, a full account of which will shortly appear in the Second Volume on the Geology of that county *.

I hope soon to lay before you a succinct view of those undescribed and thin fields of coal in Shropshire, which have been accumulated in ancient bays, covering the edges of the grauwacke formations, or resting upon the old red sandstone and mountain limestone. As these fields are carried under the great trough of northern Salop and Cheshire, may we not reasonably infer, that at some future day a vast emporium of deeply seated coal may be discovered and worked beneath the new red sandstone of that district ?

But to how many other parts of this island may we not apply similar speculations ? How many and how vast are these carboniferous fields, with the true details of which we are entirely unacquainted ?

If, Gentlemen, I specially invoke your continued exertions in *this* department, it should be borne in mind that the results must essentially benefit our fellow-creatures; and I am therefore confident that the time is come, when, duly estimating our labours, the whole country will proclaim, that " *Geology is a pursuit of the deepest national importance.*" With this feeling it is that our lists are already adorned with some of the most honoured names in the land ; and the only

---

* I am informed that Mr. E. Hall, of Manchester, has made an addition to our local carboniferous geology, by the completion of a MS. map of South Lancashire coal tract.

boon which we demand in return for our gratuitous efforts is, that the landed proprietors of England will enrich our archives with sections and illustrations of their several neighbourhoods.

In thus adverting to the practical uses of geology, and in asserting that our advances have been firmly secured, by patiently working out the evidences offered by the fossil world; we must at the same time allow, that our progress has been occasionally checked by the promulgation of captivating but untenable theories.

Persuaded as we are that there is no royal road to the truths we are in search of, let us guard against hastily conceived speculations, which none can form more readily than those who have least laboured in our vocation; recollecting that theories are only to be tolerated so far as they accord with Nature's laws and positive observations.

Let us not cease to weed out from the school of English geology the schemes of those who would seek to grasp the conclusion of the problem before the very data have been fully placed before them. Acting on the maxims of the great father of modern philosophy, and proceeding steadily from the known to the unknown, let us not be appalled by the magnitude of the difficulties we have yet to vanquish,—but let each of us strive to bring annually to these halls, fruits earned by the sweat of his brow; conscious, if any laurels be decreed by posterity to the geologists of this age, that those will have the largest share, who by their own discoveries have best contributed to lay the true foundations of the science.

In a science like our own, receiving the perpetual accession of new discoveries which limit or extend our previous conclusions, it is obvious that few geological memoirs can be perfect, when they first proceed from the author's pen, however experienced in observation. The ordeal, therefore, our writings have to pass through in the animating discussions which they elicit within these walls, may be considered the true safeguard of our scientific reputation. This excellent practice, sanctioned by long experience and your approval, not only ameliorates your transactions, by calling forth and embodying the unrestrained opinions of practised observers; but it further operates in cementing us into a community of good feeling, and gives to our assemblies that stamp of energy and friendship which has long characterized this Society.

The term of my services, Gentlemen, is now expired; and I bid you farewell, with heartfelt thanks for the countless proofs of kind cooperation you have given me, and which, more than I can express, have bound me to your interests and welfare. My gratification is this day complete, in having to record, that among the numerous acts of which you may be proud, there is no one more creditable to your feelings, or better devised to consolidate the prosperity of this Institution, than the last expression of your will, by which you have transferred the power from my hands to those of one, whose life has been devoted to your cause, and who may justly glory in having been the first President of the Geological Society of London.

## ZOOLOGICAL SOCIETY.

Feb. 12 (*continued*).—With this (Dr. Weatherhead's) communication M. Geoffroy-Saint-Hilaire was only partially acquainted, by the extracts from it given by Mr. Owen (with some observations upon them,) as an Appendix to his Paper on the Mammary Glands of the *Ornithorhynchus paradoxus*, published in the Philosophical Transactions for 1832: he requests to have a literal copy of the communication.

He recalls attention to the history of our knowledge of the sexual organs of *Ornithorhynchus*; refers to M. Meckel's discovery of a gland, situated under the integuments of the *abdomen* of the female, and considered by him as mammary, and to his own subsequent observations on this subject, in which these glands are regarded as analogous to the structure that surrounds the true mammary glands of the *Shrews*; and hints at the probability that M. Meckel may not, in 1833, entertain the same ideas which he expressed in 1826. M. Geoffroy-Saint-Hilaire repeats some of the most striking peculiarities of the organs of reproduction: 1, the existence of a *uterus* and *vagina* in a state of atrophy, which he has repeatedly represented under the name of a little indistinct organ, the utero-vaginal canal; 2, the non-continuity of the urinary bladder to the ureters; 3, the interposition, when in action, of the genital organ between the folds, &c.; and, referring to his published accounts of the sexual anomaly in all its details, reproduces the conclusion to which he has been led by his observation of these parts. The organization, he finds, is that of a *Reptile*; now, such as the organ is, such must be its function; the sexual apparatus of an oviparous animal can produce nothing but an egg.

The statement that a milky fluid has been observed is one which especially attracts M. Geoffroy-Saint-Hilaire's attention: he is anxious to know the details of this observation. Supposing it established, rather than believe in a secretion of real milk from long cellular *cæca*, of which Meckel's gland is composed, (whereas, he states, it can be secreted only from lactiferous *ganglia*,) he would be disposed to think that this gland might secrete carbonate of soda [lime?], the earthy matter of which egg-shells are composed. This would be extraordinary, he admits; but what is there about the organization of the *Monotremata* that is not extraordinary, or, in other words, different from what we find in the *Mammalia?* This additional anomaly seems to lead to its necessary consequence, he remarks, and an hypothesis which suggests the necessity of further examination is far better, in his opinion, than an assimilation to normality, founded on strained and mistaken relations, which invites indolence to believe and slumber.

M. Geoffroy-Saint-Hilaire concludes by repeating his request for a literal copy of the whole of the letter addressed by Lieut. the Honourable Lauderdale Maule to Dr. Weatherhead. If the facts contained in it, he remarks, should make him change his opinion, so much the better: he would rather be put right, than indulged in any views formed *à priori*; in this way he learns more; and it is to him always more gratifying to get rid of an error in science than to introduce into it an additional observation.

The Vice-Secretary stated, that the request of M. Geoffroy-Saint-Hilaire for a copy of the letter in question had been complied with. He also referred to the Proceedings of the Committee of Science and Correspondence, Part II. p. 179, for an account of the glands discovered in *Echidna* by Mr. Owen, (see our last report, under Oct. 23, vol. ii. p. 476.) who, in his observations there published, briefly adduces several reasons why little difficulty should be experienced in the consideration of the *Monotremata* as oviparous or ovoviviparous, and at the same time as mammiferous animals.

A letter was read from William Willshire, Esq., Corr. Memb. Z.S., H.M.'s Vice-Consul at Mogadore, giving an account of a *Reptile,* known by the Arabs under the name of *el Dub*. A living specimen of the animal, presented to the Society by Mr. Willshire, accompanied the letter. It is the *Uromastyx acanthinurus,* described and figured by Mr. Bell in the first volume of the 'Zoological Journal,' from specimens brought from Fezzan by Capt. Lyon. The *Dub* is noticed by Marmol, Capt. Lyon, and other travellers; but the precise species to which the reptile so named was referrible had not, previously to the arrival of Mr. Willshire's specimen, been satisfactorily ascertained.

A note from Col. Hallam was read, accompanying drawings of the *Mango-fish, Polynemus paradisæus,* Linn.; and of two individuals of a race of *pigs* with only two legs, the hinder extremities being entirely wanting. The latter, Col. Hallam states, were observed "at a town on the coast in the Tanjore country, in the year 1795: they were from a father and mother of a similar make, and the pigs bred from them were the same."

The exhibition was resumed of the collection of *Shells* formed by Mr. Cuming on the western coast of South America, and among the islands of the South Pacific Ocean. The new species brought on the present evening under the notice of the Society were accompanied by characters by Mr. G. B. Sowerby. They were named as follows:—Byssoarca *Lithodomus, pacifica, alternata, maculata, mutabilis, divaricata, decussata, illota, velata, solida, pusilla, truncata, lurida,* and *parva;* Arca (§ æquivalves) *tuberculosa, Nux, reversa, concinna, emarginata, formosa, auriculata, biangulata, multicostata,* (§§ inæquivalves,) *obesa, labiata, labiosa, quadrilatera, brevifrons,* and *cardiiformis*: the shell last named has at first glance the appearance of, and might easily be mistaken for, a *common Cockle.*

At the request of the Chairman, Mr. Martin read Notes of his dissection of a *slender Loris, Loris gracilis,* Geoff., which had recently died at the Society's Gardens. It was presented by Captain Faith.

The specimen of *Apteryx australis,* Shaw, which was figured in the 'Naturalists' Miscellany,' plates 1057 and 1058, was exhibited; and Mr. Yarrell called the attention of the Meeting to its several parts in detail, which he described fully, with reference to the illustration of a paper on that interesting bird.

Feb. 26.—A specimen was exhibited of a *Seal*, presented to the Society by Mr. Henry Reynolds. It was obtained by that gentleman from a native of New Holland, who stated that he brought it from the interior of the country adjoining the settlement of New South Wales. The marine habits of the animal (a species of *Arctocephalus*, and most probably the *Otaria Peronii*, Desm.) render this statement problematical. Should it be correct, it would seem to indicate the existence of salt water in large masses at a distance remote from the coast.

A specimen was exhibited of the *Carolina Cuckoo, Coccyzus Carolinensis*, Bon., which was killed in the last autumn in the preserves of Lord Cawdor in Wales: it was communicated for exhibition by His Lordship. Two instances of the occurrence of a bird of the same species in Ireland have been recorded.

Dr. Grant called the attention of the Society to a specimen of a *Cephalopod*, forming part of his own collection, which he exhibited in illustration of a paper "On the Zoological Characters of the Genus *Loligopsis*, Lam., and Account of a New Species from the Indian Ocean."

Mr. Yarrell read a Paper "On the Laws which regulate the Changes of Plumage in Birds."

March 12.—A letter was read, addressed to the Vice-Secretary by M. Geoffroy-Saint-Hilaire, For. Memb. Z.S., and dated Paris, March 5, 1833. It acknowledges the receipt of the copy of the letter of Lieut. the Honourable Lauderdale Maule to Dr. Weatherhead respecting the *Ornithorhynchus*, and states that the writer has proposed a system calculated to put an end to the controversy respecting these animals. This system is contained in a "Memoir on the Abdominal Glands of the *Ornithorhynchus*, falsely presumed to be mammary, but which secrete, not milk, but mucus, destined for the first nutriment of the young, when newly hatched," published in the 'Gazette Medicale,' under the date of Feb. 18th. A copy of the Memoir was laid on the table, and an abstract of it was read.

M. Geoffroy-Saint-Hilaire translates the whole of Lieut. Maule's letter, and quotes also Mr. Owen's observations on the Mammary glands of *Echidna*, from the Proceedings of the Committee of Science and Correspondence. He then enters into some details on the history of our knowledge of the *Monotremata*, and on the various opinions which have been held respecting their mode of generation, and the nutrition of their young. Recurring to the very curious observation of Lieut. Maule, he admits the effusion of a fluid of a milky appearance, but he doubts that this fluid was actually milk. "To arrive so rapidly at this decision," he proceeds, "many impossibilities must have been forgotten. You have not the function, nor the result of the function which characterizes the *Mammalia*, if the organs that produce it are truly wanting. Now this is what I think I can demonstrate; and what I undertake to do in the following remarks.

"For this purpose I seek for analogous facts; and they have long since been furnished to me by the *Shrews*. There are on each side of the bodies of these animals two kinds of glands arranged parallel to each other. 1st, Internally, conglobate and truly lactiferous glands, of the known structure: 2ndly, Externally, an apparatus formed of *cæca,* furnished with some membranous and diaphragmatic *fræna,* and with many cellulosities. This apparatus, in the young state and during the inactivity of the sexual organ, consists only of a longitudinal projection without distinct characters; but during the season of sexual excitement, this projection becomes enlarged and is visibly surmounted on its internal surface by a multitude of small parallel *cæca,* disseminated over and attached to the glandular body, like the bristles upon a brush. These *cæca* open on the projection made by the gland, which on its tegumentary surface has but a single excretory orifice. The secretion consists of a *mucus* possessing a very powerful odour.

* * * * * *

"The epigastric artery is divided into two principal branches; one passing towards the median line to supply the mammary glands; the other ramifying externally and performing the same function with regard to the odoriferous glands. The same structure exactly is presented by the ventral glands of the *Ornithorhynchus,* two characters excepted, which do not militate against the determination and analogy assigned to them: viz. a much more extensive development, and two secretory orifices instead of one, as in the *Shrews.* I explain this difference by the atrophy and entire suppression of the internal epigastric branch. This branch being annihilated, there is no formative vessel, and consequently no apparatus produced,—no mammary gland; but, on the other hand, the whole arterial alimentation passing more excentrically by means of the single terminal branch, the apparatus to which this branch is distributed is proportionally enlarged. This shows why and how the odoriferous glands have reached, in the *Monotremata,* their maximum of development. Where the apparatus becomes more considerable, the function is so much the more powerful, and the mucus secreted must in fact exist in such quantity in the *Monotremata,* that its effusion may become a fact susceptible of observation.

"I should not be surprised, if this mucus, more abundant and more substantial in the *Monotremata,* became the nutriment of the young after their hatching. The *Monotremata* would act, in this respect, like some aquatic birds which conduct their young after hatching to the water, and assist them in their substantation. The maternal instinct would lead the female *Ornithorhynchus* to effect the contraction of the gland, which is possible by the efforts of the *panniculus carnosus* and the great oblique muscle, between the fibres of which the gland is seated, and thus to procure for the young, at several periods of the day, by way of nutriment, an abundant supply of mucus. If this education is carried on in the water, where we know, by the history of the generation of frogs and the nutrition of their tadpoles, that the mucus combines with the ambient medium, becomes thick, and supplies an excellent nutriment for the early age of these reptiles, we shall understand the utility of the ventral glands of the *Ornithorhynchus,* as furnishing a source of nutriment for the young of these animals,—for young *ovipara* newly hatched. When we meet with such curious organic conditions, we do not attempt, by a truly retrograde march, to throw back well averred differential facts, decidedly acquired to science, by means of a forced assimilation, among other facts peculiar to the class of *Mammalia;* but on the contrary we are under the necessity of placing the *Monotremata* further within the limits of oviparous animals.

* * * * * * *

" At the other extremity of the scale of beings, where the fishes are placed, we meet with a gland secreting mucus, extending along the sides from the head to the tail. Ascending the scale, we see it separate into fractions ; some *Reptiles*, and among others the *Salamanders*, have it large and forming a continuous band, as in *Fishes :* we have said in what state it is found in the *Monotremata*."

In a postscript, dated February 19th, M. Geoffroy states that at a Meeting of the Academie des Sciences on the previous day, M. de Blainville had read a paper, in which he maintained his former opinions on the subject of the *Monotremata,* and supported the views of Mr. Owen. He states that some contradictions and physiological impossibilities contained in it had been noticed by MM. Duméril and Serres, in the course of the discussion, but does not enter into any details.

The reading having been concluded of the abstract of the views proposed by M. Geoffroy-Saint-Hilaire in the memoir submitted, Mr. Owen addressed the Society on its subject. The following is an outline of his observations.

When the glands in question were first detected by M. Meckel, that eminent anatomist at once regarded them as mammary. M. Geoffroy-Saint-Hilaire objected to this mode of viewing them, that their structure is not conglomerate, like that of mammary glands, but lobed and consisting of numerous *cæca,* resembling the structure which he has described as existing in the odoriferous glands which surround the *mammæ* of the *Shrews*; hence he concluded that their function is similar to that of the corresponding organs, as he considered them, in these little animals, namely, to secrete an odorous substance for the purpose of attracting the other sex in the season of heat. M. von Baer subsequently proved that it is incorrect to assume that a mammary gland must necessarily be conglomerate, by showing that these organs in the *Cetacea* consisted of simple *cæca*, a structure even less complicated than that demonstrated in *Ornithorhynchus* at a later period, by Mr. Owen. During his investigation of the structure of these glands Mr. Owen proved, by comparing their condition with the state of the sexual organs in several individuals which he examined, that they correspond in the phases of their development with the true mammary glands, their greatest size being attained when the ovaries appear to have recently parted with their contents. The fact of their development being at its maximum at about the time of the birth of the young, evidently indicating the connexion of their function with this period, M. Geoffroy-Saint-Hilaire at first conjectured that they might secrete the earthy matter of the egg-shell, (see p. 60,) with which he conceives the young to be provided when brought into the world ; but this may be regarded as improbable, the tubes, (upwards of a hundred and fifty in number and opening by as many orifices,) which convey the secretions from the glands being so very slender and elongated as to be evidently adapted for carrying fluids. M. Geoffroy-Saint-Hilaire's subsequent and most recent opinion is that they secrete mucus, which being squeezed out by the mother in the water, becomes thereby thickened, and adapted for the aliment of the young; but Mr. Owen remarked that as he had shown that similar glands exist in *Echidna,* animals inhabiting sandy places, and unfitted for going into the water, such cannot be their use in *Echidna* at least, and it may therefore be concluded that such is not their use in *Ornithorhynchus*.

Mr. Owen added, that he had purposely limited his observations on the present occasion to the theories propounded by M. Geoffroy-Saint-Hilaire respecting the uses of the abdominal glands of *Ornithorhynchus*. Lest, however, it should be inferred from his silence as to the other views advanced by that distinguished zoologist in the two communications recently laid before the Society, that he coincided in them, he thought it necessary to remark that he was by no means disposed to admit their general correctness.

Extracts were read from a letter addressed to the Secretary of the Society, by Charles Telfair, Esq., Corr. Memb. Z.S., and dated Port Louis (Mauritius), November 8th, 1832. It accompanied some skins of *Mammalia* and *Birds,* and a collection of *Fishes, Mollusca,* and *Crustacea,* presented to the Society by its writer. It also announces it as probable that specimens of the *Tendraka* and *Sokina* of Madagascar, will shortly be obtained for the Society. Mr. Telfair has recently had opportunities of making some researches about the buried bones of the *Dronte* or *Dodo,* found in the island of Rodriguez. The result of these researches he communicates, and incloses letters addressed to him by Col. Dawkins, Military Secretary to the Governor of the Mauritius, and by M. Eudes, resident at Rodriguez.

At the request of the President, Mr. William Thompson of Belfast exhibited a specimen of a *Tern* shot by him in June last on one of the three Copeland Islands, which are situated a few miles off the north-east coast of the county of Down, Ireland. Mr. Thompson stated that the bird was evidently identical with those described as the young of the *Arctic Tern, Sterna Arctica,* Temm., in the Appendix to Capt. Parry's Voyage in 1819-20, page 203. In a detailed description of the specimen, which was read, Mr. Thompson pointed out various differences of proportions and colouring between it and the adult *Arctic Tern,* specimens of which, as well as of *Sterna Hirundo* and *Sterna Dougalii,* were shot by him on the same day, thus affording opportunity for comparison of these several species in a recent state and at precisely the same season.

Mr. Thompson availed himself of the opportunity to exhibit also specimens of the *black-headed Gull, Larus capistratus,* Temm., and of the *Sandwich Tern, Sterna Cantiana,* Temm., which were shot in the neighbourhood of Belfast. It is believed that no previous instance of the occurrence of these birds in Ireland has been recorded.

Specimens were exhibited of the *woolly* and *hairy Penguins* (so called) of Dr. Latham. They form part of the collection of the President, by whom they were communicated for exhibition. Mr. Yarrell briefly described them.

The exhibition was resumed of Mr. Cuming's shells, accompanied by characters from the pen of Mr. G. B. Sowerby: the following are the names of the species exhibited on the present occasion. CUMINGIA (a new genus, which should be placed near to *Amphidesma*) *mutica, lamellosa, coarctata,* and *trigonularis;* CORBULA *nuciformis,* (found at a depth of six fathoms in sandy mud at Real Llejos, Central America, and also in a fossil state near Guayaquil,) *bicarinata, biradiata, nasuta, ovulata, radiata,* and *tenuis*; BULINUS *Chilensis, punctulifer, rugiferus, pruinosus, Laurentii, unifasciatus, bilineatus, corneus, erythrostoma,* and *chrysalidiformis.*

At the request of the President, Mr. Gould exhibited a specimen of a *Toucan,* remarkable for the peculiar form of the feathers on the back part of the head and cheeks. They are without barbs towards their extremities, the shafts being widely expanded; those of the crown of the head are curled and horn-like, and, being of a jet black colour, bear some resemblance to fine ebony shavings; as they proceed along the neck they become straighter, narrower, and spatulate: the feathers of the cheeks have the latter form, and are straw-coloured slightly tipped with black. Mr. Gould proposed for it the name of PTEROGLOSSUS *ulocomus.*

March 26.—Specimens were exhibited of numerous *Mammalia* recently obtained by the Society from that part of California which adjoins to Mexico. They comprehended several species hitherto apparently undescribed, to which the attention of the Meeting was particularly called by Mr. Bennett, who characterized them as follows: MEPHITIS *nasuta;* DIDELPHIS *Californica,* and *breviceps;* SPERMOPHILUS *spilosoma,* and *macrourus;* SCIURUS *nigrescens;* and LEPUS *nigricaudatus.* Mr. Bennett concluded by calling the attention of the Society to two skins forming part of the same collection, which, notwithstanding their marked difference in fur and colour from an arctic specimen of the *Meles Labradoria,* Sabine, he felt disposed to consider as referrible to that species. They accord sufficiently with the *Tlacoyotl* of Hernandez.

A specimen was exhibited of a species of *Sepiola* from the Mauritius, which had been presented to the Society by Charles Telfair, Esq., Corr. Memb. Z.S., and Dr. Grant explained its distinctive characters by comparison with a specimen of the *Sepiola vulgaris* of the Mediterranean, exhibited for that purpose. He showed that while the body of the Eastern species is four times the size of that of the European, its arms do not exceed in length those of the latter species. On account of this comparative shortness of its members he proposed to designate it as the *Sepiola stenodactyla,* regarding it as the type of a new species distinguished from the single species previously known not merely by the important structural character just noticed, but also by the greater number of pedunculated suckers on its *tentacula,* and by the markings of the *tentacula,* which are transversely banded, those of the European species having round spots.

Dr. Grant described the animal in detail, and exhibited a drawing in illustration of his description.

Dr. Grant subsequently gave a demonstration of the structure of the heart and of the distribution of the blood-vessels of the *large In-*

*dian Tortoise, Testudo Indica,* Linn., which died lately at the Society's Gardens. The two systemic *aortæ* were distinctly seen to commence by separate orifices from the ventricle, as in the aquatic *Chelonia,* and not by a single orifice as stated by Cuvier to occur in the *land Tortoises* (Leçons, iv. p. 221). Dr. Grant directed the attention of the Members to the size and condition of the two *ductus arteriosi,* one leading from each pulmonary artery to the descending *aorta* of the corresponding side, which in this adult animal were still obvious and strong cords, though with their canals almost obliterated. He observed that the *Chelonia* here exhibited as a permanent character what is found in *Birds* only at an early period of their life; the *ductus arteriosus* being double in birds in their fœtal state, and the one on the right side disappearing before that on the left, while in *Mammalia* the left only is present in the embryo.

April 9.—Several extracts were read from a letter, addressed by Dr. A. Smith, Corr. Memb. Z.S., to Mr. Yarrell, and dated Port Elizabeth, Algoa Bay, December 22, 1832. They related to various points in the history of certain *Mammalia* and *Birds* of South Africa: among other particulars Dr. Smith stated his belief that the *Hyæna vulgaris,* Cuv., does not inhabit South Africa; its place being occupied by the *Hyæna villosa,* Smith, which bears, when young, considerable resemblance to that species.

An extract was read from a letter, addressed to the Secretary by Charles Telfair, Esq., Corr. Memb. Z.S., and referring to a Viverridous animal obtained by that gentleman from Madagascar, which lived for several months in his possession, and on its death was transmitted in spirit to the Society. Mr. Telfair states his belief that the animal is new to science; a belief in which Mr. Bennett participated, and stating his impression that the animal should be regarded as the type of a new genus, nearly allied to, but distinct from, *Paradoxurus,* he proposed for it the name of *Cryptoprocta ferox.*

Some remarks by Mr. Spooner on the *post mortem* appearances of the *Moose Deer,* which died suddenly, at the Society's Gardens, on the morning of the 28th of March, were read.

A specimen was exhibited of an *Antelope,* previously undescribed, which forms part of the collection of Mr. Steedman, by whom it was communicated to the Society. It was characterized by Mr. Ogilby, who gave a detailed description of it, as the *Antilope ellipsiprymnus.*

Mr. Ogilby subsequently called the attention of the Society to a specimen of a Mammiferous Quadruped, also communicated by Mr. Steedman for exhibition, which he described in detail with reference to a paper "On the Characters and Description of a new Genus of *Carnivora,* called *Cynictis.*"

The new genus proposed by Mr. Ogilby connects the family of the *Civets* with that of the *Dogs,* participating with the one in its organs of mastication, and with the other in those of locomotion, and consequently ranging with *Proteles,* Isid. Geoff., as a second genus, intermediate between those two groups. *Proteles,* however, partakes in some degree of the characters of the *Hyænas,* while *Cynictis* is more immediately interposed between the *Dogs* and *Ichneumons,* to the latter of which it bears a pretty close resemblance in external form.

The generic characters may be thus expressed :

CYNICTIS.

*Dentes primores,* $\frac{6}{6}$; *laniarii,* $\frac{1-1}{1-1}$; *molares,* $\frac{6-6}{5-5}$, quorum utrinque utrinsecus tres priores spurii, quartus carnarius, sequentes tuberculati.

*Pedes* digitigradi, digitis 5—4, unguibus falcularibus longis fossoriis.

*Cauda* longa, comosa.

Genus inter *Ryzænam* et *Herpestem* intermedium, et dentibus et digitorum numero.

CYNICTIS STEEDMANNI. *Cyn. rufus, dorso saturatiore; genis, collo, lateribus caudâque rufis griseo intermixtis; caudæ apice sordidè albo.*

Long. *corporis* cum capite, 1 pes 6 unc.; *caudæ,* 1 pes; *capitis,* a rostro ad auriculæ basin, $2\frac{1}{8}$ unc.; *auriculæ,* $\frac{3}{4}$; *auriculæ* latitudo, $1\frac{3}{4}$.

The general colour, as well as the whole external appearance of the animal, is that of a small *Fox.*

Mr. Ogilby described in detail the generic and specific peculiarities, and pointed them out on the preserved skin and on the *cranium*; in the latter, as in that of *Herpestes,* the bony ring surrounding the orbit is complete. He added also references to the Travels of Sparrman, for a notice apparently of this animal; and to those of Mr. Barrow, (vol. i. p. 185,) in which a brief, but perfectly intelligible account of it is contained: it is there said to be "known to the colonists under the general name of *Meerkat.*"

Mr. Steedman's specimen was obtained in the neighbourhood of Uitenhage, on the borders of Caffraria.

Lieut. Col. Sykes exhibited a fœtus of a *Panther,* preserved in spirit, and exhibiting all the markings of the adult; thus showing that the animals of this species do not undergo the changes in markings in their progress towards maturity which are generally found to occur in the genus *Felis.*

April 23.—A letter addressed to the Secretary by Mr. J. C. Lees, was read. It was accompanied by a drawing of the animal referred to in it, which was exhibited: it represented a species of *Glaucus,* Forst.

A note was read, addressed to the Secretary by Charles Telfair, Esq., Corr. Memb. Z.S. It was accompanied by a fossil bone from Vohemar in Madagascar, which was exhibited. The bone was considered as "part of the palate of a fish, called, in these seas, *la gueule pavée.*" It was contrasted with the bones constituting the grinding apparatus of the *spotted Eagle Ray, Myliobatis Narinari,* Dum., from which it was remarkably distinct both in form and structure. It appears to be referrible to the inferior pharyngeal bone of a gigantic species of *Scarus*.

The exhibition of Mr. Cuming's *Shells* was resumed, the following new species among them being characterized by Mr. Broderip and Mr. G. B. Sowerby; the former premising that the innumerable varieties presented by the genus described, render the conclusive establishment of new species in it a task of great difficulty. Conus *tiaratus, tornatus, nivifer* (one variety possibly Lamarck's *Con. nivosus*), *nanus, luteus, concinnus, recurvus* (its markings sometimes resembling *Con. Amadis*), *Nux* (may be a variety of *Con. sponsalis*), *monilifer, Archon* (approaches some varieties of *Con. Cedo-nulli* in contour and markings), *Musivum* (allied to *Con. Textile*), *purpurascens, Gladiator, Orion, geographus*, and *Princeps*.

In further illustration of his Paper "On the Laws that regulate the Changes of Plumage in Birds," Mr. Yarrell exhibited several varieties of British species, which possessed in part only the plumage common to the race. In some of these the feathers assumed at the moult were of the natural colour, and distinct from those previously borne; from which it was inferred, that, as the bird increased in age and strength, the plumage would assume entirely the colours peculiar to the species. Mr. Yarrell also referred to some newly-collected series of feathers, which were shown.

## LINNÆAN SOCIETY.

May 7.—A paper was read, entitled, "Observations on the Development of the Theca, and on the Sexes of Mosses." By William Valentine, Esq. F.L.S.

May 24.—This day the Anniversary Meeting was held.

The President read the list of Members deceased and withdrawn from the Society during the year elapsed since the last Anniversary. The list of the former, containing twelve names, included those of Joshua Brookes, Esq.; Samuel Galton, Esq.; the Rev. J. Harriman, a zealous British botanist, and a frequent contributor to the earlier volumes of English Botany; Sir E. Home; John Shaw, Esq. F.A.S.; Arthur Tyton, Esq.; and W. Withering, Esq., who edited the later editions of a popular work on British Plants by his father, the late Dr. Withering. The list of Foreign Members deceased comprised the distinguished names of Latreille, Rudolphi, Scarpa, and Sprengel. One Associate has also died since the last Anniversary, Andrew Duncan, M.D., Professor of Materia Medica in the University of Edinburgh.

Twenty-eight Fellows, seven Foreign Members, and four Associates have been elected into the Society during the past year.

The Society then proceeded to the election of the Council and Officers for the ensuing year, when the following were chosen:—

Council:—Edward Lord Stanley; Francis Boott, M.D.; Robert Brown, Esq., D.C.L.; John Curtis, Esq.; C. G. B. Daubeny, M.D.; L. W. Dillwyn, Esq. M.P.; Edward Forster, Esq.; Major-Gen. Thomas Hardwicke, Esq.; Thomas Horsfield, M.D.; A. B. Lambert, Esq.; W. G. Maton, M.D.; J. F. Royle, Esq.; J. Sabine, Esq.; R. H. Solly, Esq.; W. Yarrell, Esq.

Officers:—*President*, Edward Lord Stanley; *Treasurer*, Edward Forster, Esq.; *Secretary*, Francis Boott, M.D.; *Under-Secretary*, Richard Taylor, Esq.

June 4.—Read a communication from Thomas Andrew Knight, Esq. F.R.S. & L.S., President of the Horticultural Society, giving an account of two remarkable examples of sagacity displayed by Birds during the period of incubation. The most remarkable of these was as follows:—A wild duck had deposited her eggs near the side of a brook, but so far above the highest level to which the water had ever been known to rise, as to be apparently perfectly secure from being overflowed. An exceedingly violent thunder-storm, however, caused the brook suddenly to rise far above its usual level; the nest was in consequence overflowed, and the eggs remained submerged during more than two hours. No expectations were entertained that the bird would ever return to the nest, or that life had not been totally extinguished in the eggs; but she did return to the nest, and every egg hatched well. The water which had covered the eggs was very warm, and the temperature of the nest and the eggs, after the water had subsided, probably led the animal, Mr. Knight conceives, to resume her labours, which he is of opinion she would not have done if a lower temperature and longer immersion in the water had extinguished life in the eggs, and of course rendered such labour abortive.

The President, in a letter addressed to the Secretary, nominated the four following Members of the Council to be Vice-Presidents for the ensuing year, commencing from the 24th of May last, viz. Robert Brown, Esq.; Edward Forster, Esq.; A. B. Lambert, Esq.; and W. G. Maton, M.D.

June 18.—A paper was read, entitled "Characters and Description of *Limnanthes*, a new genus of plants allied to *Floerkea*," by Robert Brown, Esq., V.P.L.S.

For specimens of the plant described the writer is indebted to the Horticultural Society, and to Mr. David Douglass, F.L.S., by whom it was recently discovered in California.

Mr. Brown was led more particularly to examine *Limnanthes*, from its resemblance to *Floerkea* of Willdenow, a genus which he had many years since investigated without being able to determine its place in the natural system. Examination proved these two plants to be so nearly akin, that they might perhaps be included in the same genus. They are here, however, separated, and the two genera are considered as forming a family distinct from all those at present known.

The place of this new family (Limnantheæ) is not absolutely determined; but it is suggested that in two remarkable points of its structure, namely, the presence of glands subtending the alternate filaments, and the existence of a gynobase, it more nearly approaches to Hypogynous families than to Perigynous, with which it has hitherto been associated.

The following are the characters of the Natural Order, and of the two Genera forming it.

### LIMNANTHEÆ.

*Flos* completus, regularis. *Calyx* 3—5-partitus, æstivatione valvatâ, persistens. *Petala* 3—5, marcescentia. *Stamina* 6—10, insertione ambiguâ (hypo-perigyna), marcescentia. *Filamenta* distincta, 3—5-sepalis opposita basi extus glandulâ munita. *Ovaria* 2—5, sepalis opposita, cum *stylo* communi 2—5-fido mediante gynobasi connexa, monosperma; *ovulo* erecto, nucleo inverso. *Achenia* subcarnosa. *Semen* exalbuminosum. *Embryo* rectus; *radicula* infera.

Herbæ (Americæ septentrionalis, paludosæ) *glaberrimæ, alternifoliæ, exstipulatæ, foliis divisis, pedunculis unifloris, ebracteatis, apice dilatato basin turbinatam calycis simulante.*

### Limnanthes.

*Calyx* 5-partitus. *Petala* 5, calyce longiora, æstivatione contortâ. *Stamina* 10. *Ovaria* 5.

Herba (Limnanthes Douglassii, Americæ occidentali-borealis) *foliis bipinnatifidis, pinnis suboppositis segmentis alternis.*

### Floerkea. *Willd.*

*Calyx* 3-partitus. *Petala* 3, calyce breviora. *Stamina* 6. *Ovaria* 2 (raro 3).

Herba (Americæ orientali-borealis) *foliis pinnatifidis, segmentis indivisis.*

Read also the conclusion of Mr. Valentine's paper on the development of the Theca, and on the Sexes of Mosses.

## FRIDAY-EVENING PROCEEDINGS AT THE ROYAL INSTITUTION OF GREAT BRITAIN.

March 29.—Mr. Faraday on Mr. Brunel's new mode of constructing arches, either of brick or stone, without the use of centerings.

April 19.—Marquis Spineto. Original recent investigations of the origin of the worship of animals in Egypt, and elsewhere.

April 26.—Dr. Ritchie on certain parts of electro-magnetism and magneto-electricity, and on new electro-magnetic apparatus.

May 3.—Mr. Faraday on the mutual relations of lime, carbonic acid and water, and their connexion with geological phænomena and theories.

May 10.—Mr. Wilkinson on ancient projectile weapons of warfare, and the progress of the application of fire and gunpowder.

May 17.—Dr. Turner on the real equivalent numbers of chemically combining bodies.

May 24.—Mr. Faraday on a new law of electric conduction and decomposition.

May 31.—Dr. Grant—A comparison between the different conditions of the circulating system in inferior animals with the stages of the development of that system in man.

June 7.—Mr. Palmer on the laws which govern the progressive motion of shingles along sea-coasts.

June 14.—Mr. Brockedon on the application of caoutchouc in manufactures, and especially in that of elastic web and cloth; with an account of certain new properties of the substance.

## XII. *Intelligence and Miscellaneous Articles.*

### ON AN HITHERTO UNOBSERVED PROPERTY OF CHLORINE.

### BY MR. A. TREVELYAN.

*To the Editors of the Philosophical Magazine and Journal of Science.*

Gentlemen,

I AM not aware that chlorine gas has been observed to possess the same property as oxygen in kindling the flame of a candle when introduced into it with the wick in an incandescent state. When attending, on the 18th of February, the lecture of the able electrician Mr. K. T. Kemp, on Chlorine, it struck me that it might possess this property, which I immediately ascertained to be the case by introducing into a jar of it, a candle, the flame of which had been previously extinguished by withdrawing it from that gas; it was immediately rekindled, and the experiment was repeated several times in the same measure of gas. Yours, &c.

6, St. Andrew's Square,
22nd May, 1833.

Arthur Trevelyan.

### CARBONATE OF POTASH FROM GREEN AND DRY PLANTS.

M. Becquerel has made some experiments on the manufacture of potash. The comparative analyses of a great number of ashes have proved that those of green wood yield a much greater proportion of saline matter, than those of dry wood. This difference is especially striking with the ashes of fern; the ley of the ashes contains a mixture of subcarbonate and sulphate of potash; the proportion of the former varies from 0·45 to 0·65; it is this variation which causes the great difference of quality and price in potash of commerce; it becomes therefore very important, in the manufacture of potash, to separate the sulphate with which the subcarbonate is mixed. M. Becquerel effected this by concentrating the solution to spec. grav. about 1·4, and allowing it to cool: the greater part of the sulphate of potash crystallizes on cooling, and the saline matter which remains in solution contains afterwards 0·90 of subcarbonate. M. Becquerel has also ascertained, by his numerous analyses of different kinds of ashes, that those of the lime-burner contain very little sulphate of potash, which is undoubtedly due to the action of the lime upon the sulphate of potash, with the assistance of charcoal. This fact, M. Becquerel remarks, may lead to some advantage, by adding lime to the wood, the ashes of which are intended for the manufacture of potash.—*Journal de Pharmacie,* Oct. 1832.

### DIFFERENCE BETWEEN ACETIC AND FORMIC ACIDS.

M. Döbereiner distinguishes formic from acetic acid, by the property which the former possesses of reducing the oxides of the noble metals in the humid way, the formic becoming carbonic acid. If, for example, acetic acid be added to a saturated solution of protonitrate of mercury, protacetate of mercury is formed, and separates in brilliant scales; formic acid, on the contrary, produces no effect in the solution till heated, and then vivid effervescence takes place and metallic mercury is precipitated.

A cold saturated solution of acetate of lead is also a good reagent for formic acid; if the acid, either concentrated or dilute, be mixed with it, crystals of formiate of lead are instantly produced in the form of brilliant stars; the experiment may be made in a watch-glass: a drop of concentrated solution of acetate of lead, added to a drop of very weak formic acid, occasions the formation of crystals of formiate of lead; the excess of acetate of lead may be removed by alcohol; the formiate is insoluble in it.

If formic acid, or, still better, formiate of soda, be added to a boiling solution of perchloride of mercury, mercury is not precipitated, but protochloride is quickly thrown down. Silver, gold and platina are precipitated from their solutions in a very divided state.

M. Döbereiner remarks, that of all vegetable products, salicine appears to furnish the greatest quantity of formic acid, when treated with peroxide of manganese and sulphuric acid; this acid is also formed in putting concentrated muriatic acid in contact with prussic acid, and leaving the mixture till the odour of prussic acid is no longer perceptible. In this case the muriatic acid occasions the azote of the prussic acid to combine with the hydrogen of the water present, to form ammonia; the oxygen liberated, combines with the carbon of the prussic acid, and forms oxide of carbon; and this last, at the moment of its formation, combines with water to give formic acid. —*Ibid.*

### ON PHOSPHOVINIC ACID, AND PHOSPHOVINATES.

M. Pelouze prepares phosphovinate of barytes by the following process: Mix equal weights of phosphoric acid, of the consistence of a thick syrup, and alcohol; keep the mixture for a few minutes at a heat of 140° to 175° of Fahr.; at the expiration of 24 hours it is to be mixed with 8 times its volume of water, and neutralized with carbonate of barytes reduced to as fine a powder as possible; the liquor is afterwards to be boiled to get rid of the excess of alcohol; it is then to be allowed to cool to about 160° Fahr., and filtered. By cooling, a fine white salt is obtained, which usually crystallizes in hexagonal laminæ.

The properties of this salt are as follows: it is inodorous; its taste is disagreeable, being both salt and bitter, like that of all soluble barytic salts. When exposed to the air it effloresces but very slowly; it is insoluble in alcohol or æther, and they immediately precipitate it from solution in water.

Its solubility in water is remarkable, as it does not increase, like that of most other bodies, with that of the temperature. It is at its maximum at about 104°. One hundred parts of water 32° dissolve 3·4 parts of the salt; at 104°, 9·36 parts, and at 212° only 2·8.

When heated, phosphovinate of barytes loses its water of crystallization, which amounts to 30-100dths of its weight, and it then assumes the brilliant aspect of mother-of-pearl. It begins to decompose at a little below a dull red heat, and then gives water, carburetted hydrogen gases, and scarcely perceptible traces of alcohol and æther, with a residue, consisting of a mixture of neutral phosphate of barytes and finely divided charcoal. There is no oil of wine, nor phosphuretted hydrogen.

The phosphovinate of barytes crystallizes in different forms, which are all derived from a very short prism with rhombic bases.

Nitric acid mixed cold with phosphovinate of barytes renders it opalescent; there are formed phosphovinic acid and nitrate of barytes; these may be easily separated by alcohol, in which the nitrate is insoluble.

According to MM. Wöhler and Liebig, sulphovinate of barytes, when dried and heated with carbonate of potash, gives alcohol; but this is not the case with the phosphovinate when similarly treated. The mixture does not begin to blacken till nearly red hot, and the carbonate of potash has no share in producing this effect.

The following salts are not precipitated, when dissolved in water, by phosphovinate of barytes, chloride of manganese, protochloride and perchloride of iron, chloride of nickel, chloride of platina, chloride of copper, and chloride of gold; but it occasions precipitates in the solution of protomuriate of tin, mercurial salts, and the salts of silver, lead and lime; the phosphovinates formed are all of them soluble in diluted acids.

The soluble phosphovinates, such as those of potash, soda, ammonia and magnesia, are very readily obtained by decomposing the phosphovinate of barytes with the sulphates of these bases.

The phosphovinate of potash crystallizes with great difficulty and too confusedly to determine its form. It is very deliquescent and fusible in its water of crystallization; and the phosphovinate of soda is similar. The phosphovinate of lime contains 4 atoms of water of crystallization. It is very slightly soluble, and precipitates in the form of small and extremely brilliant micaceous laminæ, when phosphovinate of barytes is poured into muriate of lime. It dissolves readily in water acidulated with vinegar or with phosphovinic acid.

Phosphovinate of strontia crystallizes with great difficulty. Like that of barytes, it is much less soluble in boiling than in warm water. It contains water of crystallization, the quantity of which has not been determined; alcohol does not precipitate the aqueous solution.

Phosphovinate of silver very much resembles that of lime in its appearance and slight solubility in water, and it is easily obtained by double decomposition on adding nitrate of silver to phosphovinate of barytes; it contains water of crystallization. The phosphovinate of lead, when anhydrous, is the most insoluble of all.

Only two of these salts were analysed by M. Pelouze; the phosphovinate of barytes yielded,

| | |
|---|---|
| Phosphate of barytes | 82·800 |
| Carbon | 9·166 |
| Hydrogen | 2·266 |
| Oxygen | 5·768 |
| | 100·000 |

M. Pelouze considers the atomic constitution of this salt to be 1 atom of phosphoric acid saturated with 2 atoms of barytes and 2 atoms of alcohol, with 12 atoms of water of crystallization. The phosphovinate of lead was found to be of analogous composition. Phosphovinic acid is obtained by gradually adding dilute sulphuric acid to an aqueous solution of phosphovinate of barytes, as long as precipitation takes place. The filtered liquor is to be evaporated, at first over the naked fire, and then *in vacuo* beside a vessel containing sulphuric acid. A liquid is obtained, which reduced to the consistence of a thick oil, cannot be further concentrated; but it does not decompose at common temperatures *in vacuo*, as sulphovinic acid does.

Phosphovinic acid may also be obtained by decomposing phosphovinate of lead with sulphuretted hydrogen.

The properties of phosphovinic acid are, that it has a biting and very acid taste; it is inodorous and colourless, of an oily consistence, and reddens the blue colour of litmus strongly. It is soluble in all proportions in water, alcohol and æther, and is capable of resisting long-continued ebullition when it is dissolved in several times its volume of water; but decomposes at this temperature, when at the *maximum* of concentration, giving at first a mixture of æther and alcohol, then carburetted hydrogen, traces of oil of wine, and a residue of phosphoric acid mixed with charcoal.

Minute crystals are always formed in the concentrated solution of phosphovinic acid, and in sunshine very brilliant crystals may be seen to form and precipitate: the quantity of these crystals is not increased by exposing the solution to cold.

Phosphovinic acid coagulates albumen, whether it is formed by the action of common phosphoric acid upon alcohol, or by phosphoric acid, which has been previously heated to redness. Not the slightest differences could be perceived, either in the composition or properties of phosphovinic acid prepared with phosphoric and paraphosphoric acid. The phosphoric acid obtained from salts, which were at first supposed to be paraphosphovinates, neutralized by potash and treated with nitrate of silver, always gave a yellow precipitate; this induced M. Pelouze to suppose, though not to assert, that paraphosphoric acid is not capable of forming double salts with inorganic bases and alcohol, and that in acting on the last-mentioned body, the isomeric property is lost. Phosphovinic acid diluted with water and put into contact, cold, with zinc and iron, occasions an abundant disengagement of hydrogen gas, and the formation of protophosphovinate of iron and of zinc. It expels carbonic acid from all carbonates.

Neither sulphuric acid nor barytes water renders the solution of phosphovinic acid turbid.

In order to determine whether phosphovinic acid was produced in as great quantity cold as hot, and how much is formed from a given quantity of phosphoric acid, the following experiments were made by M. Pelouze, suggested as he states by the excellent memoir of Hennell on Sulphuric Æther.

Ten grammes of very concentrated phosphoric acid were dissolved in water, and ten other grammes in an equal quantity of alcohol, and the mixture was set aside in a bath of ice for 24 hours. Lastly, 10 grammes of the same acid mixed with the same proportion of alcohol, were boiled for some minutes. The quantities of phosphate of barytes yielded by the three liquors, were as follows:

| | |
|---|---|
| 1st | 21·8 gr. |
| 2nd | 15·0 |
| 3rd | 14·8 |

These experiments prove that by the action of phosphoric acid upon alcohol, about one fourth of it is converted into phosphovinic acid, and that this conversion is not sensibly modified by boiling the mixture. They also prove that the decomposition of phosphovinic acid is much more difficult to effect, than that of sulphovinic acid.

It is to this circumstance that must be attributed the small production of æther, when phosphoric acid is made to act upon alcohol, and not, as has been supposed, to the inertia of phosphoric acid with respect to this liquid, since, even at the temperature of melting ice, the contact of these bodies occasions the formation of a great quantity of phosphovinic acid.—*Ann. de Chim. et de Phys.* lii. p. 37.

---

## NOTICE OF THE DISCOVERY OF COAL-MEASURES, AND OF FOSSIL FRUITS, AT BILLESDON COPLOW, IN LEICESTERSHIRE.

### BY JOSEPH HOLDSWORTH, ESQ.

It has always appeared to me that there are some very partially-surveyed districts, south-east of the red marl, in all probability possessing features sufficiently indicative of mineral treasures to call into action a just spirit of enterprise, and incite to trials of discovery upon the most effective scale: but the reigning theory of the day has hoisted the standard of prejudice over those unfortunate lands, and by its doctrine of the prevailing and continuous dip—by its "sweeping generalizations,"—loaded the valuable fuel they may contain with almost miles in thickness of superincumbent strata.

As a lover of Nature, and duly impressed with the magnitude and hazard of the undertaking I was about to engage in, (and which has now been daily progressing more than two years,) for the discovery of coal in this hitherto unexplored and condemned district; having somewhat qualified myself for the task, by attentive perusals of

Williams's excellent practical History of the Mineral Kingdom, and repeated actual examinations of the distant coal formations, &c.,—I commenced here the most diligent researches for those "*local indications*," whose undeviating laws point out the absolute existence of mineral treasures, and which infallible criterions have evidently led to the discovery of mines in almost all situations where they are known. In the course of these investigations I was so fortunate as to discover a *real outburst* of a stratum of coal (accompanied by all its usual concomitants), and which I succeeded in distinctly tracing, by numerous sinkings, for a distance of nearly three miles, along its longitudinal line of bearing, the coal with the accompanying measures dipping into the basin where the trial is being made, and where they have all been found lying in the regular successive order indicated by their crops or bassets. I may here state that the adventitious hills, &c., which surround these measures, abound in masses, fragments, and thin veins of coal and coal-smuts, which, though possessing no decisive characters in themselves, are, as Williams asserts, so many signs of the coal neighbourhood: these indications have been investigated, and their importance confirmed, by the testimony of experienced geologists and practical men. From an admeasurement along the line of declivity, from the pit to the crops, and the best judgement which could be formed (under existing circumstances) of the degree of inclination of the strata, it was calculated that a workable seam of coal would not be found at a less depth than about 110 fathoms from the surface. We are now somewhat under that distance; and there certainly is every reason to believe, from the nature of the measures, and the immense quantities of coal they have been for a length of time impregnated with, that a valuable delph will ere long be hit upon. The whole of the measures hitherto explored have been of the most promising description and decisive character as real coal-measures, and found lying in the most regular stratified order: the first 25 fathoms, consisting of strong slaty bind, contain about 9 solid feet of excellent iron-stone, in beds from 3 to 10 inches thick; immediately below this, about 30 feet of dun marl or free-stone bands are found, alternating in layers from 1 to 3 inches thick; to these succeeds a gray rock 27 feet thick; 20 fathoms of hard gray or free-stone bands then occur, divided by thinnish strata of beautiful light blue and black shales, containing 2 thin veins of coal; under these rocks lie 7 fathoms of a hard bastard dun, all much impregnated with coaly matter; below this, an exceedingly hard striped rock occurs, 30 inches thick; then a red dun, or rather shale, 1½ fathom; then a rock, beautifully striped with black, white, brown, and dun, about 3½ fathoms; next a brown dun, about 3 fathoms; and, lastly, a strong black shale, occasionally finely striped with white: the whole of the measures have been *proved* (as colliers term it) by washings, and almost every inch of the last 30 yards has partaken very largely of the coal itself, which has gradually increased in quantity down to the present depth; in the sediment yielded by the washings of the last few yards, the proportion of coal has been more than one half! This but imperfect description of the section of measures will convey to the reader but an inadequate idea of their frequent changes and respective natures; it will merely serve to show the kind of formation actually existing here;—they must be seen to be properly appreciated. Some of the disciples of Mr. Smith's school thought well, at the commencement of my undertaking, publicly to announce, that I should not come upon these coal-measures before I had penetrated the ponderous series of lias, red-marl, and sand strata intervening between this spot and the north-western coal districts; founding their assertions upon Mr. Smith's hypothesis of the vast ranges of strata delineated on his Geological Map of England, taking a regular and continuous dip, "stratum super stratum," to the eastward. Now, though it be unquestionably true that the *prevailing* dip of the strata of Great Britain is to the east, it is nevertheless equally true that such declivity is but of a partial or local nature. To this now generally received opinion, I may adduce one entertained by Mr. Williams upon the subject (vol. ii. p. 86.):—"In all my perambulations and researches," he says, "I have never been able to trace any particular class of strata for any considerable extent; for two or three hundred yards, or two or three hundred miles, are both small compared with the circumference of the earth. I once took it for granted, as many do, that every stratum was a zone; but on more accurate examination, both in the Highlands and Lowlands, I corrected my error; and now frequent observation and experience have convinced me that there is *no such thing* as a very long stretch of the same strata."

However this may be, it is well known that modern geologists determine the geographical extent of particular strata by the fossil exuviæ they respectively contain, and, moreover, that such fossil remains give a determinate and peculiar character to the strata in which they are imbedded. With reference to this subject, I have to state that in the very centre of that vast range of strata denominated "lias," (but on the *spot* I have described as containing an apparently insulated mass or patch of the coal formation,) I have recently discovered, from eleven to sixteen feet from the surface, and below two regular strata of iron-stone, a *vast number* of *fossil fruits*, of different species, and accompanied with a variety of other vegetable remains, but which remains are in such an imperfect state that no characters can be given of them: the fruits are respectively distinguished by the most marked and perfect characters of their original organization. I may enumerate the following as being particularly distinguishable: viz. fruit resembling a large walnut, partly enveloped in the outer husk, the shell and kernel presenting very evident characters of resemblance; several others of this kind, mostly inclosed in the green or outer rind; another, like a peach or nectarine, with stone in the centre; the top of a pear; one similar to an orange, in a very perfect state of preservation, showing the rind and quarters; small nut; fir-apples, and other fruits of large dimensions, perfectly distinguishable as originally organs of fructification, but which cannot be identified with any now existing in this country. The ferruginous fluid which flows in great abundance through all the interstices of the stratum in which the fruits, &c., are deposited, has converted all the above-named vegetable and other substances into a substance of its own nature. Some of the fossil fruits I have shown to several of the most eminent botanists, chemists, mineralogists, &c., in London, who have (with but one exception) unanimously pronounced them of the order of *Carpolithes*, or fossil fruits and seeds; and there exists little or no doubt of their being natives of a tropical climate, or at least of a much warmer climate than this country has probably ever enjoyed, during the historical period.

I am fully prepared to prove whatever I have here stated, and shall feel great pleasure in submitting specimens of these fossils, &c., to the inspection of the *initiated*; and I flatter myself that every unbiassed individual who examines them will allow that I have effected something towards the opening of a new and extensive field to the enterprising miner, which will at no distant day, by the blessing of Providence, become not only an inestimable benefit to this neighbourhood, where it is much required, but a new source of common wealth and national prosperity.

Coplow House, Jan. 17, 1833. JOSEPH HOLDSWORTH.

[An account of the discovery of coal in the district north-east of Leicester, by Mr. F. Forster, will be found in Phil. Mag. and Annals, vol. v. p. 347.—EDIT.]

## COHESION OF CAST IRON.

Mr. Eaton Hodgkinson, whose valuable papers on Suspension Bridges, and the Strength of Cast-iron Beams, were noticed in the Lond. and Edinb. Phil. Mag. vol. i. p. 207, as published in the Manchester Philosophical Memoirs, has lately been trying some further experiments on the direct cohesion of cast-iron, which will in a great measure remove the doubts that long subsisted on that important point; proving that when cast-iron prisms are exposed to transverse strains, the neutral line between the tensile and the compressive resistance is not in the centre, according to the theory of Mr. Tredgold; and that the results of Capt. Brown and Mr. G. Rennie's experiments, which limit the cohesive strength to about eight tons to the square inch, are confirmed. The experiments were made on a large scale, and with great care to preserve the resultant of the straining force in the line of the centre of the transverse sections.

B. B.

*Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London; by Mr. GIDDY at Penzance, and Mr. VEALL at Boston.*

| Days of Month, 1833. | Barometer. | | | | | Thermometer. | | | | | Wind. | | | Rain. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | London. | | Penzance. | | Boston 8½ A.M. | London. | | Penzance. | | Bost. 8½ A.M. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
| | Max. | Min. | Max. | Min. | | Max. | Min. | Max. | Min. | | | | | | | |
| May 1 | 29·711 | 29·553 | 29·434 | 29·328 | 29·27 | 57 | 49 | 56 | 43 | 51 | S. | SW. | NW. | 0·08 | 0·400 | 0·21 |
| 2 | 29·700 | 29·541 | 29·478 | 29·281 | 28·96 | 63 | 53 | 58 | 47 | 53 | S. | SW. | SW. | ... | ·130 | ·10 |
| 3 | 29·839 | 29·755 | 29·678 | 29·581 | 29·15 | 72 | 46 | 56 | 52 | 61 | S. | S. | W. | ·10 | ... | ... |
| ○ 4 | 30·085 | 29·932 | 30·072 | 29·778 | 29·25 | 81 | 51 | 61 | 50 | 68·5 | W. | S. | calm | ... | ... | ... |
| 5 | 30·453 | 30·280 | 30·316 | 30·172 | 29·70 | 73 | 42 | 61 | 47 | 66 | NE. | N. | calm | ... | ... | ... |
| 6 | 30·500 | 30·461 | 30·372 | 30·354 | 29·95 | 69 | 41 | 64 | 47 | 63·5 | NE. | SE. | calm | ... | ... | ... |
| 7 | 30·436 | 30·194 | 30·266 | 30·160 | 29·95 | 70 | 50 | 63 | 48 | 66 | NE. | SE. | calm | ... | ... | ... |
| 8 | 30·107 | 29·935 | 30·016 | 29·860 | 29·60 | 72 | 47 | 62 | 50 | 56 | E. | SE. | calm | ... | ... | ... |
| 9 | 29·914 | 29·836 | 29·816 | 29·760 | 29·27 | 71 | 48 | 62 | 48 | 66 | S. | W. | calm | ... | ... | ... |
| 10 | 30·017 | 29·948 | 29·910 | 29·816 | 29·35 | 67 | 45 | 64 | 48 | 58 | S. | S. | calm | ... | ... | ... |
| ☾ 11 | 30·115 | 30·080 | 30·057 | 30·016 | 29·59 | 75 | 48 | 64 | 48 | 57 | S. | SE. | calm | ... | ... | ... |
| 12 | 30·080 | 29·926 | 30·069 | 30·016 | 29·48 | 81 | 50 | 63 | 47 | 63·5 | S. | NW. | calm | ... | ... | ... |
| 13 | 30·137 | 30·032 | 30·116 | 30·016 | 29·45 | 76 | 45 | 62 | 50 | 62 | SW. | SW. | calm | ... | ... | ... |
| 14 | 30·229 | 30·055 | 30·096 | 29·963 | 29·63 | 77 | 51 | 63 | 52 | 64·5 | SW. | SE. | NW. | ... | ... | ... |
| 15 | 30·005 | 29·836 | 29·866 | 29·866 | 29·37 | 86 | 51 | 65 | 53 | 72 | S. | SE. | calm | ... | ·130 | ... |
| 16 | 29·968 | 29·899 | 29·863 | 29·863 | 29·20 | 83 | 52 | 66 | 53 | 72·5 | W. | S. | W. | ... | ... | ... |
| 17 | 30·075 | 29·836 | 30·013 | 29·763 | 29·18 | 86 | 55 | 62 | 54 | 75 | W. | SW. | SE. | ... | ·140 | ... |
| 18 | 30·288 | 30·230 | 30·222 | 30·216 | 29·68 | 70 | 50 | 62 | 45 | 62 | E. | N. | calm | ... | ... | ·02 |
| ● 19 | 30·249 | 30·195 | 30·072 | 30·066 | 29·75 | 70 | 50 | 62 | 50 | 60 | E. | SE. | E. | ·50 | ... | ... |
| 20 | 30·272 | 30·127 | 30·166 | 30·066 | 29·60 | 72 | 45 | 64 | 52 | 56·5 | SW. | SW. | NE. | ... | ... | ·20 |
| 21 | 30·401 | 30·341 | 30·266 | 30·260 | 29·82 | 79 | 48 | 65 | 50 | 60·5 | SW. | SE. | calm | ... | ... | ... |
| 22 | 30·398 | 30·353 | 30·266 | 30·254 | 29·83 | 80 | 45 | 67 | 51 | 66 | SE. | SE. | S. | ... | ... | ... |
| 23 | 30·389 | 30·329 | 30·254 | 30·248 | 29·80 | 76 | 47 | 71 | 53 | 68·5 | E. | SE. | calm | ... | ... | ... |
| 24 | 30·331 | 30·214 | 30·254 | 30·192 | 29·65 | 80 | 48 | 71 | 54 | 68 | E. | SE. | calm | ... | ... | ... |
| 25 | 30·213 | 30·051 | 30·098 | 30·072 | 29·40 | 82 | 50 | 71 | 55 | 71 | SW. | N. | calm | ... | ... | ... |
| ☽ 26 | 30·337 | 30·178 | 30·142 | 30·075 | 29·72 | 73 | 39 | 64 | 54 | 57 | NE. | SE. | NE. | ... | ... | ... |
| 27 | 30·324 | 30·208 | 30·210 | 30·198 | 29·80 | 73 | 41 | 64 | 48 | 56·5 | N. | SE. | NW. | ... | ... | ... |
| 28 | 30·268 | 30·136 | 30·210 | 30·198 | 29·70 | 75 | 44 | 67 | 49 | 62 | W. | SE. | calm | ... | ... | ... |
| 29 | 30·170 | 30·168 | 30·160 | 30·104 | 29·66 | 67 | 41 | 66 | 49 | 60 | NE. | SE. | calm | ... | ... | ... |
| 30 | 30·275 | 30·203 | 30·104 | 30·104 | 29·77 | 69 | 40 | 64 | 49 | 60·5 | E. | SE. | calm | ... | ... | ... |
| 31 | 30·253 | 30·136 | 30·104 | 30·098 | 29·77 | 75 | 44 | 68 | 53 | 63 | E. | SE. | calm | ... | ... | ... |
| | 30·500 | 29·541 | 30·372 | 29·281 | 29·55 | 86 | 39 | 71 | 43 | 62·8 | | | | 0·68 | 0·800 | 0·53 |

Remarks.

*London.*—May 1. Heavy dew: rain. 2. Drizzly. 3–11. Fine. 12. Fine: cloudy, with lightning. 13, 14. Very fine. 15—18. Very hot. 19. Heavy rain, which fell to the depth of half an inch, the barometer at the same time standing high. 20—25. Hot and dry. 26. Cloudy: fine: cold at night. 27—31. Very fine.—Although this month has been remarkably hot and dry for this period of the season, vegetation has nevertheless gone on well; the abundance of moisture in the earth from the copious rains in the preceding month supporting it till a good supply was again received on the 19th, which, after the 3rd, was the only day on which rain fell during the month.

*Penzance.*—May 1, 2. Rain: fair. 3. Misty. 4. Fair. 5—7. Clear. 8—10. Fair. 11, 12. Clear: fair. 13. Fair. 14. Fair: rain at night. 15. Clear: foggy. 16. Fair: rain at night. 17. Fair. 18. Clear. 19. Fair. 20. Misty: fair. 21, 22. Fair: clear. 23—25. Clear. 26, 27. Fair. 28—31. Clear.

*Boston.*—May 1. Fine: rain P.M. 2. Stormy: rain early A.M. 3. Cloudy. 4. Fine: thermometer 76° 3 P.M. 5—7. Fine. 8. Cloudy. 9. Fine. 10, 11. Cloudy. 12—14. Fine. 15. Fine: thermometer 82° 2 P.M. 16. Fine. 17. Fine: thermometer 57° 4 A.M., rose to 85° 3 P.M.: rain with thunder P.M. 18. Fine. 19. Fine: rain P.M. 20. Cloudy. 21—25. Fine. 26. Cloudy. 27, 28. Fine. 29—31. Cloudy.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

*AUGUST* 1833.

## XIII. *Proposed Philosophical Experiments. By* H. F. Talbot, *Esq. M.P. F.R.S.**

### 1. *On the Velocity of Electricity.*

SOME ingenious experiments have lately been made by Mr. Wheatstone, with a view to determine the velocity of the electric spark *passing through air* by means of a revolving mirror. But has it ever been shown with certainty that the passage of electricity, *even through a conducting body*, is performed in a space of time so short as to be absolutely inappreciable? An experiment is upon record in which the spark was sent through seven miles of iron wire, which it is said to have traversed in an instant. But it may fairly be presumed that the philosophers who made this observation, could not answer for an interval of time smaller than the tenth part of a second. Now, as the revolving mirror gives us the power of increasing the accuracy of observation at least a thousand-fold, I will suggest a method of applying it to determine this question.

Let the greatest length of wire that can be procured, be disposed so that the two extremities are brought very nearly together. Let one end of the wire receive the spark from the machine, and the other end give it out again to any body which communicates with the earth.

If the flashes of electric light, entering the wire, and leaving it after traversing its whole length, appear simultaneous to the eye, take a mirror mounted on a revolving axis, and place

---

* Communicated by the Author.

it in such a position that (the mirror being at rest) the images of the two sparks coincide, or are superposed one upon the other.

This being effected, let the observation be made through a fixed tube, placing the combined image exactly in the centre of the tube; then if the mirror be made to revolve with great speed, if any separation of the combined spark into two take place, it will be a proof of the existence of an interval of time between them.

The necessity of the tube is apparent; for if the eye were directed to other points of the revolving mirror, the two images would appear separate from the mere effect of perspective.

### 2. *Proposed Method of ascertaining the greatest Depth of the Ocean.*

This is a problem concerning which we can hardly be said to possess any certain knowledge; since our power of sounding does not extend much beyond a thousand fathoms. But in the central parts of the Atlantic and Pacific, the ocean may be many leagues in depth;—at least such is the confident opinion of Laplace. As this is one of the most important points in the physical constitution of the globe, it would be very desirable, if possible, to reduce it to the test of actual experiment.

The method which I would propose, with some hope that it would prove successful, is to let fall from the deck of a ship one of the newly-invented percussion shells, which would explode on striking the ground; and the interval of time before the explosion was heard, would give the depth of water with great accuracy. The experiment should be first tried in a known depth of water, say a hundred fathoms, or whatever lesser depth would be consistent with security. The descent of the shell through the water would after the first few seconds be uniform, as is well known to be the case with all heavy bodies moving in a resisting medium. The time taken by the sound in returning through the water might be neglected, unless great accuracy were required; since it would move at the rate of a mile in half a second.

If it should be objected that the report of the shell might not be audible at great depths, I would remind the reader that in M. Colladon's experiments the sound of a *bell* was distinctly heard through the water of the lake of Geneva for a distance of *nine miles.*

[To be continued.]

## XIV. *List of the Simple Minerals of the Counties of Down, Antrim, and Derry. By* James Bryce, *Jun.M.A.; Member of the British Association for the Advancement of Science, of the Geological Society of Dublin, of the Natural History Society of Belfast, &c.*[*]

IN a small work, entitled "Tables of Simple Minerals, Rocks and Shells, with local Catalogues of Species[†]," published by me about two years since, there was given a list of the minerals found in the North of Ireland,—the list being confined to the minerals of the three northern counties, the productions of the others being but imperfectly known. Impressed with the importance of making catalogues of local productions more extensively known than they could be by means of a work of the above kind, I avail myself of the extensive circulation of the Philosophical Magazine, to make naturalists generally acquainted with the minerals of the North of Ireland.

Sir C. L. Giesecké has lately published an Irish Mineralogy, appended to his descriptive Catalogue of the Royal Dublin Society's Collection. The appearance of this work should be hailed with pleasure by every one interested in promoting a knowledge of the Natural History of Ireland. It is to be hoped that it will speedily be followed by an Irish Flora, and an Irish Fauna. It was not, however, to be expected that, in the present state of our knowledge, a work of this kind could be at all complete, although the indefatigable zeal and accomplished skill of Sir C. Giesecké have effected much. A chief inducement to the publication of the present article is to supply some of the deficiencies in his Catalogue. In the following list several species new to mineralogists will be observed. These have been all analysed and named by Dr. Thomson, who kindly permitted them to be published in the work above referred to. An account of some of them has since been published by him in the Edinburgh Transactions. For the discovery of many of these new species we are indebted to the active research of Mr. Patrick Doran, an intelligent mineral dealer.

### *Simple Minerals of Down, Antrim, and Derry.*

*Common Quartz.*—Very common everywhere; forms large veins in the Grauwacké of Down, and in the Mica Slate of Western Derry.

*Rock Crystal.*—Frequent in the Trap formations, in very large crystals in

---

[*] Communicated by the Author.

[†] Belfast: Simms and M'Intyre; Longman and Co. London; John Cumming, Dublin; Smith and Son, Glasgow.—[This work was noticed in Phil. Mag. and Annals, N.S. vol. xi. p. 224.—Edit.]

that rock at Benbradagh near Dungiven: one mass 70 pounds in weight, and apparently a fragment of a crystal, was found there. It is found also in the Granite of Down, and Mica Slate of Derry.

*Smoky Quartz.*—In the Mourne Granite, and the Trachytic Porphyry of Sandy Brae, Antrim.

*Amethyst.*—Found in the Granite of Mourne, by Mr. Patrick Doran, in small but beautiful crystals.

*Flint.*—In the Chalk of Derry and Antrim.

*Common Opal.*—Very common in the Trap rocks; also in dykes of Greenstone, traversing grauwacké in Down.

*Semi-opal.*—Rare: in the Trap of Antrim.

*Precious Opal.*—In the Porphyry of Sandy Brae, of a red and green colour. Sir C. Giesecké.

*Calcedony.*—Very common in Trap.

*Carnelian.*—On the shores of Lough Neagh, where, according to Sir C. Giesecké, Chalcedony, Sardonyx, Onyx, and Agates, also occur.

*Hyalite.*—Occurs in glass-white botryoidal masses on the Granite of Mourne. Sir C. Giesecké gives the Causeway as a locality.

*Heliotrope.*—On the shores of Lough Neagh.

*Iron Flint.*—In Rathlin, and according to Sir C. Giesecké on the shores near the Causeway.

*Jasper.*—In many parts of the Trap district, with the Coal of Coal Island, and in Bowlders at Hollywood, Down.

*Splintery Hornstone.*—In Bowlders, Ballymena; Giesecké. Also in Greenstone, Carnmoney, near Belfast.

*Conchoidal Hornstone.*—In Bowlders, Rostrover; Giesècké.

*Woodstone.*—At Lough Neagh, and in the Alluvial Soil in the vicinity. Also rarely in Down.

*Pitchstone.*—Forms veins in Granite near Newry, and occurs in the Porphyry of Sandy Brae.

*Lydian Stone.*—At Rostrover, Down; Giesecké. Also in Trap at Magilligan, Derry.

*Flinty Slate.*—Abundant in Down.

*Pearl Stone.*—Abundant in the Porphyry of Sandy Brae. Also in Greenstone near that place; Giesecké.

*Common Felspar.*—Very common.

*Glassy Felspar.*—In masses, often very large, in the Trap rocks; in small bits in the Sandy Brae.

*Porphyry.*

*Adularia.*—In small decomposed fragments, Mourne; Giesecké. Mr. Doran finds it there in the same rock in large opalescent masses.

*Labradorite.*—Found by Mr. Doran in Mourne, of a dull gray colour, and faint play of colours; it occurs in the Porphyry subordinate to Granite.

*Disintegrated Felspar.*—In the Mourne Granite.

*Albite.*—In the Mourne Granite, in small prismatic crystals.

*Apophyllite.*—Crystallized in prisms variously bevelled, of splendent lustre, from Dunseverie, near Giants' Causeway.

*Mornite.*—Found in the Greenstone of Mourne, by Mr. P. Doran, and analysed and named by Dr. Thomson. It occurs in greenish-red masses, and consists of silica, alumina, and lime.

*Chlorphærite.*—I found this substance lately in the Greenstone of Carnmoney near Belfast. It occurs massive; colour dark-green; lustre vitreous. It is accompanied by specular iron, and is much more beautiful than the Chlorphærites of England or Scotland.

*Common Hornblende.*—Very common; crystallized in acicular prisms: Fairhead.

*Basaltic Hornblende.*— Occurs in lamellar masses at Fairhead and other places.

*Slaty Hornblende.*—Subordinate to primary Rocks in many places.

*Kirwanite.*—Found by Mr. P. Doran in the Greenstone and Porphyry of Mourne, and named by Dr. Thomson. It occurs in radiated concretions of a dark-green colour, and consists of silica, protoxide of iron, lime, alumina, and water.

*Asbestous Tremolite.*—In Mourne: Grauwacké.

*Olivine* and *Augite.*—Occur frequently in Trap Rocks.

*Common Schorl.*—Is found in the Mica Slate of Antrim and Derry; also in the Mourne Granite.

*Tourmaline.*—In the Mourne Mountains, in various forms; Giesecké.

*Friable Zoisite.*—Of a dirty white colour. It occurs in light-gray decomposing Clay Slate near Annalong, Mourne. First noticed by Mr. P. Doran.

*Common Garnet.*—In small dodecahedrons, of a reddish-brown colour, in the Derry Mica Slate.

*Precious Garnet.*—In small dodecahedrons, of a red colour, in the Mourne Granite; Giesecké.

*Natrolite, Scolezite, Mesolite, Stilbite, Heulandite, Analcime, and Chabasite.*—Occur more or less frequently in all our Traps. Sir C. Giesecké thinks the analcime rare in our trap rocks. I have found it very common. Stilbite occurs also in Mourne Granite, of a white colour and bright pearly lustre.

*Laumonite.*—Discovered in four-sided prisms, of a pure white colour, in the Mourne Granite, by Mr. P. Doran. Sir C. Giesecké found it at Downhill, in Trap.

*Thomsonite.*—I found what Dr. Thomson pronounced to be a new variety of this mineral in Greenstone near Ballymoney, Antrim.

*Hydrolite* and *Leveyne.*—Discovered in the Amygdaloid of Little Deer Park, Glenarm, by Mr. P. Doran. They are fully described by Dr. Thomson, in the Transactions of the Royal Society of Edinburgh, vol. XI. part ii.

*Antrimolite.*—This mineral has been analysed and named by Dr. Thomson. It consists of silica, alumina, lime, and potash, and a large proportion of water. It occurs in cylindrical and conical masses, having an axis of calcareous spar, from which it is radiated, and resembles much the common fibrous mesotype. Sp. gr. 2·09.

*Lehuntite.*— Occurs massive, of a yellowish-white colour: constituents, silica, alumina, soda, and water. Sp. gr. 1·9. It was found at Carncastle near Glenarm, by Mr. P. Doran; analysed by Dr. Thomson, and named in honour of Captain Lehunt.

*Harringtonite.*—This mineral occurs massive, of a snow-white colour: constituents, silica, alumina, water, lime, and soda: found at Portrush, by Mr. P. Doran; analysed by Dr. Thomson, and named in honour of a friend in Dublin.

*Mesole.*—At Downhill, in Amygdaloid; Giesecké.

*Erinite.*—Occurs in small detached pieces, of a green colour, in a Steatitic Greenstone. It consists of silica, water, alumina, and protoxide of iron. It was found by Mr. P. Doran at Dunseveric, under high-water mark;—from this circumstance the analysis gave a trace of common salt.

*Phillipsite.*—Of a yellowish colour, and in variously modified rhomboids, has been recently found in Amygdaloid in Island Magee, by Mr. P. Doran.

*Chalilite.* — A mineral very recently found by Mr. P. Doran in the Porphyry of Sandy Brae; and named by Dr. Thomson, from its resemblance to red flint. It consists of silica, alumina, water, lime, and peroxide of iron.

*Abrazite,* or *Gismondine.*—Recently found in small globular masses in the Amygdaloid of Island Magee, by Mr. P. Doran.

*Epistilbite.*—Recently found by Mr. P. Doran in the Trap of Rathlin and Portrush.

*Clay Slate, Whet Slate, Drawing Slate, Alum Slate, Bituminous Slate, Claystone, Tripoli, Slate Clay, Potter's Clay, Lithomarge, Fuller's Earth, Green Earth, Mountain Soap, Bole, Wacké, Iron Clay.*—Occur frequently within the district.

*Steatite.*—Frequent in the Primary and also in the Trap Rocks.

*Potstone.*—Said by Sir C. Giesecké to occur in the Trap of Island Magee.

*Common Chlorite.*—Occasionally with Quartz in Primary Rocks.

*Rock Cork* and *Rock Leather.*—Occasionally between the strata of Chalk.[?]

*Emery.*—Is said to occur in Mourne.

*Topaz* and *Beryl.*—Are well known as occurring in the Granite of Mourne.

*Calc Spar.*—Of various forms; common everywhere.

*Satin Spar.*—Frequent in Trap Rocks.

*Fibrous Arragonite.*—Met with at Downhill and the Causeway.

*Calcareous Tufa* and *Stalactites.*—Common; the latter chiefly in Trap caverns.

*Aphrite.*—Is said to occur on the Transition Slate, Mourne. I have not seen it.

*Agaric Mineral.*—Lining Flint balls, Ballycastle, along with Rock Cork; also at Sleive Gallion in the same manner.

*Hydrocarbonate of Lime and Magnesia.*—In the Amygdaloid of Downhill, in spheroids having the appearance of a puddingstone. It is called by Sir C. Giesecké, Hydrocarbonate of Lime. Dr. Thomson has discovered Magnesia in it*.

*Rhomb Spar* and *Carbonate of Magnesia.*—Occur in the Magnesian Limestone at Holly and Belfast. The granular, compact, and fibrous varieties of Gypsum and Selenite are found in various places in Antrim, in the variegated Marl subordinate to the new red sandstone.

*Vulpinite.*—I recently found this mineral in a Trap dyke at the base of the Cave Hill near Belfast; it is of a laminated structure and sky-blue colour. Sir C. Giesecké mentions Rathlin as a locality, I know not on what authority.

*Heavy Spar.*—Occurs in Lead mines in several places; also in the Old Red Sandstone of Cushendun. *Sulphate of Strontia* is said to occur with it in Newtonards lead mine.

---

* Perhaps Mr. Bryce will inform us, in a future communication, whether this mineral is allied to that which the late Mr. W. Phillips, at the suggestion of Mr. Brayley, described under the appellation of Hydrocarbonate of Lime, in the last edition (1823) of his Elementary Introduction to Mineralogy, p. 161. "The latter mineral we are informed, in a communication from Mr. Brayley, is the result of the action of the trap dykes of the Giants' Causeway upon the chalk which they have intersected, and, according to the analysis of the late Dr. Da Costa, would appear to be composed of 4 atoms carbonate of lime and 3 atoms water; indicating, probably, that the hygrometric water of the original chalk, under the combined influence of heat and pressure, has entered into combination with the earthy salt: or the water may have been derived from a former superincumbent ocean. It would not be difficult to account for the formation of a similar hydrate in the cavities of an amygdaloid, such as that alluded to by Mr. Bryce." —EDIT.

*Strontianite.*—The Arragonite of the Causeway contains a small portion of Strontian.

*Alum.*—Occurs efflorescent on the Slate Clay of the Lias formation at White Head near Carrickfergus; also at Coal Island, Derry: Giesecké.

*Aluminite.*—In Trap at Gerron Point and Portrush.

*Copper Pyrites.*—With Galena, Newtonards, Down.

*Iron Pyrites.*—Abounds in Trap and other rocks.

*Magnetic Iron Ore.*—Occurs in great abundance in Trap at Portmuck, Island Magee, where it was first found by my friend Mr. M'Adam; it is crystallized in octahedrons; lustre splendent.

*Specular Iron.*—Not uncommon in our Trap Rocks, crystallized in rhomboids.

*Micaceous Iron Ore*—In several places in Mourne Mountains. Anhydrous Bisilicate and anhydrous Disilicate of Iron have been found in Mourne by Mr. P. Doran, and recognised by Dr. Thomson. Red Hamætite, Clay Iron Stone, and Bog Iron Ore are met with in several places.

*Galena* and *Green Phosphate of Lead.*—Occur in the Newtonards lead mines, Down.

*Radiated Gray Antimony.*—Said by Sir C. Giesecké to occur near Londonderry.

*Rutile.*—Occurs in Quartz in Mourne.

*Coal.*—Its different varieties are common.

*Amber.*—Said to occur in the Coal of Rathlin, in small bits.

Belfast Academy, Feb. 12, 1833.

## XV. *On certain Changes of Colour, induced by chemical and other Agents, in the Membrane lining the Choroid Coat of the Eye; in Reply to an Editorial Note in Lond. and Edin. Phil. Mag. and Journ., vol.* i. *p.* 115. *By* G. H. FIELDING, *Esq. M.R.C.S. Curator of Comparative Anatomy to the Hull Literary and Philosophical Society.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

I BEG leave to send you the following reply to a note appended by you, to a communication of mine in vol. i. page 115. of your New Series. For that note I feel much obliged to you; inasmuch as it led to further investigation, and to another entirely novel, and I think decisive experiment on the point. I am, Gentlemen, Your obedient Servant,

GEO. H. FIELDING.

The part of my communication to which your remarks apply is the following: "6thly. It is possible by chemical agents (which, according to Bichat, have not the slightest effect on the pigmentum of the eye) to destroy and restore these colours at pleasure. Take a section of a beast's eye in which the colours are vivid, and dip it into any dilute acid (nitric, muriatic or sulphuric), you will perceive the colours immediately begin to fade; now dip the portion in cold water, and on taking it out you will find the colours have disappeared; dip it again into the acid, and the colours will reappear as if by the touch of a magic wand; immerse it again in the water, and they will disappear; and so on, as often as you please. The same effect is produced by a solution of ammonia. With a pigment this could not occur; and my impression is, that these beautiful colours depend upon the thickness and disposition of the thin laminæ, of which, by dissection, I can prove this membrane to be composed. The cause of the disappearance and reproduction of the colours by chemical agency, I conceive to be merely the effects of heat and cold upon these thin plates, causing alternate expansion and contraction." Your observation is as follows: "Are not these changes of colour more probably referrible to the alterations of texture necessarily induced upon so delicate an organized structure by the application of chemical agents?"

Now, Gentlemen, the main object of my argument is to prove that the part in question is membrane, and not pigment. With this I think you seem to agree, by your use of the words "organized structure;" but you feel disposed to think that the curious changes in appearance in the experiment above detailed, are owing to some actual change in texture produced by chemical means.

If, therefore, I can show that these changes may be exhibited without the intervention of chemical agency, it will suffice both to satisfy your objection, and to strengthen my own position.

In the first place, I should argue that if by any of the means that I have named, we had actually altered the *texture* of an *organized part*, we could not have restored it to its primary state again at pleasure; and therefore, if the colour had once been discharged, because of this actual alteration effected chemically in the texture, it would have remained discharged. But to prove my opinion that the singular phænomena detailed in the experiment are the simple result of changes produced in the actual thickness of the membrane by alternate expansion and contraction from alternate heat and cold produced by the acid and the water, and not from any chemical effect on the texture of the membrane, I think the following experiment will be sufficient.

Carefully detach the choroid membrane of a beast's eye from the sclerotica, remove the humours and the retina, and wash off all the brown pigment with water and a camel's hair brush. Then suspend the choroides in a current of air to dry. Observe carefully the nature of the bright colours of the membrana versicolor on the internal surface when wet. As soon as the whole is thoroughly dry, examine it again, and you will find that all the colours have vanished. Immerse the collapsed membrane in water (or for more expedition in tepid water), and as the parts are gradually expanded you will find that the colours will be restored as beautiful as ever. This you may repeat as often as you like, with the same result.

In the choroid of a sheep, which I had injected minutely with vermilion, the effect of this experiment was most beautiful. The original colour of the membrana versicolor was a rich blue, but when dry the red injection was alone visible. With a little management I contrived to get it under the field of my microscope so as to see the actual process of the change. The blue surface came stealing over the red injection like a cloud, and gradually increased in density till the injection was fairly obscured by it.

---

## XVI. *An Attempt to assign the Cause of the Spontaneous Combustion of Charcoal. By Mr.* JOHN DAVIES, *Member of the Wernerian Society of Edinburgh, &c. and Lecturer on Chemistry, &c.*[*]

IN the interesting paper which has just been read[†], no attempt has been made by the author of it to furnish an explanation of the phænomenon which he has established and described: and as every inquiring mind will direct its attention to a rationale of the operation, I presume that some remarks which have occurred to me within the last few days, and which may at least supply some aid in the discussion, may be, without impropriety, appended to the paper. These remarks, though theoretical, are countenanced by experimental analogies, which, if they fail to establish the accuracy of the speculation, may at least excuse its introduction.

A statement of the mode in which the charcoal in question is made, will be necessary in the subsequent explanation. Small fragments of wood, generally stripped of their bark, are put into iron cylinders, and exposed to intense heat, in order to effect the distillation of the volatile constituents for the manufacture of iron liquor. Now Mr. Brunner resorted to a similar procedure in obtaining potassium from potash and charcoal; and, as we know that potash may be procured

---

[*] Read before the Literary and Philosophical Society of Manchester, November 4, 1831; and now communicated by the Author.

[†] Mr. Davies here alludes to Mr. Hadfield's paper on the same subject, given in our last Number, p. 1.—EDIT.

from the wood employed by Mr. Hadfield, we have in his manufacture the same operation and the same materials as in M. Brunner's experiment, and may therefore expect the same results. The only difference would be, that as M. Brunner used much potash, he procured a large proportion of the metallic base; while in the other case the potassium must be in small quantity, because all the potash present would be only that supplied by the wood subjected to distillation: and yet, upon the whole, the quantity extracted under the latter circumstances is not inconsiderable; for it is by the combustion of such wood in America, where it is of comparatively little value, that the potash is principally formed which is consumed in the arts and manufactures in every part of Europe.

It is manifest, therefore, that in the formation of Mr. Hadfield's charcoal, potassium must in small quantities be liberated.

Supposing the presence of potassium in fresh charcoal to have been established, we have now to explain its operation; and this appears to be effected upon the assumption that the metal lingers in the pores of the charcoal, incased, as it were, in the substance, until it be at length exposed to the action of atmospheric air and aqueous vapour. This view of the subject derives plausibility from the facts, that the combustion does not commence at any considerable depth below the surface; and that when a thermometer is introduced into the mass, the ignition generally originates in that place; that is to say, the combustion occurs exactly where it might be expected, since it takes place at the part which, favourably situated, is most exposed to the action of the supporter of combustion.

This general view of the spontaneous combustion is directly countenanced by the excellent paper of Colonel Aubert, inserted in the *Bulletin des Sciences Militaires* for January, which Mr. Hadfield has afforded me the opportunity of consulting. This ingenious foreigner shows by a number of decisive experiments, that the absorption of air and moisture are indispensable in the production of the phænomenon*. He proves also (what Mr. Hadfield has in a different way very clearly confirmed), that no carbonic acid is formed before the incandescence occurs;—a fact strictly in accordance with the hypothesis which I have offered; since, upon this hypothesis, the oxygen of the air, instead of forming an acid with the carbon, produces, by its superior affinity, an alkali with the potassium. The next position which he establishes is, that the carbon increased in weight in proportion to the quantity

---

* See Phil. Mag. and Annals, N.S. vol. ix. p. 148.—Edit.

of air and moisture absorbed; and this should, according to the explanation suggested, occur, the alkali formed being much heavier than its metallic base. It appears that, to produce the ignition, the charcoal should not only be reduced to powder soon after its formation, but that the sooner it is so reduced the more certain and considerable will be the effect. Now this fact also is entirely consistent with the explanation; because when the pulverization has been delayed, air and moisture will have gradually produced the alkali, by a process imperceptible because the minute portions of potassium would be at comparatively distant intervals from each other, and thus would not be in sufficient quantity at any one place to produce a sensible effect.

Colonel Aubert pulverized a mixture of charcoal and sulphur; and he found that, under these circumstances, no ignition ever occurred. The reason is obvious; for the potassium, which has been conceived to be the cause of the combustion, entered, during the trituration, into combination with the sulphur.

He also triturated charcoal with nitre; and he again found that the spontaneous combustion was prevented. Now nitre, by mingling with the potassium, would check its too rapid absorption of oxygen; and the effect of his experiment is in this way sufficiently accounted for.

The presence of potassium seems to account for the circumstance, that when charcoal is moistened and subjected to heat, carburetted hydrogen is set at liberty. In this instance it would appear that the water is decomposed, the hydrogen evolved, and the oxygen united with the potassium to form the alkali. If the heat be continued, carbonic oxide would be evolved; the oxygen absorbed in the first part of the operation being again detached from the metallic base. Now this explanation corresponds precisely, I believe, with the order in which, in such an experiment, these gases are produced.

All the circumstances observed by Mr. Hadfield and Col. Aubert appear therefore perfectly reconcilable with the supposition, that the spontaneous incandescence is owing entirely to the oxidation of the potassium liberated from the wood during the manufacture of the charcoal.

Dr. Thomson in the second volume of his History of Chemistry, published since my paper was read to our Society, has thrown additional plausibility upon my explanation, by his attempt to show that pyrophorus owes its property of catching fire, when in contact with oxygen, to a little potassium which is reduced to the metallic state during the formation of the pyrophorus.

## XVII. *Contributions to the Geology of Northumberland and Durham.* *By* N. J. Winch, *Esq. F.G.S. & A.L.S.*

[Concluded from p. 35.]

*An Account of the different Strata sunk through in the Engine Pit, Seghill Colliery, Northumberland: in Fathoms, Yards, Feet, and Inches.*

| | | *F.* | *Y.* | *F.* | *I.* | *F.* | *Y.* | *F.* | *I.* |
|---|---|---|---|---|---|---|---|---|---|
| Outset | | 2 | 0 | 0 | 0 | | | | |
| Blue clay | | 14 | 0 | 0 | 0 | | | | |
| Post girdles | | 0 | 0 | 0 | 6 | | | | |
| Blue metal | | 1 | 0 | 0 | 0 | | | | |
| Coal | High main coal | 0 | 0 | 2 | 6 | 17 | 1 | 0 | 0 |
| Blue metal | | 1 | 1 | 1 | 0 | | | | |
| Coal | | 0 | 0 | 0 | 3 | | | | |
| Gray metal | | 0 | 0 | 2 | 6 | | | | |
| Blue metal | | 2 | 0 | 0 | 0 | | | | |
| Coal | | 0 | 0 | 0 | 5 | | | | |
| Gray metal | | 3 | 0 | 0 | 0 | | | | |
| Post mixed with whin: got a great quantity of water in this stone | | 10 | 1 | 0 | 10 | | | | |
| Coal | | 0 | 1 | 0 | 4 | | | | |
| Dark-gray metal | Grey's seam | 0 | 0 | 0 | 6½ | | | | |
| Coal | | 0 | 1 | 0 | 2 | 19 | 0 | 0 | 0½ |
| Blue metal or thill | | 0 | 1 | 0 | 3 | | | | |
| Coal | | 0 | 0 | 0 | 5 | | | | |
| Blue metal | | 0 | 0 | 2 | 6 | | | | |
| Post girdle | | 0 | 0 | 1 | 2 | | | | |
| Gray metal | | 1 | 0 | 2 | 11 | | | | |
| Post | | 0 | 1 | 0 | 9 | | | | |
| Gray metal | | 1 | 0 | 2 | 4 | | | | |
| Whin girdles | | 0 | 0 | 2 | 0 | | | | |
| Gray metal | | 1 | 0 | 0 | 4 | | | | |
| Black stone | | 0 | 1 | 1 | 3 | | | | |
| Coal | | 0 | 0 | 0 | 5 | | | | |
| Gray metal mixed with girdles | | 3 | 1 | 0 | 8 | | | | |
| Coal | Hartley-Yard coal | 0 | 0 | 2 | 10½ | 10 | 1 | 2 | 10½ |
| Gray metal | | 0 | 1 | 1 | 9 | | | | |
| Blue metal | | 0 | 1 | 1 | 6 | | | | |
| Post girdles | | 0 | 0 | 0 | 6 | | | | |
| Blue metal with thin post girdles | | 0 | 1 | 1 | 7 | | | | |
| White post with partings and water | | 9 | 0 | 1 | 4 | | | | |
| Foul slaty coal | Hartley stone coal | 0 | 0 | 0 | 11 | | | | |
| Coarse do. | | 0 | 0 | 1 | 8 | | | | |
| Gray and black metal | | 0 | 0 | 1 | 11 | | | | |
| Coal | | 0 | 0 | 1 | 3 | 12 | 1 | 0 | 5 |
| | | | | | | 60 | 0 | 0 | 4 |

Seghill Colliery is six miles to the north-east of Newcastle, and the value of its section is to show the difference between the strata at Gosforth on the south side of the great dyke, and at this mine, which is about two miles on the north side of it from Killingworth. The sections of Hartley and Killingworth Collieries (see first series of Geological Transactions, vol. iv. p. 31. and 32.) also serve to throw considerable light on the northern division of this mining field, though the identity of the various coal seams situated to the north and to the south of the dislocation is still a problem unresolved. However, I trust the great professional knowledge of Mr. Buddle, aided by the numerous documents in his possession, will enable him soon to elucidate this obscure but interesting subject.

*An Account of the Strata sunk through at the Engine Pit Manor Wallsend Colliery, near South Shields, Durham.*

| | | | Fath. | Ft. | In. | Fath. | Ft. | In. |
|---|---|---|---|---|---|---|---|---|
| Clay | | | 10 | 5 | 0 | | | |
| Broken freestone with water | | | 1 | 1 | 0 | | | |
| Blue metal | | | 0 | 4 | 0 | | | |
| Black stone | | | 0 | 0 | 6 | | | |
| *Coal* | 1ft. | 2in. | | | | | | |
| Band | 0 | 7 | | | | | | |
| *Coal* | 1 | 0 | | | | | | |
| | | | 0 | 2 | 9 | | | |
| | | | | | | 13 | 1 | 3 |
| Blue metal | | | 2 | 0 | 4 | | | |
| Gray metal, post with girdles and water | | | 4 | 2 | 9 | | | |
| Gray metal | | | 3 | 1 | 0 | | | |
| *Coal* | | | 0 | 1 | 10 | | | |
| | | | | | | 9 | 5 | 11 |
| Thill stone | | | 0 | 3 | 0 | | | |
| Gray metal post girdles and water | | | 3 | 4 | 0 | | | |
| Post, with water | | | 13 | 3 | 0 | | | |
| Gray metal | | | 3 | 1 | 0 | | | |
| Post | | | 0 | 5 | 0 | | | |
| Gray metal | | | 2 | 2 | 0 | | | |
| Post and water | | | 2 | 3 | 0 | | | |
| Black stone | | | 3 | 3 | 0 | | | |
| *Coal* | | | 0 | 0 | 4 | | | |
| Gray metal | | | 2 | 4 | 0 | | | |
| *Coal* | | | 0 | 0 | 4 | | | |
| Post and water | | | 10 | 4 | 0 | | | |
| Post girdles and metal | | | 1 | 4 | 0 | | | |
| *Coal* | | | 0 | 0 | 3 | | | |
| Thill stone | | | 1 | 2 | 0 | | | |
| Post | | | 1 | 3 | 0 | | | |
| Gray metal | | | 0 | 5 | 0 | | | |
| *Coal* | | | 0 | 1 | 10 | | | |
| | | | | | | 49 | 0 | 9 |
| Gray metal | | | 7 | 3 | 8 | | | |
| Stony *Coal* | | | 0 | 1 | 2 | | | |
| Thill stone | | | 0 | 2 | 6 | | | |
| Carried forward | | | 8 | 1 | 4 | 72 | 1 | 11 |

| | | | | Fath. | Ft. | In. | Fath. | Ft. | In. |
|---|---|---|---|---|---|---|---|---|---|
| Brought forward | | | | 8 | 1 | 4 | 72 | 1 | 11 |
| Post with water | | | | 7 | 2 | 0 | | | |
| *Coal* | | | | 0 | 1 | 5 | | | |
| | | | | | | | 15 | 4 | 9 |
| Blue metal | | | | 2 | 5 | 6 | | | |
| *Coal* | | | | 0 | 1 | 10 | | | |
| | | | | | | | 3 | 1 | 4 |
| Post and water | | | | 5 | 5 | 6 | | | |
| Blue metal | | | | 1 | 4 | 6 | | | |
| Strong *coal* | | | | 0 | 0 | 6 | | | |
| Thill stone | | | | 0 | 1 | 6 | | | |
| Post, commonly called the 70-fathom post | | | | 11 | 5 | 6 | | | |
| Blue metal | | | | 0 | 3 | 2 | | | |
| Post girdles | | | | 2 | 0 | 1 | | | |
| Blue metal | | | | 0 | 3 | 3 | | | |
| Post with metal partings | | | | 1 | 0 | 3 | | | |
| Black stone | | | | 3 | 3 | 4 | | | |
| Gray metal | | | | 0 | 4 | 0 | | | |
| Main post | | | | 4 | 4 | 0 | | | |
| *Coal* | High main coal | 1 ft. | 9 in. | | | | | | |
| Band | | 1 | 7 | | | | | | |
| *Coal* | | 0 | 9 | | | | | | |
| Band | | 0 | 7 | | | | | | |
| *Coal* | | 1 | 9 | | | | | | |
| | | | | 1 | 0 | 5 | | | |
| | | | | | | | 34 | 0 | 0 |
| | | | | | | | 125 | 2 | 0 |
| Blue metal stone | | | | 8 | 3 | 0 | | | |
| Hard post | | | | 0 | 5 | 0 | | | |
| Bored. | | | | 9 | 2 | 0 | | | |
| Hard post | | | | 8 | 3 | 0 | | | |
| *Coal* | | | | 0 | 1 | 5 | | | |
| Thill stone | | | | 0 | 0 | 7 | | | |
| | | | | | | | 18 | 1 | 0 |

### *An Account of the Strata passed through in sinking the Pit at High Heworth, 21st of July* 1821.

| | Fath. | Ft. | In. | Fath. | Ft. | In. |
|---|---|---|---|---|---|---|
| Soil | 0 | 1 | 0 | | | |
| Strong brown clay | 1 | 5 | 0 | | | |
| Brown post | 1 | 2 | 8 | | | |
| White flaggy post | 0 | 5 | 4 | | | |
| Light-brown freestone post | 3 | 1 | 0 | | | |
| White flaggy post | 0 | 1 | 10 | | | |
| Brown post | 0 | 1 | 10 | | | |
| Cashey metal | 0 | 0 | 4 | | | |
| *Coal* | 0 | 0 | 6 | | | |
| | | | | 8 | 1 | 6 |
| Thill | 0 | 2 | 0 | | | |
| Blue metal mixed with post girdles | 1 | 3 | 0 | | | |
| *Coal* | 0 | 0 | 4 | | | |
| | | | | 1 | 5 | 4 |
| Carried forward | | | | 10 | 0 | 10 |

| | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|
| Brought forward | | ... | | 10 | 0 | 10 |
| Thill | 0 | 4 | 0 | | | |
| Gray metal and post girdles | 5 | 3 | 0 | | | |
| White post with metal partings | 4 | 2 | 0 | | | |
| White post mixed with round whin balls | 0 | 2 | 0 | | | |
| White post with partings | 0 | 5 | 0 | | | |
| Blue stone | 2 | 1 | 4 | | | |
| *Coal* | 0 | 0 | 2 | | | |
| | | | | 13 | 5 | 6 |
| Thill | 0 | 3 | 6 | | | |
| Blue metal | 5 | 0 | 9 | | | |
| *Coal* | 0 | 0 | 4 | | | |
| | | | | 5 | 4 | 7 |
| Black slate | 0 | 2 | 2 | | | |
| Seamy post and post girdles, with blue metal | 1 | 3 | 0 | | | |
| Whin | 0 | 2 | 3 | | | |
| Post with thin partings | 0 | 3 | 4 | | | |
| Blue metal | 0 | 5 | 8 | | | |
| *Coal* | 0 | 0 | 4 | | | |
| | | | | 3 | 4 | 9 |
| Thill | 0 | 2 | 0 | | | |
| Black stone | 0 | 1 | 10 | | | |
| Thill | 0 | 4 | 0 | | | |
| Gray metal mixed with post girdles | 1 | 4 | 0 | | | |
| Gray post | 0 | 1 | 6 | | | |
| Blue metal stone | 2 | 3 | 0 | | | |
| Black stone | 0 | 4 | 10 | | | |
| *Coal* | 0 | 1 | 6 | | | |
| | | | | 6 | 4 | 8 |
| Thill | 0 | 2 | 0 | | | |
| Black stone | 0 | 3 | 0 | | | |
| *Coal* | 0 | 0 | 1 | | | |
| | | | | 0 | 5 | 1 |
| Thill | 0 | 2 | 10 | | | |
| Gray metal | 1 | 0 | 6 | | | |
| Post girdles | 0 | 2 | 0 | | | |
| Gray metal | 0 | 3 | 6 | | | |
| Whin | 0 | 1 | 4 | | | |
| Blue stone | 1 | 1 | 9 | | | |
| *Coal* | 0 | 0 | 5 | | | |
| | | | | 4 | 0 | 4 |
| Thill | 0 | 1 | 6 | | | |
| Blue stone | 0 | 1 | 3 | | | |
| Post girdles | 0 | 1 | 4 | | | |
| Whin | 0 | 0 | 9 | | | |
| Gray metal | 0 | 2 | 0 | | | |
| Seamy post | 0 | 1 | 3 | | | |
| Whin | 0 | 1 | 0 | | | |
| Post | 0 | 2 | 0 | | | |
| Blue metal | 0 | 5 | 0 | | | |
| Pudding stone | 0 | 0 | 7 | | | |
| *Coal* | 0 | 0 | 9 | | | |
| | | | | 2 | 5 | 5 |
| Carried forward | | | | 48 | 1 | 2 |

| | | | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|---|
| Brought forward | | | | | | | 48 | 1 | 2 |
| Black slate | | | | 0 | 2 | 9 | | | |
| Thill | | | | 0 | 1 | 8 | | | |
| Seamy post | | | | 0 | 2 | 0 | | | |
| Blue stone | | | | 0 | 0 | 9 | | | |
| *Coal* | | | | 0 | 0 | 8 | | | |
| | | | | | | | 1 | 1 | 10 |
| Black slate | | | | 0 | 2 | 2 | | | |
| *Coal* | | | | 0 | 0 | 3 | | | |
| | | | | | | | 0 | 2 | 5 |
| White thill | | | | 0 | 2 | 3 | | | |
| Blue stone | | | | 2 | 5 | 4 | | | |
| *Coal* | | | | 0 | 0 | 3 | | | |
| | | | | | | | 3 | 1 | 10 |
| Thill | | | | 0 | 1 | 0 | | | |
| Gray metal | | | | 0 | 4 | 0 | | | |
| Strong gray post | | | | 3 | 1 | 0 | | | |
| Blue stone | | | | 0 | 3 | 8 | | | |
| Seamy post | | | | 1 | 4 | 4 | | | |
| Blue stone | | | | 2 | 2 | 6 | | | |
| Strong gray metal and post girdles | | | | 3 | 5 | 10 | | | |
| Post | | | | 7 | 0 | 6 | | | |
| Strong gray metal with girdles | | | | 0 | 5 | 6 | | | |
| Gray post | | | | 1 | 5 | 8 | | | |
| White post mixed with metal | | | | 1 | 4 | 0 | | | |
| Gray metal | | | | 0 | 3 | 2 | | | |
| Black stone | | | | 0 | 0 | 2 | | | |
| Crow *coal* | High main coal | 0ft. | 4in. | | | | | | |
| Band | | 0 | 2 | | | | | | |
| *Coal* | | 2 | 10 | | | | | | |
| *Coal* (coarse) | | 0 | 4 | | | | | | |
| Band | | 1 | 3 | | | | | | |
| *Coal* | | 2 | 2 | | | | | | |
| | | | | 1 | 1 | 1 | | | |
| | | | | | | | 26 | 0 | 5 |
| Coarse *coal* and slate | | | | 0 | 0 | 11 | | | |
| Thill | | | | 0 | 1 | 10 | | | |
| Black stone | | | | 0 | 4 | 11 | | | |
| Blue stone | | | | 0 | 4 | 6 | | | |
| Black stone | | | | 0 | 4 | 0 | | | |
| Blue stone | | | | 1 | 2 | 4 | | | |
| Gray metal stone | | | | 0 | 5 | 9 | | | |
| Blue stone | | | | 1 | 0 | 0 | | | |
| *Coal* | Metal coal | 0ft. | 6in. | | | | | | |
| Brown band | | 0 | 11 | | | | | | |
| *Coal* | | 2 | 6 | | | | | | |
| | | | | 0 | 3 | 11 | | | |
| | | | | | | | 6 | 4 | 2 |
| Thill | | | | 0 | 1 | 4 | | | |
| Gray metal stone | | | | 2 | 1 | 0 | | | |
| Black stone | | | | 0 | 1 | 4 | | | |
| Black stone and post girdles | | | | 0 | 5 | 2 | | | |
| Black stone | | | | 0 | 1 | 6 | | | |
| *Coal* | | | | 0 | 1 | 1 | | | |
| | | | | | | | 3 | 5 | 5 |
| Carried forward | | | | | | | 89 | 5 | 3 |

| | | | Fath. | Ft. | In. | Fath. | Ft. | In. |
|---|---|---|---|---|---|---|---|---|
| Brought forward | | | | ... | | 89 | 5 | 3 |
| Thill | | | 0 | 2 | 11 | | | |
| Gray metal and post girdles | | | 0 | 2 | 9 | | | |
| Gray metal | | | 1 | 1 | 2 | | | |
| *Coal,* very pure splint | | | 0 | 1 | 0 | | | |
| | | | | | | 2 | 1 | 10 |
| Thill | | | 0 | 1 | 4 | | | |
| Blue stone | | | 3 | 1 | 10 | | | |
| Black stone | | | 0 | 1 | 0 | | | |
| Fine splint *coal* | | 0ft. 8in. | | | | | | |
| Coarse *coal* | | 0 8 | | | | | | |
| | | | 0 | 1 | 4 | | | |
| | | | | | | 3 | 5 | 6 |
| Dark gray metal with balls of whin | | | 2 | 4 | 0 | | | |
| Gray metal, rather hard | | | 0 | 2 | 11 | | | |
| Scamy post girdles with thin layers of metal | | | 2 | 0 | 2 | | | |
| Whin | | | 0 | 0 | 10 | | | |
| Scamy post | | | 1 | 0 | 8 | | | |
| Whin | | | 0 | 1 | 1 | | | |
| Gray scamy post with thin layers of metal | | | 1 | 1 | 3 | | | |
| Gray metal | | | 0 | 1 | 0 | | | |
| *Coal,* bright but tender | Yard coal | 0 10½ | | | | | | |
| Gray metal band | | 0 1½ | | | | | | |
| *Coal,* coarse and scamy | | 2 4¼ | | | | | | |
| | | | 0 | 3 | 4¼ | | | |
| | | | | | | 8 | 3 | 3¼ |
| Thill | | | 0 | 2 | 9 | | | |
| Gray post | | | 0 | 2 | 8 | | | |
| Blue stone | | | 2 | 1 | 4 | | | |
| Black stone | | | 0 | 4 | 9 | | | |
| Gray metal with ironstone balls | | | 2 | 1 | 2 | | | |
| Gray metal with post girdles | | | 1 | 0 | 8 | | | |
| Whin | | | 0 | 1 | 4 | | | |
| Gray metal with post girdles | | | 0 | 4 | 1 | | | |
| Whin | | | 0 | 0 | 8 | | | |
| Gray metal with post girdles | | | 0 | 5 | 4 | | | |
| White post | | | 0 | 1 | 8 | | | |
| Gray metal with thin girdles | | | 0 | 2 | 4 | | | |
| Blue stone | | | 0 | 3 | 0 | | | |
| *Coal* | Bensham seam | 1 6½ | | | | | | |
| Band | | 0 1 | | | | | | |
| *Coal* | | 1 1½ | | | | | | |
| Band | | 1 10½ | | | | | | |
| *Coal* | | 1 5 | | | | | | |
| Band | | 0 0¾ | | | | | | |
| *Coal* | | 0 6¼ | | | | | | |
| | | | 1 | 0 | 7½ | | | |
| | | | | | | 11 | 2 | 4½ |
| Thill | | | 0 | 2 | 5 | | | |
| Blue metal | | | 2 | 0 | 0 | | | |
| *Coal* | | 0 2 | | | | | | |
| Band | | 0 3 | | | | | | |
| *Coal* | | 0 11 | | | | | | |
| | | | 0 | 1 | 4 | | | |
| | | | | | | 2 | 3 | 9 |
| Carried forward | | | | ... | | 118 | 3 | 11¾ |

| | | | *Fath.* | *Ft.* | *In.* | *Fath.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|
| Brought forward ... ... | | | ... | | | 118 | 3 | 11¾ |
| Thill ... ... ... ... ... ... ... ... ... | | | 0 | 1 | 0 | | | |
| Gray metal stone ... ... ... ... ... ... ... | | | 1 | 2 | 9 | | | |
| Post mixed with whin ... ... ... ... ... ... | | | 0 | 1 | 7 | | | |
| Gray metal with thin post girdles ... ... ... ... | | | 0 | 4 | 7 | | | |
| White post ... ... ... ... ... ... ... ... | | | 0 | 5 | 6 | | | |
| Black stone ... ... ... ... ... ... ... ... | | | 0 | 0 | 2 | | | |
| *Coal* ... ... ... | Six quarter coal | 0ft. 9in. | | | | | | |
| Brown slaty band | | 0 10 | | | | | | |
| *Coal* ... ... ... | | 1 3¼ | | | | | | |
| Splint ... ... ... | | 0 5¼ | | | | | | |
| | | | 0 | 3 | 3½ | | | |
| | | | | | | 4 | 0 | 10½ |
| Thill ... ... ... ... ... ... ... ... ... | | | 0 | 0 | 6 | | | |
| Post ... ... ... ... ... ... ... ... ... | | | 0 | 1 | 6 | | | |
| Blue metal ... ... ... ... ... ... ... ... | | | 2 | 4 | 5 | | | |
| *Coal* ... ... | Five quarter coal ... | 1 10½ | | | | | | |
| Splint ... ... | | 0 3 | | | | | | |
| *Coal* ... ... | | 0 11 | | | | | | |
| | | | 0 | 3 | 0½ | | | |
| | | | | | | 3 | 3 | 5½ |
| Thill ... ... ... ... ... ... ... ... ... ... | | | 0 | 1 | 2 | | | |
| Strong gray metal stone ... ... ... ... ... | | | 0 | 4 | 2 | | | |
| Strong gray post mixed with whin ... ... ... | | | 0 | 3 | 7 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 1 | 2 | 2 | | | |
| *Coal* ... ... ... ... ... ... ... ... ... | | | 0 | 0 | 2 | | | |
| | | | | | | 2 | 5 | 3 |
| Thill ... ... ... ... ... ... ... ... ... | | | 0 | 0 | 10 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 0 | 2 | 0 | | | |
| Post girdles mixed with metal ... ... ... ... | | | 0 | 2 | 0 | | | |
| Black stone ... ... ... ... ... ... ... ... | | | 0 | 0 | 7 | | | |
| Thin post girdles mixed with metal ... ... ... | | | 0 | 3 | 6 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 0 | 3 | 0 | | | |
| Post girdles ... ... ... ... ... ... ... ... | | | 0 | 0 | 9 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 0 | 3 | 2 | | | |
| Post girdle ... ... ... ... ... ... ... ... | | | 0 | 0 | 10 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 0 | 3 | 4 | | | |
| Thin post girdles separated by metal partings ... | | | 0 | 3 | 2 | | | |
| Gray post mixed with whin ... ... ... ... ... | | | 0 | 5 | 0 | | | |
| Blue stone ... ... ... ... ... ... ... ... | | | 0 | 0 | 5 | | | |
| Strong white post ... ... ... ... ... ... ... | | | 0 | 4 | 0 | | | |
| Blue metal stone ... ... ... ... ... ... ... | | | 0 | 4 | 5 | | | |
| Coarse and brassy *coal* ... | Low main coal | 0 2 | | | | | | |
| Splint *coal* ... ... ... | | 0 1½ | | | | | | |
| *Coal* (fine) ... ... ... | | 4 1½ | | | | | | |
| Bottom *coal* (not so fine) | | 0 9 | | | | | | |
| | | | 0 | 5 | 2 | | | |
| | | | | | | 7 | 0 | 2 |
| Slaty black stone ... ... ... ... ... ... ... | | | 0 | 0 | 10 | | | |
| Strong gray post ... ... ... ... ... ... ... | | | 1 | 1 | 5 | | | |
| Gray metal with thin girdles ... ... ... ... | | | 0 | 1 | 3 | | | |
| Strong gray post ... ... ... ... ... ... ... | | | 0 | 5 | 10 | | | |
| Black stone ... ... ... ... ... ... ... ... | | | 0 | 0 | 5 | | | |
| Thill ... ... ... ... ... ... ... ... ... | | | 0 | 1 | 9 | | | |
| Blue metal stone ... ... ... ... ... ... ... | | | 0 | 3 | 0 | | | |
| | | | | | | 3 | 2 | 6 |
| Total depth sunk ... ... ... | | | ... ... ... | | | 139 | 4 | 2¾ |

Let us now turn our attention to that part of the district which is situated on the south side of the Tyne. At Jarrow, two miles west of South Shields, the well-known high main seam of coal is nearly two hundred fathoms below the surface of the earth, but in the vicinity of the latter place the accompanying section gives us a depth of about seventy-nine fathoms. This remarkable difference is not owing to any considerable inequality on the surface, but from the coal-measures here rising at an unusual angle to the east. It was long ago observed by the viewers or professional men here, that from the neighbourhood of Heworth the high main coal, the very best seam on the Tyne, or even in the north of England, became injured as it proceeded in a south-easterly direction, by being interstratified by a band of coal of inferior quality with an admixture of stony matter and iron pyrites. This they called the Heworth Band; and though borings were made near the Scots House in the vicinity of the Boldon Hills, there appears not to have been sufficient encouragement resulting from the trial to induce one of the most enterprising and opulent coal owners of his day to prosecute the undertaking by sinking a shaft. Owing to the high main coal being deteriorated by this band, an opinion prevailed very generally, even among professional men, that no mine would be worked to profit near or under the magnesian limestone formation; and as far as the high main seam was the object of their speculations, they were not far from the truth. I am not aware that the limestone was ever thought to be the direct cause of rendering the coal of inferior quality; but one thing was certain, that whenever the collieries on the south side of the Tyne extended their workings in the direction of the limestone hills, the Heworth band was sure to intervene and injure the coal. How far this is the case to the southward, will appear when the section of Hetton Colliery comes under consideration.

[To be continued.]

---

## XVIII. *Table of the First, Second, and Third Powers of the Sines to Centesimal Parts of the Versed Sine.* By B. Bevan, Esq.

*To the Editors of the Philosophical Magazine and Journal of Science.*

Gentlemen,

The following table of the first, second, and third powers of the *sines* to centesimal parts of the *versed sine*, will be found useful in several calculations. Perhaps they will be allowed to occupy a place in your Magazine.

Yours truly, B. Bevan.

| Versed Sines to Rad. 100. | Sines. | (Sines)$^2$ | (Sines)$^3$ | Versed Sines to Rad. 100. | (Sines) | (Sines)$^2$ | (Sines)$^3$ |
|---|---|---|---|---|---|---|---|
| 1 | 14·1067 | 199 | 2807 | 51 | 87·1722 | 7599 | 662422 |
| 2 | 19·8997 | 396 | 7880 | 52 | 87·7268 | 7696 | 675146 |
| 3 | 24·3105 | 591 | 14368 | 53 | 88·2666 | 7791 | 687185 |
| 4 | 28·0000 | 784 | 21952 | 54 | 88·7919 | 7884 | 700035 |
| 5 | 31·2250 | 975 | 30444 | 55 | 89·3029 | 7975 | 712190 |
| 6 | 34·1174 | 1164 | 39712 | 56 | 89·7998 | 8064 | 724146 |
| 7 | 36·7560 | 1351 | 49657 | 57 | 90·2829 | 8151 | 735896 |
| 8 | 39·1198 | 1536 | 60199 | 58 | 90·7524 | 8236 | 747437 |
| 9 | 41·4608 | 1719 | 71271 | 59 | 91·2086 | 8319 | 758764 |
| 10 | 43·5890 | 1900 | 82819 | 60 | 91·6515 | 8400 | 769873 |
| 11 | 45·5961 | 2079 | 94794 | 61 | 92·0815 | 8479 | 780759 |
| 12 | 47·4974 | 2256 | 107154 | 62 | 92·4986 | 8556 | 791419 |
| 13 | 49·3052 | 2431 | 119861 | 63 | 92·9031 | 8631 | 801847 |
| 14 | 51·0294 | 2604 | 132881 | 64 | 93·2952 | 8704 | 812042 |
| 15 | 52·6783 | 2775 | 146182 | 65 | 93·6750 | 8775 | 821998 |
| 16 | 54·2586 | 2944 | 159737 | 66 | 94·0425 | 8844 | 831712 |
| 17 | 55·7763 | 3111 | 173520 | 67 | 94·3981 | 8911 | 841181 |
| 18 | 57·2364 | 3276 | 187506 | 68 | 94·7418 | 8976 | 850402 |
| 19 | 58·6430 | 3439 | 201673 | 69 | 95·0737 | 9039 | 859371 |
| 20 | 60·0000 | 3600 | 216000 | 70 | 95·3939 | 9100 | 868085 |
| 21 | 61·3107 | 3759 | 230467 | 71 | 95·7027 | 9159 | 876541 |
| 22 | 62·5780 | 3916 | 245055 | 72 | 96·0000 | 9216 | 884736 |
| 23 | 63·8044 | 4071 | 259748 | 73 | 96·2860 | 9271 | 892668 |
| 24 | 64·9923 | 4224 | 274527 | 74 | 96·5609 | 9324 | 900334 |
| 25 | 66·1438 | 4375 | 289379 | 75 | 96·8246 | 9375 | 907730 |
| 26 | 67·2607 | 4524 | 304287 | 76 | 97·0773 | 9424 | 914856 |
| 27 | 68·3447 | 4671 | 319238 | 77 | 97·3191 | 9471 | 921701 |
| 28 | 69·3974 | 4816 | 334218 | 78 | 97·5500 | 9516 | 928286 |
| 29 | 70·4202 | 4959 | 349214 | 79 | 97·7701 | 9559 | 934586 |
| 30 | 71·4143 | 5100 | 364213 | 80 | 97·9796 | 9600 | 940604 |
| 31 | 72·3809 | 5239 | 379204 | 81 | 98·1784 | 9639 | 946342 |
| 32 | 73·3212 | 5376 | 394174 | 82 | 98·3667 | 9676 | 951796 |
| 33 | 74·2361 | 5511 | 409115 | 83 | 98·5444 | 9711 | 956965 |
| 34 | 75·1266 | 5644 | 424014 | 84 | 98·7117 | 9744 | 961847 |
| 35 | 75·9934 | 5775 | 438862 | 85 | 98·8686 | 9775 | 966441 |
| 36 | 76·8375 | 5904 | 453649 | 86 | 99·0152 | 9804 | 970744 |
| 37 | 77·6595 | 6031 | 468364 | 87 | 99·1514 | 9831 | 974758 |
| 38 | 78·4602 | 6156 | 483001 | 88 | 99·2774 | 9856 | 978478 |
| 39 | 79·2401 | 6279 | 497549 | 89 | 99·3932 | 9879 | 981905 |
| 40 | 80·0000 | 6400 | 512000 | 90 | 99·4987 | 9900 | 985038 |
| 41 | 80·7403 | 6519 | 526346 | 91 | 99·5942 | 9919 | 987875 |
| 42 | 81·4616 | 6636 | 540579 | 92 | 99·6795 | 9936 | 990416 |
| 43 | 82·1645 | 6751 | 554692 | 93 | 99·7547 | 9951 | 992659 |
| 44 | 82·8493 | 6864 | 568678 | 94 | 99·8198 | 9964 | 994605 |
| 45 | 83·5165 | 6975 | 582527 | 95 | 99·8749 | 9975 | 996252 |
| 46 | 84·1665 | 7084 | 596236 | 96 | 99·9200 | 9984 | 997601 |
| 47 | 84·7998 | 7191 | 609795 | 97 | 99·9550 | 9991 | 998650 |
| 48 | 85·4166 | 7296 | 623200 | 98 | 99·9800 | 9996 | 999400 |
| 49 | 86·0744 | 7399 | 636443 | 99 | 99·9950 | 9999 | 999850 |
| 50 | 86·6025 | 7500 | 649519 | 100 | 100·0000 | 10000 | 1,000,000 |

## XIX. *A Catalogue of Comets. By the Rev.* T. J. HUSSEY, *A.M. Rector of Hayes, Kent.*

[Continued from vol. ii. p. 455.]

[The Chronology employed is that of Petau or Petavius.]

A, the comet of 1680. B, that of 1652. C (Halley's), that of 1682. D, that of 1759. E, that of 1661. F, that of 1677.

| Number. | Year of Appearance A. C. | Same as that of | Month or Season when it appeared. | Place or Direction in which it appeared. | By whom mentioned. | Remarks. |
|---|---|---|---|---|---|---|
| 121 | 449 | ... | November..... | Leo, Virgo, Bo. | Chinese Records. | |
| 122 | 451 | ... | June............ | Near the Pleia. | Chinese Records. Idat. Isidor. &c. | |
| 123 | 467 | ... | ...... | ...... | Chron. Pasch. Theophan. &c. | Seen 40 days. |
| 124 | 499 | ... | ...... | ...... | Zonaras. | |
| 125 | 501 | ... | Feb. March ... | ...... | Chinese Records. | |
| 126 | 504 | ... | ...... | ...... | Galfredus. Boethius, &c. | |
| 127 | 507 | ... | August......... | N.E. | Chinese Records. | |
| 128 | 519 | ... | ...... | ...... | Chron. Pasch. Theophan. &c. | |
| 129 | 520 | ... | Oct. Novemb. | E. | Chinese Records. | |
| 130 | 524 | ... | ...... | ...... | Cedrenus, &c. .. | Seen 26 days. |
| 131 | 530 | ... | Sept. Oct..... | Arct.λμU.Ma. | Chinese Records. | |
| 132 | 531 | A | September .... | ...... | Theoph. Cedren. Zonar. &c.... | |
| 133 | 533 | ... | March ......... | ...... | Chinese Records. | |
| 134 | 534 | ... | ...... | Betw$^{n}$ ♌ ♍ & Bootes to Peg. | Chinese Records. | |
| 135 | 539 | ... | ...... | Sagittarius ... | Procop. Abulph. Chinese Rec. | Elements computed by Burckhardt*. |
| 136 | 556 | ... | November.... | ...... | Malala, &c. | |
| 137 | 560 | ... | October ....... | ...... | Chinese Records. | |
| 138 | 563 | ... | ...... | ...... | Gregor. of Tours. | |
| 139 | 565 | ... | April......... | Urs. Maj. to Aquila and Pegasus.... | Chinese Records. | Elements computed by Burckhardt*. |

| * No. | Year. | Passage through the Perihelion in Mean Time at Greenwich. | Longitude of the Perihelion at the Orbit of the Comet. | Longitude of the ascending Node. | Inclination of the Orbit. | Perihelion Distance, that of the Earth being 1. | Logarithm of the Mean Motion. | Motion. |
|---|---|---|---|---|---|---|---|---|
| 50 | 240 | Nov. 9$^{d}$ 23$^{h}$ 51$^{m}$ | 9$^{s}$ 1° 0′ | 6$^{s}$ 9° 0′ 0″ | 44° 0′ 0″ | 0·371000 | 0·605000 | Direct. |
| 135 | 539 | Oct. 20 14 21 | 10 13 30 | 1$^{s}$ 28 or 7$^{s}$ 28° | 10 0 0 | 0·341200 | 0·660523 | D. |
| 139 | 565 | July 8 23 51 | 2 28 0 | 5 8 0 0 | 62 0 0 | 0·719000 | 0·174840 | R. |
| 140 | — | July 14 11 51 | 2 20 0 | 5 9 30 0 | 59 0 0 | 0·832000 | 0·080130 | R. |

| Number. | Year of Appearance A. C. | Same as that of | Month or Season when it appeared. | Place or Direction in which it appeared. | By whom mentioned. | Remarks. |
|---|---|---|---|---|---|---|
| 140 | — | ... | August ......... | .... | Chinese Records. | Elements computed by Burckhardt*. |
| 141 | 566 | ... | ...... | Towards the Pole | Abulph. Marius. | Seen 70 days. |
| 142 | 568 | ... | July ............ | Gemini........ | Chinese Records. | |
| 143 | — | ... | September.... | Scorpio ♒ Equul. Pegas. Aries ......... | Chinese Records. | Seen 69 days. |
| 144 | 574 | ... | May.......... | Bootes, Ursa Major ....... | Chinese Records. | |
| 145 | 575 | ... | April............ | Near Arcturus. | Chinese Records. | |
| 146 | 580 | ... | ...... | .... | Gregor. of Tours. | |
| 147 | 581 | ... | January........ | S.W. | Chinese Records. | |
| 148 | 582 | ... | January....... | .... | Gregor. of Tours. | |
| 149 | 584 | ... | ...... | .... | Aimoin, &c. | |
| 150 | 588 | ... | November.... | Head of Capricornus ..... | Chinese Records. | |
| 151 | 590 | ... | ...... | .... | Bonfinius. | |
| 152 | 595 | ... | January......... | β ♒ α Equulei to Androm. and Aries .. | Simocat. Aimoin, Chin. Rec. | |
| 153 | 602 | ... | ...... | .... | Ced. Zonar, &c. | |
| 154 | 605 ± a? | ... | April, May... | .... | Paul. Diacon. &c. | |
| 155 | — ± b? | ... | Nov. Dec..... | .... | Paul. Diacon. &c. | |
| 156 | 607 | ... | March.......... | Gemini, Ursa Major, Pers. Medus. Herc. | Chinese Records. | |
| 157 | — a? | ... | April........... | Pisces, Androm., Aries, Virgo...... | Chinese Records. | |
| 158 | — b? | ... | October...... | Virgo, Leo ... | Chinese Records. | |
| 159 | 608 | ... | ...... | Auriga, Taurus, Ursa Major, Scorp......... | Chinese Records. | Of a dusky colour; the tail had a considerable vibratory motion. |
| 160 | 615 | ... | July.......... | Ursa Major .. | Chinese Records. | |
| 161 | 617 | ... | July.......... | Leo .......... | Chinese Records. | |
| 162 | — | ... | October...... | Pegasus ...... | Chinese Records. | |
| 163 | 626 | ... | March ....... | Perseus ...... | Ch. Pasch. Chi. R. | |
| 164 | 632 | E | ...... | .... | Theoph. Cedren. | Seen 30 days. |
| 165 | 634 | ... | September .... | Aquar., Equul. | Chinese Records. | |
| 166 | 639 | ... | April, May.... | Taurus ....... | Chinese Records. | |
| 167 | 641 | ... | August....... | North of Leo and Virgo.. | Chinese Records. | |
| 168 | 663 | ... | September.... | Bootes ....... | Chinese Records. | |
| 169 | 667 ? | ... | May, June... | Between Auriga & Taurus | Chinese Records. | |
| 170 | 668 | ... | May.......... | Between Auriga & Taurus | Chinese Records. | |

* See note in preceding page.

[To be continued.]

ERRATUM.—Page 283. Some errors having been left in the note, the elements of the comet of A.D. 240, are repeated above in p. 101.

## XX. *Remarks on* Mr. Drummond Hay's *Observations on the* Gopher-wood *of the received Version of the Scriptures. By* Charles T. Beek, *Esq.*

*To the Editors of the Philosophical Magazine and Journal of Science.*

Gentlemen,

IN a paper which appears in your Magazine for June, headed "Notices of certain Plants of Marocco," Mr. Drummond Hay supports the opinion, that the *Cedar* was the wood of which Noah built the Ark, on the authority of the Chaldee Paraphrase, in which the word of the Hebrew text גֹּפֶר (*Gopher*), Gen. vi. 14, is represented by the word קְדְרוֹס (*Kadros*), which is usually rendered *cedrus*.

I am not aware, however, that the Targum is of itself entitled to greater deference than the various authorities which exist in favour of other descriptions of wood. The whole of these authorities are cited in Dr. Rees's Cyclopædia, in the article "Ark."

But my object in addressing you is neither to dispute the claims of the Cedar, nor to advocate those of any other tree; but simply to show what is the literal meaning of the words of the text עֲצֵי־גֹפֶר (*hatzé-gopher*), which the translators of our authorized version have written *Gopher-wood*.

Now the interchange between the letters ג and כ being common in the Hebrew and cognate languages, owing to their being letters of the same organ, and of nearly the same sound (see Lee's Hebrew Grammar, 2nd Edit. p. 35. Art. 78.), I consider the word גֹּפֶר (*Gopher*) to be in fact identical with כֹּפֶר (*Kopher*), which occurs with it in the same verse, and of which the meaning is *Pitch*. Should it be objected that it is hardly likely that these letters are thus convertible in the same passage, another instance of the like interchange may be adduced from this very account of the Deluge: וַיִּסְגֹּר יְהוָה בַּעֲדוֹ (Vayisgór *yehováh báhadó*). 'And God *shut up* (the Ark) on him.' Gen. vii. 16. וַיִּסָּכְרוּ מַעְיְנֹת תְּהוֹם (Vayissákherú *mahyenóth tehóm*). 'And the fountains of the deep—were *shut up*.' Gen. viii. 2.

Isaac Delgado, a learned Jew, who in 1789 published an English translation of the Pentateuch, in like manner considers גֹּפֶר to be equivalent to כֹּפֶר. He accordingly reads "*pitched planks*"; עֲצֵי being, as he says, in the plural number, and signifying *planks* or *boards*. But in this latter respect he is clearly in error; since the primary and proper meaning of עֵץ (*ḥētz*), of which עֲצֵי is the plural in the state of construction, is *Tree* and not *Plank*. See Gen. i. 29. Deut. xxii. 6. and innumerable other texts.

Thus the literal translation of the words of the text עֲצֵי־גֹפֶר is "*Trees of Pitch*," or "*Pitch Trees*," meaning the wood of that description of tree from which pitch is obtained.

It remains to be ascertained what tree, the product of the country where the Ark was built, is most likely to have had this name applied to it by Moses;—on which I confess my incompetency to offer an opinion.

Another observation on Mr. Drummond Hay's paper I make with regret. It is with respect to his remarks on the manner in which Padre Felipe Scio has rendered these same words עֲצֵי־גֹפֶר, and likewise the words עֲצֵי־שִׁטִּים (*ḥatzé-shittím*), Exod. xxv. 10, in his Spanish Version of the Bible. I have no intention to advocate the worthy Padre's translation, but I feel persuaded that Mr. Drummond Hay would not have ridiculed him for his "utter ignorance" if he had not overlooked the fact, that this *modern Spaniard* has merely followed the *ancient* authority of the Vulgate; he having translated the "*ligna lævigata*" of that version by "*maderas labradas*," and the "*ligna de setím*" of the same by "*maderas de setím*." I am, Gentlemen,

Your most obedient Servant,
CHARLES T. BEEK.

North Buildings, Finsbury Circus,
June 7, 1833.

---

## XXI. *Characters of some undescribed Genera and Species of* Araneidæ. *By* JOHN BLACKWALL, *Esq. F.L.S. &c.*[*]

### *Tribe*, TUBITELÆ, Latreille.

### Genus, *Savignia*.

EYES six in number, unequal in size; four of them, which are disposed in a transverse row behind the anterior prominence of the cephalothorax, are separated by large intervals, the two intermediate ones being the smallest of the six, and immediately before each of the lateral eyes another is situated.

[*] Communicated by the Author.

Maxillæ greatly enlarged at the base externally, where the palpi are inserted, and inclined towards the lip, which they encompass.

Lip short, broad, prominent at the apex, and semicircular.

Legs moderately robust; the anterior and posterior pairs, which are the longest, equal in length; the third pair is the shortest.

The name of M. Savigny, which I have bestowed upon this genus, is connected with highly interesting discoveries in this department of zoology.

### *Savignia frontata.*

Cephalothorax oval, convex above, with a minute indentation in the medial line of the posterior region, and an acute perpendicular eminence of a conical form in front, surmounted by a tuft of fine hair. Mandibles small, dentated on the inner side, and inclined towards the pectus, which is heart-shaped. These parts, with the maxillæ and lip, are of a brownish-black colour. Legs and palpi brown, with a tinge of red. Each tarsus has three claws at its extremity; the two upper ones are finely pectinated, and the inferior one is abruptly inflected near its base. The fourth and fifth joints of the palpi are expanded laterally; the former projects an apophysis in front tapering into an acute point curved outwards; both are convex externally, concave within, and are connected with the sexual organs, which are highly developed, complicated in structure, and of a very dark red-brown colour. Abdomen oval, rather convex above, projecting over the base of the cephalothorax; it is sparingly clad with hair, glossy and black.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{12}$th of an inch; breadth of the cephalothorax, which equals that of the abdomen, $\frac{1}{28}$; length of a fore leg $\frac{1}{10}$.

The above is the description of a male, which sex is found in considerable abundance, in the months of October and November, on rails in the immediate vicinity of Crumpsall Hall, near Manchester. I have not yet succeeded in capturing a single female; and concerning the œconomy of the animal, I can merely state that it is active during the day.

The short and broad lip, the converging maxillæ, the large intervals between the eyes (those of the lateral pairs excepted), and the difference in the relative length of the legs, at once distinguish this spider from the species constituting the genus *Dysdera*, to which it is nearly allied.

### Genus, *Walckenaëria.*

Eyes eight in number, unequal in size, disposed in pairs on the anterior eminence of the cephalothorax, which is elongated and acute. One pair is seated on its summit, a second a little lower, in front, describing with the former a trapezoid whose anterior side is the shortest; and the two other pairs are placed obliquely, one on each side of the frontal eminence. The eyes of the lateral pairs, which are geminated, are the largest, and those of the anterior pair are the smallest of the eight.

Maxillæ strong, convex externally, greatly dilated at the base, where the palpi are inserted, encompassing the lip.

Lip short, broad, prominent at the apex, and semicircular.

Legs robust; the anterior and posterior pairs, which are the longest, equal in length in the females; the third pair is the shortest.

I have conferred upon this singular genus the name of a distinguished living arachnologist, the celebrated Baron Walckenaër.

*Walckenaëria acuminata.*

Cephalothorax oval, gibbous above, with a minute indentation in the medial line of the posterior region, and terminating in an acute prominence before. Pectus oblong heart-shaped. Mandibles vertical, moderately strong, convex in front, and dentated on the inner side. These parts, with the maxillæ and lip, are glossy, and of a dark brownish-black colour. Palpi robust, and without claws; the third joint is remarkably short, and the fourth and fifth joints are somewhat dilated. Legs hairy, but destitute of spines. Each tarsus has three claws at its extremity; the two superior ones are strongly pectinated, and the inferior one is abruptly inflected near its base. The colour of these organs is bright rufous. Abdomen oval, rather convex above, projecting a little over the base of the cephalothorax; it is sparingly clad with hair, glossy, and deep black. The plates of the spiracles are of a pale yellow colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{3}{20}$ths of an inch; length of the cephalothorax $\frac{1}{13}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{15}$; length of a fore leg $\frac{1}{5}$; length of a leg of the third pair $\frac{1}{6}$.

Similar to the female in colour, and in the relative length of its legs, but rather smaller than she is, the male has the anterior part of the cephalothorax much more elongated and slender, measuring about $\frac{1}{20}$th of an inch in length; it is elevated vertically, and dilated near the middle and at the apex, the latter dilatation being separated by a transverse groove into an upper and a lower segment, both of which are rough with short strong hairs. On these enlargements the eyes are situated. The third joint of the palpi expands gradually towards its anterior extremity; the fourth joint is short, terminating in three apophyses, and on the upper part of the inner apophysis, which is longer than either the exterior or the inferior one, and is curved outwards, a small prominence occurs; the fifth or terminal joint is somewhat oval, convex externally, concave within, comprising the sexual organs, which are black, with a tinge of red; they are highly developed and complicated in structure, having a strong spiny process on the outer side curved into a circular form.

My brother, Mr. Thomas Blackwall, discovered this remarkable spider in the month of October 1832, under stones and on rails in the township of Crumpsall, near Manchester.

### *Walckenaëria cristata.*

In colour this species is similar to *Walckenaëria acuminata*, with the exception of the legs, which have a deeper shade of rufous; but in external structure it presents several obvious points of difference. The anterior part of the cephalothorax is less elevated and acute, and the pectus is shorter and broader proportionally.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{11}$th of an inch; breadth of the abdomen $\frac{1}{22}$. The fore and hind legs, which are the longest and equal in length, measure $\frac{1}{10}$, and the third pair is the shortest.

The relative length of the legs is different in the sexes; the male has the fourth pair the longest, measuring $\frac{1}{8}$th of an inch; then the second, the third pair being the shortest. The anterior eminence of the cephalothorax is shorter and very much stronger than the same part in the male of *Walckenaëria acuminata*; it is divided into two segments at the summit by a deep transverse groove, and each is surmounted by a tuft of fine hair inclined towards the groove and forming a crest. One pair of eyes is seated on the hinder part of the posterior division of the eminence, near its summit, and another pair is situated near the summit of the anterior division, in front, describing with the former a trapezoid whose shortest side is before; the other eyes are disposed in pairs, one on each side of the frontal prominence, and are geminated. The eyes of the lateral pairs are the largest, and those of the anterior pair the smallest of the eight. The third joint of the palpi is enlarged at its anterior extremity; the fourth presents two apophyses, one small, projecting underneath; the other, which is much larger and tapers to a point, curved outwards, being situated in front; the fifth joint, and the anterior apophysis of the fourth are expanded laterally; they are convex externally, concave within, and are connected with the sexual organs, which are highly developed, exhibiting several curved spiny processes, (a certain indication that the animal has attained maturity,) and are of a dark red-brown colour.

Mr. T. Blackwall discovered this minute species in October, 1832. It is found in abundance under stones in the township of Cheetham, near Manchester.

### *Walckenaëria cuspidata.*

This species is precisely similar in colour to *Walckenaëria acuminata*, but in the form of the pectus it resembles *Walckenaëria cristata.* The upper part of the cephalothorax is not so gibbous as that of either of the other species belonging to the genus, and has no indentation in the medial line of the posterior region.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{10}$th of an inch; length of the cephalothorax $\frac{1}{20}$; breadth $\frac{1}{26}$; breadth of the abdomen $\frac{1}{22}$. The legs of the first and last pairs, which are the longest and equal in length, measure $\frac{1}{7}$th, and those of the third pair, which are the shortest, $\frac{1}{9}$th.

The male is rather smaller than the female, but the relative length of its legs is the same. In the trapezoid formed by the four intermediate eyes, immediately in front of the posterior pair, it has a small, conical, acute prominence surmounted by a few fine hairs. The fourth joint of the palpi terminates in two apophyses, the smaller one projecting on the under side; the longer has a prominence at its exterior part near the base, and curves outwards in front of the fifth joint, which is somewhat oval, convex externally, concave within, comprising the sexual organs; they are highly developed and complicated in structure, with a strong spine externally curved into a circular form.

This spider occurs on rails in the vicinity of Manchester, in the month of November.

By the pointed form of the anterior part of the cephalothorax, the converging maxillæ, and the structure of the legs, the spiders of this genus are connected with the *Drassi;* but they differ from them essentially in the disposition and relative size of the eyes, and in the figure of the lip.

### Genus, *Textrix.*

Eyes eight in number, unequal in size, disposed in two transverse rows on the anterior part of the cephalothorax; four constituting the anterior row, which is slightly curved, are adjacent and minute, the two intermediate ones being the smallest of the eight; the posterior row is greatly curved, with its convexity directed forwards; it comprises the other four eyes, which are large and separated by wide intervals, the two intermediate ones being the largest of all.

Maxillæ powerful, curved towards the lip, enlarged and rounded at the apices.

Lip large and nearly quadrate.

Legs moderately long, tapering to their extremities; the fourth pair is the longest, the other three pairs being equal in length.

The spiders belonging to this genus are sedentary, constructing a horizontal web of a compact texture, with which a tube is connected conducting to the spider's retreat, in the crevices of rocks and walls, and in the intervals among stones.

### *Textrix agilis.*

Cephalothorax inversely heart-shaped, but elongated and very prominent before; the sides, which are glossy, slope abruptly, and are marked with deep furrows extending from the carina to the margins, and a narrow longitudinal indentation occupies the medial line of the posterior region; its colour is dark brownish-black, with a yellowish-white band of short hairs extending along the carina, and numerous long black hairs in front. Mandibles strong, conical, armed with a few teeth on the inner side, and inclined towards the pectus, which is heart-shaped. These parts, with the maxillæ and lip, are brownish-black; the two latter organs being much the palest, particularly at their extremities. The legs and palpi are light brown, with brownish-black bands, and are furnished with numerous erect, slender, black spines. There are three claws at the extremity of each tarsus; the two superior ones are long, curved, and deeply pectinated, and the inferior one is provided with a pair of small teeth on each side near the base, where it is inflected; beneath the claws are two strong bristles thickly clad with minute hairs on the under side. (In order to discern this structure a highly magnifying power must be employed.) A slender, curved, pectinated claw terminates each palpus. Abdomen oval, projecting a little over the base of the cephalothorax; it is thickly covered with hair, and is black above with a broad, dentated band along the middle, of a yellowish-white colour; the anterior part of the band comprises four small black spots, two on each side of the medial line, forming a parallelogram; the sides of the abdomen are mottled with yellowish-white, and the under part is reddish-brown, marked with a few minute yellowish-white and black spots. The plates of the spiracles are yellowish-white. The superior spinning mammulæ, which are much longer than the rest, very prominent, and triarticulate, have the papillæ, or delicate tubes from which the silk issues in the act of spinning, disposed along the under side of the terminal joint; their colour, and that of the intermediate pair, is red-brown, the inferior pair being black.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, not including the spinners, $\frac{3}{10}$ths of an inch; length of the cephalothorax $\frac{1}{8}$; breadth $\frac{1}{10}$; breadth of the abdomen $\frac{1}{10}$; length of a posterior leg $\frac{7}{20}$; length of a leg of the first, second, and third pairs $\frac{3}{10}$; length of a superior spinning mammula $\frac{1}{20}$.

The male is smaller and darker coloured than the female, but the relative length of its legs is the same; their absolute length, however, is greater, a posterior leg measuring $\frac{2}{5}$ths of an inch. The third and fourth joints of the palpi are short, the latter projecting a strong acute apophysis from the outer side of its anterior extremity; the fifth joint is of an oblong oval figure pointed before; it is convex and hairy externally, concave within, comprising the sexual organs, which are highly developed, complex, with prominent, curved spiny processes, and are of a brownish-black colour tinged with red.

In the summer of 1830, I found this active spider on rocks and stone-walls in the pass of Llanberis, Caernarvonshire; and I have since met with it in abundance at Oakland, in Denbighshire, and in other parts of North Wales. The *Textrices* are nearly allied to the *Araneæ* of M. Latreille, which comprise the *Tegenariæ* and *Agelenæ* of M. Walckenaër, and the *Arachnes* of M. Savigny. By the disposition of the eyes they also appear to connect the *Tubitelæ* with the *Citigradæ* through the medium of the genus *Dolomedes.*

### *Tribe*, INEQUITELÆ, Latreille.

### Genus, *Manduculus.*

Eyes eight in number, unequal in size, arranged in two transverse rows on the anterior part of the cephalothorax; the four intermediate ones, which are the largest, form a square, and the other four are disposed obliquely in pairs on the sides of the square, the eyes constituting each being placed on a small eminence, and nearly contiguous.

Maxillæ long, inclined towards the lip, enlarged at the base where the palpi are inserted, and slightly so at the apices, which converge abruptly and are contiguous.

Lip large, triangular, truncated at the vertex.

Legs long and slender; the first pair is the longest, then the second, the third pair being considerably the shortest.

Mandibles very powerful, convex in front, diverging widely at their lower extremities, and armed with a long moderately curved nail, and two rows of teeth on the inner side. Those of the male have an obtuse, conical prominence near the insertion of the nail, which latter appendage has a small indentation about the middle externally, and a corresponding projection, or minute tooth, within.

### *Manduculus ambiguus.*

Cephalothorax rather large, convex above and glossy; it is of an oval form truncated in front, with an indentation in the medial line of the posterior region; the colour is light reddish brown, with a black band along the middle, one on each side, just above the margins, and a short black streak directed backwards from each lateral pair of eyes. The pectus is heart-shaped, and rather darker coloured than the cephalothorax. The colour of the mandibles is light reddish-brown, that of the maxillæ and lip being dark red-brown. Legs and palpi yellowish-brown; they are sparingly supplied with hair, but the former are destitute of spines. Each tarsus has three claws at its extremity; the two superior ones are finely pectinated, and the lower one is abruptly inflected near its base. A single claw, pectinated about one third of its length, (the last tooth of the series being much the longest,) terminates each palpus. Abdomen oval, projecting a little over the base of the cephalothorax; the colour is yellowish-brown, above irregularly bordered with black; a narrow longitudinal band of pale yellow, having its anterior half bordered with black, and comprising a slender black streak, occupies the medial line. Along each side extends a broad band of dull yellow, which is palest on the upper edge, and is tinged with light brown below. Underneath the abdomen is yellowish-brown, with a band of a darker hue along the middle, bounded on each side by a faint yellow line. The plates of the spiracles are yellow. This species varies considerably in colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{4}$th of an inch; length of the cephalothorax $\frac{1}{9}$; breadth $\frac{1}{11}$; breadth of the abdomen $\frac{1}{8}$; length of an anterior leg $\frac{3}{8}$; length of a leg of the third pair $\frac{1}{5}$.

The male, which is smaller than the female, has the abdomen more distinctly marked; the upper part being almost black, and the medial and lateral bands nearly white. The third joint of the palpi is strong and very short; the fourth is dilated regularly to its anterior extremity, which is truncated; and the fifth has two slender apophyses, the shorter one attached to the upper side of the sexual organs, the longer connected with the same organs on the inner side and extending beyond them. The sexual organs are glossy, of a globular form, with a pointed elongation anteriorly; their colour is dark reddish-brown, approaching to black.

This spider, which was discovered by Mr. T. Blackwall in September 1831, under stones and rubbish in the township of Crumpsall, pairs in the month of October. In it are combined several striking characteristics of the genera *Theridion* and *Tetragnatha*. Allied to the former by the structure of the mouth, and the irregularity of the insignificant web it fabricates, it resembles the latter in the form and relative length of the legs, which it frequently extends in the same manner as *Tetragnatha extensa*; thus closely connecting by its organization and œconomy the *Inequitelæ* with the *Orbitelæ*.

Oaklamb, near Llanwrst, Denbighshire,
July 12th, 1833.

## XXII. *On the alleged Discovery of Coal at Billesdon, Leicestershire. By the* Rev. W. D. Conybeare, M.A. F.R.S.

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

IN the last Number of your valuable Journal, (p. 76) is a "Notice of the Discovery of Coal-measures at Billesdon, Leicestershire," which strongly illustrates the misunderstanding, so much to be regretted, that is often found to prevail in the minds of those engaged in practical researches, with regard to those *generalized views of science*, which are the only guides of really effective inquiries, but which are by such persons hastily thrown aside, under the entire misconception that they are founded only on data purely theoretical; whereas, in fact, the general views of systematic science are necessarily, wherever they are just, founded primarily on an extensive induction from practical observation, and from practical observation alone. They present, indeed, merely the combined and condensed results of the very widest practical observation,—divested only of the very obvious cause of error which a narrow spirit of judging from mere local acquaintance with a single district must necessarily introduce.

Thus in the notice which has occasioned these remarks, Mr. Holdsworth announces the discovery of coal-measures at Billesdon, without anything like a precise description of the thickness, range or extent of a single bed of coal; and relying only on washing from the materials produced by boring;

which, after all, are so loosely described, that it seems very probable that they may be nothing more than fragments of fossil wood, known to be very common in the lias formation, instead of true coal. In like manner the fossil vegetable remains mentioned by him, are described only under the old and vague name of Carpolithes, without any indication which can enable us to judge whether they belong to the species usually associated with the regular coal-measures or not. The notice is also destitute of every thing like a general account of the geological relations of the district; and it is hastily assumed that scientific geologists would previously have pronounced against the possibility of the occurrence of *any* coal in that neighbourhood; although the slightest acquaintance with any standard work on geology would have informed Mr. Holdsworth, that, besides the principal carboniferous formation, others are recognised, especially that connected with the sands of the inferior oolite, in the eastern moorlands of Yorkshire, and at Brora in Scotland. Now it so happens that these very sands of the inferior oolite, assuming a character very similar to their type in Yorkshire, range from Belvoir along the eastern portion of Leicestershire, and skirt on Billesdon itself. It seems, therefore, by no means improbable that if Mr. Holdsworth has really found any coal, it may belong to this formation; but his description does not at all state whether the site of his discovery be in these sands, or in the subjacent lias.

When also the general geological structure of Leicestershire is considered, no scientific geologist, assuredly, would have ventured to pronounce it highly improbable that, by piercing the lias itself, the *great carboniferous measures* might have been reached in the neighbourhood of Billesdon; since in no very distant portion of the same county, we see the older transition rocks of Mount Sorrel bursting forth in immediate proximity to the lias of Barrow-on-Soar. In like manner it is easy to suppose that some great undulation of the inferior strata may throw up the great coal-measures beneath the lias at Billesdon. Under very similar circumstances coal is found throughout the great coal-field of Somersetshire: at Newton near Bath, for instance, it is largely worked in the very midst of a lias district; but whether any similar circumstances exist near Billesdon, we are left in total ignorance.

These are the points which require to be examined into, in order to give the experiment now conducting at Billesdon the slightest probability of success; without such investigation, it can only end in disappointment and loss.

I remain, Gentlemen, your constant reader,

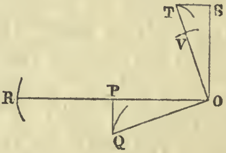
W. D. Conybeare.

# XXIII. *Note on the subject of Conical Refraction. By* J. MacCullagh, *Fellow of Trinity College, Dublin*[*].

WHEN Professor Hamilton announced his discovery of Conical Refraction, he does not seem to have been aware that it is an obvious and immediate consequence of the theorems published by me, three years ago, in the Transactions of the Royal Irish Academy, vol. xvi. part ii. p. 65, &c. The indeterminate cases of my own theorems, which, optically interpreted, mean conical refraction, of course occurred to me at the time; but they had nothing to do with the subject of that paper; and the full examination of them, along with the experiments they might suggest, was reserved for a subsequent essay, which I expressed my intention of writing. Business of a different nature, however, prevented me from following up the inquiry.

I shall suppose the reader to have studied the passage in pp. 75, 76, of the volume referred to. He will see that when the section of either of the two ellipsoids employed there is a *circle*, the semiaxes—answering to OR, O$r$, and to OQ, O$q$, in the general statement[†]—are *infinite* in number, giving of course an infinite number of corresponding rays. And this is *conical refraction.* I shall add a few words on the two cases:—

1. When RO$r$ is a circle, any two of its rectangular radii may be taken for OR and O$r$. The line OS and the tangent plane perpendicular to it at S are fixed; but the point of contact T is variable, for the plane ROS in which it lies changes with OR. Thus we get a curve of contact on the tangent plane of the wave surface, and a cone of rays OT derived from the same incident ray. The vibrations of any ray OT are in the line TS passing through the fixed point S, as follows from a general remark in the place referred to.



The three right lines OQ, O$r$, OT, are at right angles to each other, and a geometer will observe that the first two of them are confined to given planes. For O$r$ is always in the plane of the circle RO$r$; and the point Q must be in a given plane, because the line OP, perpendicular to the plane that touches the ellipsoid in Q, is in a given plane RO$r$.

---

[*] Communicated by the Author.

[†] The right line O$qr$ is perpendicular to the plane of the figure, and intersects the two ellipsoids in $q$ and $r$.

2. When $QOq$ is a circle, the points T and V coincide in a nodal point $n$, where the two sheets of the wave surface cross each other. At this point there are an infinite number of tangent planes, for $OQ$ and $Oq$ are now indeterminate. The same refracted ray $On$ may therefore be derived from any one of an infinite number of incident rays, and its polarization will differ accordingly; for the vibrations are in the line $nS$ drawn from the node to the foot of the perpendicular $OS$ on the tangent plane. The ray $On$, however, is always accompanied by another, but variable, refracted ray.

The three lines $OP$, $Oq$, $OS$, are at right angles to each other, and the first two of them are confined, as before, to given planes. For $Oq$ is in the plane of the circle $QOq$; and $OP$ being perpendicular to the tangent plane at Q must lie in a given plane. These given planes are parallel to two principal tangent planes passing through $n$ and touching the circle and ellipse that compose the wave section in the plane of the nodes: whence it is easy to see that every nodal tangent plane intersects the two principal tangent planes in lines that are constantly at right angles; for these lines are parallel to $OP$ and $Oq$.

The examination of both cases is completed by the following theorem: —

When three right lines at right angles to each other pass through a fixed point, in such a manner that two of them are confined to given planes, the plane of these two, in all its positions, touches the surface of a cone whose sections parallel to the given planes are parabolas; while the third right line describes another cone, whose sections parallel to the same planes are circles.

The application is obvious. We see that the curve of contact in the first case is a circle. The points S in the second case are also in a circle.

---

## XXIV. *On the Manufacture of Sulphuric Acid, and on the White Crystalline Substance which is formed during that Process.* By S. L. Dana, *M.D.*

*To Richard Phillips, Esq.*

Dear Sir,

I SEND you the remarks on the manufacture of oil of vitriol, which I had the pleasure of reading to you in your laboratory this morning. I made the observations in the winter of 1831, at the laboratory of the Newton Chymical Company near Boston, in the United States of America. I had not at that time met with Dr. Henry's analysis of the white solid which is occasionally found in the lead-houses in this country; but the analysis which I made of the substance to which the following remarks refer, showed its composition to be similar to that stated by Dr. Henry. My experiments were directed chiefly to the effects of the formation of this crystalline substance in the lead-houses. Such as they are, I submit them to your disposal. Very truly yours,

London, June 12, 1833. SAMUEL L. DANA.

---

The solid is confusedly crystallized in needles, or aggregated in crystalline grains, which appear like those produced in some sublimations. I have observed it also in flat four-sided prisms 1½ inch long, and in interlacing filaments from 3 to 5 inches in length.

1. Dissolved in a small portion of water, violent effervescence occurs, and red fumes appear as gas escapes from the water. The same phænomena occur if dissolved in a large quantity of water, except that the red fumes *are less* abundant: the water becomes deep blue, which changes to green, and finally the water becomes yellowish. If the solution of the crystalline matter is largely diluted with water, the colour disappears, but always at the point of solution; at the point of contact, between the solid and the water, there the colour is blue, at the moment of escape of gas from the solid. The green-coloured solution effervesces strongly on further dilution with water, giving off deutoxide of azote, and becomes blue green.

2. All the above phænomena appear if the experiment is made in an atmosphere of hydrogen, nitrogen, or carbonic acid gas, but the red fumes are less abundant.

3. If the crystalline solid is laid on snow, it tinges it immediately deep blue. There is no escape of gas. It melts the snow and sinks into it like hot iron, the temperature falling at the same time. From +30° to −16° is the greatest reduction which I have observed; at −16° the solid appears not to be acted upon, and the blue tinge gradually disappears.

4. The solution in water was found to be sulphuric acid, nitrous acid, and deutoxide of azote.

5. The solid dissolves very slowly in oil of vitriol of sp. gr. 1·84; a few bubbles of air escape. The solution contains nitrous acid, which cannot be driven off by boiling.

6. It dissolves with effervescence, greater or less, according to the density of the oil of vitriol. Effervescence is brisk when the sp. gr. of the oil of vitriol is from 1·35 to 1·45. In oil of vitriol of sp. gr. from 1·60 to 1·70 it is difficultly soluble, and there is

very little escape of nitrous vapour; the solution becomes pale yellow like nitrous acid. At +60° Fahr. gas partially escapes, and this is again reabsorbed as the temperature falls. At +35° to 20° Fahr. no gas escapes from the solution, nor can concentration of the solution expel all the nitrous acid.

7. When the solid is dissolved in oil of vitriol of sp. gr. 1·060, the immediate decomposition of the nitrous acid is prevented: the process goes slowly on. About fourteen days are necessary for the complete evolution of all the deutoxide of azote arising from this decomposition; bubbles of gas escape during the whole time; yet when these cease, nitrous acid is found in the solution; no agitation drives it off, nor will sulphurous acid gas decompose it.

8. If a current of sulphurous acid gas is passed through a green-coloured solution of the crystalline solid in water, this colour is discharged, and the solution becomes pale yellow; effervescence takes place throughout the whole liquid; nothing but deutoxide of azote escapes.

The action of water in forming sulphuric acid, seems to me to have never been rightly understood. It is well known that the above-mentioned white solid cannot be produced by nitrous vapour and sulphurous acid gas, unless water is present. What then is the action of water? I suppose that by it, red nitrous vapour is decomposed into *nitric* and hyponitrous acids. The *nitric* acid is immediately decomposed by the sulphurous acid gas, sulphuric acid and hyponitrous acid result; these unite with the water and form the white crystalline solid. I explain the above phænomena, and some facts which occur in the manufacture of oil of vitriol, as follows:—

It is evident from Experiment (2) that the effervescence is due *in part* to the escape of nitrous vapour; and deutoxide of azote also escapes, arising from the decomposition of hyponitrous acid, by the action of water. In oil of vitriol this decomposition is either prevented or retarded; hence there is less of the red-fume appearance according to the density of the oil of vitriol, none appearing in concentrated oil of vitriol. At the moment of solution of the solid in water, the hyponitrous acid gives it a blue colour; but this acid is immediately decomposed into the nitric and nitrous acids, and deutoxide of azote. The nitrous acid being yellow, converts the *blue* to *green*, and this last colour is probably deepened by the presence of deutoxide of azote, such being the fact, with respect to saturating nitrous acid with deutoxide of azote. But the nitrous acid is yellow; hence as this preponderates, the solution finally becomes yellowish.

The nitric acid, and a portion of the deutoxide of azote are retained by the water. Hence in starting a new lead-house, or whenever *fresh* water is used, there is withdrawn at once a large portion of that element which is essential to the acidification of the sulphurous gas; it is withdrawn either as nitric acid, or as deutoxide of azote. As the water of the lead-house becomes slightly acidulated by sulphuric acid, part of the *nitrous* acid is also retained by it (7); it undergoes no further decomposition. As the chamber absorbs sulphurous acid gas, this acts on the *deut*oxide of azote, and *prot*oxide* is the result; it acts on the nitric acid, the usual decompositions occur, and we have the nitric and nitrous acids and deutoxide of azote produced. As the acidulated waters of the lead-house increase in density, less sulphurous acid is absorbed, and the nitrous acid is retained, undergoing no further change. Hence we easily account for the fact, that little sulphuric acid can be obtained by using fresh water in the chambers. The nitrous acid vapour is withdrawn, being changed into nitric acid, deutoxide and protoxide of azote, and being itself partly retained as such.

The white solid, I suppose, is formed in every part of a lead-house, and falls like hail into the water or acid on the floor. Cold condenses the moisture of the lead-house; and I have generally observed the formation of this substance to take place either at the escape valve, or on the sides of the house, when the thermometer falls to 40°. When the thermometer sinks to 0, its production is very rapid; and in long-continued very cold weather it concretes on the walls of the lead-house from ½ to 1 inch in thickness. The effervescence is not observed at first in the vast body of water in the lead-house, because, as the nitrous acid is decomposed, the deutoxide is retained; as the density of the liquid increases, effervescence begins. It is very perceptible at the sp. gr. 1·29; and at 1·33 it is in its greatest vigour. The acidulated water is then filled with nitrous acid and deutoxide of azote. If it is poured from one vessel into another it foams like beer. It hisses and boils in the lead-house, and the surface of the liquid is covered with froth, and fermentation seems to pervade the whole mass (as in Experiment 8). But the manufacturer of oil of vitriol may

---

* I have been led to the belief, from some results in the large way, that such a change may occur. Some say it actually does, and attribute it "to the too violent action of the water." Since I have been in London, I have learned from Dr. Turner's Chemistry, 4th edition, that Gaultier de Claubry has made experiments on this white solid, and observed that a little *nitrogen* gas is always disengaged when the solid is produced: it is doubtless owing to the cause above stated. It deserves further investigation, and its production is probably owing to peculiar circumstances, and is the cause of the great variation of the products sometimes noticed by the manufacturers.

sustain loss by allowing the gravity of house-acid to become too high, say to 1·60. The Experiment (6) will show that; and if the gravity is allowed to reach that degree, the solid, as it falls into it, will undergo but partial decomposition. The nitrous acid will be retained; and as there is little absorption of sulphurous acid gas, the nitrous acid is little acted upon; it is drawn off with the oil of vitriol, and does not wholly quit it unless the oil of vitriol is combined with a base. When the acid is drawn from the lead-house at sp. gr. 1·25 to 1·30, it gives off copious fumes of sulphurous acid, because enough of the solid has not been precipitated into it to convert the absorbed sulphurous into sulphuric acid; nor is it probable that sufficient nitrous gas can be absorbed, as such, from the chamber already filled with sulphurous gas, to effect such a change: it can be effected only by having the white solid put into it. If acid is drawn from the lead-house from sp. gr. 1·35 to 1·40, then it is filled with deutoxide of azote and with nitrous vapour; we perceive this by its smell when the acid is boiled. When acid is drawn from the house at sp. gr. 1·60 and upwards, very little decomposition of the solid having taken place, we then see the red vapour fill the retort neck, when the acid is concentrated; but we do not smell it when the acid is boiled in the leaden kettle; it requires probably a higher degree of heat than that of the kettle, to drive off the nitrous acid; it is not all driven off even by concentration.

It is evident too from the effects of cold in Experiments (3 and 6) that the hyponitrous acid is not decomposed at low temperatures, or when decomposed, the gas resulting is retained by the liquid. Hence, in very cold weather, part of the crystalline solid is collected on the walls of the lead-house; that which falls into the liquid is less easily decomposed, and when decomposed, its gases are more readily retained. This is the reason why the manufacturer suffers; his product of acid is less, because the sulphurous acid gas, not having nitrous vapour to mix with and precipitate it, escapes dry and almost invisible. The great truths are well known, that in the manufacture of oil of vitriol, loss always occurs when fresh water only is used in the lead-house, or when the weather is very cold, or when the gravity of the house-acid is too high. The best results are obtained by an even temperature of 50° Fahr. Steam cannot be used to obviate the inconveniences of cold, unless applied to heat the acid liquid in the house; for unless the temperature of this is kept up, the mere warming of the walls would be immaterial. Too much steam injected into the chamber lessens the product of acid, it acts like fresh water, rendering the nitrous vapour useless.

According to the above view of the formation of sulphuric acid, there ought not to be any nitric acid in the liquid drawn from a lead-house: it ought to be wholly decomposed by sulphurous acid. Yet it is well known that nitric acid is found—and on M. Gay-Lussac's theory ought to be found—in the house-acid. This is, however, accidental; it may be always prevented. It requires time only to effect the total decomposition of all the nitric acid;—by time, I mean, continuing the process so long that sulphurous acid shall be constantly present in the house, and that the gravity of the house-acid be not too low. If the gravity is low, the nitric acid formed will of course be very weak: it is then to be determined whether sulphurous acid gas will decompose this weak nitric acid. I distilled ½ ounce of nitrate of potash with ¼ ounce of oil of vitriol, sp. gr. 1·84, diluted with its bulk of water. The acid vapours were received into 2½ ounces of water. The acidulated water acted rapidly on copper; a current of sulphurous acid gas was passed through it; a few bubbles of gas escaped, probably deutoxide of azote. The liquid was saturated with sulphurous gas: it then acted not upon copper; a small portion of oil of vitriol, sp. gr. 1·84, was added to it; violent effervescence occurred, sulphurous acid gas escaped, followed immediately by red nitrous vapour. The liquid changed to a deep yellow colour, and acted rapidly on copper. The nitric acid therefore was not decomposed in this case till the added oil of vitriol had abstracted a portion of water,—an effect equivalent to the concentration of the nitric acid. The experiment was repeated, using undiluted oil of vitriol. The gas from 1 ounce of nitre, ½ ounce of oil of vitriol, sp. gr. 1·84, was received into 4 ounces of water; the gravity became 1·036, and the liquid was slightly tinged yellow. Sulphurous acid gas was passed through it, and a brisk effervescence took place; deutoxide of azote was evolved; the yellow tinge disappeared. The effervescence ceased in about four hours. The liquid was saturated with sulphurous gas; its gravity became 1·060. The apparatus stood some days; sulphurous gas was repeatedly passed through the liquid at different temperatures, from 32° to 212° Fahr. It had the same character with copper as above stated: a portion of the liquid, mixed with pure muriatic acid, rapidly dissolved gold; the nitric acid was therefore undecomposed. Common aqua fortis, diluted to sp. gr. 1·08, treated as above with sulphurous acid, was not decomposed.

The effervescence observed in these experiments is owing to the decomposition of *nitrous* acid; for if the liquid is boiled, red nitrous vapour escapes, and sulphurous acid no longer causes any effervescence. It is deutoxide of azote only which escapes during the effervescence; and during the boiling, no red vapours appear if free oxygen gas is excluded from the vessel. The above experiments were reversed by passing the vapour from sulphuric acid and nitre over a weak solution of sulphurous acid in water. No effervescence took place, except when a drop of *strong* nitric acid fell from the beak of the retort into the liquid. The nitrous acid vapour was rapidly absorbed by the sulphurous acid solution, and whatever nitric acid was formed by the action of the water remained undecomposed.

It is evident that by adding oil of vitriol to weak nitric acid in a solution of sulphurous acid gas in water, the nitric acid can be decomposed; the oil of vitriol acting to concentrate the nitric acid. Now, in the manufacture of oil of vitriol, either by intermitting or continuous combustion, nitric acid is formed by the action of the house-acid water, either on the white solid, or on the absorbed nitrous vapour. As the lead-house acid increases in gravity, it is equivalent to adding oil of vitriol to weak nitric acid: hence, if the process be continued long enough, all the nitric acid will be decomposed: the proper remedy is, to burn sulphur only, to add sulphurous acid gas alone. The decomposition of the nitric acid seems to be perfected when the house-acid is of a *dark-brown* colour, a change owing to the absorption of sulphurous acid gas. I made a solution of the crystalline solid in water, and passed a current of sulphurous acid gas through it, to test the truth of the above opinion. By continuing the action of the sulphurous acid gas till all effervescence was over,—from green, the liquid became brown, and showed no trace of nitric acid. Pale yellow acid is not uncommon in a lead-house. I have seen it also deep *green* and deep yellow. At the sp. gr. 1·58 or 1·53, all these coloured acids effervesce briskly: when a current of sulphurous acid gas is passed through them, they become light-coloured, white, and then speedily turn brown; the action ceasing, there are no traces of nitric acid in them. The dark colour of lead-house acid is then evidently due to absorbed sulphurous acid gas. When all the nitric acid is decomposed, the house-acid is tinged only brown, and by boiling, the sulphurous acid, which it holds in solution, is driven off; as the workmen say, " the kettle clears off," the liquid becomes pellucid. As long as there are any bubbles in the liquid from the chamber, the nitric acid is not wholly decomposed; the colour and appearance then are important guides to the manufacturer at what period to draw off his acid. A quiet, still, pale-brown liquor is the desirable point. If the acid is drawn from the lead-house after a few days' burning, torrents of sulphurous acid gas are then evolved by boiling: the nitric acid is here too weak to decompose the sulphurous acid gas, absorbed by the water of the house. If W denote the colour to be white, D dark, X traces of nitric acid, and O its absence, then the following will denote the number of drawings or lead kettles-full from lead-houses under my superintendence. I tested each lot to ascertain the presence of nitric acid.

11 times ........... W and X
1 — ........... W — O
10 — ........... D — O
2 — ........... D — X

One house gave 7 D and O
4 W and X; its product of acid was 2·78 pounds for one pound of sulphur burned.

Another house gave W and X all the time; its product was 2·67 of acid for one pound of sulphur.

## XXV. *On the Power of an Electro-Magnet to retain its Magnetism after the Battery has been removed. By the Rev.* William Ritchie, *LL.D. F.R.S. Professor of Natural Philosophy in the Royal Institution of Great Britain and in the University of London.*

*To Sir David Brewster.*

Dear Sir,

ALMOST as soon as the mode of making an electro-magnet was invented, it was observed that the lifter of soft iron, did not fall off when the contact was broken, but remained suspended for a considerable time after. Mr. Watkins has an electro-magnet which retains its lifter for days, and will even afford a magneto-electric spark for a long period after the contact with the battery has been broken. But what is a fact with one electro-magnet is not so to the same extent with another, and I have succeeded in getting a very powerful electro-magnet which possesses this property in a very inferior degree. One obvious circumstance which must modify the retaining power, is the quality of the iron and its degree of softness. The harder the iron, the more powerful will be the retentive force, and the longer it will continue. But the most remarkable circumstance which modifies the retaining power, and one which as far as I know has not been previously observed, is the *length of the magnetic circuit.* When the electro-magnet is very short, and the poles near each other, the retaining power is exceedingly small. When the magnet is very long, the retaining power is very great. I have three magnets all made from the same kind of iron; one about six inches in circuit, another about a foot, and the other four feet. When connected with the battery they possess nearly equal powers. When the contact is broken,—in the first case the lifter falls off almost instantaneously; in the second it does not fall off, but requires a force of several pounds to separate it a considerable time after the contact is broken; the third requires a much greater weight to separate the lifter when it has been removed a considerable time from the battery. By making one still longer, it is probable the retaining power will be increased.

The reason of this curious fact appears to be the following. The molecules of the electric fluid acting on each other with the same force, will obviously return to their natural position most rapidly when the length of the circuit, through which the action takes place, is diminished. If it be diminished till the coercitive force of the iron be overbalanced by the tendency of the molecules to return to their natural state of equilibrium, from which they have been forced by the action of the conducting wire, the electro-magnet will lose all its retaining power.

Before I discovered this curious and, I believe, novel fact, I was led to conclude that an electro-magnet had no power in inducing permanent magnetism on hard steel, when the magnetic circuit is completed by the lifter. The electro-magnet which I had used in all my experiments was the short one of very soft iron, which scarcely possesses any retaining power. With this magnet, though possessing a lifting power of 50 or 60 pounds, I could scarcely induce the slightest magnetism, and was therefore naturally led to the conclusion that an electro-magnet was deficient in this power. In repeating the experiments with a different electro-magnet, (though still by accident a very short one,) I always arrived at results almost negative. Mr. Children having stated to me that Mr. Watkins communicated powerful magnetism by an electro-magnet, induced me to re-examine the subject. When I discovered the circumstance which modifies the retaining power, it immediately occurred to me that the same circumstance would likely modify the power of inducing permanent magnetism. Having arranged an unmagnetized horse-shoe of tempered steel, I began, as before, with the short magnet; and found that scarcely any permanent magnetism was induced. Having taken the next magnet in succession, and used it in the common way of magnetizing, a considerable degree of magnetic power was induced: when I employed the magnet four feet long, a much greater permanent effect was the result. The power of an electro-magnet to communicate permanent magnetism, even with the very long magnet which I have employed, is much inferior to that of a permanent magnet possessing the same lifting power. Hence, to magnetize to saturation it will be useful to employ a very long electro-magnet.

Having thus reduced these curious facts to a general principle, I have taken the liberty of requesting you to give them a place in the Philosophical Magazine.

I am, dear Sir, yours truly,

University of London, July 18, 1833. WILLIAM RITCHIE.

---

## XXVI. *On certain curious Properties of Common and Electro-Magnets. By the Rev.* WILLIAM RITCHIE, *LL.D. F.R.S. Professor of Natural Philosophy in the Royal Institution of Great Britain and in the University of London.*

*To Richard Taylor, Esq.*

Dear Sir,

IN a series of experiments which were read at a meeting of the Royal Society some time ago, I stated that when an electro-magnet had the magnetic state induced on it by remaining in contact with the battery for some time, it required a considerable time to induce an equal magnetic power by changing its poles; but that the same power was again rapidly restored, by inducing the poles at the same extremities as at first. The success of the experiment depends much on the length of the soft iron horse-shoe magnet, and on the weakness of the battery. To render the effect very striking, a long magnet and a weak voltaic power are conditions absolutely necessary. But the property does not only belong to an electro-magnet, but in a more striking degree to a permanent magnet of hard steel. If a horse-shoe of tempered steel be magnetized in the usual way and allowed to remain for some time (the longer the better), and if its magnetism be completely destroyed by an opposite touch, it will be found exceedingly difficult to communicate magnetism to it by reversing the poles. If after repeated touches a small power should be induced, it will not only be destroyed by a *single* touch of the same magnet, but will even have its poles reversed. If the operation be continued even for a considerable length of time, by successively changing the poles, it will still be found that it will be magnetized much more rapidly in the direction in which it was originally magnetized than in the contrary.

There appear to me only two ways of accounting for this curious fact. We must either suppose that the electricity having been first arranged in a particular direction is afterwards more easily arranged in trials in the same direction than in the contrary:—or, that in reversing the poles we do not destroy the whole of the magnetism formerly induced, but actually arrange a new series of atoms in an opposite direction; so that when the magnet has lost all its power, it has done so, simply because we have two equal magnets formed on the same piece of steel, having their poles in opposite directions.

The magnetism which has been newly induced is more easily destroyed than that which has been induced days or years ago; since by suddenly destroying the newly induced magnetism, the old, being held by a more powerful *coercitive* force, will regain its force when its temporary antagonist power has been removed.

As this curious fact appears to me new, and sufficiently interesting to be made known, I request you to give it a place in the Philosophical Magazine.

I am, dear Sir, yours truly,

University of London, July 18, 1833. WILLIAM RITCHIE.

---

## XXVII. *On Minium.* *By* RICHARD PHILLIPS, *F.R S. &c.*[*]

AFTER the last sitting of this Society, the President mentioned to me a paper on Minium, by M. Dumas, contained in the 49th volume of the *Annales de Chimie et de Physique*, dated April 1832.[†] In this memoir the author shows that minium is a very different compound from what it is usually supposed to be, and consequently that it is not a sesquioxide, or as it is sometimes termed, deutoxide of lead. Dr. Dalton also recalled my attention to his having previously announced the same fact in his New System of Chemical Philosophy, published in 1827 (vol. ii. p. 39).

Opinions so different from those commonly entertained, induced me to make some experiments on the subject, and an account of them may not be altogether unacceptable to this Society, tending, as they do, to confirm the views of its learned President, and proving their originality. Before I state the opinions of Dr. Dalton, or of M. Dumas, or my own experiments, it will be proper to give the generally admitted composition of the yellow or protoxide, and of the brown or per-

---

[*] Read before the Literary and Philosophical Society of Manchester, early in the present year.

[†] An abstract of M. Dumas' results will be found in Lond. & Edinb. Phil. Mag. vol. ii. p. 402.

oxide, of lead. Dr. Dalton in his work already alluded to, considers the protoxide as composed of 7 oxygen and 90 lead, and the peroxide of 14 oxygen and the same quantity of metal. Now as these differ but little from the atomic proportions usually adopted, I shall consider the protoxide as composed of an atom of oxygen = 8 + 104 an atom of lead, and the peroxide of 16 = 2 atoms oxygen + 104 of lead.

It is well known that when red-lead is treated with nitric or acetic acid, it is separated into protoxide, which is dissolved, and peroxide remaining unacted upon; and Dr. Dalton correctly observes, that if minium were a sesqui-oxide, it ought to leave more than 50 per cent. of peroxide when acted upon by either of the above-named acids; the sample, however, which he examined left only 20 per cent. of peroxide, proving that it was not a sesqui-oxide.

Dr. Dalton concludes from his experiments that "*the minium of commerce is constituted of* 1 *atom of oxygen, holding* 6 *atoms of yellow oxide together; or it is composed of* 100 *lead and* 9·07 *oxygen.*" And he observes, that "*when it is digested in cold acetic acid the residuum constitutes another oxide, consisting of* 1 *atom oxygen and* 3 *of yellow oxide, or* 100 *lead, and* 10·4 *oxygen, possessing the same colour as the former, but distinguishable by its not being acted on by cold acetic acid, and by its containing twice as much brown oxide and extra oxygen as minium.*"

These experiments are, I confess, new to me, and certainly have not excited the attention which they merit; and without at present entering further into this part of the subject, I shall just state that I have found acetic acid to separate a large proportion of protoxide from minium, without altering its colour at all; and consequently proving that it is not a sesqui-oxide, for if it were, the residue would become brown by the development of peroxide. If, however, the dilute acetic acid be used in excess, then this change actually occurs, at least so I found it; but this does not appear by Dr. Dalton's experiments.

M. Dumas in the paper above referred to, does not state the opinions of other chemists in detail, consequently it cannot be ascertained whether he was acquainted or not, with those of Dr. Dalton; he merely says, that previous analysts do not agree as to the nature of minium. The facts stated by M. Dumas indeed prove the existence of several varieties of minium; and according to his experiments, which appear to have been conducted with great care, the increase of oxygen goes on very slowly from 8·26 per cent. in the product of the first calcination, to 8·79 contained in the minium of the eighth operation. He found also that white lead submitted to three calcinations gave a fine orange minium, containing 9·24 per cent. of oxygen; this, however, he observes is still below the proportion required to constitute the lead a sesqui-oxide, and which, in fact, amounts to 10·38 per cent.

M. Dumas states minium of the eighth operation to consist of 74 protoxide, and 26 peroxide; that obtained by calcining white lead, of 66·8 protoxide, and 33·2 peroxide; and pure minium he considers as equivalent to 65·1 of protoxide with 34·9 of peroxide.

I shall now state the results of my own experiments on minium; that which I used appeared to be free from carbonate of lead, and was moderately dried before submitting it to the following experiments:—Two hundred grains were digested in an ounce of strong nitric acid, diluted with half a pint of water; 49·6 grs. of peroxide were left, consequently the minium was separated into

| | |
|---|---|
| Protoxide of lead .......... | 75·2 |
| Peroxide of lead ........... | 24·8 |
| | 100·0 |

I also boiled some of the minium with excess of moderately strong acetic acid; by this operation it was separated into

| | |
|---|---|
| Protoxide .................... | 74·2 |
| Peroxide...................... | 25·8 |
| | 100·0 |

These results do not differ much; but taking the mean, we have minium resolved into

| | |
|---|---|
| Protoxide..................... | 74·7 |
| Peroxide...................... | 25·3 |
| | 100·0 |

Now this result differs considerably from that obtained by Dr. Dalton; he procured only 20 per cent. of peroxide. The cause of this difference is readily explained by referring to M. Dumas's Table of Experiments; from which it appears that minium of the third calcination yields only 20·3 per cent. of peroxide; while that of the eighth gives 26 per cent. Dr. Dalton appears to have employed a specimen of the former, while I used one of the latter.

In order to determine the proportion of pure minium in the specimen which I used, I added separate portions of 200 grains each, to the annexed quantities of strong acetic acid, diluted with half a pint of water; viz. one, two, two and a half, and three drachms. I found that the minium digested in the first lost 22 per cent.; in the second 27·5; and in the third

29·1 per cent.; and in all these cases the residue remained perfectly unchanged in colour: the quantity of protoxide dissolved by the fourth portion of acid I did not determine, for the residue had acquired a slight brown tint, showing that a portion of the pure minium had been decomposed. From these experiments I conclude that the maximum of protoxide had been dissolved by the acetic acid, and consequently that the specimen consisted of

| | |
|---|---|
| Pure Minium................ | 70·9 |
| Protoxide.................... | 29·1 |
| | 100·0 |

It now only remained to determine the composition of the 70·9 of pure minium. I therefore treated a portion of it with great excess of diluted nitric acid, by which it was separated into

| | |
|---|---|
| Protoxide.................... | 66 |
| Peroxide...................... | 34 |
| | 100 |

It will be observed that this determination agrees very nearly with that resulting from the action of nitric acid upon red-lead. I have already stated that it gave 25·3 per cent. of peroxide, while, as will appear by a slight calculation, according to the action of nitric acid upon the *pure* minium, it should have yielded 24·1 per cent.

We may consider the constitution of minium under different points of view:—first, merely as a compound of lead and oxygen; in this case 104, an atom of lead appears to be combined with 9·8 of oxygen, which are proportions irreducible to any probable atomic constitution. Indeed on inspecting M. Dumas's Table of the composition of eight different kinds of red-lead, it must be admitted that this substance is a mixture of true red oxide with variable proportions of protoxide.

The next question is, What is the constitution of the true red oxide? by which I mean that left unchanged by the action of dilute acetic acid upon common red-lead.

Now I have shown that this is resolvable into 66 of protoxide, and 34 of peroxide; and these results agree very closely with those of M. Dumas, who states what he calls *pure* minium, to be composed of 65·1 protoxide, and 34·9 peroxide, which I agree with him in considering as equivalent to two atoms of the former, and one atom of the latter, or three atoms of lead and four atoms of oxygen. And I have great pleasure in observing that these results are in perfect accordance with the statement of Dr. Dalton, long since published; for he mentions that the red oxide, left after the action of dilute acetic acid upon common red-lead, consists of an atom of oxygen, and three atoms of yellow oxide, which are of course equivalent to four atoms of oxygen, and three of metal.

## XXVIII. *Reviews, and Notices respecting New Books.*

*Report of the First and Second Meetings of the British Association for the Advancement of Science; at York in* 1831, *and at Oxford in* 1832*: including its Proceedings, Recommendations, and Transactions.* London, 1833, 8vo, pp. 624; with an engraved Geological Section through Europe.

[Continued from vol. ii. p. 464.]

IN concluding our account of Prof. Airy's Report on the progress of Astronomy, we have to remark that he has omitted to notice certain important observations of Saturn, of recent date, the statement of which would have formed part of his sixth section. We do this in the spirit of endeavouring to render still more complete, so far as our reading enables us, his meritorious labours, and not at all in that of complaining of a single omission, in a series of details probably more copious and more comprehensive than any similar collection. The observations to which we allude are those made in 1828 by MM. Schwabe and Harding, repeated with doubtful result by Sir J. South and Sir J. Herschel, but subsequently confirmed by Struve, (all recorded in the Monthly Notices of the Astronomical Society,) which have shown that the rings are not absolutely concentric with the body of Saturn, and the theoretical importance of which (subsequently, however, to the printing of Prof. Airy's Report) has been pointed out and explained by Sir John Herschel*.

Professor Airy's Report is followed by a short "Report on the Tides" by Mr. Lubbock: It commences with a brief sketch of the successive improvements which the theory of the tides has undergone, from the time when the details left open by Newton were taken up by Bernoulli, Euler, and Maclaurin, to the prize question on the general problem proposed last year by the Academy of Sciences at Petersburgh. This is followed by some historical and critical remarks

---

* See Phil. Mag. and Annals, N.S., vol. iv. pp. 62, 136; and Sir John Herschel's volume on Astronomy in the Cabinet Cyclopædia, p. 284. It occurs to us that it would be at once interesting and useful, as much difference of opinion still exists in the scientific world, on the precise character of the relative value possessed by observation and experiment, and by mathematical investigation, respectively, if some competent authority would reply explicitly to the following question:—Had the oscillation of the centre of gravity of the rings round that of the body of Saturn been demonstrated theoretically before it had been observed? or has the observation of the fact (previously unsuspected) produced an improvement in the theory? The fact was no sooner established than the necessity of it became evident; but had it been predicted by mathematical theory, or not?

on the construction of Tide Tables for predicting the time and height of high water at any port; in which the author notices the results he has himself obtained by discussing the observations made at the London Docks. In August 1831, we find that, at the request of the Council of the Royal Society, directions were sent from the Admiralty to the master attendants at Woolwich, Sheerness, Portsmouth, and Plymouth, to cause observations of the Tides to be made, and to forward reports quarterly. The observations which have accordingly been made are in the possession of the Royal Society; but Mr. Lubbock remarks, "I have not been able to ascertain that any observations are made on the coast of Scotland and in this country, with the exceptions I have noted; and at Liverpool these interesting phænomena pass away unheeded and unrecorded. I trust that the influence of the British Association will be exerted to remove in some degree this national reproach."

A valuable set of instructions for making and recording observations of the tides are next given; and these, deeming them of the utmost importance to the progress of this most interesting branch of science, we transfer entire to our pages; at the same time earnestly requesting such of our correspondents or readers as may possess suitable opportunities, to institute, or cause to be instituted, regular observations agreeably to those instructions.

"Observations of the Tides should record particularly,

"The time and height of high water.

"The time and height of low water.

"The direction of the wind and the height of the barometer and thermometer should be noted, and the direction and velocity of the current should also be described.

"The circumstances of high water are more interesting, and admit generally of more accurate observation, than those of low water.

"The height of the water must be given from some fixed mark or line*, which should be described accurately, so that it may be easily recovered. It should also be carefully stated whether the time in which the observations are given is mean or apparent, and how obtained.

"The name of the observer, or his initials, should be attached to each observation. The simplest method of observation appears to me by means of a staff, carefully graduated, connected with a float, and working through a collar where the height is read off. The staff must be kept in a vertical position by means of friction rollers; the float should be in a chamber to which the water has access by a small opening, in order that the ripple may be as much diminished as possible. It would be convenient to have a clock close to the tide gauge; and if made to strike minutes, so much the better. The observer should note the height of the water at the end of every minute, for half an hour before the expected time of high water, and until there can be no doubt that the time of high water is past. The minute at which the water stood the highest, or the time of high water, is then easily seen. This process is tedious, and it might be imagined that it would suffice to note the time when the water reaches a certain height shortly before high water, and the time when it reaches the same line in its descent; but the water rises

---

* "I consider this of particular importance, and I allude to it because it has not been complied with in some observations transmitted to the Royal Society. Observations of the *rise* are useless."

and falls by jerks, and much too irregularly for this plan to be adopted with safety, at least in our river.

"Mr. Palmer has described, in the Philosophical Transactions, a self-registering machine which is intended to give the time and height of high-water; and I believe it is intended to set one up at the London Docks, but I have not heard that it is yet in operation. The principle consists in a style, or pencil, which is moved horizontally by the tide along the summit of a cylinder, which is turned round slowly and uniformly; the pencil describes a curve upon paper wound round the cylinder, which curve indicates the fluctuations of the water. The motion of the tide being originally vertical, is changed by a common mechanical contrivance of the simplest kind.

"When it is intended to make a long series of observations, it is of course very desirable to adopt every precaution to ensure accuracy; but many persons have it in their power to make observations, which may be useful in determining the *establishment* of a port, or the mean interval between the moon's southing and the time of high water, without any expensive apparatus.

"For this purpose the observations during one lunation, or even less, may suffice, where, as in the river Thames, the rise is considerable and the tides little subject to irregularities. In the open ocean, where the rise on the contrary is small, the tide often hangs half an hour at high water, and the phænomena take place very irregularly. At St. Helena the rise in springs, according to Dr. Maskelyne, is 39 inches, and in neaps 20 inches; and I apprehend that less information could be elicited from a year's observations there, than from a month's observations at the London Docks. When a few observations only are made with a view of determining the establishment, they should not be used to determine that quantity absolutely, but they should be compared with observations at some place of which the establishment is accurately known, or where observations are continually carried on. It would be very desirable for those who are able, to combine so as to effect the monography or detailed description of the tides through some short extent of coast, such as that which has been effected by M. Daussy for the coast of France."

Some observations on the progress of the tide-wave around the globe, and on the *cotidal* lines which represent the successive positions of its crest, conclude the Report. Our readers are already aware of the value of the contributions to the planetary theory, the theory of the moon, and other portions of Physical Astronomy, which have accrued from Mr. Lubbock's application of his powerful analytical talents to those subjects. We hope we may infer from the following passage near the end of this Report, that the theory of the tides will ere long receive an equal degree of improvement from the same source:—"The analytical investigation of the motions produced by changes of temperature, and of the propagation of heat in fluids, is one of extreme difficulty, and has not yet been attempted. In order to approach this important question with any chance of success, it seems necessary to consider the problem in the first instance in its most simple form, and one in which the results of theory can easily be compared with those of observation."

We have next to notice a "*Report upon the Recent Progress and Present State of Meteorology*," by James D. Forbes, Esq., F.R.S. L. & E. &c., since elected Professor of Natural Philosophy in the University of Edinburgh, in the room of the late Sir John Leslie. This Report cannot fail to be highly advantageous in directing the labours of meteorologists to those subjects of investigation afforded by the atmosphere and its various attributes and relations, to which it is now indispensable, in order to impart a truly scientific form to Meteorology, that their combined and methodical attention should be directed. Consisting, however, almost entirely, of minute details, it is not susceptible of abridgement: we shall therefore confine our notice of it to extracting the "contents," together with a notice of the results of the author's own investigations relative to the horary oscillations of the barometer, of which no previous account has been given in the Philosophical Magazine.

The following are the "contents" of the Report:—

"*Introduction*, Discoveries on Heat; Systematic Works on Meteorology. *Constitution of the Atmosphere. Temperature*, Thermometers; Atmospheric Temperature; Climatology; Decrease with Height; Proper Temperature of the Globe. *Atmospheric Pressure*, Barometers; Periodical Variations; Accidental Variations; Variation with Height. *Humidity*, Hygrometers; Distribution of Vapour in the Atmosphere. *Atmospheric Phænomena and Precipitations*, Winds; Rain; Atmospherical Electricity, Hail; Aurora Borealis, its Influence on the Magnetic Needle."

Mr. Forbes sums up the results he has obtained with respect to the horary oscillations of the barometer, in the paragraphs now subjoined.

"In 1828 I published some observations made by myself at Rome the previous year*. Though continued only for a short time, yet, as I frequently made twelve or fourteen observations in a day, I was enabled to trace out very well the diurnal curve of variation, establish the critical hours of morning and evening maxima and afternoon minimum, and give an approximation to the amount.

"Since that, I have investigated with great care, during the years 1827–30, the oscillation in latitude 56°,—the most northerly point in Europe at which any observations of long continuance on this subject have been made. The results have been published at length in the Edinburgh Transactions†; and I have also entered into an analysis of all the existing information on the subject. The following are the general results at which I have arrived.

"1st, That near Edinburgh, in lat. 56°, the mean annual oscillation between 10 A.M. and 4 P.M. is ·0106 inch, or $0^{mm}\cdot27$.

"2nd, That the hours of maxima are further from noon in spring and summer than in autumn and winter; and that the amount of oscillation of both the diurnal periods diminishes regularly through the seasons from spring to winter. These conclusions, derived directly from my own observations, I have shown to be the most probable for all parts of the globe, as far as existing observations guide us.

"3rd, That the St. Bernard observations, and those of Captain Parry in the arctic regions, both indicate a *true negative* oscillation, though the second result has been overlooked by M. Bouvard.

"4th, That M. Bouvard's hypothesis and formula mentioned above, are founded upon too hasty generalization. This I have shown upon various

---

* Edinburgh Journal of Science, January and April 1828.

† Vol. xii. The title of the paper is, "On the Horary Oscillations of the Barometer near Edinburgh, deduced from 4410 Observations; with an Inquiry into the Law of Geographical Distribution of the Phænomenon." An abstract has been printed in the Edinburgh Journal of Science for April 1832.

grounds, but especially from his own quotation of the St. Bernard observations, where, as the mean temperature is much above 0° cent. in summer and below it in winter, the oscillation should be distinctly *positive* in the former case, and *negative* in the latter. This I have shown to be precisely the reverse of the fact.

"5th, Availing myself of M. Bouvard's excellent Table, with such additions as I could make to it, I proceeded to investigate, from observations made near the level of the sea alone, the influence of latitude in modifying the oscillation; and from a careful combination of the best results, by reducing the squares of the errors to a minimum, I obtained the following equation, which represents wonderfully well the existing observations:

$$z = 3{\cdot}031 \cos^{\frac{5}{2}} \theta - {\cdot}381$$

for millimetres, $z$ being the oscillation in latitude $\theta$. This gives for the equatorial oscillation $2^{\text{mm}}{\cdot}650$, and for the poles $-{\cdot}381$. The latitude where the oscillation changes its sign, or is $= 0$, is 64° 8′.

"6th, In the course of this investigation, having selected the observations at Cumana and Toulouse, (both being places where the oscillation is *positive*,) for obtaining approximate values of the constants in the formula, I found to my surprise and satisfaction, that from these observations alone, we might have inferred, *à priori*, not merely a *negative* oscillation in the arctic circle, but one not differing sensibly in amount from the actual observation of Captain Parry[*].

"7th, I have determined from the formula the mean atmospheric tide from the equator to the pole to be equivalent to the weight of a stratum of air $10\frac{1}{5}$ metres in thickness; and the mean for the whole *surface* of the earth to be 16 metres, the air being considered under the usual pressure and temperature."

[To be continued.]

## *Dr.* PEARSON'S *Introduction to Practical Astronomy.* 4to. 2 vols.

[Concluded from vol. i. p. 457.]

The First Section of the Second Volume of this work consists of "Preliminary Remarks" on the objects of Astronomical Science, and on the interest of those objects as manifestations of Divine wisdom, power, and benevolence.

After these remarks our author commences §. II. with that which is properly the subject of his work, viz. the best means of making correct astronomical observations, the first requisite for which is a suitable and well situated observatory.

In §. III. we have an account of two constructions of a rotative dome. This part, in the construction of the roof of an observatory, is essential, as it is the only convenient mode of making an equatorial or altitude and azimuth instrument fully effective for the purposes for which they are designed. It is desirable therefore that this dome should revolve without difficulty; which it cannot be expected to do, when there is much friction arising from a warping of the parts. The construction of Smeaton, though very ingenious, is not free from this defect. But the last dome, described by our author as having been constructed by himself at the suggestion of Troughton, appears to be free from this defect; as the ebony balls

[*] See Art. 15. of the paper.

upon which the dome revolves will at once accommodate themselves to a trifling shrinking of the parts. We imagine that the author's objection to the light copper covering might be obviated, by having an interior covering (not in contact with the copper) made of some material that is a bad conductor of heat: perhaps oil-cloth might be found effectual for this purpose.

From §. IV. to §. VII. inclusive we find an interesting and instructive account of the most important instrument used in practical astronomy, the REFRACTING TELESCOPE. The account of this instrument given in these sections is extremely valuable, for the practical instructions contained in them, as to certain requisites in determining the goodness of a telescope.

In §. IV., Art. 9—14, our author details the results of his own experience, in the examination of the figure of an object-glass. The rest of this and the two following Sections are dedicated to the description of the celestial eye-piece, from the single lens, to the most effective combination, the eye-pieces of Huygens and Ramsden,—the first denominated the *negative* eye-piece, where the image is formed behind the second lens of the combination, and the latter the *positive* eye-piece, the image being formed before it. This last is the eye-piece used in telescopes furnished with the spider's lines. Both these constructions are found to diminish the aberration arising from sphericity, and also from the unequal refrangibility of light. For determining the power of the telescope our author has given a dioptric formula, for the focal length of a single equivalent lens, expressed in terms of the focal lengths of the combined lenses and the distance between their centres; which formula contains the principle of the celestial eye-piece with variable magnifying powers.

The next Section contains an account of diagonal or reflecting eye-pieces to be used for high altitudes; but our limits will not allow us to enter further into details. Section VI. contains an account of the celestial eye-piece with variable powers, with a small Table of powers constructed for one of the author's telescopes. In §. VII. we have an account of the erect or terrestrial eye-piece, with its various modifications and improvements.

In §. VIII. we have an explanation of the principle of ACHROMATISM. We extract from this section an interesting statement relating to the actual construction of an object-glass, according to Sir John Herschel's computations, in his paper "on the Aberration of Compound Lenses and Object-glasses."

"An object-glass having three convex surfaces, and only one concave, was constructed by Tulley from Sir John Herschel's computations; and though the formation of the flint lens was very different from what he had been accustomed to execute in his ordinary practice, yet he succeeded in accomplishing his object. The object-glass turned out so good, that it was competent to separate double stars of the first class, and to exhibit minute objects very distinctly with an aperture of 3·25 inches, and a focal length of 45·0."

The next Section is appropriated to the description of various kinds of stands for refracting telescopes. It is of the greatest importance to be furnished with a stand that will insure steadiness to the telescope while in use; for where there is any tremulous motion in the telescope, the distinctness of vision is completely destroyed. In this Section the best methods of supporting the telescope are detailed by engravings. In §. X. is given an explanation of the construction of a more useful stand, viz. the equatorial stand; by means of which a star can be followed by the telescope without altering its elevation, or more strictly its inclination to the polar axis.

We come now in §. XI. to the description of a useful and elegant little instrument, the DYNAMETER. The manner of applying this is very simple, and the following short account of its construction will render it quite intelligible. The object-glass of a telescope is itself considered as the *object* placed before the eye-lens at a distance $=F+f$ from its centre ($F$ and $f$ being the solar focal lengths of the object- and eye glass respectively), and consequently an *image* of the *object-glass* will be formed by the eye-lens at some distance $=\delta$ from its centre. Let $D =$ diameter of object-glass, and $d =$ diameter of its image. Then the power of the telescope $(P) = \frac{F}{f}$.

But by a principle in Optics $\frac{F}{f} = \frac{F+f}{\delta}$

and by similar triangles $\frac{F+f}{\delta} = \frac{D}{d} \because P = \frac{D}{d}$.

Now we can measure D exactly: if then we can also measure $d$, we have a much more certain and easy method of obtaining the value of P than is furnished by the equation $P = \frac{F}{f}$. The DYNAMETER enables us to measure it exactly.

In §. XII. we find a description of the large refracting telescope made by the celebrated Fraunhofer of Munich, and preserved in the Imperial Observatory at Dorpat.

Our author having described the refracting telescope, now comes, in §. XIII., to explain the construction of the four kinds of REFLECTING TELESCOPES.

In §. XIV. we find an account of various kinds of stands for reflecting telescopes. That which appears most deserving of notice, as best calculated for giving stability to a heavy Gregorian or Cassigranian telescope, was constructed by Mr. Tulley. The contrivances in this stand for producing quick and slow motions are indeed truly beautiful. After describing some other kinds of stands, the author concludes this section, by giving some rules to be observed in the adjustment of the different parts of a Newtonian reflecting telescope.

In §. XV. we have an account of an instrument, contrived, and with indefatigable perseverance finished, by one of the most extraordinary men that ever lived;—this is the great 40-feet reflector of Sir William Herschel. Besides the description of this instrument, is given one of Sir William Herschel's curious calculations relating to the time that it would take to (what he terms) *sweep* the visible heavens with his 40-feet reflector, with the power of 1000. He supposes that he may obtain 100 favourable hours in the year; then he calculates that to *sweep* the northern hemisphere, and such part of the southern as is visible, by directing the axis of his telescope into each point of space for a single instant, would require 811 years; so that his 40-feet telescope may furnish work for his descendants for some generations. Our author concludes this Section by giving a list of the works of Sir W. Herschel.

The next Section gives an account of a telescope of the Herschelian construction, which was erected at Greenwich, a few years since, by a self-taught artist of Aberdeen, of the name of Ramage. In this construction the mechanism is much more simple than that of Sir W. Herschel's great telescope.

Section XVIII. is taken up with a very curious account of what Sir William Herschel has denominated the *space penetrating power* of a telescope: we believe he was the first person who considered this subject. This power consists in the most advantageous combination of the *magnifying power* with the *quantity of light*. After a very interesting discussion of the subject, he illustrates the difference between this power and the magnifying power by observations of several nebulæ and clusters of stars; also of the satellites, of the Georgian planet, and of the Satellites of saturn.

The Sections commencing with XVIII. and ending with XLVIII. are almost entirely taken up with the important subject of measuring with accuracy small celestial arcs. The first of these Sections gives an historical epitome of the gradual improvements which have taken place in this department of practical astronomy, from the earliest times that we have any account of attempts being made to determine the places of the heavenly bodies, to the present time;—from the date, when the third part of a degree was only appreciated by estimation, to the present day, when the tenth part of a second may be appreciated, probably with greater certainty.

The Micrometers, which are described in the following Sections, may be divided into classes, which may again be subdivided as follows:—

Class I. *Single Image Micrometers;* containing,

(1.) Where the measure is taken by means of two parallel *spider's lines*, the distance of the separation of which can be accurately estimated:

(2.) Where the measure is obtained from a *divided scale,* placed in the common focus of the object- and eye-glasses:

(3.) By means of *reticulated diaphragms*, with which the required measure is obtained only by means of a troublesome calculation, deduced from the *time* of passage.

Class II. *Double Image Micrometers;* containing,

(1.) The divided *Object-glass* micrometer:

(2.) The divided *Eye-glass* micrometer, with the *Catoptric* micrometer, by Ramsden:

(3.) *Prismatic* and *Cuneiform* micrometers:

(4.) *Doubly-refracting Crystal* micrometers.

Class III. *Binocular Micrometers.*

Class IV. *The Verniers.*

Class V. *The Reading Microscopes.*

Sections XIX. and XX. are taken up with the description of the *Spider's-line Micrometer,* under its most improved form, as constructed by Troughton. The author explains in these Sections, how to obtain the value of the micrometer screw, &c. &c.

He has described in §. XXIII. an instrument of his own, called a *Polymetric Reticle.* We have no doubt that for many purposes this micrometer is as perfect as any that requires illumination.

We refer to §. XXII. for the means of making the spider's lines or the divisions visible in the dark.

The next method of measuring small arcs, which depends on a single image, is the *reticulated diaphragm.* The account of the various diaphragms, with the method of registering and reducing the observations as given by La Caille and Smeaton, are contained in the Sections from XXIV. to XXVII. inclusive.

We come in §. XXVIII. to the second class of micrometers, viz. the *Double Image Micrometers,* which we must pass over with the same brevity as the others.

Section LXXXVI. contains the account of another Double Image Micrometer, by Amici, which our author had not seen when this part of the work was sent to the press. When Dr. Maskelyne was dissatisfied with the performance of the divided object-glass, he suggested another plan, the account of which is given in §. XXXV. It consisted in applying two thin prisms instead of the divided lens, for measuring the sun's or moon's diameter; and the great advantage gained was, that both the images were equally bright in all parts of the lengthened scale. Dr. M., however, dying before he had matured his plan, it seems never to have been made much use of. But our author discovered how to avail himself of this principle for measuring *small angles.* He has called this the *Cuneiform Micrometer;* and for the account of this construction we refer to §. XXXVI.

We now come to the application of the doubly-refracting crystal to the construction of a double image micrometer. The account of the application of this curious substance, to the purposes of micrometrical measurements, is contained in four Sections.

After giving a complete account of Sir David Brewster's micrometrical telescope, the author goes on to the description of the third class of micrometers, viz. *Binocular Micrometers*: this is contained in the next two Sections. The first of these gives an account of a *Lamp Micrometer,* invented and used by Sir W. Herschel. We would particularly direct our readers to an attentive perusal of Section XLIV. as containing valuable directions for the use of Position Micrometers.

The next kind of micrometer is that which is independent of the telescope, the *Vernier.* But before this, or the reading microscope can be made use of, it is necessary to be enabled to give a *slow* and *steady* motion to the radius carrying the vernier on the limb of the instrument, or to the limb itself. Therefore before our author enters upon the description of these last means of measuring small arcs, he gives the description of the best construction for clamps and tangent screws. We believe that Dollond's clamp, described in Art. 5, page 275, is the *best* for insuring a steady motion to a large instrument like the mural circle. After this the principle of the VERNIER is fully described in §. XLVII. Our author next minutely describes the construction of Troughton's Reading Microscope.

After having described the means of measuring small arcs, our author comes to the description of the principal instruments in an observatory: but preparatory to this, he describes two of the most important and indispensable appendages required in making their adjustment. The first is the Plumb-line, and the second the Spirit-level.

In §. LIII. we find an account of the most improved construction of the Transit clock, which, as the late Professor Robison has justly described it, is one of the principal pieces of furniture in an observatory. The author divides the different escapements into five classes. They may however be comprised in two, (viz.) those in which the maintaining power of the clock is *immediately* applied in sustaining the vibrations of the pendulum; and those in which the same power is only *mediately* applied to this purpose. In the first class are contained all the first four of our author's classification; and the second contains the Remontoir and Hardy's Escapement. The performance of those of the first class is open to the practical objections pointed out by our author, viz. the *variable* nature of the force applied *immediately* through the train of mechanism, to support the motion of the pendulum, which variation depends on a variety of causes, such as the thickening of the oil, &c. The second class is free from this objection, for the pendulum is only supported by the maintaining power *mediately*, (*i.e.*) an independent and invariable power is put into action by the maintaining power in the first instance, and *when put in action* becomes independent of the maintaining power, and *then* acts in keeping up the pendulum. The performance of these clocks is surprisingly exact. To Cumming we believe we are indebted for the remontoir, and we understand that Mr. Browne of Portland-place has one of this construction by Cumming, of which the performance is admirable. But the reader who is interested in this subject, cannot do better than refer to the article alluded to by our author in Rees's Cyclopædia; in which he has fully treated on the subject with his usual clearness. The escapement which is described in the work under consideration is Hardy's, which justly deserves to be classed among the most refined improvements of modern horology.

In §. LX. we find the account of the magnificent Transit instrument at Greenwich, constructed by Troughton.

Our author in §. LXI. adds full instructions for observing, and *systematically* registering Transits; and then, in the two following Sections, details the methods of reducing the observed into mean right ascensions.

In §. LXIV. our author gives a description of the Transit circle, by Troughton. This description is accompanied by an admirably executed plate.

After a Section explaining the method of reducing the apparent to the mean polar distance, the author gives the description of the Altitude and Azimuth Circle, by Ramsden, which is placed at Palermo. The observations of 7646 stars, forming Piazzi's Catalogue, were made with this instrument.

In Section LXVII. we find an account of the Westbury Circle, by Troughton.

In §. LXVIII. the author describes an Altitude and Azimuth instrument in his own possession. This instrument was constructed by Troughton, but divided by Thomas Jones while its maker was an invalid. As it appears to be the largest instrument of the kind ever made by this eminent artist, it also seems the most complete.

Section LXIX. treats of a new instrument, contrived by a well known practical astronomer, Captain Kater, the intention of which is to do away with the necessity of a level or plumb-line in the adjustment of a Vertical Circle, or Zenith instrument; the utility of which has been differently spoken of in different observatories. But the contrivance deserves further trial; and the description here given will enable any instrument-maker to construct it either in the horizontal or vertical form.

In §. LXX. our author describes the uses and construction of the portable Altitude and Azimuth instrument, and introduces a Table of formulæ required in the solution of Spherical triangles, which is essential in the use of this instrument.

Section LXXI. makes us acquainted with a very portable Altitude and Azimuth instrument of the author's own contrivance.

In §. LXXII. we find a detailed account of the next principal instruments in the Greenwich Observatory; the two great Mural Circles, by Troughton and Jones.

The next Section contains an account of two very curious circular instruments, on the repeating principle, by the late eminent artist Reichenbach. To the English reader these are more matters of curiosity than anything else; because, notwithstanding the great ingenuity displayed in their construction, we conceive them to be liable to give uncertain results when compared with our own more perfect instruments.

In the next two Sections are described the constructions of two Repeating Circles, one by Troughton, and the other by G. Dollond.

The account of the Equatorial, another important instrument in an observatory, is contained in §. LXVII. and §. LXVIII.

In §. LXXIX. and the three following Sections is contained the account of Zenith instruments. Of these there are two kinds. In the first the telescope itself moves through a small angle from the vertical, and in the second the telescope has no angular motion, and the means of measuring a small angle from the zenith is contained in the telescope itself. The first of these have been termed Zenith

Sectors; and the last, Zenith Micrometers, the account of which is contained in §.LXXXII. The first Zenith Sector, by Graham, is remarkable as the means by which Bradley was led to the discovery of the aberration of light. Also a full account of a complicated Zenith Sector, by Ramsden; and also of a much more elegant, much more simple, and we have no doubt quite as accurate a one by Troughton.

In the following Section will be found an account of another of Troughton's instruments, a portable Quadrant.

In §. LXXXIV. is given the account of Ramsden's Polar instrument.

After an interesting account of the fixed telescopes used at Greenwich, at the suggestion of the Astronomer Royal, for the purpose of settling the question of annual parallax in the fixed stars, our author, in §. LXXXVII. and some of the following Sections, describes the construction and use of another class of instruments,—those employed in Nautical Astronomy. The first which is considered, is the first effective instrument of this kind that was ever contrived: it is generally known under the name of Hadley's Sextant, with which the angle between two objects is measured by means of reflection from two mirrors, and the inclination of the mirrors is half the required angle. In the Section appropriated to the description of this beautiful instrument, the author, after giving a short account of the original invention, proceeds to give an accurate detail of the instrument in its most perfect form.

Our author has detailed all the successive improvements made in this instrument, in the account he has given in his Section LXXXVIII.

But Troughton comes last of all; and he seems in this instance, as in all others, to have put the finishing stroke of perfection to the construction of these instruments. The whole of §. LXXXIX. is devoted to the description of the Reflecting Circle with three verniers. The inventor's own directions for completing the adjustments are also added.

After explaining in the two following Sections how these instruments are of use in determining the latitude at sea, and also the time and (by means of it) the longitude; in §. XCII. XCIII. and XCIV. are explained in detail the most accurate methods of approximating to the true longitude, both by sea and land.

The Sections in which Dr. Pearson explains the process of computing the longitude by lunar distances and by occultations are particularly valuable. The details of the latter process are from §. XCV. to §. XCIX., and this forms the most complete treatise on the subject we know of. Our author informs us that in this important and difficult part of his work, he was assisted by M. Mossotti, one of the 40 Members of the *Societa Italiana,* and Professor of Mathematics at Buenos Ayres; to whom also he has before expressed himself indebted for an ingenious paper (§. XXIX.) on the Errors of the divided Object-glass Micrometer.

In §. XCIX. we have the methods of computing an occultation of the Sun by the Moon, commonly known by the name of an Eclipse of the Sun.

In the concluding Section of this elaborate work we find similar excellent expressions of the same principle, which was displayed in the opening Section. We cannot do better than confirm our remarks by quoting our author's own words.

"When the practical astronomer has proved, and can confide in his various and delicate resources, his mind, like his telescope, is pointed to heaven, and his soul is wrapped up in the contemplation of objects, that prove beyond contradiction the immutability of those laws by which the Omnipotent Creator upholds, actuates, and directs the luminous bodies composing this solar system. Whenever he detects a glaring discrepancy in his comparative observations, or in the errors of his clock, he arraigns not the heavenly bodies, or the earth on which he stands, as subject to move under the misguidance of capricious laws; but suspects his own imperfect powers, or the tendency of material mechanism to change its position or dimensions, by variations of temperature; and a repetition of the observations stamps a conviction of the truth of such supposition on his mind in characters indelible. He finds in every failure a proof of human impotency; but in the general agreement of all his successful efforts, discovers a regulating power infinitely greater than his own, and participates in the feelings of the poet, who considering that a complete observatory displays the sublimest works both of God and man, thus expresses his admiration:—

"'Here truths sublime, and sacred science charm,
Creative arts new faculties supply;
Mechanic powers give more than giant's arm;
And piercing optics more than eagle's eye;—
Here man explores Creation's wond'rous laws,
That teach him to adore the GREAT DESIGNING CAUSE.'"

## XXIX. *Proceedings of Learned Societies.*

### ROYAL SOCIETY.

Feb. 28. THE reading of a paper, entitled, "Experimental Determination of the Laws of Magneto-electric Induction in different masses of the same Metal, and of its Intensity in different Metals," by Samuel Hunter Christie, Esq. M.A. F.R.S., was commenced.

March 7.—The reading of Mr. Christie's paper was resumed and concluded.

Mr. Faraday, in his valuable papers entitled "Experimental Researches in Electricity," has advanced the proposition, that "when metals of different kinds are equally subject, in every circumstance, to magneto-electric induction, they exhibit exactly equal powers with respect to the currents which either are formed or tend to form in them;" and "that the same is probably the case in all other substances." The author not being satisfied with the conclusiveness of the experiments adduced in support of this proposition,—in order to determine its correctness, subjected different metals directly to the same degree of magneto-electric excitation, in such a manner, that the currents excited in them should be in opposite directions (as was the case in Mr. Faraday's experiment), and also that these opposing currents should have the same facility of transmission; so that the difference of their intensities, if any existed, might admit of measurement. He then minutely describes the apparatus he contrived with this view, and which consisted of helices of copper and of iron wire, covered with silk, each making sixty-five turns, but in opposite directions, and crossing each other alternately, and surrounding a cylinder of soft iron, which was rendered magnetic by the application of the large magnet belonging to the Royal Society, which the Council had placed at his disposal while engaged in these researches. The result of the experiment showed that the force of the currents from the copper helix considerably exceeded that from the iron helix, and appeared to be even more than double. By a modification of the apparatus, he found that the intensities of the currents in the two wires were very accurately proportional to their conducting powers; and hence the uniformity of the results obtained by Mr. Faraday is easily explicable.

The next object of Mr. Christie was to determine the order of the relative intensities and conducting power of several of the metals: but previously to engaging in this inquiry, he made a series of experiments, with a view of determining the law of intensities as depending upon the length and diameter of the wire through which the current is transmitted. For this purpose it was necessary to devise means of making and breaking the contact in as invariable a manner as possible. This he accomplished by letting the same weight fall from a constant height when the contact was to be broken, and suddenly relieving the cylinder of the tension caused by the same weight when the contact was to be formed. He ascertained that portions of wire connected with the one which formed the circuit, but not included in the circuit itself, had scarcely any influence on the intensity of the current. He then enters into various theoretical investigations as to the mode of deducing the absolute intensities of the currents in this mode of experimenting.

By comparing the intensity of the electricity in wires of one metal with that in wires of each of the others, by means of the arrangement described in the beginning of the paper, and taking a mean of the results, he found the relative intensities in the following metals to be, silver 1520, gold 1106, copper 1000, zinc 522, tin 253, platinum 240, iron 223, and lead 124. The author compared these results with those obtained by Davy, Becquerel, Professor Cumming, and Mr. Harris, and states what he considers may have been the causes of the differences.

The second object of the author's inquiry relates to the law of variation of the intensity of the electricity excited in wires of different diameters: for determining which he compares the effects of three different wires of which the diameters were in the proportion of 4, 2, and 1. The results occupy several tables: and the deduction from them, with regard to the law in question, is, that the intensity varies nearly as the square of the diameter: but several causes contribute to interfere with the accuracy of this determination, and to exhibit the power as a mean of 1·844 instead of 2; the principal of which is the action of the coils upon each other.

By other methods, in which two wires of different lengths and diameters are placed so as to oppose each other in their effects, the accuracy of the conclusion that this power is the square, was satisfactorily established. Hence he arrives at the general conclusion, that the intensity or conducting power varies as the mass or weight directly, and as the square of the length inversely.

A paper was then read, entitled, "Note on the Tides." By John William Lubbock, Esq. V.P. and Treasurer of the Royal Society.

This communication contains some interesting results which Mr. Lubbock has obtained from observations made at Plymouth, Portsmouth, and Sheerness, under the superintendence of the Masters attendant at those dockyards. Mr. Dessiou has, with extraordinary perseverance, just completed the discussion of about 6000 additional observations of the tides at the London Docks, with a view to found on a more certain basis the corrections of the moon's parallax and declination. The results which he has obtained are utterly irreconcilable with the theory of Bernoulli, and therefore the tables computed upon that theory must be rejected as inaccurate.

A paper was also read, entitled, "On the Nature of Sleep." By A. P. W. Philip, M.D. F.R.S. L. & E.

The author intends the present paper as a continuation of his inquiries into the relations subsisting between the nervous and muscular systems, which form the subject of his former papers, but which would be incomplete without the consideration of their condition during sleep. With this view he proposes to determine the particular organs, on the condition of which this peculiar state of the system depends; the laws by which it is governed; and the influence it has upon other parts of the system. The necessity of intervals of repose applies only to those functions which are the medium of intercourse with the external world, and which are not directly concerned in the maintenance of life. The organs subservient to these two classes of functions may be viewed as in a great degree distinct from one another. The brain and spinal marrow constitute alone the active portions of the nervous system. The law of excitement, which regulates the parts connected with the sensorial functions, including sensation, volition, and other intellectual operations, and the actions of the voluntary muscles, is uniform excitement, followed by a proportional exhaustion; which, when occurring in such a degree as to suspend their usual functions, constitutes sleep; all degrees of exhaustion which do not extend beyond the parts connected with the sensorial functions being consistent with health. On the other hand, the law of excitement of those parts of the brain and spinal marrow which are associated with the vital nerves, and are subservient to the vital functions, is also uniform excitement; but it is only when this excitement is excessive that it is followed by any exhaustion; and no degree of this exhaustion is consistent with health. The law of excitement of the muscular fibre, with which both the vital and sensitive parts of the brain and spinal marrow are associated, namely, the muscles of respiration, is interrupted excitement, which, like the excitement of the vital parts of these organs, is, only when excessive, followed by any degree of exhaustion. The author conceives that the nature of the muscular fibre is everywhere the same; the apparent differences in the nature of the muscles of voluntary and involuntary motion depending on the differences of their functions, and on the circumstances in which they are placed: and he concludes, that, during sleep, the vital, partaking in no degree of the exhaustion of the sensitive system, appears to do so simply in consequence of the influence of the latter on the function of respiration, the only vital function in which these systems cooperate.

The author proceeds to make some observations on the cause of dreaming, the phænomena of which he conceives to be a natural consequence of the preceding proposition. In ordinary sleep, the sensitive parts of the brain, with which the powers of the mind are associated, are not in a state of such complete exhaustion as to preclude their being excited by slight causes of irritation, such as those which accompany the internal processes going on in the system. The sensorium is the more sensible to the impressions made by these internal causes, inasmuch as all the avenues to external impressions are closed, and the mind is deprived of the control it exercises, during its waking hours, over the train of its thoughts, by the help of the perceptions derived from the senses, and the employment of words for detaining its ideas, and rendering them objects of steady attention, and subjects of comparison.

March 14.—A paper was read, entitled, "On the Figures obtained by strewing Sand on Vibrating Surfaces, commonly called Acoustic Figures." By Charles Wheatstone, Esq. Communicated by Michael Faraday, Esq. D.C.L. F.R.S.

The author, after adverting to the imperfect notice taken by Galileo and by Hooke of the phænomena which form the subject of this paper, ascribes to Chladni exclusively the merit of the discovery of the symmetrical figures exhibited by plates of regular form when made to sound. He proposes a notation, by means of two numbers separated by a vertical line, for expressing the figures resulting from the vibrations of square or rectangular plates. He gives a table of the relative sounds expressed both by their musical names and by the number of their vibrations, of all the modes of vibration of a square plate, as ascertained by the experiments of Chladni. He then proceeds to class and analyse the various phænomena observed under these circumstances, and shows that all the figures of these vibrating surfaces are the resultants of very simple modes of oscillation, occurring isochronously, and superposed upon one another; the resultant figure varying with the component modes of the vibration, the number of the superpositions, and the angles at which they are superposed. In the present paper, which forms the first part of his investigation, he confines himself to the figures of square and other rectangular plates.

The author finds that the principal results of the superposition of two similar modes of vibration are the following:—first, the points where the quiescent lines of each figure intersect each other remain quiescent points in the resultant figure; secondly, the quiescent lines of one figure are obliterated, when superposed, by the vibratory parts of the other; thirdly, new quiescent parts, which may be called points of compensation, are formed whenever the vibrations in opposite directions neutralize each other; and, lastly, at other points, the motion is as the sum of the concurring, or the differences of the opposing vibrations at these points. After considering various modes of binary superposition, the author examines the cases of four co-existing superpositions.

When the vibrations of the superposed modes are unequal in intensity, there is formed a figure intermediate between the perfect resultant and one of its compounds. These figures the author denominates *imperfect resultants.*

In each series of transitions there are certain points which are invariable during all the changes: these are quiescent points, formed by the nodal lines of one figure intersecting those of the other, and the centres of vibration, where the maxima of positive or negative vibration agree in each component mode of vibration. The points of compensation are changeable. Transitional figures appear when the sides of the plate are nearly, but not exactly, equal.

The author next considers the figures obtained on square plates of wood and other substances, having different degrees of elasticity in different directions. He concludes this part of his paper by an account of some optical means of representing the figures noticed by Chladni.

March 21.—The reading of a paper, entitled, "Experimental Researches in Electro-magnetism," by the Rev. William Ritchie, LL.D. F.R.S. was commenced.

March 28.—The reading of Dr. Ritchie's paper was resumed and concluded.

This communication consists of three parts. In the first part the author shows that the common deflecting galvanometer, in which the deflecting forces are assumed to be as the tangents of deflection, is founded on false principles, and consequently leads to erroneous results. The wire forming the coil is of considerable thickness, and therefore there is no fixed zero from which the deflections can be reckoned. The length of the coil, also, being generally short, occasions another serious error, as the theoretical investigation is founded on the supposition of an indefinite length. In proof of the inaccuracy of the indications of the common deflecting galvanometer, the author took two elementary batteries, the plates of one being one inch square, and those of the other two inches. The tangents of the deflections of the needle (proper precautions having been taken for the equally free passage of all the electricity evolved in either case,) were very nearly as 1 to 2, though it is obvious that the real quantities of voltaic electricity were as 1 to 4. The author's torsion galvanometer gave the degrees of torsion nearly as 1 to 4. Other experiments led to similar conclusions.

The author then examines the laws which were supposed to connect the conducting power of a wire for electricity, with its length and diameter, and which, according to Professors Cumming and Barlow, varies directly as the diameter, and inversely as the square root of the length; but, according to MM. Becquerel and Pouillet, directly as the square of the diameter, and inversely as the length. He points out the false conclusions of M. Becquerel, and that he has, in fact, deduced the value of *two* unknown quantities from *one* equation; and that M. Pouillet having arrived at his through the fallacious indications of the common deflecting galvanometer, they are equally erroneous. The author then shows that the law pointed out by Cumming and Barlow is, in ordinary cases, nearest the truth; though, under certain circumstances, the limits of even that law may be passed. Hence, and from a series of experiments with the torsion galvanometer, he arrives at the unexpected conclusion, that there is no determinate law of conduction, either for the length or diameter of the wire, but that it must vary, in every case, with the size of the plates, and the energy of the acid solution used in exciting them. This conclusion the author shows to be in accordance with the views of conduction which he had previously published; namely, that there is no actual transfer of electricity, but that all the phænomena result from the definite arrangement of the electric fluid essentially belonging to the conducting wire.

The second part of this paper relates to certain properties of electro-magnets. No attempt seems to have been hitherto made to investigate the law which connects the lifting power of electro-magnets with their length. The author found, by experiments with two soft iron horse-shoe electro-magnets, to each of which the same short horse-shoe lifter was adapted, and the circuit of one four times that of the other, that their lifting powers were nearly inversely as the square root of their lengths. By increasing the strength of the battery with which they were connected, their lifting powers approached more nearly to a ratio of equality; by diminishing it, the ratio increased in favour of the shorter magnet. Hence the law in this case seems to be as indefinite as in that of common electric induction, and the relation of the powers to vary with the energy of the inducing voltaic influence. By another experiment, the author shows that all that is necessary in preparing a powerful electro-magnet is simply to roll a ribbon of copper about a short bar of soft iron, and to use a short horse-shoe lifter of soft iron. The quality of the iron has great influence on the power of an electro-magnet; and the author found that the worst part of a bar of the worst iron he could procure made by far the best.

A bar electro-magnet, four feet long, which scarcely retained any power when its connexion with the battery was broken, on being *re-connected* with it, in the *same* direction as before, was *rapidly* converted into a powerful magnet; but after being removed, and its wires now connected with the *opposite* poles, it required a long time to convert it into a magnet of much inferior power; as if the atoms of electricity, having been first put in motion in one direction, are afterwards more easily turned in that direction than in the contrary.

The author failed in his attempts to make a permanent horse-shoe magnet of tempered steel by the touch, with an electro-magnet: not the slightest trace of magnetism was communicated to the steel; on the contrary, a previously magnetized horse-shoe magnet had its power completely destroyed by similar means.

Dr. Ritchie describes a method of making an electro-magnet revolve in a horizontal direction about its centre, by permanent magnets properly arranged. This method consists in changing the poles of the soft iron magnet the moment it passes the pole of the steel magnet, so that attraction is almost instantaneously changed into repulsion, and the motion rendered continuous.

In the third part the author describes a mode of obtaining a continuous current of electricity by the induction of common magnets. Any number of soft iron cylinders, having a coil of copper ribbon covered with thin tape wound round the middle, are fixed in such a manner to a revolving table, that they can be brought in rapid succession opposite to the poles of a permanent horse-shoe magnet: the soft iron cylinders are thus converted into temporary magnets. The copper ribbons are so connected, by means of wires soldered to their ends, with well amalgamated discs beneath, that their contact with them is successively made and broken, as often as the soft iron cylinders pass opposite the poles of the permanent magnet: and a delicate galvanometer is made to form part of the circuit. On putting the revolving table into rapid motion, an electric state is induced on the copper ribbon, and consequently on the continuous circuit, from the moment the magnet has begun to act on it till it has acquired its state of greatest magnetic power. The connexion being then broken, by the wire attached to the end of the copper ribbon leaving the amalgamated disc of copper beneath, the needle would return to its former position were it not prevented by the formation of a new current, from the next cylinder of iron coming within the action of the magnet; and, by employing a greater number of magnets, the development of the fresh current may be effected before the preceding one has been broken off, and the needle be thus made to show a steady deflection.

The author failed in all his attempts to effect chemical decomposition, even of the most easily decomposable compounds, by means of the nearly constant current of electricity produced by his present apparatus; and previous to making a more powerful one, he wished to ascertain whether water be a conductor of electricity thus developed, or not. For this purpose a film of hot water, of more than fifty square inches, was made to form part of the circuit of the magneto-electric battery; the whole being properly connected with an exceedingly delicate galvanometer. On making the apparatus revolve rapidly, not the slightest deflection of the needle was perceptible. Hence, if so large a surface of hot water be incapable of conducting as much electricity as would agitate the most delicate astatic needle, though the exciting cause was sufficient to make a wire revolve round a magnet, and overcome the resistance of the mercury through which it was dragged, it would require an enormous power of this kind to *decompose* water. The author, therefore, considers it unlikely that electricity induced by magnets will ever supply the place of the voltaic battery in effecting chemical decomposition; and he concludes by observing, that "as no increase of electro-magnetic power is gained by increasing the *decomposing* powers of a battery, and as action and reaction are equal, it appears improbable that we shall ever obtain high decomposing powers by any increase in magneto-electric induction."

A paper was then read, entitled, "Notice of the Remains of the recent Volcano in the Mediterranean." By John Davy, M.D. F.R.S. Assistant Inspector of Army Hospitals.

The author communicates an account given by Captain Swinburne, dated the 24th of August, of a dangerous shoal, in latitude 37° 9′ N. and longitude 12° 43′ E., consisting principally of black sand and stones, with a circular patch of rock, which has been left by the volcano that lately appeared in the Mediterranean. Captain Swinburne furnished the author with two specimens of the air which was seen rising from the site of the volcano, in small silver threads of bubbles. These were found, upon examination by chemical tests, to consist of between 9 and 10 parts of oxygenous to 79 or 80 of azotic gases.

The author adduces arguments in favour of the supposition that this air is disengaged from sea water at the bottom in contact with the loose and probably hot ashes and cinders composing the shoal, rather than that it arises from the extinct volcano. He is also disposed to extend this theory to the explanation of the gases disengaged from hot springs, which are generally found to consist of a mixture of oxygenous and azotic gases, the former being in less proportion than in atmospheric air, in consequence of its abstraction by oxidating processes from the air originally contained in these waters.

## ZOOLOGICAL SOCIETY.

May 14.—Various skins of *Birds* from Switzerland, presented to the Society by the Administration of the Musée Académique of Geneva, were exhibited. They comprised several species not previously contained in the collection.

At the request of the Chairman, a paper by Mr. Gould "On a new Genus of the Family *Corvidæ*" was read. The genus proposed by Mr. Gould comprehends the *Pica vagabunda*, Wagl., *Pica Sinensis*, Gray, and a third species which the author believes to have been hitherto unnoticed. To this group, on account of its arboreal habits, he gives the name of *Dendrocitta*, applying the specific name of *leucogastra* to the new species, which he regards as the type of the genus. The shortness and comparative feebleness of the *tarsi* in *Dendrocitta*, and its more elongated tail, the feathers of which are equally graduated, except the two middle ones which are much longer than the others, distinguish it from the typical *Picæ*, the *common Magpie* for example. These characters are in accordance with its habit of wandering from tree to tree in search of its food. It is further distinguished by the form of its bill. All the species yet known are natives of Eastern Asia.

Mr. Bennett called the attention of the Society to the skin and skeleton of an animal recently living in the Menagerie, and exhibited in illustration of a paper "On the Family of *Chinchillidæ*, and on a New Genus referrible to it," the commencement of which he read. The animal in question was purchased, in June 1832, from a dealer, who was completely ignorant of the locality from which it was originally obtained; and was brought by Mr. Bennett under the notice of the Committee of Science and Correspondence at its first meeting in that month. He then stated his conviction that it would be found to constitute the type of a new genus, intimately related to *Lagostomus* and *Chinchilla*, which he proposed to designate by the name of *Lagotis*, adding the specific denomination of *Cuvieri*, in commemoration of the illustrious naturalist, whose irreparable loss the world of science was just then called upon to deplore. He deferred, however, the completion of his account of the animal, until he should be enabled, at its death, to add the dentary and other internal characters, to the more obvious external distinctions on which he then relied. That opportunity having now occurred, he proceeded on the present occasion to redeem his pledge, and also to take a general view of the history, zoological characters and anatomy of the family to which it manifestly belongs.

As regards the history of *Lagotis*, although the last of the three animals constituting the family to come under the cognizance of zoological science, Mr. Bennett stated that he had little doubt that it was in fact the earliest known to travellers in South America, which he had no hesitation in assigning as its native country. He believed it to be the *Viscacha* of all the writers from Pedro de Cieça downwards, (including Acosta, Garcilasso, De Laet, Nieremberg, Feuillée, Ulloa, Vidauré, Molina, Schmidtmeyer and Stevenson,) who have mentioned that animal as an inhabitant of the Western or Peruvian acclivities of the Andes. The *Lagostomus*, on the other hand, is clearly the *Viscacha* described by so many travellers as colonizing the vast plains eastward of that great chain. Among these he cited Dobrizhoffer, Jolis, D'Azara, Proctor, Head, Miers and Haigh. For its zoological history he referred to its various describers, from M. De Blainville to M. Lesson. To complete the history of *Chinchilla* he also gave an account of the various notices regarding it, which have appeared since September 1829, the date of his account of it in the 'Gardens and Menagerie of the Zoological Society.'

The following characters point out the situation occupied by the three animals in the Order *Rodentia*, and the generic differences that exist between them.

Trib. HERBIVORA, F. Cuv.

*Dentes molares eradicati, per totam vitam pulpá persistente crescentes.*

Fam. CHINCHILLIDÆ.

*Dentes incisores superiores simplices; molares* $\frac{4-4}{4-4}$, *e lamellis osseis binis ternisve tænialibus inter se parallelis, substantiá vitreá omnino circumdatis, constantes: coronidibus invicem exactè oppo-*

*sitis, attritu complanatis.* Americæ Australis incolæ, gregarii, subterranei, mites. Artus postici anterioribus subduplò longioribus. Cauda producta, ad apicem supernèque longè setosa.

### Gen 1. LAGOTIS.

*Dentes incisores* $\frac{2}{2}$ *acutati; molares* $\frac{4-4}{4-4}$, *singuli e lamellis tribus completis obliquis constantes. Cranium posticè supernèque arcuatum, tympani cellulis superioribus inconspicuis. Pedes omnes tetradactyli, pollice omninò deficiente, unguibus parvis subfalcularibus. Auriculæ longissimæ. Cauda longa.* Rupicolæ (Peruviani) vellere molli caduco induti.

LAGOTIS CUVIERI.

### Gen. 2. CHINCHILLA.

*Dentes incisores* $\frac{2}{2}$ *acutati; molares* $\frac{4-4}{4-4}$, *singuli e lamellis tribus completis obliquis constantes, præter anticum inferiorem bilamellosum lamellâ anteriore profundè bilobâ. Cranium posticè retuso-truncatum, supernè depresso-complanatum, tympani cellulis conspicuè inflatis. Pedes antici pentadactyli, pollice completo; postici tetradactyli, unguibus parvis subfalcularibus. Auriculæ amplæ. Cauda longiuscula.* Rupicolæ Chilenses et Peruviani, vellere mollissimo tenacissimo induti.

1. *Chinchilla lanigera*, Benn.

2? *Chinchilla aurea.*

*Callomys aureus*, Isid. Geoffr. St. Hil. in Ann. Sci. Nat. tom. 21, p. 291.

### Gen. 3. LAGOSTOMUS.

*Dentes incisores* $\frac{2}{2}$ *acutati; molares* $\frac{4-4}{4-4}$, *singuli e lamellis binis completis obliquis constantes, postico superiore trilamelloso. Pedes antici tetradactyli, pollice omninò deficiente, unguibus parvis falcularibus; postici tridactyli, unguibus productis rectis robustis. Auriculæ mediocres. Cauda mediocris.* Campestres Bonarienses et Paraguaienses, vellere parùm utili induti.

*Lagostomus trichodactylus*, Brookes.

In the *Lagotis Cuvieri* the fore feet, like the hinder, have only four toes, there being no vestige of a thumb; and the claws are small, slightly sharpened, and entirely concealed by long and somewhat bristly hairs. Those of the hinder feet are similar in shape and rather larger; but that of the inner toe is flattened, curved inwards, and exposed, the hairs immediately adjoining it giving place to a tuft of about eight rows of short, stiff, horny, curved bristles, approaching nearly in their rigidity to the comb-like appendage, which is found in almost the same situation in the *Ctenodactylus Massonii*, Gray. A similar structure also occurs in the *Chinchilla*.

Mr. Bennett afterwards entered at length into the internal anatomy of *Lagotis* and *Chinchilla*, and gave a full description of their skeletons, dwelling more particularly on the points of difference existing between them. He concluded by some observations on the tribe of *Rodentia* to which these animals are referrible, and on the genera which compose it.

May 28.—At the request of the Chairman, Mr. Gould adverted to a specimen of a *Hornbill*, now living at the Society's Gardens. He regarded it as a very young individual of the *concave Hornbill* of Dr. Latham, *Buceros cavatus*, and exhibited, in illustration of the adult characters of the bird, specimens of it from the Society's Museum.

A Paper was read "On the Characters of several New Genera and Species of Coleopterous Insects, by the Rev. F. W. Hope." It was accompanied by drawings of the objects represented, exhibiting the generic characters in detail. The insects described were the following; characters of which are given in the "Proceedings" of the Society.

APLOA (n.g. Carabidarum Truncati-pennium, Lebiæ affine) *picta*; CALOSOMA *Orientale*; CHLÆNIUS *Sykesii*; OICEOPTOMA *tetraspilotum*; LANGURIA *Nepalensis* (probably the type of a subgenus); OPILUS *auripennis* (may be regarded as the type of a subgenus); COPTORHINA (n. g. Copridi affine) *Africana*, and *Klugii*; PHÆNOMERIS (n. g. Anomalæ affine) *magnifica*; MACRONATA *tetraspilota*; CETONIA *cretosa*; LUCANUS *Downesii*, and *æratus*; PHOLIDOTUS *irroratus*; ANTHICUS *cyaneus* (the type of a subgenus, for which Mr. Hope proposes the name of *Anthelephila*); ISACANTHA (n. g. Curculionidarum Infracticornium) *Rhinotioides*; LUPROPS (n. g. Helopidarum) *chrysophthalmus*; LAMIA *Roylii*, and *Crux nigra*; PRIONUS *Hayesii* (Long. 4½ unc.; lat. ad humeros, 12 lin.; elytrorum, 17. *Hab.* in Africâ. This magnificent insect is not surpassed in size by any Coleopterous species with which Mr. Hope is acquainted), *Cumingii*, and *Pertii* (for this last Mr. Hope proposes the generic name of *Dissosternum*); URACANTHA (n. g. Stenocoro affine) *triangularis*; and SCOLECOBROTUS (n. g. Uracanthæ affine) *Westwoodii*.

## XXX. *Intelligence and Miscellaneous Articles.*

### PROCEEDINGS OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT THE RECENT MEETING AT CAMBRIDGE.

*June* 24.—A GREAT majority of the Members of the Association having arrived at Cambridge, together with several hundred other gentlemen,—cultivators, amateurs, or well-wishers to science, who were desirous of uniting themselves with it, the general plan to be followed in the subsequent proceedings was this day arranged and promulgated. It was substantially the same as that pursued at Oxford last year, of which an account was given in our first volume, p. 77. We shall therefore omit on the present occasion what would be so nearly a repetition of the details then stated, and proceed at once to enumerate the Provisional Committees of the Sections.

### I. *Mathematical and General Physics.*

*Chairman*, Sir D. Brewster; *Deputy Chairman*, Rev. G. Peacock; *Secretary*, Professor Forbes:—Lord Adair, Professor Airy, Professor Babbage, Mr. F. Baily, Mr. Barton, Professor Barlow, Mr. Blackwall, Mr. Bowstead, Sir T. M. Brisbane, Professor Christie, Rev. H. Coddington, Mr. Cooper, Dr. Corrie, Mr. Dollond, Lieutenant Drummond, Mr. D. Gilbert, Rev. R. Gerswell, Professor W. R. Hamilton, Hon. C. Harris, Mr. G. Harvey, Sir John F. W. Herschel, Mr. E. Hodgkinson, Mr. Hymers, Professor T. Jarrett, Dr. Lardner, Mr. Lubbock, Mr. R. Murphy, Mr. Philpott, Mr. R. Potter, jun., Professor Baden Powell, Mr. Quetelet, Professor S. P. Rigaud, Dr. Robinson, Rev. R. Walker, Mr. W. L. Wharton, Mr. C. Wheatstone, Rev. W. Whewell, Rev. R. Willis.

### II. *Chemistry, Mineralogy, &c.*

*Chairman*, Dr. Dalton; *Deputy Chairman*, Professor Cumming; *Secretary*, Professor Miller:—Mr. Thomas Allan, Professor Daniell, Professor C. Daubeny, Professor Faraday, Rev. W. V. Harcourt, Mr. Snow Harris, Mr. J. F. W. Johnston, Mr. Marshall, Mr. Pearsall, Mr. Richard Phillips, Dr. Prout, Professor W. Ritchie, Rev. W. Scoresby, Mr. W. Sturgeon, Professor Turner.

### III. *Geology and Geography.*

*Chairman*, Mr. G. B. Greenough; *Deputy Chairmen*, Rev. Dr. Buckland and Mr. R. I. Murchison; *Secretaries*, Mr. William Lonsdale and Mr. John Phillips:—Dr. Boase, Mr. James Bryce, jun., Mr. Joseph Carne, Major Clerke, C.B., Rev. W. D. Conybeare, Sir Philip de M. G. Egerton, Dr. Fitton, Rev. Professor Hailstone, Mr. G. Mantell, Lieutenant Murphy, R.E., Marquis of Northampton, Professor A. Sedgwick, Colonel Silvertop, Mr. William Smith, Mr. J. Taylor, Mr. W. C. Trevelyan, Mr. H. T. M. Witham, Rev. J. Yates.

### IV. *Natural History.*

*Chairman*, Rev. W. L. P. Garnons; *Deputy Chairman*, Rev. L. Jenyns; *Secretaries*, Mr. C. C. Babington and Mr. D. Don:—Mr. Agardh, Mr. Blackwall, Mr. W. J. Burchell, Professor Burnett, Mr. W. Christy, Mr. Allan Cunningham, Mr. J. Curtis, Mr. E. Forster, Mr. J. E. Gray, Professor J. S. Henslow, Professor Lindley, Mr. Ogilby, Dr. J. C. Prichard, Mr. J. Sabine, Mr. Selby, Mr. R. Taylor, Mr. W. G. Werscow.

### V. *Anatomy, Medicine, &c.*

*Chairman*, Dr. Haviland; *Deputy Chairman*, Dr. Clark; *Secretaries*, Dr. Bond and Mr. Paget:—Dr. Alderson, Sir C. Bell, Professor Burnett, Mr. Broughton, Mr. Clift, Mr. Dugard, Mr. H. Earle, Dr. Marshall Hall, Dr. Hewett, Dr. Jermyn, Dr. Malcavey, Dr. Macartney, Professor Mayo, Dr. Paris, Dr. Prout, Dr. Roget, Dr. Thackeray, Dr. A. T. Thomson, Dr. D. Thorp.

A discussion was commenced in the Physical section in the morning, and resumed at a general meeting of the Association in the Senate-

House in the evening, on the phænomena of shooting stars and of the aurora borealis; in which Dr. Robinson of Armagh, Dr. Dalton, Sir John Herschel, Professor Airy, Mr. Scoresby, Mr. Whewell, Professor Christie, and Mr. D. Gilbert, engaged. It was stated by some that the aurora was never elevated more than from three to seven miles above the earth's surface; while others contended that its altitude was ninety or a hundred miles: this discrepancy led to an earnest recommendation that the phænomena should be more carefully and accurately observed.

*June* 25.—A meeting of the General Committee took place at ten o'clock, in the hall of Trinity Hall, on general business.

At eleven and twelve, meetings of the sections were resumed in the Schools and Caius College Hall, for receiving and discussing communications, &c. The following were the subjects examined respectively in the appropriate sections.

Remarks on certain Atmospheric Phænomena observed at Hull in March and April 1833. By G. H. Fielding, Esq.

On Naval Architecture. By J. Owen, Esq.

An Account of some Experiments relating to Isomorphism, undertaken at the request of the Association, by Dr. Turner and Professor Miller.

A communication was made by Dr. Daubeny, on the Nature and Quantity of the Gases given from off the Surface of the Water in certain Thermal Springs.

Mr. John Taylor exhibited Sections of the Shafts of the Deepest Mines, and gave some particulars respecting them.

Observations relative to the Structure and Functions of Spiders. By Mr. Blackwall.

Observations on the Pith of Plants. By Professor Burnett.

Observations on the Structure and Functions of the Nervous System, by Dr. Macartney, of Dublin, who detailed a considerable number of highly interesting and important original facts.

At one o'clock the General Meeting was held; when we observed present, besides the eminent individuals mentioned as attaching themselves to the sections,—Earl Fitzwilliam; Lord Cavendish, M.P.; J. Brocklehurst, Esq., M.P.; G. W. Wood, Esq., M.P.; J. W. Childers, Esq., M.P.; R. G. Townley, Esq., M.P.; Sir T. Acland; &c.—and also the following distinguished engineers: Mr. Watt, Mr. G. Rennie, Mr. Brunel, Mr. Bramah, Mr. Lowe, Mr. Grafton, Mr. Hawkins, Mr. Hodgkinson, &c.

Professor Buckland (the President of the Association at the Oxford meeting,) took the chair, and opened the business of the Meeting with some congratulatory remarks on the success which had attended the Association. He then briefly alluded to the Reports which had been published, as communicated to the Meeting at Oxford, and resigned the office of President to Professor Sedgwick.

Professor Sedgwick, having taken the chair, proceeded to address the Meeting at considerable length. He announced that Mr. Whewell had at his request prepared a review of the Reports on the progress and present state of various branches of science, which had been presented at the Meeting of last year: he noticed summarily the publication of those Reports, and the contents of some of them, dwelling particularly on those of Mr. Whewell's own Report on the Progress of Mineralogy: and, finally, announced that His Majesty and the Government, wishing to manifest their attachment to science, and to confer some mark of royal favour upon an illustrious philosopher, have conferred upon Dr. Dalton a pension out of the Civil List.

Mr. Whewell then addressed the assembly at great length, in reference to the objects of the Association, and read his exposition of its preceding transactions. This he subsequently printed, and presented to the Members.

The President then rose, and expressed his personal thanks to Mr. Whewell for that Report. He (the President) had addressed the Meeting, he observed, as Members of the British Association; but many of them were not as yet Members at all. The Committee had the power of admitting new Members; but that admission must be ratified by the General Meeting. Now if the proposition were made to this Meeting by some gentleman, they could confirm what the Committee had done. This might be carried by acclamation, by a show of hands, or, if they pleased, they could call for a scrutiny upon every vote; but if they dare trust their delegates, and carry the motion at once by acclamation, they would, by that act, create three or four hundred new philosophers; which would be doing a great work.

It was then moved by Mr. John Taylor, seconded by Professor Airy, and carried,—"That the persons whose names had been enrolled by the Committee since the last Meeting, be elected Members of this Association."

The President then offered another suggestion to the Meeting, which was, "That the Council shall have authority to elect Members of this Association; each case being subject to the approbation of the next General Meeting."

Mr. Murchison moved, and Professor Buckland seconded, this Resolution, which was adopted.

After the appointment of the Auditors, it being half-past 3 o'clock, the Meeting was adjourned till the evening.

The Association met again in the evening, at 8 o'clock, in the Senate-House.

Mr. John Taylor read a Report on the subject of Mineral Veins; in which he went largely into the history of the science, and the different theories which have been propounded by philosophers on this subject. There are three leading hypotheses: first, that which supposes metallic veins to have been open fissures, caused by some eruption, and filled up with various matters, by aqueous solution, from above: the second theory is, that these fissures were formed by violence done to the strata, and filled up by matter from within the earth, forced up by heat, and becoming a mineral substance; the third theory is, that the whole formation was contemporaneous with the rocks themselves. Each of these theories was investigated in the Report, and became the subject of an animated discussion, in which Dr. Buckland, Professor Whewell, Dr. Boase, Mr. John Phillips, and Mr. Fox, severally took part. The learned Chairman summed up, and the Meeting adjourned.

*June* 26.—At the Sectional Meetings the following communications were read :—

Mr. Potter on the Action of Glass of Antimony on Light.

Account of a Barometer Cistern. By Mr. Newman. Communicated by Mr. Willis.

Account of a New Reflecting Telescope. By Thomas Davison. Communicated by Mr. Turner.

Professor Oersted on the Compressibility of Water.

A communication on the Specific Gravity of Gases. By Dr. Dalton and Dr. Prout.

An Account of the Experiments relative to the Sulphur Salts.

Dr. Turner gave an account of his Experiments on Atomic Weights.

Dr. Daubeny read a Memoir on the Action of Light on Plants, and on the Action of Plants on the Atmosphere.

Mr. Trevelyan exhibited Specimens of Coprolites and Fossil Fish.

Mr. Murchison exhibited the Ordnance Maps, geologically coloured by himself, of the counties of Salop, Hereford, Radnor, Brecon, and Carmarthen, accompanied by enlarged sections; and explained the mineral structure of the country described.

A paper containing some Observations on Genera and Sub-Genera. By Mr. Jenyns.

On the Water contained in Bivalve Shells. By Mr. Gray.

Observations on the Classification of Ruminating Animals. By Mr. Ogilby.

Notice of a Memoir on the Natural Laws which appear to regulate the Distribution of the powers of producing Heat and Light among the different groups of the Animal Kingdom. By Mr. Brayley.

Observation on the Motion and Sounds of the Heart.

Observations, by Mr. H. Earle, on the Mechanical Functions of the Bulb of the Urethra.

Illustrations of the Effects of Irritant Poisons on Mucous Surfaces.

At the General Meeting, the President having taken the chair, the different Chairmen of the Sections read the Reports of their proceedings; after which, Mr. Peacock read a paper on the recent progress of the Integral and Differential Calculus; Professor Lindley his Report on the principal questions debated in the Philosophy of Botany; and Mr. Rennie a paper on Hydraulics, considered as a branch of Engineering.

*June* 27.—At the General Meeting, the President in the chair, it was moved by Dr. Buckland, and seconded by Mr. John Taylor, "That the gentlemen whose names were enrolled by the Committee yesterday be elected Members of the Association."

Mr. John Taylor having been called upon by the President, gave a statement of the finances and numerical strength of the Association; of which the following is an abstract:—

| | £. | s. | d. |
|---|---|---|---|
| Total Receipts . . . | 1430 | 0 | 0 |
| Disbursements . . . | 186 | 4 | 4 |
| | £1243 | 15 | 8 |

The number of Members when the Meeting was commenced was 680; but a greater number had joined since. If the rough numbers were correct, the number of new Members would amount to 689 at Cambridge;—total number of Members, 1369. There will be about 1000*l.* more to be received; and after paying the expenses of this Meeting, a balance will remain of about 2000*l.*

Professor Henslow invited the Members of the Association to an excursion in a barge on Saturday, to make some botanical and entomological researches in the fens.

The President then called upon the Chairmen of the Sections to make their Reports, which were given by the following gentlemen:—

Mr. Peacock, as Chairman of the Mathematical and Physical department.

Professor Dalton, as President of the Chemical department.

Mr. Greenough, as President of the Geological department.

Mr. Garnons, as President of the Natural History department.

Dr. Haviland, as President of the Medical department.

Professor Christie then read a Report on Magnetism; in which he considered, first, the direction of the terrestrial magnetic force; and secondly, the intensity of the magnetic force. In the course of this Report the learned Professor regretted that this was the only country in Europe in which observations on this important science were not made in a national observatory.

Mr. Whewell then delivered a Report on the knowledge we have of the strength of materials; in which he entered into the history of that science, and presented a variety of facts in illustration of his subject. After which the Meeting adjourned.

A numerous auditory again assembled in the Senate-House this evening, the several Sections being engaged in their different departments. At about ten o'clock Professor Sedgwick took the chair.

Mr. Whewell delivered an exposition of his recent researches relative to the tide-wave, illustrating them by reference to maps which he had constructed for the purpose.

Professor Farish addressed the Meeting on the subjects of railways and steam-carriages.

*June* 28.—The several Sections met as usual at ten o'clock; and at one o'clock the last Public Meeting of the Association was held in the Senate-House.

The President announced that the Report read by Mr. Whewell had been printed; and that any Member of the Association might receive a copy of it gratuitously, by applying at the Society's office. It was printed, not at the expense of the Association, but of Mr. Whewell himself; to whom the thanks of the Association were afterwards returned.

The Reports of the Sections were then presented by the respective Chairmen.

Mr. Challis read a paper on the Theory of Fluids; in which he treated of the leading hydrostatical and hydrodynamical problems; the latter of which chiefly occupied his attention, and which he divided in the following manner:—1st, the motion of fluids in vessels and pipes; 2nd, the determination of the velocity of the propagation of motion in air; 3rd, the musical vibrations of the air; 4th, the theory of waves; 5th, resistance to a ball pendulum, supposing it to oscillate in a small degree.

The President announced, that since the preceding day, among the names which had been enrolled by the Committee, were the names of the illustrious Dr. Chalmers, Professor Jameson, and Dr. Henry, sen., of Manchester; on each of whom he passed a high eulogium, and who were then elected Members of the Association by acclamation.

He then stated that the Meeting for 1834 would take place at Edinburgh, in the month of September, probably in the early part of it; and expressed his approbation of this determination of the Committee. He observed, that it was not in consequence of its being the seat of a University that Edinburgh had been selected: the Association was not to be considered as an academic body. "We (said the President) are citizens of the world; we belong to the republic of science, and go to Edinburgh as a large capital, in the vicinity of a large manufacturing district." The Society, he observed, owed a debt of gratitude to Sir David Brewster and others, and were going to Edinburgh, as dutiful children, to acknowledge it. "We have had a pressing invitation," he concluded, "and shall have a cordial reception."

It was afterwards announced that Sir Thomas Brisbane was the *President* elect; Sir David Brewster and Dr. Robinson the *Vice-Presidents*; the Rev. W. V. Harcourt, and Mr. Phillips of York, *General Secretaries*; Mr. John Taylor, *Treasurer*. Dr. Robinson and Professor Forbes, *Secretaries for Edinburgh*; and the Rev. W. Whewell and Professor Henslow, *Secretaries for Cambridge*. He pronounced a warm eulogium upon the President elect, who is the President of the Royal Society of Edinburgh: he had fought for his country in time of need; and while Governor of a distant colony (New South Wales), had established and carried on an observatory at his own expense.

Professor Babbage next addressed the Meeting on the subject of his proposal for collecting and publishing the numerical quantities which he has termed the Constants of Nature and Art; of which we shall give a further account in our next.

Mr. Brunel, Earl Fitzwilliam, the Rev. W. Scoresby, the Marquis of Northampton, the Rev. Dr. Lloyd, the President, Professor Buckland, Professor Hamilton, Professor Airy, Mr. Murchison, and the Rev. W. V. Harcourt, having severally addressed the assembly, this Third Meeting of the British Association for the Advancement of Science was then dissolved by the President.

In our next Number we purpose to give some additional particulars of the scientific business transacted at this Meeting.

## ANALYSIS OF TWO SULPHUREOUS SPRINGS NEAR WEYMOUTH.

### BY R. PHILLIPS, F.R.S. &C.

One of these springs, called the Nottington Spa, rises about three miles from Weymouth, and has been known and frequented for a considerable time. The other, named the Radipole Spa, is of recent discovery, and is only one mile distant from the town.

The saline contents of these waters are so small in quantity, that they must be considered as quite inert; and therefore those who wish to avail themselves merely of the sulphuretted hydrogen, may take them in larger quantity than if they were active in other respects.

After repeated trials I have found scarcely any variation in the quantity of the saline matter of the Nottington Spa; but that of the Radipole has varied a little. The proportions of sulphuretted hydrogen, however, differed considerably at different times in both. The only circumstance which I have constantly observed respecting the sulphuretted hydrogen is, that the Radipole Spa always contained the larger proportion.

The nature and quantity of the saline and earthy contents of the springs were ascertained by the usual well-known methods. The quantity of sulphuretted hydrogen was determined by putting nitrate of silver into a bottle, and pumping the fresh water upon it. Chloride and sulphuret of silver were of course precipitated together; the former was dissolved by ammonia, in which the sulphuret of silver is insoluble; and this being washed and dried, the sulphuretted hydrogen gas was calculated from the quantity of sulphuret obtained.

Contents of an Imperial gallon:—

Nottington Spa.

| | | |
|---|---|---|
| Sulphuretted hydrogen gas | 4·5 | cubic inches. |
| Azotic gas | 9·4 | |
| Oxygen gas | 1· | |
| Bicarbonate of lime | 33·62 | grains. |
| ——————— magnesia | 4·28 | |
| ——————— iron | 0·20 | |
| Common salt | 9·70 | |
| Sulphate of lime | 1·70 | |
| ————— magnesia | 1·93 | |
| ————— soda | 1·89 | |
| Alumina | 1·14 | |
| Silica | 1·38 | |
| Carbonaceous matter | 0·26 | |

Radipole Spa.

| | | |
|---|---|---|
| Sulphuretted hydrogen gas | 6·1 | cubic inches. |
| Azotic gas | 10·4 | |
| Oxygen gas | 1·4 | |
| Bicarbonate of lime, and a trace of<br>Bicarbonate of magnesia | 39·41 | grains. |

| | |
|---|---|
| Bicarbonate of iron | 0·40 |
| Common salt | 13·13 |
| Sulphate of lime | 9·58 |
| ——— magnesia | 8·49 |
| Silica | 0·61 |
| Carbonaceous matter | 0·37 |

---

## ELASTIC FLUIDS EVOLVED FROM VOLCANOS.

M. Boussingault having examined the gases emitted from many of the volcanos near the equator, has arrived at the following conclusions :—

1st. That the elastic fluids disengaged from the volcanos near the equator, are the same in the different volcanos ; viz. vapour of water in great quantity ; carbonic acid gas, sulphuretted hydrogen gas, and sometimes the vapour of sulphur.

2ndly. That the sulphurous acid and azote, which are met with in the craters of these volcanos, are to be considered as accidental substances.

3rdly. That muriatic acid, hydrogen and azote are not among the gases disengaged from the volcanos at the equator.—*Ann. de Chim. et de Phys.* tome lii. p. 5.

---

## LUNAR OCCULTATIONS FOR SEPTEMBER AND OCTOBER.

*Occultations of fixed Stars by the Moon, visible at Greenwich in the Year* 1833. *Computed by* THOMAS MACLEAR, *Esq.; and circulated by the Astronomical Society.*

*** The *angles* are reckoned *from* the northernmost point, and also *from* the vertex, *towards* the right hand, round the circumference of the Moon's image, as exhibited in an inverting telescope.

| 1833. | Stars' Names. | Magnitude. | Ast. Soc. Cat. No. | Immersions. | | | | Emersions. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sidereal time. | Mean time. | Angle from North Point. | Angle from Vertex. | Sidereal time. | Mean time. | Angle from North Point. | Angle from Vertex. |
| | | | | h m | h m | ° | ° | h m | h m | ° | ° |
| Sept. 6 | (179) Tauri | 6 | 550 | under | the ho | rizon | | 21 5 | 10 2 | 275 | 238 |
| | 97 *i* Tauri | 5·6 | 559 | 22 18 | 11 15 | 69 | 29 | 23 3 | 11 59 | 327 | 286 |
| 8 | 36*d* Gemin. | 6·7 | 844 | 0 21 | 13 10 | 66 | 25 | 1 10 | 13 59 | 308 | 266 |
| 30 | (225) Ceti | 7 | 214 | under | the ho | rizon | | 19 24† | 6 47 | 334 | 295 |
| Oct. 4 | 123 ζ Tauri | 3·4 | 684 | 2 38 | 13 44 | 77 | 40 | 3 39 | 14 44 | 310 | 282 |

† Rising at emersion.

*Meteorological Observations made by Mr.* THOMPSON *at the Garden of the Horticultural Society at Chiswick, near London; by Mr.* GIDDY *at Penzance, and Mr.* VEALL *at Boston.*

| Days of Month, 1833. | Barometer. |  |  |  |  | Thermometer. |  |  |  |  | Wind. |  |  | Rain. |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | London. |  | Penzance. |  | Boston | London. |  | Penzance. |  | Bost. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
|  | Max. | Min. | Max. | Min. | 8½ A.M. | Max. | Min. | Max. | Min. | 8½ A.M. |  |  |  |  |  |  |
| June 1 | 30·087 | 29·922 | 29·954 | 29·904 | 29·55 | 84 | 51 | 68 | 55 | 68 | S. | SW. | calm | ... | ... | ... |
| ○ 2 | 29·740 | 29·591 | 29·804 | 29·574 | 29·18 | 71 | 49 | 64 | 49 | 62 | NW. | SW. | calm | 0·20 | 0·200 | ... |
| 3 | 29·589 | 29·498 | 29·554 | 29·536 | 28·93 | 70 | 39 | 61 | 48 | 60 | S. | W. | W. | ... | ·350 | 0·32 |
| 4 | 29·633 | 29·587 | 29·636 | 29·566 | 29·10 | 73 | 41 | 59 | 48 | 63·5 | SE. | W. | W. | ... | ·100 | ... |
| 5 | 29·780 | 29·714 | 29·680 | 29·666 | 29·20 | 75 | 45 | 65 | 51 | 64 | W. | SW. | E. | ... | ... | ... |
| 6 | 29·900 | 29·817 | 29·810 | 29·660 | 29·25 | 75 | 50 | 60 | 52 | 68 | S. | S. | NW. | ... | ·330 | ... |
| 7 | 30·100 | 30·009 | 30·090 | 30·013 | 29·37 | 75 | 52 | 65 | 50 | 68 | W. | SW. | NW. | ... | ... | ·23 |
| 8 | 30·264 | 30·146 | 30·210 | 30·163 | 29·48 | 72 | 47 | 66 | 55 | 64 | W. | W. | NW. | ... | ... | ... |
| 9 | 30·311 | 30·305 | 30·254 | 30·207 | 29·63 | 81 | 50 | 64 | 56 | 69 | W. | SW. | W. | ... | ... | ... |
| ☾ 10 | 30·403 | 30·013 | 30·210 | 30·010 | 29·60 | 87 | 53 | 66 | 55 | 70·5 | W. | S. | calm | ... | ... | ... |
| 11 | 29·699 | 29·833 | 29·990 | 29·763 | 28·94 | 71 | 50 | 60 | 55 | 76 | SW. | NW. | NW. | ... | ·170 | ... |
| 12 | 29·809 | 29·759 | 30·016 | 29·860 | 29·04 | 64 | 47 | 62 | 49 | 54 | SW. | W. | NW. | ·10 | ... | ... |
| 13 | 29·687 | 29·425 | 29·616 | 29·410 | 29·11 | 67 | 43 | 62 | 52 | 54·5 | SW. | W. | calm | ·10 | ·340 | ·8 |
| 14 | 29·797 | 29·414 | 29·576 | 29·416 | 28·95 | 68 | 38 | 60 | 52 | 54 | W. | NW. | N. | ·14 | ·125 | ·57 |
| 15 | 29·967 | 29·869 | 29·696 | 29·696 | 29·43 | 68 | 52 | 62 | 48 | 58 | SE. | SW. | calm | ·26 | ·380 | ... |
| 16 | 29·802 | 29·681 | 29·660 | 29·566 | 29·20 | 73 | 50 | 65 | 55 | 60 | W. | W. | calm | ·07 | ... | ·06 |
| ● 17 | 29·934 | 29·857 | 29·910 | 29·813 | 29·26 | 78 | 50 | 64 | 52 | 64 | W. | W. | NW. | ·20 | ... | ·24 |
| 18 | 30·116 | 30·071 | 30·063 | 30·030 | 29·50 | 74 | 53 | 66 | 49 | 61 | W. | W. | NW. | ... | ... | ... |
| 19 | 30·073 | 29·971 | 29·913 | 29·913 | 29·50 | 69 | 53 | 62 | 56 | 56·5 | SW. | SW. | NW. | ·04 | ·360 | ... |
| 20 | 29·941 | 29·914 | 30·030 | 29·933 | 29·40 | 73 | 46 | 64 | 54 | 59 | W. | NW. | calm | ·01 | ... | ·70 |
| 21 | 30·025 | 29·988 | 30·060 | 30·060 | 29·46 | 75 | 54 | 63 | 52 | 62 | W. | NW. | calm | ... | ... | ·39 |
| 22 | 29·977 | 29·966 | 30·060 | 29·860 | 29·38 | 72 | 51 | 62 | 53 | 57 | SW. | SW. | W. | ·54 | ·230 | ... |
| 23 | 29·590 | 29·513 | 29·666 | 29·666 | 29·05 | 64 | 47 | 60 | 54 | 61 | W. | W. | calm | ·10 | ... | ... |
| ☽ 24 | 29·790 | 29·640 | 29·710 | 29·666 | 29·12 | 66 | 40 | 60 | 48 | 56 | W. | NW. | NW. | ·22 | ·145 | ·48 |
| 25 | 29·903 | 29·890 | 29·860 | 29·816 | 29·39 | 70 | 46 | 63 | 47 | 61·5 | W. | N. | calm | ... | ... | ... |
| 26 | 29·800 | 29·636 | 29·816 | 29·672 | 29·33 | 67 | 52 | 55 | 48 | 64 | W. | NE. | E. | ·48 | 2·320 | ... |
| 27 | 29·917 | 29·662 | 29·772 | 29·666 | 29·13 | 74 | 53 | 61 | 48 | 60 | W. | SW. | W. | ·05 | ... | ·10 |
| 28 | 29·849 | 29·737 | 29·569 | 29·536 | 29·33 | 79 | 57 | 60 | 54 | 68·5 | S. | S. | SE. | ... | 0·235 | ... |
| 29 | 29·854 | 29·778 | 29·660 | 29·536 | 29·20 | 73 | 54 | 63 | 53 | 66 | W. | SW. | NW. | ... | ·015 | ... |
| 30 | 29·862 | 29·838 | 29·786 | 29·766 | 29·30 | 70 | 49 | 61 | 53 | 66 | SW. | SW. | W. | ·12 | ·300 | ... |
|  | 30·403 | 29·414 | 30·254 | 29·410 | 29·27 | 87 | 38 | 68 | 47 | 62·5 |  |  |  | 2·63 | 5·600 | 3·17 |

Remarks.

*London.*—June 1. Hot and dry. 2. Overcast: rain. 3—9. Very fine. 10. Slight haze: hot and dry. 11. Fine in the morning, with brisk wind: boisterous at noon: cloudy and windy at night. 12. Dry and windy: cloudy and boisterous at noon. 13. Rain. 14. Fine: rain at night. 15. Fine: rain. 16. Heavy rain. 17. Fine: heavy shower in the evening. 18. Fine. 19. Overcast: rain. 20. Rain: fine. 21. Cloudy. 22. Cloudy: rain at night. 23. Windy, with showers. 24. Fine in the morning: heavy shower at noon, with some hail: clear. 25. Fine. 26. Rain. 27. Showery. 28—30. Very fine.

*Penzance.*—June 1. Fair. 2. Fair: showers. 3, 4. Fair: rain. 5. Fair. 6. Rain. 7. Fair. 8. Clear: fair. 9, 10. Fair. 11. Rain: fair. 12. Fair: rain at night. 13. Fair. 14. Rain: fair. 15. Fair: rain. 16—18. Fair. 19. Rain: fair. 20. Fair. 21. Fair: light rain. 22. Clear: rain. 23, 24. Fair: showers. 25. Clear. 26. Very heavy rain throughout. 27. Fair: rain. 28. Rain. 29, 30. Fair: showers.

*Boston.*—June 1. Fine. 2. Cloudy: rain P.M. 3. Cloudy. 4, 5. Fine. 6. Fine: rain P.M. 7. Fine. 8. Cloudy. 9, 10. Fine. 11. Cloudy and stormy. 12. Stormy. 13. Cloudy: rain early A.M.: tremendous storm of thunder and lightning, hail, and rain P.M. 14. Cloudy. 15. Fine: rain P.M. 16. Rain. 17. Stormy. 18. Cloudy. 19. Rain. 20. Rain: rain P.M. 21, 22. Cloudy. 23. Cloudy: rain A.M. and P.M. 24, 25. Fine. 26. Cloudy: 27. Cloudy: rain early A.M. 28, 29. Fine. 30. Cloudy.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

*SEPTEMBER* 1833.

## XXXI. *Experimental Researches in Electricity.—Third Series. By* MICHAEL FARADAY, *D.C.L. F.R.S. M.R.I. Fullerian Prof. Chem. Royal Institution, Corr. Mem. Royal Acad. of Sciences, Paris, Petersburgh, &c. &c.*[*]

§ 7. *Identity of Electricities derived from different Sources.*
§ 8. *Relation by Measure of common and Voltaic Electricity.*

### § 7. *Identity of Electricities derived from different Sources.*

265. THE progress of the electrical researches which I have had the honour to present to the Royal Society, brought me to a point at which it was essential for the further prosecution of my inquiries that no doubt should remain of the identity or distinction of electricities excited by different means. It is perfectly true that Cavendish[†], Wollaston[‡], Colladon[§] and others, have in turn removed some of the greatest objections to the acknowledgement of the identity of common, animal and voltaic electricity, and I believe that philosophers generally consider these electricities as really the same. But on the other hand it is also true, that the accuracy of Wollaston's experiments has been denied[||], and that one of them, which really is no proof of chemical decomposition by com-

---

[*] From the Phil. Trans. for 1833, Part I. This paper was read before the Royal Society, Jan. 10 and 17, in the present year. Abstracts of the author's First and Second Series of Experimental Researches in Electricity, containing § 1 to § 6, will be found in Phil. Mag. and Annals, N.S. vol. xi. pp. 445, 447.

[†] Phil. Trans. 1776, p. 196.

[‡] Ibid. 1801, p. 434.

[§] *Annales de Chimie*, 1826, p. 62, &c.

[||] Phil. Trans. 1832, p. 282, note.

mon electricity (309. 327.), has been that selected by several experimenters as the test of chemical action (336. 346.). It is a fact, too, that many philosophers are still drawing distinctions between the electricities from different sources; or at least doubting whether their identity is proved. Sir Humphry Davy, for instance, in his paper on the Torpedo*, thought it probable that animal electricity would be found of a peculiar kind; and referring to that, in association with common electricity, voltaic electricity and magnetism, has said, "Distinctions might be established in pursuing the various modifications or properties of electricity in these different forms, &c." Indeed I need only refer to the last volume of the Philosophical Transactions to show that the question is by no means considered as settled†.

266. Notwithstanding, therefore, the general impression of the identity of electricities, it is evident that the proofs have not been sufficiently clear and distinct to obtain approbation from all those who were competent to consider the subject; and the question seemed to me very much in the condition of that which Sir H. Davy solved so beautifully,—namely,

* Phil. Trans. 1829, p. 17. "Common electricity is excited upon non-conductors, and is readily carried off by conductors and imperfect conductors. Voltaic electricity is excited upon combinations of perfect and imperfect conductors, and is only transmitted by perfect conductors or imperfect conductors of the best kind. Magnetism, if it be a form of electricity, belongs only to perfect conductors; and, in its modifications, to a peculiar class of them[a]. Animal electricity resides only in the imperfect conductors forming the organs of living animals, &c."

† Phil. Trans. 1832, p. 259. Dr. Davy, in making experiments on the torpedo, obtains effects the same as those produced by common and voltaic electricity, and says that in its magnetic and chemical power it does not seem to be essentially peculiar,—p. 274; but he then says, p. 275, there are other points of difference; and after referring to them, adds, "How are these differences to be explained? Do they admit of explanation similar to that advanced by Mr. Cavendish in his theory of the torpedo; or may we suppose, according to the analogy of the solar ray, that the electrical power, whether excited by the common machine, or by the voltaic battery, or by the torpedo, is not a simple power, but a combination of powers, which may occur variously associated, and produce all the varieties of electricity with which we are acquainted?"

At p. 279 of the same volume of Transactions is Dr. Ritchie's paper, from which the following are extracts: "Common electricity is diffused over the surface of the metal;—voltaic electricity exists within the metal. Free electricity is conducted over the surface of the thinnest gold leaf as effectually as over a mass of metal having the same surface;—voltaic electricity requires thickness of metal for its conduction," p. 280: and again, "The supposed analogy between common and voltaic electricity, which was so eagerly traced after the invention of the pile, completely fails in this case, which was thought to afford the most striking resemblance," p. 291.

---

[a] Dr. Ritchie has shown this is not the case, Phil. Trans. 1832, p. 294.

whether voltaic electricity in all cases merely eliminated, or did not in some actually produce, the acid and alkali found after its action upon water. The same necessity that urged him to decide the doubtful point, which interfered with the extension of his views, and destroyed the strictness of his reasoning, has obliged me to ascertain the identity or difference of common and voltaic electricity. I have satisfied myself that they are identical, and I hope the proofs I have to offer, and the results flowing from them, will be found worthy the attention of the Royal Society.

267. The various phænomena exhibited by electricity may, for the purposes of comparison, be arranged under two heads; namely, those connected with electricity of tension, and those belonging to electricity in motion. This distinction is taken at present not as philosophical, but merely as convenient. The effect of electricity of tension, at rest, is either attraction or repulsion at sensible distances. The effects of electrical currents may be considered as 1st, Evolution of heat; 2nd, Magnetism; 3rd, Chemical decomposition; 4th, Physiological phænomena; 5th, Spark. It will be my object to compare electricities from different sources, and especially common and voltaic electricities, by their power of producing these effects.

### I. *Voltaic Electricity.*

268. *Tension.*—When a voltaic battery of 100 pairs of plates has its extremities examined by the ordinary electrometer, it is well known that they are found positive and negative, the gold leaves at the same extremity repelling each other, the gold leaves at different extremities attracting each other, even when half an inch or more of air intervenes.

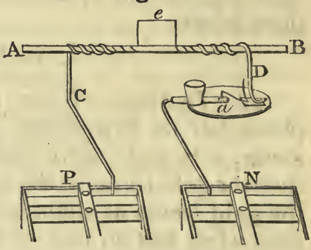
269. That ordinary electricity is discharged by points with facility through air; that it is readily transmitted through highly rarefied air; and also through heated air, as for instance a flame; is due to its high tension. I sought, therefore, for similar effects in the discharge of voltaic electricity, using as a test of the passage of the electricity either the galvanometer or chemical action produced by the arrangement hereafter to be described (312. 316.).

270. The voltaic battery I had at my disposal consisted of 140 pairs of plates four inches square, with double coppers. It was insulated throughout, and diverged a gold leaf electrometer about one third of an inch. On endeavouring to discharge this battery by delicate points very nicely arranged and approximated, either in the air or in an exhausted receiver, I could obtain no indications of a current, either by

magnetic or chemical action. In this, however, was found no point of discordance between voltaic and common electricity; for when a Leyden battery (291.) was charged so as to deflect the gold leaf electrometer equally, the points were found equally unable to discharge it with such effect as to produce either magnetic or chemical action. This was not because common electricity could not produce both these effects (307. 310.), but because when of such low intensity the quantity required to make the effects visible (being enormously great (371. 375.),) could not be transmitted in any reasonable time. In conjunction with the proofs of identity hereafter to be given, these effects of points also prove identity instead of difference between voltaic and common electricity.

271. As heated air discharges common electricity with far greater facility than points, I hoped that voltaic electricity might in this way also be discharged. An apparatus was therefore constructed (fig. 5.), in which AB is an insulated glass rod upon which two copper wires, C, D, are fixed firmly; to these copper wires are soldered two pieces of fine platina wire, the ends of which are brought very close to each other at *e*, but without touching; the copper wire C was connected with the positive pole of a voltaic battery, and the wire D with a decomposing apparatus (312. 316.), from which the communication was completed to the negative pole of the battery. In these experiments only two troughs, or twenty pairs of plates, were used.

Fig. 5.



272. Whilst in the state described, no decomposition took place at the point *a*, but when the side of a spirit-lamp flame was applied to the two platina extremities at *e*, so as to make them bright red-hot, decomposition occurred; iodine soon appeared at the point *a*, and the transference of electricity through the heated air was established. On raising the temperature of the points *e* by a blowpipe, the discharge was rendered still more free, and decomposition took place instantly. On removing the source of heat, the current immediately ceased. On putting the ends of the wires very close by the side of and parallel to each other, but not touching, the effects were perhaps more readily obtained than before. On using a larger voltaic battery (270.), they were also more freely obtained.

273. On removing the decomposing apparatus and inter-

posing a galvanometer instead, heating the points *e* as the needle would swing one way, and removing the heat during the time of its return (302.), feeble deflections were soon obtained: thus also proving the current through heated air; but the instrument used was not so sensible under the circumstances as chemical action.

274. These effects, not hitherto known or expected under this form, are only cases of the discharge which takes place through air between the charcoal terminations of the poles of a powerful battery, when they are gradually separated after contact. Here the passage is through heated air exactly as with common electricity, and Sir H. Davy has recorded that with the original battery of the Royal Institution this discharge passed through at least four inches of air*. In the exhausted receiver the electricity would *strike* through nearly half an inch of space, and the combined effects of rarefaction and heat was such upon the inclosed air as to enable it to conduct the electricity through a space of six or seven inches.

275. The instantaneous charge of a Leyden battery by the poles of a voltaic apparatus is another proof of the tension, and also the quantity, of electricity evolved by the latter. Sir H. Davy says†, "When the two conductors from the ends of the combination were connected with a Leyden battery, one with the internal, the other with the external coating, the battery instantly became charged, and on removing the wires and making the proper connexions, either a shock or a spark could be perceived: and the least possible time of contact was sufficient to renew the charge to its full intensity."

276. *In motion.* i. *Evolution of Heat.*—The evolution of heat in wires and fluids by the voltaic current is matter of general notoriety.

277. ii. *Magnetism.*—No fact is better known to philosophers than the power of the voltaic current to deflect the magnetic needle, and to make magnets according to *certain laws*; and no effect can be more distinctive of an electrical current.

278. iii. *Chemical decomposition.*—The chemical powers of the voltaic current, and their subjection to *certain laws*, are also perfectly well known.

279. iv. *Physiological Effects.*—The power of the voltaic current, when strong, to shock and convulse the whole animal system, and when weak to affect the tongue and the eyes, is very characteristic.

280. v. *Spark.*—The brilliant star of light produced by the

---

* Elements of Chemical Philosophy, p. 153.

† Ibid. p. 154.

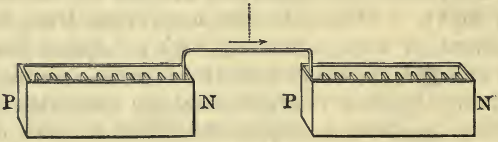
discharge of a voltaic battery is known to all as the most beautiful light that man can produce by art.

---

281. That these effects may be almost infinitely varied, some being exalted whilst others are diminished, is universally acknowledged; and yet without any doubt of the identity of character of the voltaic currents thus made to differ in their effect. The beautiful explication of these variations afforded by Cavendish's theory of quantity and intensity requires no support at present, as it is not understood to be doubted.

282. In consequence of the comparisons that will hereafter arise between wires carrying voltaic and ordinary electricities, and also because of certain views of the condition of a wire or any other conducting substance connecting the poles of a voltaic apparatus, it will be necessary to give some definite view of what is called the voltaic current, in contradistinction to any supposed peculiar state of arrangement, not progressive, which the wire or the electricity within it may be supposed to assume. If two voltaic troughs PN, P′N′, fig. 1. be symmetrically arranged and insulated, and the ends NP′ connected by a wire, over which a magnetic needle is suspended, the wire will exert no effect over the needle; but immediately that the ends PN′ are connected by another wire, the needle will be deflected, and will remain so as long as the circuit is complete. Now if the troughs merely act by causing a peculiar arrangement in the wire either of its particles or its electricity, that arrangement constituting its electrical and magnetic state, then the wire NP′ should be in a similar state of arrangement *before* P and N′ were connected, to what it is afterwards, and should have deflected the needle, although less powerfully, perhaps to one half the extent which would result when the communication is complete throughout. But if the magnetic effects depend upon a current, then it is evident why they could not be produced in *any* degree before the circuit was complete; because prior to that no current could exist.

Fig. 1.



283. By *current*, I mean anything progressive, whether it be a fluid of electricity, or two fluids moving in opposite directions, or merely vibrations, or, speaking still more ge-

nerally, progressive forces. By *arrangement*, I understand a local adjustment of particles, or fluids, or forces, not progressive. Many other reasons might be urged in support of the view of a *current* rather than an *arrangement*, but I am anxious to avoid dilating unnecessarily upon what can be supplied by others at the moment.

## II. *Ordinary Electricity.*

284. By ordinary electricity I understand that which can be obtained from the common machine, or from the atmosphere, or by pressure, or cleavage of crystals, or by a multitude of other operations; its distinctive character being that of great intensity, and the exertion of attractive and repulsive powers, not merely at sensible but at considerable distances.

285. *Tension.* The attractions and repulsions at sensible distances, caused by ordinary electricity, are well known to be so powerful in certain cases, as to surpass, almost infinitely, the similar phænomena produced by electricity, considered as of other kinds. But still those attractions and repulsions are exactly of the same nature as those already referred to under the head *Tension, Voltaic electricity* (268.); and the difference in degree between them is not greater than often occurs between cases of ordinary electricity only. I think it will be unnecessary to enter minutely into the proofs of the identity of this character in the two instances. They are abundant; are generally admitted as good; and lie upon the surface of the subject: and whenever in other parts of the comparison I am about to draw, a similar case occurs, I shall content myself with a mere announcement of the similarity, expanding only upon those parts where the great question of distinction or identity is still controverted.

286. The discharge of common electricity through heated air is a well-known fact. The parallel case of voltaic electricity has already been described (272, &c.).

287. *In motion.* i. *Evolution of Heat.* The heating power of common electricity when passed through wires or other substances, is perfectly well known. The accordance between it and voltaic electricity is in this respect complete. Mr. Harris has constructed and described* a very beautiful and sensible instrument on this principle, in which the heat produced in a wire by the discharge of a mere spark of common electricity is readily shown, and to which I shall have occa-

---

* Philosophical Transactions, 1827, p. 18. Edinburgh Transactions, 1831. Harris on a New Electrometer, &c. &c.

sion to refer for experimental proof in a future part of this paper (344.).

288. ii. *Magnetism.* Voltaic electricity has most extraordinary and exalted magnetic powers. If common electricity be identical with it, it ought to have the same powers. In rendering needles or bars magnetic, it is found to agree with voltaic electricity, and the *direction* of the magnetism, in both cases, is the same; but in deflecting the magnetic needle, it has been found deficient, so that sometimes the power has been denied altogether, and at other times distinctions have been hypothetically assumed for the purpose of avoiding the difficulty*.

289. M. Colladon, of Geneva, considered that the difference might be due to the use of insufficient quantities of common electricity in all the experiments before made upon this point; and in a memoir read to the *Académie des Sciences* in 1826†, describes experiments, in which, by the use of a battery, points, and a delicate galvanometer, he succeeded in obtaining deflections, and thus establishing identity in that respect. MM. Arago, Ampere, and Savary are mentioned in the paper as having witnessed a successful repetition of the experiments. But as no second witness of these effects has come forward, MM. Arago, Ampere, and Savary, not having themselves published (that I am aware of,) their acceptance of the results, and as others have not been able to obtain the effects, M. Colladon's conclusions have been by some doubted or denied; and an important point with me was to establish their accuracy, or remove them entirely from the received body of experimental evidence. I am happy to say that my results fully confirm those by M. Colladon, and I should have had no occasion to describe them, but that they are essential as proofs of the accuracy of the final and general conclusions I am enabled to draw respecting the magnetic and chemical action of electricity, (360. 366. 367. 377. &c.).

290. The plate electrical machine I have used is fifty inches in diameter; it has two sets of rubbers; its prime conductor consists of two brass cylinders connected by a third, the whole length being twelve feet, and the surface in contact with air about 1422 square inches. When in good excitation, one revolution of the plate will give ten or twelve sparks from the conductors, each an inch in length. Sparks or flashes from ten to fourteen inches in length may easily be drawn from the

---

* Demonferrand's *Manuel d'Electricité dynamique*, p. 121.

† *Annales de Chimie*, xxxiii. p. 62.

conductors. Each turn of the machine, when worked moderately, occupies about $\frac{4}{5}$ths of a second.

291. The electric battery consisted of fifteen equal jars. They are coated eight inches upwards from the bottom, and are twenty-three inches in circumference, so that each contains one hundred and eighty-four square inches of glass, coated on both sides, independent of the bottoms, which are thicker glass, and contain each about fifty square inches.

292. A good discharging train was arranged by connecting metallically a sufficiently thick wire with, first, the metallic gas pipes of the house, then with the metallic gas pipes belonging to the public gas works of London; and finally, with the metallic water pipes of London. It was so effectual as to carry off instantaneously electricity of the feeblest tension, even that of a single voltaic trough, and was essential to many of the experiments.

293. The galvanometer was one or the other of those formerly described (87. 205.), but the glass jar covering it and supporting the needle was coated inside and outside with tinfoil, and the upper part (left uncoated, that the motions of the needle might be examined,) was covered with a frame of wire-work, having numerous sharp points projecting from it. When this frame and the two coatings were connected with the discharging train (292.), an insulated point or ball, connected with the machine when most active, might be brought within an inch of any part of the galvanometer, yet without affecting the needle within by any ordinary electrical attraction or repulsion.

294. In connexion with these precautions, it may be necessary to state that the needle of the galvanometer is very liable to have its magnetic power deranged, diminished, or even inverted by the passage of a shock through the instrument. If the needle be at all oblique in the wrong direction to the coils of the galvanometer, when the shock passes, effects of this kind are sure to happen.

295. It was to the retarding power of bad conductors, that I first looked with the hope of being able to make common electricity assume more of the characters and power of voltaic electricity, than it is usually supposed to have.

296. The coating and armour of the galvanometer were first connected with the discharging train (292.); the end B (87.) of the galvanometer wire was connected with the outside coating of the battery, and then both these with the discharging train; the end A of the galvanometer wire was connected with a discharging rod by a wet thread four feet long;

and finally, when the battery had been positively charged by about forty turns of the machine, it was discharged by the rod and the thread through the galvanometer. The needle immediately moved.

297. During the time that the needle completed its vibration in the first direction and returned, the machine was worked, and the battery charged; and when the needle in vibrating resumed its first direction, the discharge was again made through the galvanometer. By repeating this action a few times, the vibrations soon extended to above 40° on each side of the line of quiescence.

298. This effect could be obtained at pleasure. Nor was it varied, apparently, either in direction or degree, by using a short thick string, or even four short thick strings in place of the long fine thread. With a more delicate galvanometer, an excellent swing of the needle could be obtained by one discharge of the battery.

299. On reversing the galvanometer communications so as to pass the discharge through from B to A, the needle was equally well deflected, but in the opposite direction.

300. The deflections were in the same direction as if a voltaic current had been passed through the galvanometer, i. e. the positively charged surface of the electric battery coincided with the positive end of the voltaic apparatus (268.), and the negative surface of the first with the negative end of the latter.

301. The battery was then thrown out of use, and the communications so arranged that the current could be passed from the prime conductor, by the discharging rod held against it, through the wet string, through the galvanometer coil, and into the discharging train (292.), by which it was finally dispersed. This current could be stopped at any moment, by removing the discharging rod, and either stopping the machine or connecting the prime conductor by another rod with the discharging train; and could be as instantly renewed. The needle was so adjusted, that whilst vibrating in moderate and small arcs, it required time equal to twenty-five beats of a watch to pass in one direction through the arc, and of course an equal time to pass in the other direction.

302. Thus arranged, and the needle being stationary, the current, direct from the machine, was sent through the galvanometer for twenty-five beats, then interrupted for other twenty-five beats, renewed for twenty-five beats more, again interrupted for an equal time, and so on continually. The needle soon began to vibrate visibly, and after several

alternations of this kind, the vibration increased to 40° or more.

303. On changing the direction of the current through the galvanometer, the direction of the deflection of the needle was also changed. In all cases the motion of the needle was the same in direction as that caused by the use of an electric battery or a voltaic trough (300.).

304. I now rejected the wet string, and substituted a copper wire, so that the electricity of the machine passed at once into wires communicating directly with the discharging train, the galvanometer coil being one of the wires used for the discharge. The effects were exactly those obtained above (302.).

305. Instead of passing the electricity through the system, by bringing the discharging rod at the end of it into contact with the conductor, four points were fixed on to the rod; when the current was to pass, they were held about twelve inches from the conductor, and when it was not to pass, they were turned away. Then, except with this variation operating as before (302.), the needle was soon powerfully deflected, and in perfect consistency with the former results. Points afforded the means by which Colladon, in all cases, made his discharges.

306. Finally, I passed the electricity first through an exhausted receiver, so as to make it there resemble the aurora borealis, and then through the galvanometer to the earth; and it was found still effective in deflecting the needle, and apparently with the same force as before.

307. From all these experiments, it appears that a current of common electricity, whether transmitted through water or wire, or rarefied air, or by means of points in common air, is still able to deflect the needle; the only requisite being, apparently, to allow time for its action: that it is, in fact, just as magnetic in every respect as a voltaic current, and that in this character therefore no distinction exists.

308. Imperfect conductors, as water, brine, acids, &c. &c. will be found far more convenient for exhibiting these effects than other modes of discharge, as by points or balls; for the former convert at once the charge of a powerful battery into a feeble spark, or rather continuous current, and involve little or no risk of deranging the magnetism of the needles (294.).

[To be continued.]

# XXXII. *On the Inflection of Light, in Reply to* Professor Powell. *By* JOHN BARTON, *Esq.*[*]

I AM much indebted to Professor Powell for the candid and friendly manner in which he has commented on the objections to the undulatory theory of light, which I adduced in my former communication. On the present occasion I propose, first, to make a few remarks in explanation or justification of what I before advanced; and then to suggest another hypothesis, which I persuade myself is capable of explaining the phænomena of inflection more completely and satisfactorily than that of Fresnel.

The first question at issue between the undulationists and myself relates to a matter of fact. Newton found that when a beam of light is suffered to fall on a very narrow slit, the beam parts in the middle, leaving a dark space between the two portions into which it is divided. This result agrees with my own observation. Professor Airy, on the contrary, finds the centre of the spectrum always relatively bright, however narrow the slit through which the light passes. I have no wish to disparage Professor Airy's authority; but I must be permitted to prefer the testimony of my own senses, supported as it is by the observations of Newton, and even, I think I may add, by the observations of Professor Powell. For although this gentleman has not succeeded in reproducing the phenomena under the exact form described by me, and delineated in my last communication, he has said enough to convince every one who reflects on the subject, of the possibility of so succeeding when the experiment is repeated with due precaution. "When," says he, "the edges approached very nearly, I observed something like the appearance described by Mr. Barton, but with this difference, that the boundaries of the dark space, instead of being continuous, diverged either way into the shadow in hyperbolic lines." Now, I am sure that if Professor Powell will reconsider the question, he will see that, from the nature of the hyperbola, there must, on his own showing, be a certain width of interval between the two knife-blades, giving a result such as I have described. In fact, it is easy, from the hyperbolic form of the lines, combined with Newton's observation that the dark space begins to appear when the interval between the two blades is less than the four-hundredth part of an inch, to assign the precise distance at which the blades must be placed, and the degree of curvature they must possess, in order to give a dark space of any required figure and dimensions. I need not dwell on this point,

---

[*] Communicated by the Author: see our preceding volume, p. 424.

since the details of the computation will be readily supplied by any one versed in mathematics. But I may add, that if Professor Powell will employ blades of less curvature, he will find the experiment succeed more readily. Those employed by him in repeating my experiment had, if I do not mistake, so inconsiderable a radius of curvature as to reduce the dimensions of the dark space within a limit too small to be conveniently observed.

It would seem, indeed, from his subsequent observations, that Professor Powell is not quite sure whether to admit or not the correctness of Newton's observation; for after saying that he cannot succeed in obtaining the results described by me, he goes on to assign certain considerations which may serve, he thinks, to reconcile the phænomena with the undulatory hypothesis, *even supposing* the facts to be such as I have asserted. The formulæ of Fresnel, he says, always suppose the opening through which the light enters the darkened chamber to be a mathematical point: whereas Newton employed for this purpose a hole a quarter of an inch in breadth. But the experiment succeeds with me equally well, whether the opening in question be large or small, while it fails equally in either case with Professor Airy; this cannot, therefore, be the source of the different results obtained by us. Indeed it appears quite incredible that the enlargement or contraction of the aperture by which the light enters the chamber can produce a difference *of such a kind* as supposed by Professor Powell. That a change in the dimensions of the aperture should affect the breadth or intensity of the dark space may be readily imagined; but that such a change should convert light into darkness appears inconceivable.

The second observation of Professor Powell under this head I am apprehensive I do not fully comprehend. He says, "It results from the well-known fact of the enlargement of the shadows of the two edges beyond their geometrical boundaries, that these shadows will coalesce before the edges meet;......and this seems very likely to have been the real result observed by Newton." Surely the formulæ of Fresnel are intended to comprise the whole of the phenomena, including among the rest that enlargement of the shadow to which Professor Powell alludes. If so, it cannot be allowable to employ this enlargement as an after correction to the results of calculations deduced from those formulæ.

With regard to another objection advanced by me against the theory of Fresnel,—its inconsistency with the observations of Newton and Biot on the distance at which the first of the dark bands cross one another in the centre of the spectrum,—Professor Powell thinks these observations not to be relied on, as being of earlier date, and performed with apparatus less susceptible of accuracy than that employed by Fresnel. I must observe, however, that the question at issue does not rest on the comparative accuracy of the methods of observation employed. Fresnel has not recorded any experiments made under circumstances similar to those which gave to Newton and Biot results so much at variance with his theory. He examined in two cases only the distance at which the first dark bands are found to intersect. In these two cases the width of the slit was, respectively, two millimetres, and one millimetre and a half*; whereas the discordant results given by the observations of Newton and Biot relate to widths below one millimetre, or the twenty-fifth part of an inch. Even, therefore, if the observations of Fresnel were as far superior in accuracy to those of his predecessors as Professor Powell assumes, it would not be decisive in favour of his theory. But I confess I cannot see any sufficient ground for attributing to the observations of Fresnel such unmeasured superiority as has been supposed. I cannot think that if Fresnel deserves all confidence to the hundredth part of a millimetre, Newton and Biot are unworthy of being trusted to the tenth part of a millimetre, as Professor Powell's reasoning implies. I cannot think that the accuracy of different series of observations is to be estimated solely by their relative antiquity. Fresnel certainly introduced one important improvement into the method of observation:—he received the rays on a lens, instead of receiving them on a sheet of paper, like Newton, or on a piece of roughened glass, like Biot: he was thus enabled to measure the intervals between the fringes by a micrometer, —a method which admits of greater accuracy than the earlier method of taking off the distance by a pair of compasses. But let it be observed that in the particular class of phænomena at present under consideration, the advantage gained by this improvement in the method of observation ceases altogether; since the question relates, not to the width of the interval between two fringes, but to the place of their intersection. With regard to another important point, the measurement of the width of the slit, there is some reason to think Newton's method of observation preferable to Fresnel's. I do not, indeed, find in Fresnel's memoir any account of the manner in which this was accomplished in his experiments; but Newton has described the method employed by himself. Having placed his knife-blades with their edges (which were

---

* *Mémoires de l'Institut,* tome v. pp. 398 and 437.

ground "truly straight,") facing each other, and their points meeting at a given small angle, he computed the interval between them at any distance from that angle, by the problem of similar triangles. This method appears susceptible of greater accuracy than any process of direct measurement. If, therefore, Fresnel employed some such direct means, I should be disposed to place greater confidence in the observations of Newton, who was no less remarkable for accuracy as an experimentalist than for genius as a mathematician. Professor Airy, indeed, finds Newton's measurements bad, because, "according to theory, when the breadth of the aperture is very small, the distance should vary as the square of the breadth," which is not found to be the case in Newton's observations. But I would ask, Is not this taking for granted the very thing to be proved? When we are seeking to bring to test the soundness of a theory by comparing it with the results of observation, can it be allowable to measure the accuracy of those very observations by their accordance or discordance with the theory in question?

The results obtained by Newton and Biot display, I think, strong internal evidence that their discrepancy with the theory of Fresnel is not attributable solely to errors of observation. It will be observed, on examining those results, that when the width of the slit exceeds the thirtieth part of an inch, or thereabouts, the observations are not greatly at variance with the theory; but in proportion as the width is reduced below this limit, the discordance between theory and observation increases; and at length, when the width is less than the four-hundredth part of an inch, it becomes a difference, not only in degree, but in kind; the theory indicating that the spectrum should be brightest at the centre, while observation shows that this centre is quite dark. Looking at this progressively increasing discrepancy between the conclusions of theory and the observed phænomena, it is difficult to avoid suspecting that it depends on some defect in the theory itself.

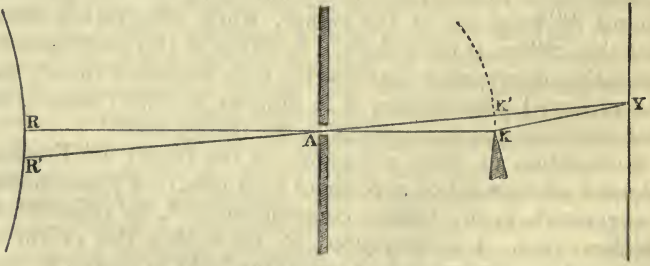
In addition to these objections to the theory of Fresnel, founded on its want of agreement with observed phænomena, I suggested, in my former communication*, an objection of another kind. I endeavoured to show that the origin of the undulations supposed to constitute light is placed in this theory at a wrong point. Fresnel and his followers placed this origin at the point of intersection—whether a pin-hole through which the rays enter the darkened chamber, or the focus of a lens occupying the same position. To me it appears that

---

[*] See Lond. and Edinb. Phil. Mag. vol. ii. p. 263.—Edit.

the true origin of the undulations should be placed at the sun's surface. I am sure, from the language of Professor Powell's reply, that I did not explain myself on this head so fully and explicitly as I ought. He says, "If the aperture be very small, it is shown by theory that the new wave diverging from it, which is produced by the sum of all the small waves belonging to the original waves from RR′, &c., will be equally strong in all directions; and A in this case is the real centre and origin from which the new undulations commence."

In our sun, it is no doubt true, as observed by Professor Powell, that the wave diverging from the point of intersection "is produced by the sum of all the small waves belonging to the original waves from RR′ &c." It is no doubt true, on the principles of the undulatory theory, that the particles of æther composing the wave R′A, on arriving at the point A are agitated by a multitude of impulses derived from other points of the sun's surface; the succeeding portion AY may therefore be considered as the joint result of all these impulses. But inasmuch as the disturbing forces in question are infinite in number, and infinitely various in force and direction, they completely counteract each other's operation; and the practical result is, that the wave emanating from the point R′ goes forward to its ultimate destination at Y, precisely as if it had not been crossed in its path by any other rays whatever. Such at least was the doctrine of Huygens, the great author of the undulatory theory. If the undulationists of the present day have seen it necessary to abandon or modify the principles of their master, it appears incumbent on them to assign some reason for the change, and to show how it may be reconciled with the laws which are admitted to regulate the undulations of elastic media.



According to Young, the point Y will always be of double brightness if the paths of the two rays AY, AKY differ in length by an integral number of undulations. But it is evident that the chances are infinite against the two rays RA, R′A, arriving at the point A in the same state: their conditions must be as diversified as the lengths of the paths which they have severally traversed in arriving from the sun. What then is the nature of the force which operates upon them at A, the point of intersection, to bring them, or one of them, into a new condition? Suppose, for instance, that the wave forming the ray RA, on arriving at the point A, happens to be at its maximum of advance, while the wave forming the ray R′A, on arriving at the same point, happens to be at its maximum of retrogression. By the theory of Huygens, each will go forward in its course quite independently, as if the other did not exist. How happens it, then, that on arriving at K and K′ they are found in one and the same state? One or both of them must have experienced an acceleration, or a retardation, such as to make up together the length of half an undulation. How has this been accomplished?

In the theory of Young, respect is had only to the two rays RA, R′A, on whose interference the colour of the point Y is supposed to depend. In the theory of Fresnel, the new wave diverging from A is supposed, as Professor Powell truly says, to be produced by the sum of all the small waves belonging to the original waves from R R′, &c. But this, though a more accurate way of stating the question than Young's, gives in practice very nearly the same results; inasmuch as those parts only of the wave entering the chamber which follow the direction of the lines AY, AKY, do in fact constitute *effectual rays* ("*rayons efficaces*"), as Fresnel has himself observed. It is essential to his theory that every part of the hemispherical wave K′K should be found in one and the same condition, as it is to the theory of Young that the two individual rays should be found in like condition at K′ and K. The simple question which I would ask of the undulationists is, how has this equality of condition been brought about? I do not see how it is possible, on their theory, to give an answer to this question.

If, however, we suppose light to consist of material particles, endued with a mutually repulsive force, and so constituting an elastic fluid of great tenuity, the question just proposed may be solved without difficulty: for that such a fluid in passing through a narrow aperture, when pressed against an opposing surface, will be thrown into a series of undulatory movements, may be shown, I think, either by reference to the known laws of the motion of fluids, or by direct experiment. Take a tube, an inch or more in diameter, closed at one end, excepting a small orifice or slit, and blow strongly through it against the flame of a candle. The flickering motion of the flame will show that the air does not issue from the orifice in an uniform stream, but in a succession of rapidly alternating movements. This fact was observed by Dr. Young, and described by him in a paper published in the Philosophical Transactions for 1800. The mode of observation that he employed was, indeed, somewhat different from that here described: he contrived to render the issuing current of air visible by combining it with smoke. If the pressure is increased, a whistling sound is produced; affording another kind of proof that the air in passing through the orifice is thrown into a state of undulation.

Now, if the particles of light be supposed to constitute an elastic fluid, it is evident that a phænomenon of the same kind must take place whenever a stream of this fluid impinges upon a narrow aperture; and in this case the formulæ of Fresnel will be applicable, with some modification, to the hypothesis here proposed, as well as to the hypothesis which supposes light to consist in the vibrations of an imaginary æther; and with this advantage, that an obvious reason is assigned why the undulations are found to have their origin at the aperture by which the light enters: for which no reason, as it appears to me, can be given on the opposite theory.

By the help of the same principle it might also be explained, I think, why a beam of light passing through a very narrow slit, is separated into two portions, leaving a dark space between them; and why the formulæ of Fresnel are found to fail in approaching this limit. But it would, perhaps, be out of place at present to enlarge on these questions, which are not likely to excite much interest while the theory on which they rest is not yet recognised or established. I could bring forward other considerations in abundance which appear to me decisive against the undulatory hypothesis; but it seems preferable thoroughly to investigate and discuss, in the first instance, the circumstances of one or two classes of phænomena, rather than to lose ourselves in a wider circle of reasoning.

I cannot conclude without again expressing my sense of the friendly spirit in which Professor Powell has criticized my former observations. I should be fastidious indeed, if I did not perceive and acknowledge that his remarks deserve to be considered in no other light than as intended, and as calculated, "to promote the common cause of scientific truth."

## XXXIII. *On* Bernoulli's *Solution of the Problem of Shortest Twilight. By* T. S. Davies, *Esq. F.R.SS. L. & E., F.R.A.S., &c.*[*]

THE problem of the shortest twilight was first solved, and very elegantly too, by Nunez, in a little quarto tract of 142 pages, printed at Lisbon in 1542; and it has engaged the attention of many distinguished authors since that time. John and James Bernoulli as well as D'Alembert and L'Hôpital discussed the problem: but the researches of the two illustrious brothers are nowhere, that I know of, to be found in print. The result is, indeed, stated in one of John Bernoulli's letters to the *Journ. des Savans*: but he says nothing that can lead us to discover the particular details of his solution. He however certainly bestowed a good deal of trouble upon it; as he says, "*J'ai résolu le problême de trouver géométriquement le jour du plus petit crépuscule, ce qui a occupé mon frère, Professeur de Mathématique à Bâle, et moi, depuis plus de cinq ans, sans en pouvoir venir à bout.*" He tells us, too, that he effected his solution by means of the differential calculus. D'Alembert, in the *Encyclopédie Méthodique* (Art. Crépuscule), undertook to give a complete solution on the supposed plan of Bernoulli: but he obtained also an equation of the fourth degree, the roots of which embarrassed him considerably. Two of the roots, it is true, he dismissed from his formula pretty readily; but not, as it appears to me, upon grounds altogether satisfactory. He does not attempt to show either how they came there or what was their actual signification; nor does he even attempt to do so with the remaining root of the remaining pair, though he employs more than three folio columns in showing (by special instead of general reasonings) that it does not belong to the minimum, and he even says, and attempts to prove, that it does not refer to the maximum twilight problem.

The intricacy of D'Alembert's solution seems to have deterred successive geometers from attempting to develop in a more advantageous form the probable method of Bernoulli, these being the only solutions (L'Hôpital's perhaps excepted, of which I cannot speak, not having his book within reach,) which I have found, in which the modern method of maxima and minima is employed. Every other solution with which I am acquainted proceeds upon certain geometrical considerations derived from the nature of the figure itself rather than from the equations of the problem: and it must be admitted that in point of facility these have very considerably the ad-

---

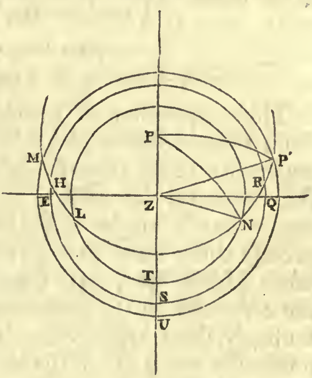
[*] Communicated by the Author.

vantage over the other method. Had, therefore, the mere solution of the problem been the object to be principally sought for, there can be no doubt that it is already rendered as simple as it ever can be; and a very ample list of such solutions may be consulted in Professor Leybourn's edition of that valuable but unpretending little periodical, the Ladies' Diary, vol. iv. p. 314. We find there the solutions of Messrs. Ivory, Wallace, and Skene, as well as the very amplified discussions of Delambre, as given both in his *Astronomie*, and in his *Histoire de l'Astronomie Ancienne*. Two other solutions by Hachette, printed in the Correspondence of the Polytechnic School, vol. ii.; and others still, by Keill, Lemonnier, Maupertuis, Emerson, Mauduit, Cagnoli, &c., may be found in the respective writings of those authors. All these, however, are of the kind which may be called geometrical, in contradistinction to the method of Bernoulli and D'Alembert.

Of these, Mr. Skene's is the only one which takes the problem in the more general form, in which another almacantar is substituted for the horizon of the common problem; and his solution is truly elegant as a specimen of the method of research which he adopted. Unfortunately it confined him to the simple question of the minimum, and he also was thereby led to give an incomplete solution, compared with that furnished by the calculus. The two cases, the maximum and the minimum, are so intimately connected that they present themselves naturally as the extreme cases of the question, *When the duration of twilight is given, to find the declination*; and they appear together in the same final equation interwoven in a single formula, and demanding in all respects equal attention. On this account, elegant as the solution of Mr. Skene is, it does not remove the necessity for reconsidering the problem under another aspect.

Some time ago, when composing a paper (since published in vol. xii. of the Edinburgh Transactions,) on the application of great-circle co-ordinates to the investigation of spherical loci, I was led to examine a considerable number of those problems which had been subjects of discussion, by the older methods of treating spherical curves—and the problem of shortest twilight amongst the rest. As, however, that problem did not properly appertain to my plan, I relinquished the inquiry for others more interesting to me at that moment, and laid aside the few memoranda which I had made concerning it. A day or two ago my attention was accidentally recalled to the subject; and as in those memoranda the problem had been viewed under its most general aspect, and the true character of all the roots of the equation assigned,—as, moreover, the problem is one of some historical celebrity, and its solution calculated to enforce an important truth,—on all these accounts its occupying a place in the Philosophical Magazine may perhaps be justified.

Problem.—*Let* EHRQ *be the horizon of the place;* Z *the zenith;* P *the pole;* ESQ *the equator;* MUP′, LNT *any two almacantars;* LNPM *a circle of declination; then it is required to find the position or polar distance of* LNPM, *so that the arc of it intercepted between the given almacantars may be a maximum or a minimum.*



Such is the more general geometrical statement of the problem in the aspect under which the Bernoullis viewed it: the angle NPP′ is the measure of the time elapsed between the sun's passing the two almacantars. In the common problem for one of these almacantars is substituted the horizon itself.

Let NP′ be the intercepted portion of the circle of declination. Denote the colatitude, or PZ, by $\lambda$: put $\varrho, \varrho_{\prime}, \varrho_{\prime\prime}$ the spherical radii of the circles LRN, LTN, and MUP′ respectively: and denote the angles ZPP′ and ZPN by $\theta_{\prime\prime}$ and $\theta_{\prime}$. Then,

$$\theta_{\prime} = \cos^{-1} \frac{\cos \varrho_{\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda}$$

$$\theta_{\prime\prime} = \cos^{-1} \frac{\cos \varrho_{\prime\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda}$$

From which we have the polar angle or measure of the time,

$$\theta_{\prime\prime} - \theta_{\prime} = \cos^{1} - \frac{\cos \varrho_{\prime\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda}$$

$$- \cos^{1} - \frac{\cos \varrho_{\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda} \ \ldots\ldots\ldots\ldots\ldots \ (1)$$

But that the time may be a maximum or a minimum, we must have

$$d \left\{ \begin{array}{l} \cos^{1} - \dfrac{\cos \varrho_{\prime\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda} \\ \cos^{1} - \dfrac{\cos \varrho_{\prime} - \cos \varrho \cos \lambda}{\sin \varrho \sin \lambda} \end{array} \right\} = 0 \ \ldots\ldots \ (2)$$

In this expression $\varrho$ is the variable, and the differentiation being performed with respect to it, we have, after transposition,

$$\frac{(\cos\lambda - \cos\varrho_{,}\cos\varrho)\operatorname{cosec}\varrho}{\sqrt{(\sin^2\lambda - \cos^2\varrho_{,}) + 2\cos\varrho_{,}\cos\lambda\cos\varrho - \cos^2\varrho}}$$

$$= \frac{(\cos\lambda - \cos\varrho_{,,}\cos\varrho)\operatorname{cosec}\varrho}{\sqrt{\sin^2\lambda - \cos^2\varrho_{,,} + 2\cos\varrho_{,}\cos\lambda\cos\varrho - \cos^2\varrho}} \cdots (3)$$

Squaring these to take the radical from the denominator, and transposing all to one side, it takes the form

$$0 = \operatorname{cosec}^2\varrho \left\{ \frac{(\cos\lambda - \cos\varrho_{,}\cos\varrho)^2}{\sin^2\lambda - \cos^2\varrho + 2\cos\lambda\cos\varrho_{,}\cos\varrho - \cos^2\varrho} \right.$$

$$\left. - \frac{(\cos\lambda - \cos\varrho_{,,}\cos\varrho)^2}{\sin^2\lambda - \cos^2\varrho_{,,} + 2\cos\lambda\cos\varrho_{,,}\cos\varrho - \cos\varrho^2} \right\} \cdots\cdots (4)$$

This expression is probably not much unlike that which John Bernoulli obtained, allowance being made for the greater generality of its objects and the difference of the notations. As, however, he merely describes it, we can only conjecture what it might have been*: at all events it does not greatly differ from that given by D'Alembert, in the *Encyclopédie Méthodique*, Art. CRÉPUSCULE. Let us now attend to the reduction of the factor within the brackets: and first, cross multiply, and arrange the resulting terms according to the powers of cos $\varrho$; then divide all the terms by $\cos^2\varrho_{,,} - \cos^2\varrho_{,}$: our result is

$$\cos^4\varrho - 2\cos\lambda\,\frac{1+\cos\varrho_{,}\cos\varrho_{,,}}{\cos\varrho_{,}+\cos\varrho_{,,}}\cos^3\varrho - \sin^2\lambda\cos^2\varrho$$

$$+ 2\cos\lambda\,\frac{1+\cos\varrho_{,}\cos\varrho_{,,}}{\cos\varrho_{,}+\cos\varrho_{,,}}\cos\varrho - \cos^2\lambda;$$

which may again be readily changed into

$$(1-\sin^2\varrho)^2 + 2\cos\lambda\,.\,\frac{1+\cos\varrho_{,}\cos\varrho_{,,}}{\cos\varrho_{,}+\cos\varrho_{,,}}\,.\,\cos\varrho\,(1-\cos^2\varrho)$$

$$- \sin^2\lambda\,(1-\sin^2\varrho) - \cos^2\lambda;$$

and this is at once converted into

$$\sin^2\varrho \left\{ \cos^2\varrho - 2\cos\lambda\,\frac{1+\cos\varrho_{,}\cos\varrho_{,,}}{\cos\varrho_{,}+\cos\varrho_{,,}}\cos\varrho + \cos^2\lambda \right\} \cdots\cdots\cdots (5)$$

Inserting instead of the bracketed factor of (4) its value given by (5), we have that equation (4) at once transformed into

$$\cos^2\varrho - 2\cos\lambda\,\frac{1+\cos\varrho_{,}\cos\varrho_{,,}}{\cos\varrho_{,}+\cos\varrho_{,,}}\cos\varrho + \cos^2\lambda = 0 \;\cdots\cdots (6)$$

---

* Johan. Bernoulli, *Opera Omnia*, tome i. p. 64.

We thus see that the factor $\sin^2 \varrho$ which arose out of the process of finding (5) is really a *foreign factor* introduced, as those factors so generally are, by elimination: and we see too how it arose; viz. by Bernoulli and D'Alembert having cancelled the factor $\operatorname{cosec}^2 \varrho$ from equation (4) merely because it was a factor of the whole equation. Had this view occurred to them, they would have depressed their biquadratic to a quadratic at once, and have escaped the embarrassment created by attempting to prove that certain roots contained in it did not fulfill the conditions of the problem, and were *therefore* inadmissible. But an important question here arose—*what is the signification of this result, and how did it make its appearance intermingled with the proper solution of the problem?* It is not enough to take those parts of a result which we can readily interpret, and reject all the others as useless or unmeaning: though such is and always has been so greatly the fashion, that scarcely a single author has insisted upon an unflinching determination to consider every solution incomplete which stops short of this consummation. It will, I have no doubt, ere long, become a fundamental principle in the philosophy of mathematics—that *every part of an algebraical result admits of complete interpretation, either by reference to the conditions which were expressed in the fundamental equations, or else in the hypotheses, tacitly made* (*in order to apply our transforming operations,*) *in the various subsequent stages of the solution.* It is, however, so much the custom to discard, without consideration or remark, all such results as do not admit of a ready and obvious application to the immediate objects before us, that facility of interpretation is the rarest of all the faculties of the geometer that we find in any considerable degree developed. No factor ought to be rejected for which a satisfactory reason cannot be given, *nor ought it to be considered foreign till the step at which it was introduced, is distinctly ascertained*: and it bespeaks both a bad taste and unpardonably negligent habits of research, to leave any part of the final equation unexplained, even in the most trivial inquiry which may be undertaken *.

---

* The valuable discussion and illustrations of this principle, given by Mr. Babbage in vol. ii. of the Cambridge Philosophical Transactions, cannot be too earnestly recommended to every young mathematician who would form a proper taste in the modern analysis, nor too diligently studied by every one who aspires to a higher character than that of a mere algebraical machine.

With regard, however, to the metaphysical views entertained by that distinguished philosopher, on the relations between the mind and certain objects of mental action, as expressed in that paper, I offer no opinion *here*, as I shall have occasion to moot that subject in another place.

Resolving now the quadratic equation (6), we have

$$\cos \varrho = \cos \lambda \, \frac{1 + \cos \rho_{,} \cos \rho_{,,} \pm \sin \rho_{,} \sin \rho_{,,}}{\cos \rho_{,} + \cos \rho_{,,}}$$

$$= \cos \lambda \, \frac{1 + \cos \overline{\rho_{,} \mp \rho_{,,}}}{\cos \rho_{,} + \cos \rho_{,,}}$$

$$= \cos \lambda \, \frac{\cos^{2} \tfrac{1}{2} \overline{\rho_{,} \mp \rho_{,,}}}{\cos \tfrac{1}{2} \overline{\rho_{,} + \rho_{,,}} \cos \tfrac{1}{2} \overline{\rho_{,} \backsim \rho_{,,}}} \quad \ldots\ldots\ldots \; (7)$$

But the question now naturally arose in D'Alembert's mind, which of these roots belongs to the *minimum*? or do they *both* designate *minima*?

It is difficult to account for that distinguished geometer overlooking the simple and common test furnished by the differential calculus itself for deciding this question: it is even difficult to conceive how the consideration of the problem itself, as presented by the diagram on the globe, should have failed to point out to him the proper interpretation of the twofold result in our last equation: yet such is the case. He devotes considerable space to proving that the lower sign of our equation does not answer to a minimum twilight. What it does answer to he does not attempt to explain; but he denies that it answers to the maximum.

The general fact, that functions of one independent variable which do not admit of indefinite increase and diminution, can never have two maxima without the intermediate occurrence of a minimum, nor two minima without an intermediate maximum, might have guided him to discover from the figure itself, that the two roots could not both indicate minima; but rather that one of them necessarily indicated the time of *maximum twilight*. However, the common appeal to the second differential coefficient determines it at once. For differentiating (6), and inserting the values of $\cos \rho$ given in (7) in the equation, we have for the test the value of

$$\cos \lambda \, \frac{1 + \cos \rho_{,} \cos \rho_{,,}}{\cos \rho_{,} + \cos \rho_{,,}} \mp \cos \lambda \, \frac{\sin \rho_{,} \sin \rho_{,,}}{\cos \rho_{,} + \cos \rho_{,,}}$$

$$- \cos \lambda \, \frac{1 + \cos \rho_{,} \cos \rho_{,,}}{\cos \rho_{,} + \cos \rho_{,,}},$$

the first and third terms of which cancel, and leave, for the test, the sign of

$$\mp \cos \lambda \, \frac{\sin \rho_{,} \sin \rho_{,,}}{\cos \rho_{,} + \cos \rho_{,,}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (8)$$

We thus see that the problem has never yet been fully solved, since the determination of the minimum depends not alone upon the choice of the signs + or − in the equation (7), but also upon the values of $\lambda_{\prime}$ $\rho_{\prime}$ and $\rho_{\prime\prime}$. The way in which this takes place is too obvious to need any further remark.

The interpretation, therefore, of Bernoulli's equation is completed and the problem at the same time resolved in the most general case that can be proposed on a spherical earth, and with a uniform declination for the period of twilight on the day in question. It might hence seem that the inquiry, in reference to everything of value which it can afford, might be properly concluded here. Nevertheless, as the curious properties which Delambre has deduced, both in his *Astronomie* and in his *Histoire de l'Astronomie*, for the particular case he considered, have in several instances remarkable analogies in the more general one above discussed, it will not be out of place to annex a few of them to the preceding investigation.

[To be continued.]

## XXXIV. *Theory of the Correction to be applied to a Ball-Pendulum for the Reduction to a Vacuum. By the Rev.* J. CHALLIS, *Fellow of the Cambridge Philosophical Society**.

IN a previous communication respecting the resistance to the motion of small spherical bodies in elastic fluids†, I attempted to explain, entirely from theoretical considerations, the manner inwhich the air is acted upon, when a pendulum consisting of a small spherical ball suspended by a very slender wire, performs very small oscillations in it; but I omitted to enter upon any calculation to ascertain the numerical value of the correction required for reducing the time of vibration in air to that in a vacuum. As the theory there advanced is competent to obtain such a result without the aid of experiment, I propose to make this the object of the present communication.

The following equation was obtained in the paper referred to:—

$$\mathrm{M}\,v^2 + m\,v^2 = 2\,g\,(\mathrm{M}-\mu)\;(h-x),$$

in which M is the mass of the ball, $v$ the velocity of its centre, $\mu$ the mass of an equal volume of air, $g$ the force of gravity, $h-x$ the vertical descent of the centre of the ball. The equation without the term $mv^2$, is that which was formerly em-

---

* Communicated by the Author.

† See Lond. and Edinb. Phil. Mag. vol. i. p. 40.

ployed in reducing to a vacuum, the effect of the motion of the fluid not being taken into account. According to our theory $m v^2$ is to be added, in consequence of the simultaneous movement of the air with the pendulum. The reasoning led to the conclusion that so little change of density takes place at the surface of the ball, that we may consider the air to be put in motion just as if it were incompressible. The influence of the air carried by the suspending wire was neglected in the theory. Also the surface of the ball was supposed to be perfectly smooth, so as to impress no motion on the aërial particles in the direction of a tangent plane. Hence the air in contact with the ball will move in directions normal to its surface, and consequently directed to a centre. Because the density is very nearly unchanged, the velocity at a given instant will very nearly vary at different points, in a radius produced, inversely as the square of the distance from the centre.

These results being admitted, we may proceed to calculate $m v^2$. For conceive two straight lines to be drawn at any instant through the centre of the ball, one in the direction of its motion, the other in any direction making an angle $\theta$ with the first. Let the plane of these two lines make an angle $\phi$ with a plane through the centre of the ball, at right angles to the suspending wire. The velocity of the air at the point where the latter line meets the surface is $v \cos\theta$; and at any point P on the line, distant by $r$ from the centre, the velocity is $\frac{v b^2}{r^2} \cos\theta$, $b$ being the radius of the ball. The mass of a fluid element at P, its density being 1, is

$$d r \times r\, d\theta \times r \sin\theta\, d\phi,$$

and the *vis viva* of the fluid in motion, or $m v^2$, is equal to

$$\iiint \left(\frac{v b^2}{r^2} \cos\theta\right)^2 r^2 \sin\theta\, d r\, d\theta\, d\phi.$$

The integral with respect to $\phi$ is to be taken from 0 to $2\pi$, with respect to $\theta$ from 0 to $\pi$, and with respect to $r$ from $b$ to infinity. Hence

$$m v^2 = b^4 v^2 \iiint \frac{d r}{r^2} \cos^2\theta \sin\theta\, d\theta\, d\phi$$

$$= 2\pi b^4 v^2 \iint \frac{d r}{r^2} \cos^2\theta \sin\theta\, d\theta$$

$$= \frac{4\pi b^4 v^2}{3} \int \frac{d r}{r^2} = \frac{4\pi b^3 v^2}{3}.$$

It follows that $m = \frac{4 \pi b^3}{3} = \mu$, and that

$$M v^2 + \mu v^2 = 2g (M - \mu) (h - x).$$

Hence $-\frac{v\,d\,v}{d\,x}$ or $f = g \frac{M - \mu}{M + \mu} = g \left(1 - \frac{2 \mu}{M}\right)$ very nearly.

and if $l'$ = the length of the seconds pendulum in air, $l$ in vacuum,

$$\frac{l'}{l} = \frac{f}{g} = 1 - \frac{2\mu}{M}, \text{ and } l' = l \left(1 - \frac{2\mu}{M}\right).$$

The coefficient by which the old correction is to be multiplied, is consequently 2.

M. Bessel has obtained by experiment 1·956 for the value of this coefficient. The experiments of Mr. Baily (Transactions of Royal Society for 1832, p. 399*,) give 1·864 for spheres 1½ inch in diameter, and 1·748 for spheres 2 inches in diameter, and consequently show that the coefficient is different for spheres of different diameter. No such difference is recognised either by the present theory, or by that of M. Poisson, who has taken into account the effect of the friction of the air against the surface of the ball. The theory of this difference, therefore, stands in need of further inquiry. Experiment is the most proper means of determining the *amount* of correction to be applied to the pendulum, but theory combined with it may enable us to determine the causes to which the correction is due.

Papworth St. Everard, Aug. 2, 1833.

## XXXV. *Characters of some undescribed Genera and Species of* Araneidæ. *By* John Blackwall, *Esq. F.L.S. &c.*†

### *Tribe*, INEQUITELÆ, Latreille.

### Genus, *Neriene.*

EYES eight in number, unequal in size, disposed in two transverse rows on the anterior part of the cephalothorax; the intermediate eyes of both rows form a trapezoid whose anterior side is considerably the shortest; the lateral ones are placed obliquely, in pairs, each pair being seated on a small eminence and geminated; the posterior eyes of the trapezoid are larger, and the anterior ones much smaller than the rest.

Maxillæ strong, inclined towards the lip, slightly dilated at

---

* An abstract of Mr. Baily's paper will be found in Lond. and Edinb. Phil. Mag. vol. i. p. 379.—Edit.

† Communicated by the Author; by whom other undescribed *Araneidæ* were characterized in our last Number.

the base where the palpi are inserted, and greatly so at the apex, which is obliquely truncated externally.

Lip short, broad, prominent at the apex, and semicircular.

Legs moderately long and robust; the anterior and posterior pairs, which are the longest, equal in length; the third pair is the shortest.

The spiders of this genus fabricate small horizontal sheets of web of a slight texture, among coarse herbage, or in cavities beneath stones, on the under side of which they take their station, in an inverted position, and watch for their prey.

### *Neriene marginata.*

Cephalothorax oval and glossy; the anterior part, on which the eyes are seated, elevated but obtuse; the posterior part depressed, with an indentation in the medial line. Mandibles strong, armed with teeth on the inner surface, and inclined towards the pectus which is heart-shaped. Maxillæ enlarged at their apices, and slightly inclined towards the lip. These parts are of a very dark brownish-black colour. Legs and palpi provided with erect spines; their colour is reddish-brown, with bands of a darker hue. Both of the superior tarsal claws are pectinated, and the inferior one is inflected near its base. A plain claw, slightly curved, terminates each palpus. Abdomen oval, rather convex above, projecting over the base of the cephalothorax; the upper part is brownish-black bordered by a dentated band of pale brown thickly spotted with white, which passes above the spinners, but whose continuity is interrupted in front by a black streak intersecting it at right angles; a series of curved, angular lines of a pale-brown colour, minutely spotted with white, extends along the middle; their convexity is towards each other, and their apices are directed forwards. Sides and under part of the abdomen brownish-black, marked with a few white spots, four minute ones, describing a large quadrangle, occurring on the latter. Plates of the spiracles dark red-brown.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{3}{20}$ths of an inch; length of the cephalothorax $\frac{1}{14}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{15}$; length of an anterior leg $\frac{1}{5}$; length of a leg of the third pair $\frac{1}{6}$.

The male resembles the female in colour, and in the relative length of its legs, but the absolute length of those organs is greater, an anterior one measuring $\frac{1}{4}$th of an inch. The third and fourth joints of the palpi are short, the latter, which is much the stronger, being fringed with long bristles on the outer side of the upper part; the fifth joint is oval, convex externally, concave within, comprising the sexual organs; they are highly developed, complex with spiny processes, and are of a brownish-black colour tinged with red. Very old males are darker coloured and have red legs.

In the months of October and November this spider is common in the plantations about Crumpsall Hall, constructing its web among the grass under the trees.

### *Neriene rubens.*

Cephalothorax inversely heart-shaped, slightly convex above, and glossy, with a depression and an indentation in the posterior region; in front is an abrupt eminence, on which are the eyes, placed on black spots. Mandibles robust, conical, strongly toothed on the inner surface, and inclined towards the pectus, which is heart-shaped. Maxillæ moderately enlarged at their apices, and inclined towards the lip. Legs and palpi hairy, the former provided with a few spines; the two superior tarsal claws are pectinated, and the inferior one is inflected near its base. Palpi abundantly supplied with black spines, one longer than the rest, projecting from the anterior extremity of the third joint. These parts, with the exceptions already noticed, are of a yellowish-red colour. Abdomen oval, somewhat convex above, projecting over the base of the cephalothorax, thinly clad with hair, glossy, and of a red-brown hue, which varies in intensity in different individuals. Sexual organs black with a tinge of red. Plates of the spiracles pale orange.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{8}$th of an inch; length of the cephalothorax $\frac{1}{16}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{18}$; length of an anterior leg $\frac{1}{6}$.

The male is rather smaller than the female, but the relative length of its legs is the same; the tibiæ of the first and second pairs are dilated underneath at their anterior extremities, and these enlargements are thickly clad with fine long hairs. The second joint of the palpi is very powerful, enlarging gradually from the base to its anterior extremity, which is armed with a strong spur, and a great number of minute, sharp-pointed, black spines, on the upper side; the third joint is short and robust; the fourth is furnished with two apophyses; the inner one is much the longer and tapers to a point: it is curved obliquely across the upper part of the fifth joint, and is provided with a strong projecting point near its base; the exterior apophysis is much shorter and more obtuse: the fifth joint is oval, convex externally, concave within, comprising the sexual organs, which are complicated in structure, exhibiting several curved, spiny processes, and are of a dark red-brown colour.

Mr. T. Blackwall found this species among heath, in Trafford Park, near Manchester, in October 1832, at which season of the year it pairs.

### *Neriene cornuta.*

Cephalothorax glossy, inversely heart-shaped, depressed behind, with a large indentation in the medial line, and the sides are marked with furrows extending from the superior part to the margins; the anterior part is elevated and surmounted by two conical protuberances directed forwards, below which, in front, the eyes are situated. Mandibles strong, conical, perpendicular, and armed with teeth on the inner surface. Maxillæ inclined towards the lip, which they encompass. Lip short, prominent at the apex, and semicircular. Pectus convex and heart-shaped. These parts are of a very dark-brown colour, the anterior portion of the cephalothorax being almost black. The colour of the legs and palpi is light red-brown. The two superior tarsal claws are slightly pectinated, and the inferior one is inflected near its base. The fourth joint of the palpi is shorter than the third, and projects three apophyses from its anterior extremity, one on the inner side, which is long, curved, and pointed; a small one in front, which is also curved, and pointed; and one on the under side, which is short and obtuse; the fifth joint is oval, convex externally, concave within, comprising the sexual organs; they are highly developed, complex with spiny processes, and are of a dark red-brown colour. Abdomen oval, rather convex above, projecting over the base of the cephalothorax, sparingly supplied with short hairs, glossy, and black, with the exception of the plates of the spiracles, which are of a pale yellow colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{10}$th of an inch; length of the cephalothorax $\frac{1}{20}$; breadth $\frac{1}{22}$; breadth of the abdomen $\frac{1}{21}$; length of an anterior leg $\frac{3}{20}$; length of a leg of the third pair $\frac{1}{9}$.

I captured males of this species in May 1833, on rails and gates at Oakland; but the female has hitherto escaped detection.

Closely allied to the spiders of the genus *Linyphia* by the disposition and relative size of their eyes, but approximating more nearly to those of the genus *Theridion* in the structure of the mouth and the relative length of their legs, the *Nerienæ* present another striking instance of propinquity between the *Inequitelæ* and *Orbitelæ*; a connexion which is further established by the mixed character of their œconomy.

*Tribe*, ORBITELÆ, } Latreille.
Genus, LINYPHIA, }

### *Linyphia minuta.*

Cephalothorax glossy, inversely heart-shaped, prominent before, with an indentation in the medial line of the posterior region, and of a dark-brown colour. Pectus heart-shaped, and very dark-brown, approaching to black. Mandibles strong, vertical, and of a dark red-brown hue. Maxillæ straight, nearly quadrate, having the exterior angle at the apex curvilinear. Lip short, and semicircular. The colour of these organs is the same as that of the mandibles. Legs and palpi long, slender, and supplied with numerous delicate spines; they are reddish-brown with brownish-black bands. First pair of legs the longest, then the second, the third pair being the shortest; the two superior tarsal claws are pectinated, and the inferior one is inflected near its base. Each palpus is terminated by a single claw, slightly curved and pectinated. The four intermediate eyes form a trapezoid whose shortest side is in front; the other four are disposed in pairs on the sides of the trapezoid, the eyes constituting each pair being contiguous, and placed obliquely on an eminence; the two posterior eyes of the trapezoid are the largest, and the two anterior ones the smallest of the eight. Abdomen oval, convex above, projecting over the base of the cephalothorax, and thinly clad with hair; the upper part is pale-brown minutely spotted with yellowish-white; along the middle extends a series of strongly marked, brownish-black angular lines with their vertices directed forwards, and a little above the spinners is an irregular, transverse, semicircular line of a yellowish-white colour: the sides are brownish-black with a slightly curved line of yellowish-white, extending from the anterior part rather more than half-way towards the spinners; underneath, the abdomen is of a brownish-black colour, and the plates of the spiracles are yellowish-white.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{6}$th of an inch; length of the cephalothorax $\frac{1}{14}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{13}$; length of an anterior leg $\frac{3}{10}$.

The body of the male is smaller and more slender than that of the female, but the legs are longer, an anterior one measuring $\frac{7}{20}$ths of an inch. The third and fourth joints of the palpi are short and strong; the fifth has two conical processes, or apophyses, on the upper part, near its articulation with the fourth joint; it is convex externally, concave within, comprising the sexual organs, which are of a red-brown colour.

I first observed this spider in little frequented rooms in Crumpsall Hall; it does not confine itself, however, to the interior of buildings, but may frequently be found on trees and shrubs, particularly such as grow against walls. In the month of September the female deposits thirty or forty spherical eggs, of a yellowish-white colour, in a cocoon of white silk, of a slight texture, and subglobose form, measuring about $\frac{1}{5}$th of an inch in diameter.

### *Linyphia luteola.*

This spider resembles *Linyphia minuta* in the form of the cephalothorax, except that the anterior part, on which the eyes are seated, is more prominent and acute; it is glabrous, and of a pale yellowish-brown colour, with black margins and a slender band of the same hue along the medial line. The eyes are placed on black spots, their arrangement and relative size being the same as in *Linyphia minuta*. The parallelism between the two species holds good also as regards the structure of the mandibles, the maxillæ, the lip, and the pectus. These parts are of the same colour as the ground of the cephalothorax. The legs are long and slender, the palpi rather short; both are provided with claws and delicate spines similar in structure to those of *Linyphia minuta*; their colour is a uniform pale yellowish-brown. The first pair of legs is the longest, then the second, the third pair being the shortest. Abdomen oval, compressed, remarkably convex above, projecting over the base of the cephalothorax; its colour is pale yellow, with minute white spots on the upper part; the sides are obscurely marked with oblique lines of a blackish hue, and above the spinners are several of a similar tint and an angular form. Plates of the spiracles yellow. In some individuals scarcely a trace of the black lines can be perceived.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{5}$th of an inch; length of the cephalothorax $\frac{1}{12}$; breadth $\frac{1}{16}$; breadth of the abdomen $\frac{1}{10}$; length of an anterior leg $\frac{2}{5}$.

The male is smaller and more slender than the female, but the cephalothorax is longer, measuring $\frac{1}{10}$th of an inch; it is very prominent and acute before, and is furnished with numerous strong, black bristles, particularly at the apex. The legs also are more elongated, an anterior one measuring $\frac{9}{20}$ths of an inch. The maxillæ are exceedingly convex externally, immediately above the insertion of the palpi; the second joint of the latter organs is robust; the third and fourth joints are very short, a strong bristle, rough with projecting points on the under side, depending from a prominence on the upper part of the anterior extremity of the former; the fifth joint is oval, convex externally, concave within, comprising the sexual organs, which are complex, with a curved pointed projection on the upper part; their colour is red-brown.

This species of *Linyphia* is plentiful in September and October, in the plantations about Crumpsall Hall, constructing, among the coarse grass beneath the trees, a horizontal web, three or four inches in diameter, on a plan similar to that employed by the other species of the genus. Like them, too, it is usually found on the under side of the horizontal sheet in an inverted position.

### *Tribe*, CITIGRADÆ, Latreille.

### Genus, *Hecaërge*.

Eyes eight in number, unequal in size, disposed in two transverse rows on the anterior part of the cephalothorax; the four constituting the anterior row, which is slightly curved backwards, are adjacent and minute, the two lateral ones being the smallest of the eight; the posterior row is greatly curved, with its convexity directed forwards; it comprises the other four eyes, which are large and separated by moderately wide intervals.

Maxillæ short, strong, convex on the under side, enlarged at the base where the palpi are inserted, rounded at the extremities, and inclined towards the lip.

Lip small, as broad as long, triangular, truncated at the apex.

Legs powerful; the fourth pair is the longest, then the first, the third pair being the shortest.

The spiders belonging to this genus are erratic, taking their prey by surprise.

### *Hecaërge maculata.*

Cephalothorax oval, convex above, depressed in the posterior region, pointed before, and covered with short hairs; its colour pale yellowish-brown, with a broad dark-brown band extending along each side of the medial line, and two fine lines of the same hue on the lateral margins; a few longish white hairs, directed forwards, occupy the space between the two intermediate pairs of eyes, and immediately below the anterior row of eyes is a small transverse parallel line of a dark red-brown colour. Mandibles small, conical, perpendicular, armed with a curved red nail at the extremity, and a few minute teeth on the inner surface; they are of a pale yellowish-brown colour, with a dark-brown elongated spot in front of each, extending from the base towards the extremity; this spot is palest in the medial line. Maxillæ pale yellowish-brown. Lip dark-brown bordered with pale-brown. Pectus heart-shaped, of a pale-yellow colour faintly tinged with green; eight dark-brown spots occur on its margins; one, which is very minute, and in some individuals wanting altogether, is situated opposite the lip; three are disposed on each side, and one is seated on its posterior extremity. Legs hairy, furnished with strong spines; thighs and terminal joint of the tarsi pale yellowish-brown, the former having two or three longitudinal lines of a dark-brown colour on the upper and outer sides, which are most conspicuous on the first and second pairs, and some minute spots of the same tint underneath; tibiæ and superior tarsal joint dark-brown, those of the first and second pairs of legs having a series of long, moveable, sessile spines on each side of the inferior part. The two tarsal claws are long, curved, and provided with three minute teeth, the terminal one being the longest; beneath them is a small brush, which enables the spider to ascend with facility smooth perpendicular surfaces. Palpi pale yellowish-brown, furnished with a few spines, two of which, on the under side of the fifth joint, are opposite and erect; a long curved claw, having three exceedingly small teeth underneath, terminates each palpus. Abdomen thickly covered with hair, oval, convex above, projecting over the base of the cephalothorax; upper part pale yellowish-brown mingled with white; three small tufts of white hair occur in front, near the cephalothorax; two narrow, obscure, brownish-black streaks, one on each side of the medial line, extend from the anterior part of the abdomen almost a third of its length, and are followed by a series of brownish-black spots, occupying the remainder of the medial line to the spinners, on each side of which is a longitudinal row of very small spots of the same hue; these streaks and spots are comprised between two irregular brownish-black bands composed principally of spots, confluent or nearly so, diminishing in size as they approach the spinners; sides and under part of the abdomen pale yellowish-brown spotted with brownish-black, the spots on the latter minute. Plates of the spiracles yellowish-brown with pale inner margins.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{4}$th of an inch; length of the cephalothorax $\frac{1}{10}$; breadth $\frac{1}{12}$; breadth of the abdomen $\frac{1}{10}$; length of a posterior leg $\frac{3}{8}$; length of a leg of the third pair $\frac{1}{4}$.

The male though smaller than the female is similar to it in colour, and in the relative length of its legs. The third and fourth joints of the palpi are short, a small pointed apophysis projecting from the outer side of the anterior extremity of the latter; the fifth joint is oval, convex above, concave beneath, comprising the sexual organs, which are highly developed, with a curved spiny process extending to the termination of the joint, and are of a red-brown colour.

This species, which I discovered in the woods about Oakland, in Denbighshire, in the month of April 1833, approximates most nearly in its general structure to the spiders of the genera *Lycosa* and *Dolomedes*; by the organization of the feet, however, it appears to connect the *Citigradæ* with the *Laterigradæ*. In the month of June the female constructs a lenticular cocoon of white silk, of a slight texture, measuring about $\frac{3}{10}$ths of an inch in diameter, which she usually attaches to the under side of a stone, depositing in it between twenty and thirty spherical eggs of a yellowish-white colour, not agglutinated together.

### *Tribe*, TUBITELÆ, Latreille.

### Genus, *Erigone*, Savigny.

### *Erigone atra.*

Cephalothorax inversely heart-shaped, very prominent before, with an indentation in the medial line of the posterior region. Mandibles powerful, rather convex in front, strongly toothed on the inner surface, and slightly inclined towards the pectus, which is heart-shaped. Maxillæ greatly enlarged at the base where the palpi are inserted, encompassing the lip, which is short and semicircular. Fourth pair of legs the longest, then the first, the third pair being the shortest. The two superior tarsal claws are pectinated, and the inferior one is inflected near its base. Eyes disposed in two transverse rows on the summit of the anterior convexity of the cephalothorax; the intermediate ones of both rows form a square, and the other four are placed obliquely in pairs, one on each side of the square. Abdomen oval, convex above, projecting over the base of the cephalothorax. This spider is sparingly clad with hair, and glossy black, with the exception of the legs and palpi, which, in adults, are of a reddish-brown colour, and of the plates of the spiracles, which are yellow.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{9}$th of an inch; breadth of the abdomen $\frac{1}{20}$; length of a posterior leg $\frac{1}{8}$.

The male differs from the female in several remarkable particulars; it is smaller, and presents, exclusively, some of those peculiarities of structure on which the generic character is established. The lateral margins of the cephalothorax are strongly dentated, and a series of short sharp spines, slightly curved forwards, occupies the medial line of its anterior convexity; each mandible also has a longitudinal row of spines, curved downwards, on its exterior side. (Small spines occur sometimes on the mandibles of old females.) The second joint of the palpi is greatly elongated, much curved, and is armed with strong spines beneath; the third and fourth joints are dilated at their anterior extremities, the former having a large conical apophysis on the lower side, and the latter two terminal apophyses, one short and broad projecting in front, the other more elongated and acute situated underneath; the fifth joint is oblong-oval, convex externally, concave within, comprising the sexual organs, which are highly developed, and of a very dark red-brown colour. The relative length of the legs likewise is different in this sex; the first pair is the longest, measuring $\frac{1}{7}$th of an inch, and the fourth, second, and third pairs decrease successively in longitudinal extent. These organs and the palpi are much redder than those of the female.

Independently of colour, the spider described above may be distinguished by its external structure from the *Erigone vagans* of M. Savigny. (*Description de l'Egypte, seconde édition*, tome xxii. p. 319—321; *Atlas de Zool.*; *Arachn.* pl. i. fig. 9.) The male of the latter species has three rows of spines on the anterior convexity of the cephalothorax; a single row on the under part of each thigh of the first pair of legs, and the second pair of legs is longer than the fourth; whereas the new spider has only one row of spines in the former situation, and none in the latter, a few very minute ones merely occurring on the inner side of the thighs of the fore legs, near their base, and the fourth pair of legs is longer than the second; moreover, each palpus of the female of *Erigone vagans* has a pectinated claw at its extremity, but the palpi of *Erigone atra* are destitute of claws.

This diminutive spider is very plentiful and decidedly diurnal. Endowed with an instinctive impulse to ascend into the atmosphere, it frequently takes aërial excursions, and is active even in winter, when the weather is mild. It pairs in June, and deposits its eggs, which are large in proportion to the size of the animal, six or seven in number, spherical, not agglutinated together, and of a pale yellowish-white colour, in a cocoon of white silk, of a slight texture, and subglobose form, measuring about $\frac{1}{10}$th of an inch in diameter; it is usually placed under stones and in crevices of the earth.

There must be something very remarkable in the internal as well as external organization of this extraordinary spider, for numerous specimens of both sexes submerged in cold water on the 21st of October 1832, remained in that situation till the 22nd of November, an interval of 768 hours, without having their vital energies suspended. It is evident, therefore, that this species possesses the power of abstracting respirable air from water, for though in the act of submersion the spiracles are usually enveloped in a bubble of air, yet so small a supply must soon be exhausted, and, indeed, it speedily disappears.

Oakland, near Llanwrst, Denbighshire,
July 29, 1833.

---

## XXXVI. *Additional Note on Conical Refraction.*
## *By* J. MacCullagh, *F.T.C.D.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

THE introductory part of my note which appeared in your last Number was written in haste, and I have reason to think it may not be rightly understood. You will therefore allow me to add a few observations that seem to be wanting.

The principal thing pointed out in the paper that I published some time ago in the Transactions of the Royal Irish Academy, is a very simple relation between the tangent planes of Fresnel's wave surface and the sections of two reciprocal ellipsoids. Now this relation depends upon the *axes* of the sections, and therefore naturally suggested to me the peculiar cases of circular section in which every diameter is an axis. Thus a new inquiry was opened to my mind. And accordingly, without caring just then to obtain final results, which seemed to be an easy matter at any time, I expressed in conversation my intention of returning to the subject of Fresnel's theory, in a supplementary paper. The design was interrupted, and I was prevented from attending to it again, until I was told that Professor Hamilton had discovered cusps and circles of contact on the wave surface. This reminded me of the cases of circular section, and the details given in my last note were immediately deduced.

I am, Gentlemen, &c.

J. MacCullagh.

Trinity College, Dublin, August 16, 1833.

## XXXVII. *A Catalogue of Comets. By the Rev.* T. J. HUSSEY, *A.M. Rector of Hayes, Kent.*

[Continued from p. 102.]

[The Chronology employed is that of Petau or Petavius.]

A, the comet of 1680. B, that of 1652. C (Halley's), that of 1682. D, that of 1759. E, that of 1661. F, that of 1677.

| Number. | Year of Appearance A. C. | Same as that of | Month or Season when it appeared. | Place or Direction in which it appeared. | By whom mentioned. | Remarks. |
|---|---|---|---|---|---|---|
| 171 | 673 | ... | ...... | ...... | Vita S$^{t}$. Leod. Centur. Chron. &c. | |
| 172 | 676 | ... | January | Virgo | Chinese Records. | |
| 173 | — | ... | Aug. Sept. | Gem., Ur. Maj. | Anast. Paul. Diac. Chin. Records. | Seen 3 months. |
| 174 | 681 | ... | Oct. Novemb. | Hercul. Aquila | Chinese Records. | Seen 17 days. |
| 175 | 683 | ... | April, May | Auriga, Taurus | Chinese Records. | |
| 176 | 684 | ... | Sept. Oct. | Tow$^{ds}$ the West | Chinese Records. | |
| 177 | — | B | December | Taurus | Anast. Paul. Diac. &c. | |
| 178 | 707 | ... | November | Tow$^{ds}$ the West | Chinese Records. | |
| 179 | 708 | ... | March | Musca, Taurus | Chinese Records. | |
| 180 | — | ... | September | ...... | Chinese Records. | |
| 181 | 711 | ... | ...... | ...... | Haly in Centil. Ptolem. ...... | Continued 11 nights with a visible motion. |
| 182 | 712 | ... | August | C. Beren., Leo, Virgo, Bootes | Chinese Records. | |
| 183 | 716 | ... | ...... | ...... | Sabell. Bizar. &c. | |
| 184 | 729 | F? | ...... | ...... | Bede. Anast. &c. | |
| 185 | 730 | ... | Aug. Sept. | Auriga, Taurus | Chinese Records. | |
| 186 | 738 | ... | April | Ursa Major ... | Chinese Records. | |
| 187 | 744 | ... | ...... | ...... | Theoph. Cedren. | |
| 188 | 760 | ... | May | Taurus, Gemini, &c. ... | Chinese Records. | Seen 59 days. |
| 189 | — | ... | May, June | To the West | Chinese Records. | |
| 190 | 762 | ... | ...... | ...... | Theophan. &c. | |
| 191 | 767 | ... | January | Delphinus | Chinese Records. | |
| 192 | 770 | ... | May | Auriga, Taurus | Chinese Records. | |
| 193 | — | ... | June, July | Auriga, Camel. | Chinese Records. | |
| 194 | 773 | .. | January | Orion | Chinese Records. | |
| 195 | 813 | ... | August | ...... | Theoph. Sim. Logoth. Zonar, &c. | |
| 196 | 815 | ... | April | Leo | Chinese Records. | |
| 197 | 817 | ... | February | Sagittarius | Chi. Rec. Eginh. Aimoin, &c. | |
| 198 | 821 | ... | February | Crater, Leo. | | |

| Number. | Year of Appearance A. C. | Same as that of | Month or Season when it appeared. | Place or Direction in which it appeared. | By whom mentioned. | Remarks. |
|---|---|---|---|---|---|---|
| 199 | — | ... | July ............ | Taurus. | | |
| 200 | 837 | ... | ...... | ...... | Chinese Records. | Elements computed by Pingré*. |
| 201 | — | ... | September.... | Aquar. Equul. Pegasus.... | Chi. Rec. Boeth. | |
| 202 | 838 | ... | November.... | Corvus......... | Chinese Records. | |
| 203 | — | ... | Nov. Dec..... | Sagitt. Scorpio | Chinese Records. | |
| 204 | 839 | ... | February ...... | Aquarius...... | Chin. Rec. Annal. Bertin. | |
| 205 | — | ... | March, April.. | Perseus ...... | Chin. Rec. Annal. Bertin. | |
| 206 | 840 | ... | March, April.. | Pega. Androm. | Chinese Records. | |
| 207 | — | ... | December...... | In the East ... | Chinese Records. | |
| 208 | 841 | ... | June, July ..... | Sagitt. Aquar. | Alber. Casin. Chin. Rec. | |
| 209 | — | ... | December to February 842 | Pisces, Pegas. | Chinese Records. Nith. Hist. | |
| 210 | 852 | ... | March.......... | Orion ....... | Chinese Records. | |
| 211 | 855 | C | ...... | ...... | Chron. Malleac. | Seen during 20 nights. |
| 212 | 857 | ... | September.... | Scorpio ....... | Chinese Records. | |
| 213 | 858 | ... | April........... | In the East .. | Ptolem. Hist. Martin. Fuld. | |
| 214 | 864 | ... | June ........... | Aries......... | Chron. Floriac. Chinese Rec. | |
| 215 | 866 | ... | April ............ | ...... | Const. Porphyr. | |
| 216 | 868 | ... | January........ | Aries, Musca.. | Chinese Records. Ann. Fuld. &c. | Seen for about 17 nights. |
| 217 | 869 | ... | September.... | Pers. Cap. Med. | Chi. Ann. Pontan. | Direction north-east. |
| 218 | 873 | ... | ....... | .... | Chron. Andega. | |
| 219 | 875 | ... | June........... | Aries ........... | Ann. Fuld. Chro. Casauv. &c. | |
| 220 | 877 | ... | March ....... | Libra........... | Chron. Novalic. | Seen 15 nights. |
| 221 | 882 | ... | January...... | .... | Annal. Fuld. Aventin. &c. | |
| 222 | 885 | ... | ...... | Betw$^{n}$ Perseus and Gemini | Chinese Records. | |
| 223 | 886 | ... | June ........... | Scorp. Sagitt. U. Ma. Bootes. | Chinese Records. | |

* Passage through the perihelion in mean time at Greenwich: March 0$^{d}$ 23$^{h}$ 51$^{m}$ 0$^{s}$.—Long. of the perihel. on the orbit of the comet, 9$^{s}$ 19° 3′ 0″.—Long. of the ascending node, 6$^{s}$ 26° 33′ 0″.—Angle between the perihel. and the node, 9$^{s}$ 7° 30′ 0″.—Inclination of the orbit, 10° or 12°.—Perihel. distance, 0·580000.—Log. of the mean motion, 0·314986.—Direction R.

The angle between the perihelion and the node having been left out of the elements of the four comets published in the last Number, the omission is here supplied.

| No. | Year. | | | |
|---|---|---|---|---|
| 50 | 240 | 2$^{s}$ | 22° | 0′ |
| 135 | 539 | 8<br>2 | 15 | 30 |
| 139 | 565 | 2 | 10 | 0 |
| 140 | — | 2 | 19 | 30 |

[To be continued.]

## XXXVIII. *Contributions to the Geology of Northumberland and Durham.* By N. J. Winch, *Esq. F.G.S. & A.L.S.*

[Continued from p. 99.]

### *An Account of Strata sunk through in the Blossom Pit, Hetton Colliery, begun December* 19, 1820, *Durham.*

| | | | | *F.* | *Y.* | *F.* | *I.* | *F.* | *Y.* | *F.* | *I.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Outset above the surface ... ... ... ... | | | | 1 | 0 | 0 | 0 | | | | |
| Soil ... ... ... ... ... ... ... ... ... ... | | | | 0 | 0 | 2 | 0 | | | | |
| Sand ... ... ... ... ... ... ... ... ... | | | | 1 | 1 | 0 | 0 | | | | |
| Gravel ... ... ... ... ... ... ... ... ... | | | | 0 | 1 | 1 | 0 | | | | |
| Limestone marl and soft limestone ... ... | | | | 3 | 0 | 0 | 0 | | | | |
| Limestone of various kinds, and the water increased gradually, from about the depth of 16 fathoms (where the machine began to pump,) to the bottom of it, to nearly 2000 gallons per minute; viz. | | | | | | | | | | | |
| —— Yellow limestone in different beds ... | | | | 15 | 1 | 2 | 6 | | | | |
| —— Blue ditto and flaggy near the bottom (called blue rag) ... ... ... | | | | 7 | 0 | 2 | 2 | | | | |
| Blue metal ... ... ... ... ... ... ... | | | | 0 | 1 | 2 | 2 | | | | |
| Sandstone when broken into was drawn by the pumps ... ... ... ... ... ... | | | | 0 | 1 | 1 | 4 | | | | |
| White metal stone, very soft ... ... ... | | | | 0 | 0 | 1 | 2 | | | | |
| Gray scamy metal stone ... ... ... ... | | | | 0 | 0 | 0 | 9 | | | | |
| Strong brown limestone mixed with whin ... | | | | 1 | 0 | 2 | 8 | | | | |
| Blue gray metal mixed with water and very soft ... ... ... ... ... ... ... | | | | 5 | 0 | 2 | 3 | | | | |
| *Coal* mixed with black metal ... ... ... | | | | 0 | 0 | 1 | 4 | 38 | 1 | 1 | 4 |
| Gray metal stone ... ... ... ... ... ... | | | | 0 | 1 | 1 | 8 | | | | |
| Blue metal ... ... ... ... ... ... ... | | | | 1 | 1 | 0 | 0 | | | | |
| *Coal* mixed with black metal ... ... ... | | | | 0 | 0 | 1 | 9 | 2 | 1 | 0 | 5 |
| Gray metal stone and water ... ... ... ... | | | | 2 | 1 | 2 | 10 | | | | |
| Section of the 4-feet Coal Seam. | | | | | | | | | | | |
| *Coal* ... ... ... ... ... ... | 0 y. | 1 ft. | 0 in. | | | | | | | | |
| Gray metal ... ... ... ... | 0 | 0 | 4 | | | | | | | | |
| Black ditto with *coal* ... ... | 0 | 0 | 7 | | | | | | | | |
| *Coal* ... ... ... ... ... ... | 0 | 1 | 10 | 0 | 1 | 0 | 9 | 3 | 1 | 0 | 7 |
| Gray metal stone or thill ... ... ... ... | | | | 0 | 0 | 1 | 4 | | | | |
| Gray ditto with partings ... ... ... ... | | | | 4 | 0 | 0 | 10 | | | | |
| Strong white post, and water in it, near the bottom, and spongy ... ... ... ... | | | | 3 | 0 | 1 | 8 | | | | |
| Three-quarter *coal* seam and water in it ... | | | | 0 | 0 | 2 | 4 | 8 | 0 | 0 | 2 |
| Gray metal stone or thill ... ... ... ... | | | | 0 | 0 | 1 | 6 | | | | |
| White post ... ... ... ... ... ... ... ... | | | | 0 | 0 | 2 | 3 | | | | |
| Gray metal ... ... ... ... ... ... ... ... | | | | 1 | 0 | 2 | 5 | | | | |
| White post with partings and water ... ... | | | | 6 | 1 | 0 | 3 | | | | |
| Carried forward ... ... | | | | 8 | 1 | 0 | 5 | 52 | 1 | 2 | 6 |

| | | | | *Fa.* | *Yds.* | *Ft.* | *In.* | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Brought forward | | | | 8 | 1 | 0 | 5 | 52 | 1 | 2 | 6 |
| Gray metal stone | | | | 0 | 0 | 2 | 8 | | | | |
| *Coal* mixed with black metal | | | | 0 | 0 | 1 | 6 | | | | |
| | | | | | | | | 9 | 0 | 1 | 7 |
| Thill | | | | 0 | 0 | 0 | 8 | | | | |
| White post | | | | 0 | 0 | 2 | 5 | | | | |
| Gray metal | | | | 0 | 0 | 2 | 2 | | | | |
| Gray metal stone with post girdles | | | | 0 | 0 | 1 | 4 | | | | |
| Gray metal | | | | 0 | 0 | 0 | 6 | | | | |
| *Coal* | | | | 0 | 0 | 0 | 10 | | | | |
| | | | | | | | | 1 | 0 | 1 | 11 |
| Thill | | | | 0 | 0 | 0 | 3 | | | | |
| Gray metal stone | | | | 0 | 0 | 0 | 10 | | | | |
| White post with wet partings 8 feet down | | | | 1 | 1 | 1 | 2 | | | | |
| Gray metal stone mixed with post | | | | 0 | 0 | 2 | 9 | | | | |
| Black and blue metal | | | | 1 | 1 | 2 | 10 | | | | |
| *Coal* | | | | 0 | 0 | 0 | 3 | | | | |
| | | | | | | | | 4 | 0 | 2 | 1 |
| Gray metal stone | | | | 0 | 0 | 1 | 3 | | | | |
| White post | | | | 1 | 0 | 1 | 9 | | | | |
| Gray and white post mixed with gray metal stone | | | | 1 | 1 | 2 | 2 | | | | |
| Whin | | | | 0 | 1 | 0 | 7 | | | | |
| White post and partings of blue metal and water wedged off | | | | 0 | 0 | 2 | 10 | | | | |
| Strong white post with a parting at bottom and water | | | | 1 | 1 | 1 | 6 | | | | |
| Strong white post and spongy with partings and water | | | | 4 | 1 | 2 | 11 | | | | |
| Gray and white post and the water wedged off | | | | 3 | 0 | 1 | 3 | | | | |
| Gray metal stone | | | | 0 | 1 | 1 | 6 | | | | |
| *Coal* | 0y. | 0ft. | 4in. | | | | | | | | |
| Gray metal | 0 | 1 | 0 | | | | | | | | |
| *Coal* | 0 | 1 | 3 | | | | | | | | |
| Band | 0 | 0 | 5 | | | | | | | | |
| *Coal* | 1 | 0 | 2 | | | | | | | | |
| Band | 0 | 0 | 4 | | | | | | | | |
| *Coal* mixed with black metal | 0 | 0 | 11 | 1 | 0 | 1 | 5 | | | | |
| | | | | | | | | 16 | 0 | 2 | 2 |
| Thill | | | | 0 | 0 | 1 | 8 | | | | |
| Gray metal stone with large balls of ironstone | | | | 1 | 0 | 2 | 4 | | | | |
| Strong gray metal with girdles | | | | 3 | 1 | 0 | 9 | | | | |
| Black metal with scares of coal | | | | 0 | 0 | 0 | 9 | | | | |
| *Coal* | | | | 0 | 0 | 1 | 2 | | | | |
| | | | | | | | | 5 | 1 | 0 | 8 |
| Black gray metal with scares of coal | | | | 0 | 0 | 2 | 8 | | | | |
| Dark gray metal with balls of ironstone | | | | 0 | 0 | 2 | 6 | | | | |
| Strong gray metal stone with strong dunnish post girdles | | | | 3 | 0 | 1 | 10 | | | | |
| Gray metal | | | | 1 | 0 | 0 | 8 | | | | |
| Five quarter *coal* seam | | | | 0 | 0 | 1 | 7 | | | | |
| | | | | | | | | 5 | 1 | 0 | 3 |
| Carried forward | | | | | | | | 94 | 4 | 2 | 11 |

| | *Fa.* | *Yds.* | *Ft.* | *In.* | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|
| Brought forward ... | | | | | 94 | 4 | 2 | 11 |
| Black metal with scares of coal ... ... ... | 0 | 0 | 0 | 6 | | | | |
| Dark gray metal ... ... ... ... ... ... | 0 | 1 | 1 | 4 | | | | |
| *Coal* ... ... ... ... ... ... ... ... | 0 | 0 | 0 | 5 | | | | |
| Gray metal stone with post girdles ... ... | 5 | 1 | 1 | 6 | | | | |
| Gray post ... ... ... ... ... ... ... | 0 | 1 | 1 | 10 | | | | |
| Blue and gray metal stone ... ... ... ... | 3 | 1 | 2 | 9 | | | | |
| Do. do. with strong girdles ... ... ... | 1 | 1 | 2 | 3 | | | | |
| Section of the High main coal seam, on the Wear, or Yard coal seam, on the Tyne. | | | | | | | | |
| Top *Coal* ... ... ... ... ... ... $0^{y.}$ $1^{ft.}$ $8^{in.}$ | | | | | | | | |
| Band ... ... ... ... ... ... ... 0 0 1 | | | | | | | | |
| *Coal* ... ... ... ... ... ... ... 1 1 9 | 1 | 0 | 0 | 6 | 14 | 0 | 2 | 1 |
| Total depth to the Main coal seam sunk through 3rd September 1822 ... ... ... | | | | | 109 | 1 | 1 | 3 |

## *An Admeasurement of the Minor Pit, (which is 45 yards to the West of the Blossom Pit), to the Main Coal Seam and Strata sunk through from there to the Hutton Coal Seam, begun December 23,* 1820.

| | *Fa.* | *Yds.* | *Ft.* | *In.* | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|
| Total depth of the Minor Pit to the thill of the Main Coal Seam, sunk through various strata similar to those specified in the Blossom Pit sinking account, as above | ........... | | | | 108 | 1 | 1 | 1 |
| White post ... ... ... ... ... ... ... | 0 | 0 | 0 | 8 | | | | |
| Gray and white post ... ... ... ... ... | 1 | 1 | 2 | 0 | | | | |
| Black metal stone ... ... ... ... ... ... | 0 | 0 | 1 | 4 | | | | |
| Blue metal with iron stone girdles ... ... | 1 | 0 | 2 | 4 | | | | |
| Black metal ... ... ... ... ... ... ... ... | 0 | 0 | 1 | 4 | | | | |
| Gray metal stone ... ... ... ... ... ... ... | 0 | 0 | 2 | 10 | | | | |
| *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 0 | 5 | | | | |
| | | | | | 4 | 0 | 1 | 11 |
| Strong gray metal stone ... ... ... ... | 0 | 0 | 2 | 0 | | | | |
| Gray and white post ... ... ... ... ... | 4 | 1 | 0 | 9 | | | | |
| Gray metal ... ... ... ... ... ... ... ... | 1 | 1 | 0 | 2 | | | | |
| *Coal* ... ... ... ... ... ... ... ... ... ... | 0 | 0 | 1 | 2 | | | | |
| | | | | | 6 | 1 | 1 | 1 |
| Gray metal ... ... ... ... ... ... ... ... | 0 | 1 | 0 | 9 | | | | |
| *Coal* ... ... ... ... ... ... ... ... ... | 0 | 0 | 0 | 4 | | | | |
| | | | | | 0 | 1 | 1 | 1 |
| Gray metal ... ... ... ... ... ... ... ... | 0 | 1 | 1 | 2 | | | | |
| Blue metal ... ... ... ... ... ... ... ... | 0 | 1 | 1 | 0 | | | | |
| Gray metal ... ... ... ... ... ... ... ... | 1 | 1 | 2 | 6 | | | | |
| Blue metal with coalpipes ... ... ... ... | 0 | 1 | 0 | 8 | | | | |
| Strong gray post ... ... ... ... ... ... | 0 | 1 | 2 | 8 | | | | |
| Do. do. with strong girdles ... ... | 0 | 1 | 2 | 2 | | | | |
| Whin ... ... ... ... ... ... ... ... ... | 0 | 1 | 0 | 0 | | | | |
| Soft gray metal ... ... ... ... ... ... | 2 | 1 | 2 | 8 | | | | |
| Carried forward ... ... | 9 | 0 | 0 | 10 | 120 | 0 | 2 | 2 |

| | | | | *Fa.* | *Yds.* | *Ft.* | *In.* | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Brought forward ... ... | | | | 9 | 0 | 0 | 10 | 120 | 0 | 2 | 2 |
| Low main *coal* seam, on the Wear, or Five-quarter coal seam, on the Tyne ... ... | | | | 0 | 1 | 1 | 1 | | | | |
| | | | | | | | | 9 | 1 | 1 | 11 |
| White post ... ... ... ... ... ... ... ... | | | | 2 | 0 | 0 | 6 | | | | |
| Whin ... ... ... ... ... ... ... ... ... | | | | 0 | 0 | 2 | 2 | | | | |
| Gray metal with post girdles ... ... ... | | | | 2 | 0 | 0 | 10 | | | | |
| Black and blue metal stone ... ... ... ... | | | | 1 | 0 | 0 | 0 | | | | |
| *Coal* ... ... ... ... ... ... .. ... | | | | 0 | 0 | 1 | 0 | | | | |
| | | | | | | | | 5 | 1 | 1 | 6 |
| Gray metal with post girdles ... ... ... | | | | 0 | 1 | 2 | 11 | | | | |
| *Coal* ... ... ... ... ... ... | 0y. | 0ft. | 4in. | | | | | | | | |
| Band ... ... ... ... ... ... | 0 | 0 | 1¾ | | | | | | | | |
| *Coal* ... ... ... ... ... ... | 0 | 0 | 7 | | | | | | | | |
| Thill ... ... ... ... ... ... | 1 | 1 | 0 | | | | | | | | |
| | | | | 0 | 1 | 2 | 0¾ | | | | |
| Strong gray metal ... ... ... ... ... ... | | | | 1 | 0 | 2 | 0 | | | | |
| Gray post ... ...... ... ... ... ... ... | | | | 1 | 0 | 2 | 4 | | | | |
| Black metal ... ... ... ... ... ... ... ... | | | | 0 | 1 | 0 | 0 | | | | |
| Blue metal with post girdles ... ... ... ... | | | | 0 | 0 | 1 | 4 | | | | |
| Strong white post ... ... ... ... ... ... ... | | | | 4 | 0 | 0 | 0 | | | | |
| Gray metal and post girdles ... ... ... ... | | | | 1 | 0 | 1 | 0 | | | | |
| Section of the Hutton coal seam, on the Wear, or Low main coal seam, on the Tyne. | | | | | | | | | | | |
| *Coal* ... ... ... ... ... ... | 1y. | 1ft. | 7½in. | | | | | | | | |
| Band ... ... ... ... ... ... | 0 | 0 | 3½ | | | | | | | | |
| Bottom *Coal* (coarse) ... ... | 0 | 1 | 3 | | | | | | | | |
| | | | | 1 | 0 | 0 | 2 | | | | |
| | | | | | | | | 11 | 0 | 2 | 9¾ |
| Total depth to the Hutton seam, or Low main seam of the collieries on the Tyne | | | | ... | ... | | | 147 | 0 | 2 | 4¾ |

The colliery, or rather the three collieries, in the neighbourhood of Hetton in the county of Durham, is at present the most important mining concern in this coal-field. These pits are said to be capable of working two hundred thousand Newcastle chaldrons of coals annually: they are situated about seven miles from Sunderland, to the south-west, and the shafts are sunk through the magnesian limestone, which here covers the coal-measures. The following extract of a letter from a professional man, on the subject of these mines, is worthy of insertion.

"A bed of soft sandstone* was found under the magnesian limestone, abounding with water, in the Hetton and Elemore Pits; but at Eppleton sinking, no water was met with till near the bottom of the sandstone. It may be remarked that at the Hetton Pits there is twenty-six fathoms of limestone, and only four feet four inches of sandstone; at Elemore twelve and a

---

* This is the soft yellow sandstone which intervenes between the magnesian limestone and the coal-measures, so ably described by Prof. Sedgwick in the Geological Transactions, in his papers on the subject read in 1826, 1827 and 1828. [Abstracts of these papers were given in the Phil. Mag. and Annals, N.S. vol. i. p. 66, and vol. iii. p. 301.—EDIT.]

half fathoms of limestone and ten fathoms and a half of sandstone; and at Eppleton only nine and a half fathoms of limestone and twenty-one fathoms of soft sandstone. The Elemore Pits are one mile south-west of the Hetton Pits, and the Eppleton about one mile north-east of the Hetton Pits." In this part of the district the dip of the coal beds is towards the east, at the rate of one yard in twenty-two; but along the coast of Northumberland, and as far south as Manor Walls End*, at the mouth of the Tyne, they rise rapidly to the east, as well as more gently towards the west. On the other hand the coal-measures south of the river Wear continue to dip regularly to the eastward. Even at Hetton the high main coal had not recovered the good quality it was formerly known to possess on the Tyne; but the low main, a very inferior coal, from being brittle and breaking into small fragments before reaching the London market, is at Hetton and other Wear water collieries a coal of very superior quality. In all these mines the *low main of the Tyne* is called the *Hutton seam.* See section of Byker St. Anthon's Colliery, Geological Transactions, first series, vol. iv. pp. 41, 42.

[To be continued.]

## XXXIX. *Remarks on one of* Mr. Talbot's *proposed Philosophical Experiments. By* C. Wheatstone, *Esq.*

*To Sir David Brewster.*

Dear Sir,

IN the last Number of the Philosophical Magazine is inserted an article, entitled "Proposed Philosophical Experiments, by H. F. Talbot, Esq. M.P. F.R.S." Upon a part of this communication, headed "On the Velocity of Electricity," I feel it necessary to make the following observations.

My experiments were not made solely with a view to determine the velocity of the electric spark *passing through air* as Mr. Talbot has inferred, but, from the first, were intended to extend to the passage of electricity through solid conductors. In fact, the very first experiment of the kind which I made, and which was shown to the members of the Royal Institution on the evening my investigations on this subject were first made public by my friend Dr. Faraday, was one by which I endeavoured to show the deviation from a vertical line of two sparks simultaneously visible at the opposite ends of a metallic conductor. Beyond this, I have for several months past communicated very generally to my scientific acquaintance the de-

---

* Almost all coals with us are now designated Walls End, whatever seams may produce them.

tails of an experiment upon a larger scale, which I hope soon to have an opportunity of executing, and which will detect and measure the velocity of electricity in its passage through a metallic conductor, though the rapidity of its transmission may exceed that of light: this I have proposed to effect, by increasing, in certain proportions, 1st, the velocity of the revolving mirror; 2ndly, the length of the conducting wire; and 3rdly, the accuracy of observing the deviation of the sparks from a vertical line. If I succeed in this point, it is obvious that we shall possess a means of directly measuring the relative conducting powers of metals, and of ascertaining numerous particulars respecting ordinary electricity which we at present have no means of determining.

Intending in the ensuing session to submit to the Royal Society all the results I have obtained, in reference to *a new optical means of measuring rapid motions, minute intervals of time, and feeble intensities of light*, I have hitherto refrained from publishing any incomplete statement of them; but I regret that this delay should have occasioned my experiments to be so far misunderstood, that one of the earliest which suggested itself to me, and which I have always considered to be of primary importance in the series, should be proposed elsewhere, several months afterwards, as an experiment yet to be tried, and be represented also as having entirely escaped my attention. I remain, Dear Sir, yours, &c.

C. WHEATSTONE.

Conduit-street, Hanover-square,
August 2, 1833.

## XL. *Experimental Contributions towards the Theory of Thermo-electricity. By Mr.* JOHN PRIDEAUX, *Member of the Plymouth Institution.*[*]

THE discovery of Professor Seebeck, that a bar of antimony, or of bismuth, heated in contact with a copper or brass wire, would affect the magnetic needle, was soon extended by chemists in this country and on the Continent to all the other metals which are of ready access; and a table of the thermo-electric order of these metals was soon published by Professor Cumming, and found to differ from the voltaic order, and also from that of conduction, whether of heat or electricity.

Other experimenters presently discovered thermo-electric currents in single masses of metal, which have been traced out with curious results[†].

---

[*] Communicated by the Author.

[†] [Papers on the thermo-magnetism of homogeneous bodies, by Mr. Sturgeon, will be found in Phil. Mag. and Annals, N.S. vol. x. pp. 1, 116, &c.—EDIT.]

M. Becquerel is, I believe, the only one who has investigated the comparative force as well as the order of arrangement of metals when acting in pairs; and having ascertained these points by a course of delicate experiments, he has been led to the inference that thermo-electricity is allied to the radiation of caloric.

The deep interest attached to a subject in which the mutual reaction of heat, electricity and magnetism is made almost tangible within a very narrow compass, led me to institute the following inquiries, with the hope of their suggesting other methods of elucidation.

I. Is thermo-electricity different from that derived from other sources: i. e. a different principle, or a different combination of principles?

II. Is it produced at the *expense* of caloric?

III. Is the radiation of heat, or any property dependent upon it, the proximate cause of thermo-electricity?

IV. Is the proximate cause connected with the conduction of heat?

V. Will not a hot bar brought into contact with a cold one of the same metal set electricity in motion; and if so, will the currents so produced bear any peculiar relation to those produced by pairs of different metals?

## I. *Is there any, and what, difference between Thermo-electricity and that derived from other sources?*

1. The most characteristic distinction between electricity and the other imponderable fluids (if such they be,) is, its [sensibly] instantaneous transmission through considerable length of solid conductors. The very low tension of thermo-electricity renders this as close a test as any to which it can be subjected. Fifty feet of iron wire (one of the worst metallic conductors,) was cut into two lengths, through which (turned at the ends, to ensure metallic contact,) two other mercury boxes were connected with those of the magnetest[*]. A thermo-electric pair, of antimony and bismuth, heated at the point of contact, had their feet dipped, first into the mercury boxes of the magnetest, which produced a deflection of 80°; and were then removed to the other pair of boxes at the end of the wires, by which the deviation was reduced to 15°; and so repeatedly; the interposition of such a length of iron wire, between the excited metals and the magnetest, withholding $\frac{4}{5}$ths of the deviation (about $\frac{19}{20}$ths of the current): yet was the

---

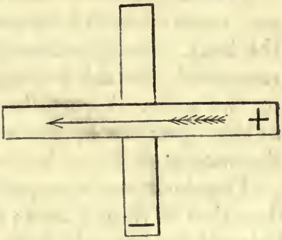
[*] I must be excused for resuming the use of this word: "galvanometer" would be hardly applicable in this instance.

instantaneous movement of the needle as evident in one case as in the other. So far, then, as promptitude of transmission through long wires is a distinction, thermo-electricity does not differ from the other kinds.

The magnetest employed in these experiments consists of a pair of sewing needles, 3 inches long, the lower one having just enough of predominance to give them terrestrial direction. The conductor, which passes only once between them, and returns beneath the lower needle, consists of four lengths of bright copper bell-wire laid together, not twisted, the ends amalgamated, and working into mercury boxes. A pair, of copper and tinned iron, by the heat of the fingers gives a deflection about 25°.

A guide-cross lies between the mercury boxes, to keep always before the eyes the relations between the current and the needle.

It is constructed of two slips of card, fastened in the centre, one over the other, with sealing-wax; one representing the magnet, the other the conducting wire. On the latter an arrow is drawn (on both sides) to indicate the direction of the current; on the former a line, also on both sides, to distinguish the marked pole.



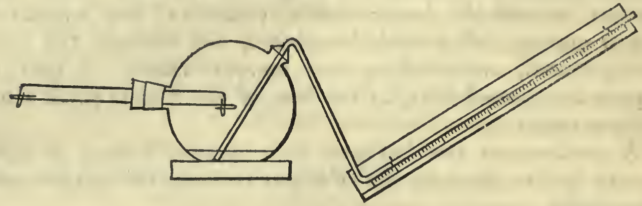
This cross turned over, on either of the slips, as an axis, or placed horizontally, vertically, or in any degree of obliquity, always exhibits the relation between the current and the needle: and being laid down, with its magnet corresponding with the position of the needle, it shows in what direction the current is passing over it; or turning it over upon the magnet as an axis, the reverse current is seen returning under it.

2. If there be any modification of electricity answering to that of Dr. Hare, a compound of electricity and caloric, this, from the mode of its generation, should be the one. But the same pair, of antimony and bismuth (1.), heated until they would drive the needle nearly round the circle, by the first impression, had not any appreciable effect on Mr. Harris's thermotest, though tried upon wires of various dimensions and different conducting powers. Thermo-electricity, then, seems to be no way distinguished as containing caloric.

Attractions and repulsions, or chemical decompositions would be precluded by its low tension; and these are its only apparent distinctions from the voltaic current, or from the electricity of the machine.

## II. *Is Thermo-electricity produced at the expense of Caloric?*

3. Into the smaller neck of a tubulated receiver was fixed an open glass tube, reaching obliquely to the bottom, and bent, siphonwise, on the outside, so as to descend a little lower than the inner end: it was then again bent upward, nearly at a right angle, and to this rising end a scale was attached.



Into the receiver was poured water tinged with cochineal, and covered with a stratum of oil, to prevent evaporation by the heat. Suction being now applied to the end, the liquid remained, on the principle of the siphon, a few degrees up on the scale. A cork thoroughly soaked in grease being fitted to the open neck, the whole constituted a very sensitive air thermometer.

The cork was now perforated by two wires; one of copper, the other of tinned iron; the latter bent off at each end, so that it could be brought into contact with, or separated from the copper by a slight turn with the fingers. Both ends of each wire were doubled, flattened and polished to ensure good contact; they projected about three inches into the receiver, and nine inches outside.

Being now set in contact, the cork was drawn out, and the ends of the wires which entered the bulb were placed between a fold of sheet copper, and heated by holding them for a given time ($25^s$) over an Argand gas light, being turned over at $15^s$, to equalize the heat in both wires. The sheet copper being now drawn off, the hot ends were thrust into the bulb, and the cork pressed in air-tight. The fluid rose quickly to about 90° (more or less, depending on slight differences in the heat, and in the quickness and force with which the cork was pressed in). After a few seconds, the liquid began again to descend, by the cooling of the wires. They were then separated, when the descent of the fluid was suddenly checked: on renewing the contact, it fell with renewed impetus; and so stopped and resumed its fall at every separation and renewal of the contact.

Other wires of the same and different metals were tried, and with many different corks; but the effect was always consistent, and indicated that the thermo-electric current did consume caloric in its production.

4. If this inference were true, it should follow that the wires heated to the same degree, should cool much more rapidly when kept in contact the whole time of cooling, than when kept all the time separate. They were therefore heated as before, and being thrust in, the fluid was allowed after rising to recede to 70°; from which its time of descent to 20°, i. e. 50°*, was observed by a seconds watch,—the wires remaining in contact.

The same proceeding was repeated, the wires remaining separate.

Precision, for reasons above given (3.), was unattainable; and the conclusion was only to be drawn from the average of many experiments. This average gave 60$^s$ for the closed wires, and *less* than 60$^s$ for the separated ones; thus the cooling seemed retarded, rather than accelerated, by the contact, and consequent electrical current. All that repetition and examination could do to avoid discrepancy was attended to, and yet these experiments seemed to contradict the preceding ones.

5. The mode of interrogation was reversed. If caloric disappeared in the production of thermo-electricity, it was not unlikely that where caloric became latent, thermo-electricity might appear.

A glass siphon being suspended by the ends over a spirit lamp, tin was dropped in and melted there, until the siphon was nearly full; the ends were then connected with the poles of the magnetest by long and similar copper wires, tinned at the points. Although copper is (generally) positive to tin, no current ensued, because both ends were alike in contact with copper. A hot iron wire being now plunged into the tin, at one end of the siphon, gave a deflection of 6°; and when transferred to the other end, a deviation to the same amount, in the contrary direction; and so repeatedly (37.): thus manifesting a current when electricity was developed. A slip of tin was now plunged into one end: of course no deviation could be expected (37.). This tin was allowed to melt there, by which caloric must have become latent. The fusion was gradual, and in full contact with metal on all sides; the electricity, if any were produced, must therefore have been continuous, and could not have acquired tension. It would

---

* Not degrees of Fahrenheit, or of any other standard scale; for the heat of the air about the wires must have been very different from that about the glass.

also have taken the copper, in preference to the tin, and the needle would have deviated accordingly.

But no deviation occurred.

Mercury, which is pretty near tin in thermo-electric power, was then substituted; and being heated to the melting point of tin, a warm iron wire was plunged in, which gave a deviation of 5°: but iron not coming well into contact with mercury, a tinned iron wire was tried, by which a deviation of 6° was obtained as before (5.). In this slips of tin were successively melted; but without any manifestation whatever on the needle.

Here we have no evidence of thermo-electricity, on the disappearance of caloric; in the preceding experiments we had no evidence of the disappearance or abstraction of caloric, in the production of thermo-electricity. To what, then, are we to attribute the contrary evidence of the previous experiments, as the apparatus was certainly air-tight?

6. When the wires were separated, the whole heated surface was exposed to the air in the bulb; and the portion between the heated ends would be most expanded, and least affected by the cooling influence of the glass. When they were in contact, this, the most effective part of the heated surface, was covered up. Hence a momentary expansion upon opening, and contraction upon closing the contact of the wires.

But since when thus in contact they cool less quickly, in proportion as they have less effect upon the air; so the whole time of descent, for 50° of the scale, should be greater, rather than less, when closed than when open.

If this were the true explanation, homogeneous wires should answer as well as those of different metals. Accordingly, two copper wires were passed through a cork, bent and heated as before (3.); and the descent of the fluid was found to be suddenly stopped and resumed, at the instants of opening and closing the contact, just as when the wires were of two different metals.

7. The evidence is therefore opposed to the expenditure of caloric in the production of thermo-electricity, and to the converse. Yet I thought the opposing experiments worth stating, (as they were not unlikely to occur to others,) to show that they had been tried, and shown to be inconclusive.

## III. *How far is the Radiation of Heat, or any collateral property, concerned in the Development of Thermo-electricity?*

8. The result of M. Becquerel's exact researches, above quoted from the *Ann. de Chim. et de Phys.*, Aug. 1829, is, that the only known property of heat in which the metals take

the same order as in thermo-electricity, is that of radiation; and therefore he supposes that two pieces of hot metal, in contact, radiate in the same proportions as they would if separate and exposed; and that thermo-electricity is a result of this inter-radiation.

This is certainly applying to the term radiation a new meaning, very little analogous to its ordinary acceptation*. Yet the same quality, whatever it may be, which occasions radiation to be more or less copious, may also determine a superficial communication, proportionately copious, though different in mode. We have evidence, too, that the superficial absorbent power for heat, is proportionate to the radiating power; and it seemed not very improbable that here might be found some trace towards the solution of the problem.

9. If the effects were due to any cause connected with, or related to radiation, they should be modified by alterations in the surfaces; and by making the surfaces of a thermo-electric pair identical, their reaction should be greatly weakened, if not neutralized altogether.

An iron and a copper wire, of the same size ($10 \times \frac{1}{16}$ inch), were well tinned from end to end, and twisted together for an inch. A similar pair, untinned, but polished, were similarly joined; and the feet tinned for $\frac{1}{2}$ an inch, that the contacts with the mercury might be alike. Instead of the tinned wires having their efficacy impaired, they gave greater deflections than the clear ones. This unexpected fact, verified in a great number of ways, led to a long course of experiments; the general bearings of which will occupy a subsequent section (VIII.).

I am at a loss to reconcile with this fact any cause connected with radiation.

10. To try radiation more directly, and on a larger scale, a plate of tinned iron was wired round with tinned iron wire, which projected at one corner, for a conductor. A sheet of soft tin was also wired round with copper wire, projecting in the same manner, and for the same purpose. The sheet tin being laid on the tin plate, with a leaf of bank post paper between, to prevent contact, the conductors were plunged into the mercury of the magnetest, and a couple of lamps placed under the tin plate. The whole soon became hot, without deflecting the needle. The tin sheet was now lifted off, the paper removed, and a few threads spread about the

---

* [It appears to us, on the contrary, that M. Becquerel here uses the term radiation in a sense perfectly similar to its ordinary acceptation: see Sir J. Herschel's remarks on the process by which radiation and conduction slide into each other, in his Prel. Disc. on Nat. Phil.—Edit.]

tin plate, to keep the sheet tin from touching it, whilst their surfaces should be fully exposed for radiation, at an extremely small distance. No deflection ensued on thus replacing the sheet tin; but on putting a slip of tin-foil in contact with both, the needle started off 25°.

A plate of polished copper was similarly used, first with sheet tin, afterwards with the tin plate; but with no effect whatever, in either case, until metallic contact was made.

The total inefficacy of such large radiating surfaces, added to the result of the preceding experiments, discourages the hope of tracing the cause of thermo-electricity to any superficial action analogous to radiation; and more convincing evidence to the same effect will appear (20. *et seq.*).

In fact I have been unable to find any table of radiation corresponding with Becquerel's thermo-electric order.

## IV. *Is the proximate cause of Thermo-electricity in any way connected with Conduction?*

12. Having previously found reason, from the experiments of others as well as my own, to conclude that the heat produced by electricity in metallic conductors (and, with due allowance, in liquids and air,) is in the order of, and probably in proportion to the resistance it encounters in the body heated, whether that resistance was owing to inferior conducting property or diminished thickness, I was led by the following experiment, compared with some of Becquerel's, to suspect a reciprocity of action, such that electricity, restricted in its passage, producing heat; so heat, allowed to flow more freely, might produce electricity.

The circuit from a voltaic coil was divided into 5 parts, the two ends next the coil, and the 5th or middle piece, being of stout copper wire, the ends each 2 feet, the middle piece 4 feet long; the connexions from each end to the middle piece were fine silver wire $\frac{1}{100}$th of an inch thick. Thus no electricity, positive or negative, could reach the middle piece except through these fine wires.

The charge being now made such as to warm the silver wires, a magnetic needle was moved along the circuit, which was laid (ap ortion of the middle piece, of course, excepted,) in the magnetic meridian. Its equidistance from the conducting wire was ensured, by the card, on which it was supported, being kept always in contact therewith. When over the copper, either of the middle or end pieces, the divergence was 36°; when over either of the silver wires, 26°. Thus heat seemed to be produced, by restriction of the current, on entering the silver wire; and the full electrical effect appeared to be restored when the obstruction was overpassed.

13. Becquerel found (*ubi supra*) that a circle of platinum wire, of equal diameter throughout, produced no current when heated in any part; but a knob being made in the circle, and heat applied near it, on either side, a current set always from the heated point towards the knob, where the heat had room to diffuse itself.

Also, that on soldering together the ends of his magnetest wire, no current ensued, when the point of junction was heated even to redness; but on touching the wire on either side of the heated point with a cold piece of the same metal, the current immediately set towards the part so touched.

14. It is true that the tables of conduction for heat and electricity, contrasted by Cumming with that of thermo-electricity, deny the presumption of any connexion between them. But there would appear to be two properties of conduction for caloric,—promptitude and final efficacy. For although we handle platinum wire, at two inches distance from a red-hot point, in operations with the blowpipe, which hardly any other metal will admit of, yet M. Despretz found that a rod of platinum *eventually* became hotter, at a given distance from a given source of heat, than any other metallic rod of equal dimensions; and if thermo-electricity be influenced by conduction at all, it must be by promptitude of conduction, for very short distances: whilst the tables hitherto published refer to a property compounded of the two, or intermediate between them.

A copper and an iron wire, drawn so that equal lengths corresponded to the atomic weights, were bound with thread for an inch each, cut off at ½ an inch above the binding,—this ½-inch bent over in the form of a hook, and the end filed flat. The two wires, thus prepared exactly alike, were fixed to a little wire frame, to keep them parallel and separate, and the filed ends dipped into melted lard. A couple of orange peas, of equal weight and size, were also dipped in the lard. When cold, the cohesion of the lard was sufficient to support the little balls against the ends of the wires. The bound part of the wires was now plunged into warm mercury, and the ball soon fell from the *copper* by fusion of the lard. The wires were then cooled by plunging the bound part into cold mercury, and the balls interchanged. On replunging into warm mercury, the ball fell again from the copper; and this always took place on repeated interchange of the balls, and alternation of cold and heat; the ball falling every time from the copper, until the mercury was cooled so far that the lard would not melt, and so that neither ball would fall. This was decisive in favour of the conducting power of copper, down to a very low heat, and at ½ an inch distance.

15. To try at still shorter distances, two other lengths of the same wire were twisted together for ½ an inch, then separated for an inch, and the other ends brought near together, for holding in a pair of cold pliers. (The twist was tarnished, to prevent metallic contact between the mercury and copper, which also was the object of the thread-binding in the former part of the experiment.) Spots of lard were now placed, at equal distances from the twist, on the iron and on the copper, and the twist plunged into the warm mercury. The lard became transparent (by melting) first on the copper: and this on repetition, whatever the distances, down to ⅛th of an inch; and whatever the temperature, so long as it was sufficient to melt the lard at all. Varying the sizes and proportions of the wires, tinning their surfaces, to prevent unequal waste of heat, *in transitu*, by radiation, did not alter the result. In every instance, for equal distances, the lard first became transparent upon the copper wire; which is thereby proved, for low heats and short distances, to retain its character as the better conductor for caloric.

16. To ascertain the conducting powers for electricity of very low tension, a pair of iron and a pair of copper wires, atomically proportioned as before, and each 2 inches long, had ½ an inch at each end bent down at right angles, and the points tinned, for equal contact with the mercury. Through these wires, two other mercury boxes were connected with those of the magnetest, an iron and a copper wire being employed on each side. Into the further boxes dipped the ends of a thermo-electric pair, of copper and tinned iron, of which the other ends were twisted together, and the twist was exposed to an equable heat, until the needle became stationary at 18°.

The short iron wires were now removed, leaving the conduction to be carried off by the short copper ones only: no appreciable change took place in the deflection.

The iron wires being now replaced, the copper ones were removed, leaving the conduction entirely to the iron. The needle receded more than a degree, and sometimes nearly 2°, confirming the superiority of copper as an electrical conductor, for extreme low tension and very short distances.

17. But as heat also enters into the question, the apparatus remaining as described, a spirit-lamp was brought under the middle of the copper leg of the thermo-electric pair, and continued there until the point acted upon by the flame became red hot. Little or no change took place in the deflection.

The lamp being then removed to the iron leg, the needle receded 2° before the heat had attained redness. Thus the conducting power of iron suffered more from heat than that of copper.

18. Iron being thus proved to be inferior in conducting power, both for heat and electricity, in circumstances directly in point, to copper, cannot owe its thermo-electric superiority to that property; and, extending the analogy to other metals, the inference at the beginning of this section would seem to be refuted. But the following section will bring the question before us in a different point of view.

[To be continued.]

---

## XLI. *Proceedings of Learned Societies.*

### ROYAL SOCIETY.

April 18. A PAPER was read, entitled, "On Improvements in the Instruments and Methods employed in determining the Direction and Intensity of Terrestrial Magnetism." By Samuel Hunter Christie, Esq. M.A. F.R.S.

The tedious nature of the observations by which the direction and intensity of the terrestrial magnetic force are determined, and the uncertainty attending the results when obtained, have long been a subject of regret to all who are engaged in the investigation of the phænomena of terrestrial magnetism. Sensible of this, the author's attention has at different times been turned to the improvement of the instruments employed for these purposes; and in this communication he proposes methods by which he considers that these instruments might be so improved that the results should be obtained with greater facility and also with greater certainty. The uncertainty attending the results obtained with the dipping needle, as at present constructed, arises principally from the two sources, friction upon the axis, and the want of coincidence of the needle's centre of gravity with the axis of motion; the latter rendering necessary the inversion of its poles. The author suggests a method by which he considers that, probably, the friction may be diminished; but he has principally directed his attention to obviate the necessity of the inversion of the poles.

In order to remove the practical difficulty attending the adjustment of the centre of gravity to the axis of motion, an operation in which the artist rarely, if ever, completely succeeds, the author proposes to dispense with this condition; and shows how the dip may then be determined, without the necessity of inverting the poles of the needle, the position of its centre of gravity having been determined previously to its being magnetized. The advantages attending the method proposed by the author are not, however, restricted to the determination of the dip with greater accuracy and greater facility: a further and still greater advantage attending the use of a dipping needle on the principle he proposes, is, that a measure of the terrestrial magnetic intensity will be obtained by the same observations which give the dip; so that, by this means, the observations usually required for that purpose, and which are of the most tedious nature, will be avoided. To effect both these objects in the most convenient manner, he proposes that the needle should be so constructed that its centre of gravity should be out of the axis of motion, in a line perpendicular to that axis and to the axis of the needle. The requisite formulæ for determining the dip and the measure of the terrestrial intensity, in this case and also when the centre of gravity is in any other position, are investigated in the paper. Mayer had previously pointed out that the dip might be determined by means of a needle having its centre of gravity out of the axis of motion, and had given the formulæ requisite for that purpose. His object, however, does not appear to have been the same as our author's,—the avoiding in all cases that source of inaccuracy, the inversion of the poles of the needle,—but simply the determination of the dip, whether the centre of gravity of the needle were made to coincide with the centre of motion, or not: the determination of a measure of the terrestrial intensity, by such means, does not appear to have entered into his contemplation.

As another form in which the same principles might be advantageously applied, the author proposes that two needles, similar in all respects, should be placed on the same axis; and points out how, by means of such a compound needle, both the dip and intensity might be determined by independent methods, so that the agreement of the results would afford a test of the accuracy of the adjustments and of the observations. He considers that the knife-edge support, which has recently been adapted to a dipping needle, would be peculiarly applicable to a needle of this construction. The sensibility of such a needle would be much greater than that of any hitherto constructed, and the utmost delicacy would be required in the adjustments; but if the needle were accurately constructed, and due care were taken in the magnetizing, and in making the adjustments and observations, the author expects that the dip and intensity would be determined to a degree of certainty hitherto unattained.

The advantages proposed to be derived from the use of a dipping needle on the principle described in this paper, are, that as the dip would be obtained without inversion of the poles, the results would be less liable to error than when that operation is necessary, and the observations would be made in less than half the time usually required; and that a measure of the intensity of terrestrial magnetism would be obtained from the same observations which give the dip, the intensity of the force being thus always determined by means of the same needle, and at the same instant as its direction.

May 2.—A paper was read, entitled, "Essay towards a first approximation to a Map of Cotidal Lines." By the Rev. William Whewell, M.A. F.R.S. Fellow of Trinity College Cambridge.

The general explanation of the phænomena of the tides originally given by Newton, although assented to by all subsequent philosophers, has never been pursued in all the details of which its results are susceptible, so as to show its bearing on the more special and local phænomena, to connect the actual tides of all the different parts of the world, and to account for their varieties and seeming anomalies. The first scientific attempt that was made to compare the developed theory with any extensive range of observations, was that of Daniel Bernouilli in 1740: the subject has since been pursued by Laplace and Bouvard, and still more recently by Mr. Lubbock. But the comparison of contemporaneous tides has hitherto been unaccountably neglected: and to this particular branch of the subject the researches of the author are in this paper especially directed; the principal object of his inquiry being to ascertain the position of what may be called *cotidal lines*, that is, lines drawn through all the adjacent parts of the ocean where it is high water at the same time; as, for instance, at a particular hour on a given day. These lines may be considered as representing the summit or ridge of the tide-wave existing at that time, and which advances progressively along the sea, bringing high water to every place where it passes. Hence the cotidal lines for successive hours represent the successive positions of the summit of the tide-wave, which in the open sea travels round the earth once in twenty-four hours, accompanied by another at twelve hours' distance from it, and both sending branches into the narrower seas. Thus a map of cotidal lines may be constructed, at once exhibiting to the eye the manner and the velocity of all these motions.

Although the observations on the periods of the tides at different places on the coast and different parts of the ocean, which have been at various times recorded, are exceedingly numerous, yet they are unfortunately for the most part too deficient in point of accuracy, or possess too little uniformity of connexion to afford very satisfactory results, or to admit of any extended comparison with theory. With a view to arrive at more correct conclusions, the author begins his inquiry by endeavouring to determine what may be expected to be the forms of the cotidal lines, as deduced from the laws which regulate the motions of water: and he proceeds afterwards to examine what are their real forms, as shown by the comparison of all the tide observations which we at present possess.

The paper is divided into five sections. In the first the author treats of cotidal lines as deduced theoretically from the known laws of the motion of fluids. On the supposition that the whole surface of the globe is covered with water, the cotidal lines would coincide with the meridians, and would revolve round the earth from east to west in something more than twenty-four hours, with a velocity of nearly 1000 miles an hour at the equator. The form and the regularity of these lines would be materially affected by the interposition of land in different parts of this ocean, whether in detached islands, or groups of islands, or large continents, occupying a considerable portion of the surface. In these cases the primary wave will be broken, deflected and variously modified, so as to give rise to secondary or derivative tides, sometimes separating into branches, and producing points of divergence; sometimes uniting at various places, or points of convergence; and at other times producing, by more complex combinations, various phænomena of interference, and other apparently anomalous results. Such is the general character of the tide-waves that actually proceed along the coasts of the Atlantic: and the modifications in their course and velocity are still more perceptible in bays, gulfs, and narrower channels and inlets of the sea, as well as in their progress along rivers. The author traces in detail the effects which these different circumstances may be expected to produce. He adverts to an important distinction which has frequently been lost sight of, between the progressive motion of the tide-wave and the actual horizontal motion of the water, or tide-current; motions which do not bear any constant relation to one another. Hence the change in the direction of the current does not invariably indicate the rise or fall of the water.

In the second section he examines the causes which have led to inaccuracy in making observations on the tides; the first of which is dependent on the circumstance just mentioned, of the occasional want of correspondence between the times of *high* and of *slack* water; the former referring to the moment of greatest elevation, the latter to that when the direction of the current changes. The other causes of error are derived from the change which takes place in the course of the day in the moon's angular distance from the sun; from the half-monthly inequality in the establishment, arising from the relative position of the sun and moon during each lunation; and from the necessity that exists of making a correction for what may be termed the *age* of the tide; that is, the interval of time which has elapsed between the period of the origin of the wave and the time of its actual arrival at the place of observation.

The third section, which forms the chief bulk of the paper, is occupied by a statement and discussion of the tide observations now extant, and which the author has, with great industry, collected from a variety of sources, both of published accounts, and of manuscript documents preserved in the Admiralty. Commencing with the tide-waves, first of the eastern and then of the western coasts of the Atlantic, he follows them to the Northern sea, and to the different coasts of the British islands, and of the German Ocean. He passes next to the examination of those of the Southern Atlantic at Cape Horn and the adjacent coasts; thence tracing them, as far as the present imperfect data will allow, along the western shores of the American continent, to the central parts of the Pacific, and in their progress across the Australian and Indian Oceans. He likewise examines the condition of the tides in rivers, as to the magnitude and velocity of the undulations, the occasional production of a high and abrupt wave, or *bore*, and as to the influence of the natural stream of the river upon the different periods of elevation or depression of the water.

The fourth section contains general remarks on the course of the tides, suggested by the preceding review of the phænomena they present; on the velocity of the tide-wave; on the form of the cotidal lines; on the currents which attend the tides; on the production of revolving currents; on the magnitude of tides; and on the constancy of the cotidal lines. He adverts also to some peculiarities resulting from interference, such as the differences of the two diurnal tides, and occasionally the occurrence of single day tides.

In the concluding section the author offers various suggestions respecting the most eligible mode of making observations on the tides, and of correctly reducing them when made.

---

## GEOLOGICAL SOCIETY.

February 27.—A paper, commenced during the last Session, entitled "Description of Parts of the Kingdoms of Valencia, Murcia, and Granada, in the South of Spain," by Capt. Cook, R.N. F.G.S., was concluded.

A paper entitled "Observations relative to the Structure and Origin of the Diamond," by Sir David Brewster, K.C.H. LL.D. F.G.S. &c., was then read.

In the year 1820, the author communicated to the Royal Society of Edinburgh a singular fact relative to the structure of the diamond, accompanied with some conjectures respecting the origin of this remarkable gem:—the present essay may be viewed as a continuation and extension of the same inquiry.

The author refers to the remark of Newton, that amber and the diamond have a refractive power three times greater in respect of their densities than several other substances; and he quotes Newton's conjecture, founded on that remark, of the diamond being probably, like amber, an unctuous substance coagulated. In proof of the intimate relation between the inflammability and absolute refractive power of bodies, Sir D. Brewster adds the facts, that sulphur and phosphorus exceed even the diamond in absolute power of refraction, and that these three inflammables stand before all solid and fluid substances in their absolute action upon light.

Another close analogy between the diamond and amber, independently of their like locality and carbonaceous nature, was traced by the author in their polarizing structure. Both of these minerals contain within their substance small cells or cavities, filled with air, the expansive force of which has communicated a polarizing structure to the parts in immediate contact with the air. The description of this structure, which is displayed from sectors of polarized light encircling the globule of air, is illustrated by drawings.

The author contends that the peculiar polarizing power around the cavities in amber and in the diamond must have been occasioned by the expansive force of the confined substance, supposed to be gaseous, compressing the sides of the cells, while the substance of the minerals was in a soft and yielding condition. A similar structure may be produced in glass, or in gelatinous masses, by a compressing force, propagated circularly from a point.

Having thus shown that the diamond was at one time in a soft or pasty state, the author argues that this state was not produced by igneous fusion. For in his laborious examination of the cavities in crystals, both natural and artificial, such as topaz, quartz, amethyst, chrysoberyl, &c., and in salts, he observed the condition of many thousand cavities; but in no case, neither in crystals formed by means of igneous fusion nor by aqueous solution, did he observe a single cavity in which the expansible fluid within had communicated a polarizing structure, similar to that around the cavities in the diamond. He believes, therefore, that the softness must have been that of semi-indurated gum; and that the diamond was derived from the decomposition of vegetable matter, as is admitted to have been the case with amber. The crystallized condition of the diamond is not to be considered as decisive against this inference, since the mineral called mellite has a distinct crystallized form, while its composition and locality attest a vegetable origin *.

A notice "On the Occurrence of the Bones of Animals in a Coal-mine in Styria," by Professor Anker, of Joanneum in Gratz, was then read.

March 13.—A paper, entitled "Geology of the Environs of Bonn," by Leonard Horner, Esq. F.G.S. F.R.S. &c., was read.

The district described by the author lies on both sides of the Rhine,—the Siebengebirge, or Seven Mountains, constitute the chief feature; and the highest point in the group, the Oelberg, is 1369 English feet above the level of the sea. It possesses peculiar interest to the geologists of England, as being the nearest point where volcanic phænomena, approaching in character to those of modern times, can be seen.

The lowest stratified rock is grauwacke, which seems to belong

---

* [As the subject of the origin of the diamond was discussed in our pages some years ago, we annex an historical remark or two to the above abstract of Sir D. Brewster's paper. In the communication to the Royal Society of Edinburgh, alluded to in the abstract, it was argued that the original compressible state of the diamond could not have arisen from the action of heat, on account of "the nature and recent formation of the soil in which it is found." Mr. Brayley, when discussing the arguments in favour, respectively, of the vegetable and the mineral origin of this gem (in a notice headed "*Origin of the Diamond*," published in the Phil. Mag. and Annals, N.S., vol. i. p. 147—149, and signed E. W. B.), observed, that the discovery, subsequently to Sir D. Brewster's researches, of a diamond in a matrix of brown ironstone occurring in beds subordinate to chlorite slate in the Brazils, and the information, also subsequently promulgated, that the diamonds of Southern India are found in an ancient breccia, removed Sir David's objection on this point. Mr. Brayley inferred, therefore, since, for aught that had been advanced to the contrary, the compressible state once possessed by the diamond might have resulted from the action of heat, that the optical characters discovered by Sir D. Brewster, did not necessarily refer its origin to the vegetable kingdom.

In the paper read before the Geological Society, however, Sir D. Brewster shows, in a direct manner, by comparing the optical characters of the diamond with those of other crystallized substances, that the original soft or pasty state of the former could not have been produced either by igneous fusion or by aqueous solution. The evidence now adduced on this point is therefore quite independent of the geological situation of the gem; and it would appear to be impossible to refer it to any other than a vegetable origin, as originally suggested by the author of the paper.

We observe that Dr. Thomson's statement of the geological situation of the diamond (Inorg. Chem. vol. i. p. 156.) is derived from the above-cited notice in the Phil. Mag. and Annals.—Edit.]

to the later ages of that deposit, and to approach in character, in some parts of the district, to the old red sandstone. There are no associated beds of limestone. The strata are in general highly inclined, but they are found at all angles; and there is neither uniformity in the strike nor in the dip; the strike is most usually N.E. and S.W., the dip more frequently S. than N. In the immediate neighbourhood of the Siebengebirge, the strata are thrown up in all directions, evidently by the eruption of the volcanic matter.

The whole of the later secondary series is wanting, and the grauwacke strata are covered, unconformably, by a tertiary deposit, consisting of beds of sand, sandstone, clays, and lignites, which collectively constitute a brown coal formation. This is covered by an extensive bed of gravel, and above the gravel is a loosely coherent, sandy loam, containing land shells of existing species, and called in the Rhine valley, *Loess*. From under the grauwacke there have burst forth a variety of unstratified rocks, consisting of various modifications of trachyte, trachytic tuff, basalt, and other modifications of trap. The main body of the Siebengebirge is composed of these volcanic rocks.

There are many varieties of the trachyte, from a highly crystalline rock, with separate crystals of felspar of great size, very like a large-grained granite, to a compact stone of uniform structure, like compact felspar or phonolite. The trachytic tuff also assumes various appearances, from that of a coarse conglomerate to a white earthy substance, scarcely distinguishable from chalk. There is no evidence of the trachyte having flowed in a stream, and the author saw it only in one place in the form of a dyke. There are several varieties of trap, but the most common is a compact black basalt, in many places in perfect columns. There are numerous dykes of basalt. A remarkable eruption of trap tuff, penetrated by basaltic dykes, occurs at Siegburg, where three cones, of about 200 feet in height, rise abruptly in the midst of an alluvial plain, nearly on a level with the Rhine.

The author points out the affinity which Von Buch has shown to exist between the mineral composition of all the unstratified rocks, and how a series of insensible gradations could be formed, through trachyte and the trap family, from granite to modern lava. He shows that a suite of specimens could be collected in the Siebengebirge, passing insensibly from large-grained white trachyte to compact black basalt; and that these hills afford many interesting facts corroborative of the opinion advanced by M. Gustave Rose respecting the identity of hornblende and augite. Notwithstanding, however, this connexion between the several volcanic rocks, the author points out distinct evidence of different epochs of formation among them. He is of opinion that the greater part of the trachytic tuff was the first ejected; that it was similar to those showers of scoriæ and ashes which frequently precede the eruptions of streams of lava; and that it is not, as some previous writers have supposed, a rock recomposed from the disintegration of pre-existing trachyte. He saw the trachytic tuff traversed in one place by a dyke of trachyte, and it contains numerous balls, like volcanic bombs, of varieties of trachyte, quite distinct in character from any found *en masse*. It is traversed in many places by trap dykes; and as these last are also found traversing solid trachyte, the subsequent eruption of the trap is demonstrated. He discovered no instance of the recurrence of trachyte after basalt had begun to flow. There is on the side of the Rhine, opposite to the Siebengebirge, an extinct volcano, of comparatively modern date, the Rodderberg, composed of cinders and scorified rocks. The crater is about a quarter of a mile in diameter, and a hundred feet deep: a farm-house, surrounded by corn-fields, stands in the middle of it.

The brown coal formation is composed of beds of loose sand, sandstone, and compact siliceous conglomerate, which often, in mineral structure, cannot be distinguished from many varieties of grauwacke; of clay, abounding with balls and layers of clay ironstone; and of many varieties of lignite, from the state of a light brown earth, to a black compact shining mass, or jet. All of these are frequently met with in thick beds, and the lignite is most extensively worked for fuel. They contain numerous impressions of leaves, and stems of trees are very abundant. With the exception of casts of *Lymnæa* and *Planorbis*, in an opake white chert, of very limited extent, no shells, fresh-water or marine, nor any remains of mammalia or birds, have been found in any part of the formation; but in some beds of the lignite, impressions of fresh-water fishes, the *Leuciscus papyraceus* of Agassiz, are found in great abundance, and there have also been found extinct species of frog, salamander, and triton, together with remains of insects, which Professor Goldfuss considers to belong to the genera *Lucanus*, *Cerambyx*, *Anthrax*, *Cantharis*, and eight others.

The author submitted the specimens which contain impressions of leaves, to the examination of Professor Lindley. Most of them are in too imperfect a state to admit of any accurate determination, but they consist generally of casts of portions of dicotyledonous leaves; and among them are two species, the existence of which is sufficient to determine the relative age of the formation, and, with great probability, the then warm climate of the North of Germany, viz. *Cinnamomum dulce* and *Podocarpus macrophyllus*: there are besides impressions of leaves very clearly belonging to the Palm. It is remarkable, however, that a recent examination by Professor Nöggerath of Bonn, and M. Cotta of Heidelberg, of an extensive suite of the *woods* found in this brown coal formation, did not disclose a single instance of a monocotyledonous tree.

A vast deposit of gravel, chiefly composed of quartz, but containing also a few fragments of basalt, trachyte, transition limestone, and *bunter sandstein*, lies over the brown coal formation, sometimes being only a thin covering, at others attaining a thickness of 125 feet. It is very distinct in character from the gravel now forming the bed of the Rhine, and is older than some of the volcanic eruptions, for a patch of it rests on the edge of the crater of the Rodderberg, covered by volcanic ashes.

The author next proceeds to point out what he considers the relative age of this brown coal formation, a task extremely difficult, from the almost total absence of shells, and the imperfect state of the means of determining an epoch of formation by fossil plants. By previous writers it has been assigned to the plastic clay of the Paris basin; but it appears to the author to possess no other character of identity than the mineral composition of some of the beds, and the occurrence of lignite, which prove nothing as to age. The amphibious animal remains resemble those of the great fresh-water deposit of Œningen; but the few shells which occur, and the plants, are identical in species with many of those occurring in the older fresh-water beds of Aix in Provence. It seems to be very clear, that it is an exclusively lacustrine deposit, and the organic remains, the only evidence of age to be relied on where there is none from superposition of other beds, imperfect as they are, would seem to indicate a more modern date than the plastic clay. The author states that a distinguished geologist of Bonn has expressed his belief that it is even older than the chalk; but that although the opinions of that experienced observer are entitled to great respect, he cannot reconcile the phænomena described with anything known respecting the secondary rocks.

The determination of the age of this brown coal formation is of the highest importance, as fixing the periods of eruption of the extinct volcanos of the Lower Rhine; for the author of this paper shows, that the trachytic tuff contains leaves of plants identical with those found in the clay and sandstone deposits; that extensive layers of trachytic tuff are interstratified with the beds of the formation in many places; and that in one situation a mass of basalt, thirty feet thick, lies upon beds of coal thirteen feet in thickness. The conclusions which the facts appear to the author to justify, are, that there existed a vast fresh-water lake, in which the brown coal beds were deposited; that *during* that deposition volcanos burst forth at the bottom of the lake, as they do now at the bottom of the sea; and that a continuance of volcanic action, or of elevatory force, raised the Siebengebirge after the deposit had ceased,—perhaps at the very time when the basalt or trap eruptions took place, since near the summit of the Mandeberg, a columnar basaltic cone, there is a patch of brown coal beds at the height of nine hundred feet above the surface of the Rhine.

The last great formation, if it may be so termed, of this district, lying *upon* the gravel in which the present bed of the Rhine is cut, is that most remarkable deposit the *Loess*, a friable sandy loam, full of existing species of land shells, without river shells, and without plants, but containing bones of the *Elephas primigenius* and *Rhinoceros tichorinus*. It is found in detached masses, of vast thickness, but without any signs of stratification, and sometimes at a height of 600 feet above the Rhine, and may be traced with scarcely any interruption from Bonn to Basle, a distance of 250 miles. The author states that all the facts yet observed with respect to it, lead him to conjecture that its origin may have been owing to the sudden bursting of an extensive lake situated somewhere between Constance and Basle, and that subsequent denuding causes have carried away the enormous mass of matter deposited by this sea of mud, leaving only detached portions as monuments of the passing of the mighty torrent.

March 27.—The first part of a memoir "On the sedimentary deposits which occupy the western parts of Shropshire and Herefordshire, and are prolonged from N.E. to S.W., through Radnor, Brecknock, and Caermarthenshires, with descriptions of the accompanying rocks of intrusive or igneous characters," by Roderick Impey Murchison, Esq. F.G.S. F.R.S. &c., was read.

After adverting to the want of definite knowledge of the order of succession, and of the fossiliferous characters of those great deposits anterior to the old red sandstone, and commonly called transition rocks (fossiliferous grauwacke, De la Beche), the author states that the task of attempting to separate them into distinct formations, was first suggested to him by the very clear and perfect exhibition of their details in the country under review.

The present work has already occupied large portions of the two last summers, and has for its basis the maps of the Ordnance survey, coloured geologically by the author. To the Master General of the Ordnance, to Col. Colby, Capt. Robe, and the Officers of His Majesty's Map-office, for their assistance in supplying him with good geographical data, and also to Mr. Budgin, one of the Field-Surveyors of the Ordnance, the author acknowledges his obligations. He next adverts to the unpublished yet valuable observations of Mr. Arthur Aikin, made many years ago in the north-eastern portion of the country described; and he further expresses his sincere thanks to many resident gentlemen who assisted him in his observations.

The memoir is divided into three parts. The first contains an account of the overlying deposits of new red sandstone, coal measures, mountain limestone, and old red sandstone, each of which is in contact with, or contiguous to, the transition rocks (grauwacke series) in some portion of the region described. The second and most extensive part explains the subdivisions and relations of the grauwacke series as exhibited within a zone of country extending from the Wrekin near Shrewsbury on the N.E., to the mouth of the Towey, near Caermarthen, on the S.W.; and the third part is to be devoted chiefly to the consideration of the rocks of intrusive or igneous characters, and their effects upon the associated strata.

Part 1. On the New Red Sandstone, Coal Measures, Mountain Limestone, and Old Red Sandstone.

1. *New red sandstone.*—This is the youngest secondary formation in contact with the transition rocks, and is exhibited on both sides of the Severn, near Shrewsbury, being superposed to coal measures, to various members of the grauwacke series, and to trap rocks of different characters, in all of which situations it is undisturbed.

The oldest strata of this formation are compared with the *rothe-todte-liegende* of Germany, or the older new red of the North of England, and are shown to underlie a dolomitic conglomerate at Alberbury and Cardeston. The superior members on the north bank of the Severn, consist of fine-grained sandstones, for the most part red, but offering at Grinshill, 7 miles N.E. of Shrewsbury, a subordinate, white building-stone, of excellent quality. Small quantities of the ores of copper and cobalt, are mentioned as occurring in the formation near Grinshill and Hawkstone, &c. Much sulphate of barytes and decomposed pyrites are diffused through the mass of these rocks. No organic remains have yet been discovered in them.

2. *Coal Measures. a. Coal field of Coalbrookdale.*—This coal-field is stated to rest at Steeraways and near Little Wenlock, on a thin band of limestone, which, from its fossils, is shown to be true mountain limestone; whilst in the contiguous extension of this field, the carboniferous strata overlie, *unconformably*, various members of the grauwacke series, with one of which, the transition limestone of Wenlock Edge, they are brought into *conformable* apposition at Lincoln Hill, on the Severn. The complicated relations of the deposits within this small and disturbed district, east of the Wrekin, are referred to the protrusion of basalt and green-stone, which occasionally tilt the strata at high angles, and sometimes occupy the seats of faults.

*b. Coal-fields in the immediate vicinity of Shrewsbury.*—Of these, the most important is a curvilinear zone extending from the north-eastern flank of the Brythin Hills to Wellbatch, near Shrewsbury, the carboniferous strata reposing on the inclined edges of the grauwacke rocks, and dipping towards a common centre beneath the new red sandstone. Detached portions of the same zone are again found at Sutton and at Uffington; and they also follow the sinuous outline of grauwacke on the northern flanks of the Longmynd and Caer Caradoc. At Pitchford, the whole carboniferous series is represented by a bituminous breccia of a few feet in thickness.

Three thin beds of coal are, for the most part, observable, and the deposit is distinguished by an included band of limestone, similar in mineral aspect to the lacustrine limestones of Central France, and containing minute shells referrible to *freshwater* genera. The vegetable remains of the associated shales are chiefly analogous to the plants of other coal-basins; but those of Le Botwood are rich in the new species, *Neuropteris cordata,* whilst the shale of Pontesbury has offered a beautiful example of *Pecopteris blechnoides* in fructification.

After demonstrating the slight commercial value which can be attached to the thin deposits of this age, the author speculates on the probable importance of the outer zone or Pontesbury-field, which he presumes may expand to a great thickness in its passage beneath the new red sandstone of N. Shropshire and Cheshire.

*c. Coal fields in the Clee Hills.*—These fields are thrown up to considerable heights above the adjoining country of old red sandstone, both in the Brown Clee, and the Titterstone Clee Hills, the coal being for the most part covered with basalt.

The Brown Clee is distinguished by two tabular summits of black basalt (Jewstone), the highest of which is 1806 feet above the sea. The coal-bearing strata have for their base a hard sandstone occasionally conglomeritic, the equivalent of the millstone grit. On three sides of this ridge, these very thin and poor coal measures repose on old red sandstone, which to the west is a coarse conglomerate; but on the fourth or south-eastern side, there is interposed between the old red and the lower coal grits, a thin zone of limestone, which the author, therefore, refers to the age of the mountain limestone. Several faults are mentioned as traversing this coal tract from S.W. to N.E., one of which has been the source of eruption of much basaltic matter.

The Titterstone Clee Hill is next described; and details are presented of those parts only which were unnoticed in Mr. R. Wright's memoir. The most important of these relate to the Knowlbury field, which, from its juxta-position to the larger field of Coalbrook, the author terms a parasitic basin, and shows that it contains five seams of coal and some bands of ironstone. The strata around the verge of this basin are highly inclined, the dip diminishing as it approaches towards a common centre. Sections across this small basin exhibit considerable faults, which always occur as upcasts towards the higher sides of the hills, where the basaltic matter has found vent: coal, included between two of these upcasts, is described as much thickened and in the state of cannel coal.

Many fossil plants of new species from the Knowlbury and Gutter Works are described by Professor Lindley. Recent investigations of Mr. Lewis are mentioned, which prove the existence of a central dyke or funnel of basalt, thereby confirming the opinion formerly expressed by Mr. Bakewell; and a complete transverse section of these hills shows, that some beds of coal have been carried up on the top of the basalt, and that this rock has flowed laterally so as also to overlie the coal. Although these coal measures rest, in the greater part of their circumference, on the old red sandstone, the existence of an interpolated band of true mountain limestone is pointed out, which from the thickness of a few feet near Bennett's-end, extends to a maximum development of about 60 feet beneath one part of the Cornbrook field, where it contains subordinate beds of fine oolite, marl of various colours, abundance of characteristic organic remains, and is much contorted and dislocated.

At Orelton, near the north-eastern extremity of this range, and thus connecting it with the more eastern coal-fields, is a tortuous range of oolitic mountain limestone, which rests upon the old red sandstone and, exhibiting some extraordinary fractures and dislocations, passes beneath the unproductive or lower coal grits.

3. *Old red sandstone.*—In the vast formation comprehended under the term old red sandstone, the author includes all the red or green marls, conglomerates, sandstones, limestones, or flagstones, the youngest or highest beds of which pass immediately beneath the mountain limestone or carboniferous strata, and the lowest overlie and graduate into, the superior members of the grauwacke series. The author gives a geographical sketch of the western side of the great trough in which this formation is deposited in Shropshire, Herefordshire, and Brecknockshire; the prevailing strike of which is shown to be from N.E. to S.W., and the usual inclination to be to the S.E. The upper beds of the formation, near the Brown Clee,

and partially near the Titterstone Clee Hills, expose a thin band of conglomerate; then follow, in descending order, red or green marls, with two or more zones of impure limestone called cornstone. To these succeed micaceous flagstones and thin-bedded building stones, with other strata of marls and cornstone. Massive varieties of concretionary limestone, termed ball-stones, range along the western foot of the Brown Clee. They are sometimes from 18 to 20 feet thick, and are very dissimilar in quality and in appearance from the thin and conglomeritic bands of the rock. Alternations of red and green marls again succeed beneath the cornstones, and the base of the whole formation is usually marked, particularly in its course from Kington to Caermarthenshire, by highly micaceous greenish and reddish tile stones associated with marl. Thick-bedded, fine-grained building stones of excellent quality are worked near Hay in Herefordshire, overlying the tile stone division. No workable seam of coal has ever been discovered in the old red sandstone. Dr. Lloyd has recently discovered near Leominster and Ludlow, in the central and calcareous sandstone beds of the formation, fossils which are chiefly referrible to undescribed species of the family of Trilobites, and with them a few fragments of plants apparently terrestrial.

An expansion upon a large scale is pointed out in the old red sandstone, which, from a narrow tongue, is described as extending all over the forest of Mynidd Eppint, on the western side of which it reposes conformably and at high angles, upon the uppermost strata of grauwacke, at the chief escarpment of that rock. Many transverse sections from the grauwacke formations to the edge of the Glamorganshire coal-basin are given by the author, and they exhibit a perfect conformability between the upper beds of the old red and the lower members of the mountain limestone, as well as a gradual passage from the old red into the grauwacke. He, however, insists that there are no two formations of the English series which can be better separated from each other for purposes of geological illustration, than the old red sandstone and the uppermost grauwacke; the former being as poor as the latter is rich in organic remains, whilst the colours and mineral characters of the two formations are also very distinct. The maximum thickness of the formation is not easily defined with accuracy, but the author has no hesitation in saying that it exceeds 4000 feet.

In the latitudes of Llandovery and Llandilo, the whole formation is thrown so much on edge, that it necessarily occupies a very small superficial breadth, whilst the very slight inclination and the undulation of the beds in Herefordshire and Brecknockshire account for its vast expansion in these counties.

Detached tracts covered with this formation are pointed out as occurring far within the frontier of the grauwacke rocks; and they are considered to be true basins of elevation which have been formed on the western sides of certain anticlinal lines, along which the inferior sediments have a reversed dip.

April 17th.—The second part of a memoir, commenced on the 27th of March, and entitled, "On the sedimentary deposits which occupy the western parts of Shropshire and Herefordshire, and are prolonged from N.E. to S.W., through Radnorshire, Brecknockshire, and Caermarthenshire, with descriptions of the accompanying rocks of intrusive or igneous characters," by Roderick Impey Murchison, Esq. F.G.S. F.R.S. &c., was read.

In this part of the memoir the author separates into distinct formations by the evidences of fossils and the order of superposition, the upper portions of those vast sedimentary accumulations, which have hitherto been known only under the common terms of transition rocks, and grauwacke. Commencing at the base of the old red sandstone, which formation he had described in the previous part of the memoir, he proceeds to give an account of the underlying deposits as they succeed to each other in descending order in Shropshire and Herefordshire.

I. *Upper Ludlow Rock.*—Equivalent, Grauwacke Sandstone of Tortworth, &c.

This group, so named because the Castle of Ludlow stands upon it, is as eminently characterized by the presence of organic remains as the old red sandstone is by their deficiency. Amid a profusion of fossils, the upper beds are characterized throughout the whole range of the formation by two species of Strophomena or Leptæna, an Orbicula, a plicated Terebratula, &c. all of undescribed species. The middle beds contain many species of Orthocerata; Serpulæ? of great size, &c.; and the lower strata are charged with a profusion of small Terebratulæ having a gryphoid form. Trilobites of the genera Homonolotus and Calymene occur. The group has a maximum thickness of about 1000 feet, is for the most part a thin-bedded sandstone, often highly calcareous, and at other times argillaceous, and in Shropshire frequently occupies distinct lofty ridges interposed conformably between the old red sandstone and the inferior limestone.

II. *Wenlock Limestone.*—Equivalents, Dudley Limestone, Transition Limestone, &c.

On the banks of the Severn near Wenlock, and in the Wenlock Edge, this group is particularly abundant in corals and Encrinites, nearly all the species of which, as well as of certain Mollusca, are found in the well-known limestone of Dudley. The exact position, therefore, which the latter occupies in the geological series of England, is thus for the first time determined.

The upper beds rising from beneath the Ludlow rock are thin-bedded and lenticular, and the lower beds in Wenlock Edge contain many concretions of very great size and of highly crystalline structure. Throughout its course in the district included between the rivers Oney and Lug, this limestone is chiefly characterized by the abundance of one species of Pentamerus, and at Aymestrey it is rich in that and other fossils*. 100 feet are considered to be about the thickness of this calcareous zone.

---

* The author cannot allude to the fossils of this district without expressing his deep obligation to the Rev. T. Lewis of Aymestrey, whose unceasing researches have contributed very essentially towards the zoological illustration of this memoir.

III. *Lower Ludlow Rock.*—Equivalent, "Die Earth."

This group is chiefly made up of incoherent, grayish, argillaceous schist, seldom micaceous. The higher strata are in some places charged with many Orthocerata of new and undescribed species, Lituites, *Asaphus caudatus*, &c. Other beds are locally distinguished by concretions of argillaceous limestone, formed around corals and other organic bodies; and towards the base of this deposit a thin calcareous zone is observable in Shropshire, containing the *Pentamerus lævis* and a new species of that bivalve, both differing from the species noted in the overlying group 2. The thickness is supposed to exceed 2000 feet.

The dislocations and faults on the Severn are described, by which this unproductive shale or "Die Earth" is brought in one point into unconformable contact with, and in another passes conformably beneath, the coal fields of Madeley and Brosely.

IV. *Shelly Sandstones.*—Equivalent, ———?

Red and green colours predominate in these sandstones, although purple and white are also frequently observed; by which characters, as well as by the nature of the stone and the specific differences in the organic remains, this formation is clearly distinguished from any of the overlying groups. Associated with the sandy strata are calcareous bands, almost made up of Productæ, Leptænæ, and Spiriferi, with crinoidal remains, all differing from those in the superior deposits. In Shropshire this formation rises at low angles from the valleys of lower Ludlow rock or Die Earth, and occupies separate ridges on the south-eastern flanks of the Wrekin and the Caer Caradoc. By a rough estimate 1500 to 1800 feet are assigned to the depth of the deposit.

V. "*Black Trilobite Flagstone,*" *&c.*—Equivalent, ———?

The prevailing Trilobite in this formation is the large *Asaphus Buchii*, which with the other associated species is never seen in any of the overlying groups. In the mountain called the Longmynd, this flagstone is made up of black schists, hard and dark-coloured grauwacke sandstone, &c., in which Trilobites have not yet been observed, although they are abundantly characteristic of the same zone in its prolongation through Radnor, Brecknock, and Caermarthen shires, where these fossils occur in black limestone and calcareous flagstone and grit. The thickness of this formation probably exceeds that of any one of the superior groups.

VI. *Red Conglomerate, Sandstone, and Slaty Schist.*

This is a vast deposit of several thousand feet in thickness, consisting of very coarse, quartzose conglomerates, which alternate with some schistose beds and much purple-coloured sandstone (Compound Sandstone of Townson), the strata of which in Haughmond, Pulverbatch, and Linley Hills, Shropshire, are highly inclined or vertical, in conformity with those of the preceding formation. No organic remains have been observed, by which, and by its very peculiar mineral structure, this formation is shown to be entirely distinct from the preceding groups.

The above six deposits are all exhibited in Shropshire, trending from N.E. to S.W., and occupying distinct ridges and valleys. In their further prolongation to the S.W. the upper Ludlow rock is uniformly persistent. Strata lithologically similar and containing the same fossils are found invariably to rise from beneath the old red sandstone in the counties of Hereford, Radnor, Brecknock, and Caermarthen; sometimes at very low angles of inclination, while at others, as in the promontories near Ludlow and Brecon, they are thrown up into saddles, and at the south-western limit of Brecknock and Caermarthen shires they are vertical or very highly inclined.

The second deposit, or Wenlock (Dudley) limestone, thins out a little to the S.W. of Aymestrey, and the groups 1 and 3 being brought together, generally occupy the same lofty escarpment in their course through S. Wales. Hence the author suggests the term Ludlow formation (the upper and lower Ludlow rock being subordinate members), as applicable to all the higher portion of this series which has a tripartite character in Salop and Hereford, due to the interpolation of the Wenlock and Aymestrey limestone.

The deposits 4, 5, and 6, are three separate formations, entirely differing from each other, and from the Ludlow formation, in their characters, mineral and fossil, and in the distinctness of their physical demarkations. They are not, however, to be traced continuously in their course from Shropshire on the N.E. to Caermarthenshire on the S.W.; though they reappear at intervals on that strike, preserving their relative places in the geological series.

In those districts where parallel ridges of all these formations are brought to day within a zone of small breadth, rocks of trappean or igneous origin are usual accompaniments, as in the neighbourhoods of the Wrekin and Caer Caradoc, in Shropshire; and again, after a long interval, in the environs of Old Radnor, Builth and Llandegley. In the intervening and featureless tracts of Clun, Knuckless and Radnor forests, where such intrusive rocks are absent, the Ludlow formation alone is spread out in undulating masses, and upon its surface are frequently found detached and elevated basins of old red sandstone.

The heights of the different groups above the sea-level vary from 500 to 2000 feet.

The author reserves for the third part of his memoir, which he proposes to communicate on a future occasion, the description of the numerous trappean and porphyritic rocks, which, in penetrating through these grauwacke deposits, have produced changes in their mineral aspect and structure. On that occasion the question of the parallelism of these sedimentary groups will be reviewed in reference to the direction of the outbursts of rocks of igneous origin. The quartz rock on the flanks of the Wrekin and Caer Caradoc, and also in the singular ridge of the Stiper Stones, will be described under the head of "Altered Rocks." The relations of the formations on the eastern side of Herefordshire will also be explained, with the view of determining whether deposits of the same age and character rise from beneath the old red sandstone in the flanks of the Malvern Hills, &c., as have been shown to exist on the opposite or western side of the great field of old red sandstone.

May 1.—A paper was first read, entitled, "Notice of a Machine for regulating high temperatures, invented by the late Sir James Hall, Bart., F.G.S.," and drawn up by Captain Basil Hall, R.N., F.G.S. &c.

A letter was afterwards read from Mr. Telfair to Sir Alexander Johnstone, V.P.R.A.S., accompanying a specimen of recent conglomerate rock, from the Island of Madagascar, containing fragments of a tusk, and part of a molar tooth of a hippopotamus; and communicated by Roderick Impey Murchison, Esq. F.G.S.

---

## ROYAL ASTRONOMICAL SOCIETY.

May 10.—The following communications were read:—

On the Latitude and Longitude of the Cape Observatory. By Mr. Henderson.

In this paper Mr. Henderson assumes the geographical position of the Cape Observatory to be 33° 56′ 3″ south latitude; $1^h\ 13^m\ 56^s$ east longitude from Greenwich; the former being determined from his own observations, and the latter from those of Mr. Fallows compared by Mr. Henderson with the corresponding observations made at European observatories. From the determination of the longitude of the Cape Observatory here stated, compared with observations made by Lieut. Meadows and by Capt. Owen, Mr. Henderson also finds that the longitudes of the two Capes which inclose False Bay may be stated as follows:—

| | |
|---|---|
| Cape of Good Hope . . . . . . | 18° 29′ 0″ |
| False Cape . . . . . . . . . . . . | 18 50 30 east of Greenwich. |

"This longitude of the Cape Point," Mr. Henderson observes, "differs only one mile from that given by La Caille (16° 10′ east of Paris—*Memoirs of Academy of Sciences* for 1751, p. 425); and it is but justice to the memory of that distinguished astronomer to remark, that the lapse of eighty years, and the superior means which the present state of the science affords, have not been able to produce any improvement in the geographical position of this part of the world, as determined by him."

Positions of Stars near the South Pole, from Observations made at the Observatory at the Cape of Good Hope; also by Mr. Henderson.

There being no conspicuous star near the South Pole, which can be observed in the day-time, even with the most powerful meridian telescopes that are used in observatories, it becomes necessary, in the southern hemisphere, for the purpose of determining the polar positions of astronomical instruments, to have recourse to stars of less magnitude than those which are observed for that purpose in the northern hemisphere, and even to increase their number, in order that one or more of them may pass the meridian at a convenient time of the night. Since Mr. Henderson's arrival at the Cape Observatory, in April 1832, seven circumpolar stars have been frequently observed with Dollond's 10-feet transit telescope, and Jones's 6-feet mural circle, for the purpose of determining the positions of those instruments with regard to the Pole. Of the stars whose places have been thus determined, believing that their positions may be of considerable use to astronomers, Mr. Henderson now communicates a Catalogue, exhibiting their mean positions reduced to the beginning of 1832 (fictitious year of the Astronomical Society's Catalogue). This Catalogue, under the title of " Positions of Stars near the South Pole for the beginning of 1832," is given in the "Monthly Notices" of the Society for May.

Various Observations made at the Cape Observatory, by Mr. Henderson, Mr. Meadows, and Mr. Fayrer: viz. observed right ascensions of the moon and stars 1832, April 10 to October 17, inclusive; observations of the moon and stars, made with the mural circle, for the determination of the moon's parallax; 1832, July 20, to January 2, 1833,—of Mars and stars, made with the mural circle, for the determination of the parallax of Mars: eclipses of Jupiter's satellite, 1832, April 12 to October 19; occultations of planets and fixed stars by the moon, 1832, August 10 to October 31; and the transit of Mercury, May 4 and 5, 1832.

A paper on the Solar Parallax. By Mr. Shires.

On the Determination of the true Heights of distant Mountains from their apparent elevations above the sea. By G. Blackburne, B.A.

The object of this investigation is to furnish a convenient formula for the computation of the terrestrial refraction in terms of the distance of the observer from the object, and the apparent elevation; and secondly, for the computation of the true height of the object itself.

June 14.—The following communications were read, some of which we shall further notice in our next Number.

I. Observations of Biela's Comet, from Nov. 18, 1832, to Jan. 3, 1833. By T. Henderson, Esq., Astronomer at the Cape of Good Hope.

II. Various Observations made at the Observatory of the Cape of Good Hope. Communicated by T. Henderson, Esq.

This series of observations, made at the Cape Observatory by Messrs. Henderson and Meadows, is a continuation of those already communicated, as noticed above.

III. Observations of *Mars*, and Stars observed with *Mars*, near the Opposition, between Oct. 14, and Dec. 22, 1832, at the Observatory, St. Helena. By Lieut. Johnson.

IV. Observations of the Magnitude, Colour, and Brightness of Stars in the Southern Hemisphere. By James Dunlop, Esq., Astronomer at Paramatta.

V. Observations of several Meridian Transits of the Moon. By the Rev. M. Ward.

VI. Observations of Occultations and Eclipses made in the year 1832, at Biggleswade, with the Wollaston Telescope. By T. Maclear, Esq.

VII. Description of a small Observatory erected at Biggleswade. By T. Maclear, Esq.

VIII. An Approximate Method of finding the Latitude from two Altitudes observed near the Meridian, with the interval of time. By Lieut. Raper.

IX. Notice of the Elliptic Orbit of $\xi$ *Boötis*, with a further Approximation to the Orbit of $\gamma$ *Virginis*. By Sir John Herschel.

X. On the Adoption of a Standard of Optical Power by Observers. By the Rev. W. R. Dawes.

XI. Description of a Double Reflecting Circle, and of a Quadruple Reflecting Sextant, made by Mr. Jones, of Charing Cross, under the direction of Captain W. F. Owen, R.N., and presented by the latter to the Society.

XII. Transits of the Moon with Moon-culminating Stars observed at Cambridge Observatory, in the months of March, April, May, and June, 1833.

Agreeably to the intention expressed in vol. ii. p. 476, we now return to some prior meetings of the Society, during the present year, which have not hitherto been noticed in the Philosophical Magazine, in order to complete our calendar of its proceedings.

February 8.—At the Annual General Meeting holden this day, being the Thirteenth, the Report of the Council was read, the Gold Medal was presented to Professor Airy, for his paper "On an irregularity of long period in the motions of the Earth and Venus," published in the Philosophical Transactions for 1832, (of which an abstract was given in Phil. Mag. and Annals, N.S., vol. xi. p. 117 : see also Lond. and Edinb. Phil. Mag., vol. i., p. 61.) and the following Fellows were elected the Council and Officers for the ensuing year: viz.

*President:* Francis Baily, Esq., V.P.R.S.—*Vice Presidents:* George Biddel Airy, Esq., M.A., Plumian Prof. Ast. University of Cambridge; Captain F. Beaufort, R.N. F.R.S.; Davies Gilbert, Esq., F.R.S.; John William Lubbock, Esq., M.A. V.P. and Treas. R.S.—*Treasurer:* John Lee, Esq., LL.D.—*Secretaries:* George Bishop, Esq.; Augustus De Morgan, Esq.;—*Foreign Secretary:* Captain W. H. Smyth, R.N. F.R.S.—*Council:* Bryan Donkin, Esq.; Lieut. Thomas Drummond, R.E.; Thomas Jones, Esq.; Rear Admiral Sir Edward Owen, K.C.B.; Lieut. Henry Raper, R.N.; Edward Riddle, Esq.; Rev. Richard Sheepshanks, M.A. F.R.S.; Robert Snow, Esq., B.A.; Lieutenant William S. Stratford, R.N. F.R.S; Thomas Turner, Esq. M.A.

April 12.—(continued from vol. ii. p. 475.) Of the researches detailed and discussed in Professor Airy's paper "On the Mass of Jupiter" read at this meeting, we have already given a summary account, at p. 314 of our last volume. Some particulars of the numerical errors discovered by the author in the *Mécanique Céleste*, and his final statement and estimate of the value of his own results, we now subjoin.

"I had at first no intention of correcting, or even examining the numbers of the *Mécanique Céleste*; but an examination simply for the verification of the typographical accuracy, led me to doubt the correctness of several of the numbers in page 94 of the fourth volume, and of those which depend on them. On further examination, I found that the variable terms, both of the radius vector and longitude, as far as I examined, were nearly correct; but that in the constant parts of the radius vector some terms were wrong in sign, one erroneous in magnitude, and one omitted. I corrected these, and then proceeded in the construction of my tables."

"In the first instance, however, to which I applied the calculations, I found, to my great astonishment, that, at the time when I had observed the satellite at extreme elongation, the tables represented it as between the earth and *Jupiter*. I satisfied myself that this was owing to no error in my own calculations, and I then compared Laplace's numbers with those of Halley and Delambre. From the tables of the former I could only infer that there was some very strange error in Laplace's epoch for 1750; from the mean conjunctions of the latter I could calculate its quantity. It will scarcely be believed, that the epoch of mean longitude in page 139 of the fourth volume of the *Mécanique Céleste* is erroneous to the amount of nearly one third of the circumference, and that this is not a typographical error, as several numbers are combined with it by addition and subtraction in the pages following it, and all correctly. I confess that my faith in the *numerical* results of the *Mécanique Céleste* has been very much weakened by these discoveries."

"At the same time, I am far from imputing any negligence to the author of that great work; for I know too well the difficulty of insuring correction in long calculations from complex formulæ: and in some of the fundamental numbers of the present computations I was saved from error only by Mr. Lubbock's re-calculations."

A list of the errata in the *Mécanique Céleste* is appended to the memoir.

Returning to Professor Airy's own researches, it is stated,—

"After applying two small corrections, one for the clock rate during the observations, and the other for obtaining the whole mass of the Jovial system, Professor Airy concludes, that we have for the log. mass of the Jovial system 6·9793486, and for the mass $\frac{1}{1048 \cdot 70}$."

"In conclusion I may remark, that I do not think this value liable to any serious error, except from a possible error in the inclination of the orbit of the fourth satellite. The effect of the greatest error of the instrument in azimuth (0′·5) that any observations have shown, acting at the greatest disadvantage, would not alter the denomination of the fraction by 0·2. But the observations used here have been made when *Jupiter* was in the most unfavourable of all positions, both from the effect of such errors, and from the smallness of the difference of right ascension, which is the immediate subject of the measures. The oppositions of 1834-5 and 1836 will be very much more favourable."

"I am far from regarding the question as definitively settled by these measures; and I offer these results to the Society as only the first fruits of my investigations. Should the regular business of the Observatory, and my other employments, leave me sufficient leisure, I hope to add considerably to their number. The necessary tables and forms of calculations are prepared; some theoretical and numerical difficulties have been surmounted; and the labour of calculating future observations will therefore be very much less than that of calculating the first."

### PHILOSOPHICAL SOCIETY OF CAMBRIDGE.

May 20.—The following communications were read:—

On the Attraction of Spheroids, by G. Green, Esq. In this paper the author presents certain analytical formulæ, in reference to triple integrals of a more general form than those offered in the attractions of spheroids of arbitrary form and density, and applies them to the problem of the attractions of ellipsoids, so as to comprise the actions on points, internal and external, in a common process, by the addition of a positive quantity, under the radical sign in the expression, for the reciprocal distance between the point acted on and any point of the ellipsoid, which quantity is afterwards made to vanish.

On the Determination of the Vibratory Motion of Elastic Fluids in Tubes of definite Length, by W. Hopkins, Esq. of St. Peter's College. The author described a series of experiments made by him with the view of subjecting to an experimental test the different solutions which have been given of this problem. The intensity of the vibrations in any part of the tube are indicated to the eye by the motion which those vibrations excite in a delicate membrane, sprinkled with light sand, and suspended in the tube. The positions of the nodal points, thus determined with great accuracy, are not such as accord with any solution of the problem hitherto given; but it was shown how all the observed phænomena are accounted for by the assumption of certain physical conditions more general than those assumed by previous writers.

An experiment was also exhibited by Mr. Hopkins, showing the effect of the interference of two aërial undulations proceeding in the *same* direction. The ends of two equal tubes, branching off from one common tube, are placed close to two ventral segments of a vibrating plate, by which the vibrations are excited in the branch tubes and interfere in the one with which they communicate. If the vibrations proceeding from the two ventral segments be in the same phase, the resulting vibration is one of great intensity; but if they are in opposite phases no sensible vibration results from them. The intensity of the vibration is indicated, as above mentioned, by a membrane which may be stretched over the mouth of the tube.

## XLII. *Intelligence and Miscellaneous Articles.*

### COMPOUNDS OF CHROMIC ACID WITH METALLIC CHLORIDES.

M. E. PELIGOT has formed several compounds of chromic acid with metallic chlorides. The bichromate of chloride of potassium is easily and œconomically produced by boiling a mixed solution of bichromate of potash and muriatic acid for some time; on cooling, a quantity of the salt in question crystallizes, in proportion to the quantities of ingredients employed.

According to M. Peligot the theory of the formation of this salt is as follows: the muriatic acid at first acts upon the potash of the bichromate, and forms chloride of potassium, and water, and at the same time free chromic acid is developed. If, when all the potash has been converted into chloride of potassium and water, the solution is allowed to cool, it soon deposits large crystals of bichromate of chloride of potassium; so that all the bichromate of potash is converted into water and bichromate of chloride of potassium before the muriatic acid, supposed to be in excess, produces protochloride of chrome, which only happens by the decomposition of the salt which is formed.

The atomic reaction is thus given:—

| Atoms employed. | | Atoms produced. | |
|---|---|---|---|
| 2 atoms chromic acid | 1304 | 2 atoms chromic acid...... | 1304 |
| 1 atom potash...... | 589 | 1 atom chloride of potassium | 931 |
| 2 atoms muriatic acid | 454 | 1 atom water ............ | 112 |
| | 2347 | | 2347 |

The principal properties of this salt are, that it crystallizes very easily; the crystals are right prisms with rhombic bases; their colour is similar to that of bichromate of potash; they do not deliquesce. The action of water on this salt is remarkable: when a crystal is moistened with it, it becomes white and opake; and if the solution be suffered to evaporate spontaneously, no crystals of the salt in question are obtained; but merely those of bichromate of potash. This latter salt is, indeed, produced whether the liquor be concentrated by heat, or exposed to spontaneous evaporation. It appears, then, that water is decomposed by the bichromate of chloride of potassium: its hydrogen combines with the chlorine to form muriatic acid which becomes free, while its oxygen unites with the potassium.

This reaction produces precisely the products employed before the formation of the bichromate of the chloride, and the nature of the operation will be shown by transposing the atoms above given:

| Atoms employed. | | Atoms produced. | |
|---|---|---|---|
| 2 atoms chromic acid . . . . | 1304 | 2 atoms chromic acid . . | 1304 |
| 1 atom chloride of potassium | 931 | 1 atom potash . . . . . | 589 |
| 1 atom water . . . . . . . . | 112 | 2 atoms muriatic acid . . | 454 |
| | 2347 | | 2347 |

By the addition of a sufficient quantity of muriatic acid, to correct the oxidizing action of the water, the bichromate of the chloide is reproduced. On account of this action of the water, it is impossible to purify this salt by crystallization: it is requisite to press it between folds of blotting paper: it almost always contains a slight excess of chlorine.

The most œconomical process for obtaining this salt has been already stated; it may also be obtained, and in a more direct manner, by mixing 2 atoms of chromic acid with 1 atom of chloride of potassium, provided the solution be rendered acid by muriatic acid. It may be procured also by treating bichloride of chrome with water saturated with chloride of potassium; and in this case all the conditions favourable to its formation are fulfilled, for the water converts the bichloride of chrome into chromic and muriatic acid. If neutral chromate of potash be used instead of the bichromate, the crystals obtained are mixed with crystals of chloride of potassium.

The following process of analysis was preferred and employed on account of its simplicity:—A portion of the salt, dried between the folds of blotting paper, was dissolved in distilled water acidified by nitric acid, and nitrate of silver was then gradually added, and the chloride obtained was washed, dried and weighed. The liquor, after the separation of the chloride of silver, was boiled with sulphurous acid; this converts the chromic acid into protoxide of chrome, and is itself converted into sulphuric acid: ammonia then precipitates protoxide of chrome by long boiling. The potash was then converted into sulphate by means of sulphuric acid, and its quantity thus determined.

The bichromate of muriate of ammonia resembles that of chloride of potassium in appearance and crystalline form, but it is much more soluble in water. By analysis it yielded—

| | |
|---|---|
| Chromic acid . . . . . | 65·5 |
| Muriatic acid . . . . . | 23·5 |
| Ammonia . . . . . . | 10·8 |
| | 99·8 |

M. Peligot found that the bichromates of the chlorides of sodium, calcium, and magnesium were deliquescent: he was unable to procure the bichromates of the chlorides of strontium and barium, on account of the precipitation of their salts from water by the muriatic acid.—*Ann. de Chim. et de Phys.* lii. 267.

## ON FOSSIL-BONE CAVERNS.

M. Tournal, jun., of Narbonne, concludes from a great variety of facts and observations, that,

1st, The bones buried in caverns have been introduced in several different manners.

2ndly, The species buried vary in different localities; and this difference depends either upon the period of deposition or the geographical position of the cavern.

3rdly, Man was contemporary with the lost species of animals which are found buried in the mud of the caverns; and these animals being regarded by all naturalists as fossil, man therefore exists in the fossil state.

4thly, The mud and pebbles found in the bone caves were not introduced by any sudden and temporary cause, as by a deluge, but on the contrary, almost always slowly, and in several different modes.

5thly, The attentive examination of the pebbles contained in the mud proves evidently that they have been introduced from neighbouring places, and consequently, that the cause which conveyed them was entirely local.

6thly, The period during which the bone caves were formed was extremely long.

7thly, In certain caverns, the mud, bones, and pebbles have been simultaneously introduced; in others, on the contrary, the mud has been deposited after the bones.

The bones of the following animals have been found in the caverns of the South of France:—

Elephant.
Rhinoceros.
Wild Boar.
Horse.
Ox, two species.
Stag, five species.
Antelope, very large.
Chamois.
Hyæna, fossil.
Hyæna, striped.
Hyæna, brown.
Dog, two species.
Goat.
Sheep.
Bear, at least two species.
Badger.
Tiger.
Lion.
Leopard.
Lynx.
Wolf.
Fox.
Weasel.
Pole-cat.
Hare.
Rabbit.
Lagomys.
Campagnol.
Birds, several species.
Land Tortoise.
Lizard (*Lacerta ocellata*).
Snake, size of the *Coluber Natrix.*

The only difference which exists between the caves of England and Germany, compared with those of the South of France, is, that in England the hippopotamus has been found, and at Sandwik in Westphalia, the glutton.—*Ann. de Chim. et de Phys.* lii. p. 161.

### ON THE VISIBILITY OF STARS BY DAY.

Sir John Herschel, in his popular Treatise on Astronomy (p. 63), notices the fact of stars being distinctly visible through the daylight by telescopes, their brightness being proportionate to the power of the instrument; but, which is unusual with that eminent author, he omits to explain the reason.

If the following be not the true reason, perhaps correspondents of the Philosophical Magazine will be kind enough to correct me.

The rays of day-light which enter the object-glass of a telescope must, from our proximity to the points of their reflection, be much more divergent than the rays of a distant star; consequently none of the former rays can be converged to so short a focus as the latter. Hence, if a telescope be so adjusted as to bring the "parallel" rays from a distant star to a focus, none of the divergent rays from the nearer atmosphere can be condensed at the same or so short a focus, and the atmospheric light within the tube cannot much interfere with the concentrated light of the star. As we cannot, while looking through a telescope at a distant ship, see the flame of a candle, or cross wires, held immediately before the object-glass, by reason of the nearer flame or wires' requiring a longer focus than the distant ship, so for the same reason we cannot, while looking through a telescope at a distant star, see the nearer light of the atmosphere which partially intercepts it. In either case that which intervenes produces no other effect than a partial obscuration of the distant object.

Sir J. Herschel notices also the fact of bright stars in the zenith being visible in the day-time, even by the naked eye, from the bottoms of deep narrow pits, or through the shafts of chimneys. May not this be owing to the divergent rays of the atmosphere spreading and losing themselves against the non-reflecting sides of the pit or shaft, so that few or none of them ever reach the bottom; while, on the contrary, all the rays from the star which enter the vertical pit proceed to its bottom without the least sensible divergence?

Redruth, July 13, 1833. RD. EDMONDS Jun.

---

## LEYBOURN'S MATHEMATICAL REPOSITORY.

The twenty-fourth Number of this valuable Work is just published, and contains the following articles:—

1. *Nugæ,* or Constructions to represent approximately the length of the circumference of a Mile.
2. Solutions of the twenty Mathematical Questions proposed in No. 22; by various Contributors.
3. New Solution to Question 531 (relating to the Αρβηλον of Archimedes), and some collateral properties of the figure; by T. S. Davies, Esq. F.R.S. Lond. & Ed.
4. Memoir of the late Sir John Leslie, K.H.
5. Notices relating to the Mathematical Parts of the Philosophical Transactions, the Transactions of the Royal Society of Edinburgh, Transactions of the Cambridge Philosophical Society, and the *Journal de l'E'cole Polytechnique.*
6. On indeterminate Problems; by James Cunliffe, Esq.
7. Supplement to the Lunar Theory; by the Rev. Brice Bronwin.
8. On the Computation of Surfaces and Solids bounded by lines and planes passing through points, by means of the coordinates of those points; by Mr. Woolhouse.
9. New Researches in Spherical Trigonometry; by T. S. Davies, Esq.
10. On the Deviation of two Curves, in answer to a note of Mr. Woolhouse, inserted in the last Number; by T. S. Davies, Esq.
11. On a partial Differential Equation; by W. Sutcliffe, Esq. A.M., Bath.
12. On the Figure of a homogeneous Mass of Fluid revolving about an axis with a given uniform Velocity; by the Rev. Brice Bronwin.
13. Translation of Dr. Matthew Stewart's Extension of Prop. 4. Lib. iv. of the Mathematical Collections of Pappus (concluded).
14. Certain Properties of Plane Triangles not generally known; by C. F. A. Jacobi.
15. Twenty new Mathematical Questions for solution in No. 26; by various Contributors.

### *Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London; by Mr. GIDDY at Penzance, and Mr. VEALL at Boston.*

| Days of Month, 1833. | Barometer. | | | | | Thermometer. | | | | | Wind. | | | Rain. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | London. | | Penzance. | | Boston $8\frac{1}{2}$ A.M. | London. | | Penzance. | | Bost. $8\frac{1}{2}$ A.M. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
| | Max. | Min. | Max. | Min. | | Max. | Min. | Max. | Min. | | | | | | | |
| July 1 | 29·873 | 29·831 | 29·916 | 29·819 | 29·19 | 66 | 40 | 58 | 48 | 58 | W. | NW. | W. | 0·20 | 0·280 | ... |
| ○ 2 | 29·998 | 29·919 | 29·969 | 29·966 | 29·35 | 76 | 45 | 60 | 48 | 58 | SW. | NW. | W. | ... | ... | ... |
| 3 | 30·121 | 30·014 | 30·116 | 29·966 | 29·48 | 69 | 44 | 62 | 47 | 58 | W. | W. | NW. | ... | ... | ... |
| 4 | 30·178 | 30·168 | 30·113 | 30·033 | 29·12 | 75 | 51 | 62 | 54 | 65 | W. | W. | calm | ... | ... | ... |
| 5 | 30·167 | 29·997 | 30·013 | 29·904 | 29·54 | 76 | 49 | 66 | 55 | 68·5 | SW. | SE. | calm | ... | ... | ... |
| 6 | 29·857 | 29·656 | 29·657 | 29·560 | 29·28 | 77 | 50 | 63 | 55 | 73 | SE. | NW. | SE. | ·01 | ·200 | ... |
| 7 | 29·767 | 29·612 | 29·660 | 29·560 | 29·02 | 68 | 55 | 64 | 50 | 73 | S. | NW. | calm | ·20 | ... | ... |
| 8 | 30·022 | 29·808 | 29·954 | 29·860 | 29·20 | 71 | 52 | 66 | 51 | 68·5 | W. | NW. | E. | ·24 | ... | ... |
| 9 | 30·108 | 30·080 | 30·107 | 30·104 | 29·51 | 73 | 45 | 68 | 55 | 58 | N. | NW. | NE. | ... | ... | ... |
| ☾ 10 | 30·031 | 29·959 | 30·104 | 30·004 | 29·46 | 76 | 51 | 69 | 56 | 54 | NW. | NW. | calm | ... | ... | ... |
| 11 | 29·992 | 29·894 | 30·004 | 30·004 | 29·36 | 69 | 53 | 64 | 55 | 65 | N. | NW. | E. | ... | ... | ... |
| 12 | 29·899 | 29·852 | 29·857 | 29·857 | 29·33 | 61 | 50 | 60 | 53 | 57·5 | NE. | NW. | calm | ... | ·125 | ... |
| 13 | 29·921 | 29·854 | 29·910 | 29·904 | 29·43 | 64 | 47 | 65 | 55 | 58 | SW. | NW. | NE. | ... | ... | ... |
| 14 | 30·002 | 29·958 | 29·907 | 29·854 | 29·46 | 73 | 54 | 63 | 53 | 63 | SW. | SW. | calm | ... | ·920 | ... |
| 15 | 30·131 | 30·006 | 30·054 | 29·910 | 29·47 | 75 | 45 | 65 | 53 | 65 | NE. | SE. | calm | ... | ... | ... |
| 16 | 30·211 | 30·194 | 30·154 | 30·110 | 29·61 | 79 | 50 | 68 | 53 | 64 | E. | NE. | calm | ... | ... | ... |
| ● 17 | 30·220 | 30·194 | 30·154 | 30·148 | 29·55 | 84 | 55 | 70 | 55 | 66 | NW. | NE. | calm | ... | ... | ... |
| 18 | 30·162 | 30·011 | 30·148 | 30·048 | 29·44 | 81 | 57 | 70 | 54 | 72 | W. | SE. | calm | ·02 | ... | ... |
| 19 | 29·906 | 29·772 | 29·948 | 29·848 | 29·20 | 76 | 57 | 66 | 57 | 66 | SW. | NW. | W. | ... | ·055 | ... |
| 20 | 29·671 | 29·618 | 29·804 | 29·804 | 28·95 | 70 | 48 | 63 | 55 | 64·5 | W. | NW. | NW. | ·18 | ·060 | ... |
| 21 | 29·877 | 29·778 | 29·904 | 29·860 | 29·12 | 70 | 46 | 63 | 53 | 63 | W. | NW. | NW. | ·05 | ... | ... |
| 22 | 29·835 | 29·697 | 29·857 | 29·798 | 29·17 | 73 | 54 | 65 | 54 | 58 | S. | SW. | W. | ·26 | ·040 | 0·10 |
| ☽ 23 | 29·912 | 29·638 | 29·945 | 29·704 | 29·13 | 70 | 48 | 64 | 57 | 63 | SW. | SW. | W. | ·40 | ·130 | ... |
| 24 | 30·196 | 30·024 | 30·098 | 30·024 | 29·43 | 75 | 48 | 65 | 53 | 60·5 | W. | N. | W. | ... | ... | ... |
| 25 | 30·327 | 30·281 | 30·210 | 30·198 | 29·68 | 77 | 45 | 67 | 52 | 63 | W. | N. | W. | ... | ... | ·30 |
| 26 | 30·311 | 30·250 | 30·204 | 30·198 | 29·70 | 80 | 57 | 69 | 53 | 63·5 | SW. | SE. | W. | ... | ... | ... |
| 27 | 30·265 | 30·255 | 30·204 | 30·192 | 29·60 | 86 | 57 | 71 | 54 | 70 | N. | SE. | W. | ... | ... | ·12 |
| 28 | 30·287 | 30·257 | 30·198 | 30·166 | 29·62 | 82 | 51 | 73 | 57 | 70·5 | E. | NE. | calm | ... | ... | ·08 |
| 29 | 30·328 | 30·308 | 30·172 | 30·166 | 29·69 | 79 | 50 | 72 | 58 | 67 | E. | NE. | calm | ... | ... | ... |
| 30 | 30·458 | 30·423 | 30·246 | 30·212 | 29·83 | 79 | 47 | 74 | 57 | 62 | NE. | NE. | calm | ... | ... | ... |
| ○ 31 | 30·429 | 30·351 | 30·292 | 30·286 | 29·83 | 79 | 47 | 68 | 57 | 61 | NE. | NE. | calm | ... | ... | ... |
| | 30·458 | 29·612 | 30·292 | 29·560 | 29·41 | 86 | 40 | 74 | 47 | 63·7 | | | | 1·46 | 1·810 | 0·60 |

Remarks.

*London.* — July 1. Fine: heavy rain, and a hail shower about 7 P.M.: clear at night. 2. Fine. 3. Fine: thunder. 4, 5. Fine. 6. Very dry. 7. Cloudy: sultry with showers. 8. Heavy rain at noon: cloudy and rather windy at night. 9—11. Fine. 12. Dry haze: fine. 13. Overcast: fine. 14—19. Very fine. 20. Fine: cloudy: showery. 21. Cloudy: showery: fine. 22. Rain: clear. 23. Cloudy: rain. 24—26. Very fine. 27. Very hot: thermometer 86° in shade. 28, 29. Very hot. 30. Cloudy: fine. 31. Overcast: clear and fine.

*Penzance.* — July 1. Showers. 2. Fair. 3. Misty: fair. 4, 5. Fair. 6. Fair: rain. 7. Fair. 8, 9. Clear. 10, 11. Fair. 12. Rain: fair. 13. Fair. 14. Fair: rain. 15. Fair. 16, 17. Clear. 18. Clear: fair. 19, 20. Clear: showers. 21. Fair. 22. Showers: fair. 23. Rain: fair. 24—31. Clear.

*Boston.* — July 1—4. Fine. 5. Cloudy. 6, 7. Fine. 8—10. Cloudy. 11. Fine. 12, 13. Cloudy. 14, 15. Fine. 16, 17. Cloudy. 18. Fine. 19. Cloudy. 20. Fine. 21. Fine: rain P.M. 22. Cloudy. 23. Fine. 24. Fine: rain P.M. 25. Fine. 26, 27. Fine: rain P.M. 28, 29. Fine. 30, 31. Cloudy.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

*OCTOBER* 1833.

## XLIII. *Notice of a Means of preparing the Organs of Respiration, so as considerably to extend the Time of Holding the Breath; with Remarks on its Application, in Cases in which it is required to enter an irrespirable Atmosphere, and on the Precautions necessary to be observed in such Cases. By* MICHAEL FARADAY, *Esq. D.C.L. F.R.S. &c. Fullerian Professor of Chemistry in the Royal Institution.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

THERE are many facts which present themselves to observant men, and which, though seen by them to be curious, interesting, and new to the world, are not considered worthy of distinct publication. I have often felt this conclusion to be objectionable, and am convinced that it is better to publish such facts, and even known facts under new forms, provided it be done briefly, clearly, and with no more pretension than the phænomena fairly deserve. It is this feeling which makes me send for your acceptance or rejection an account of an effect, new to me, and to all to whom I have mentioned it, and which seems to have some valuable applications.

At one of the scientific meetings at the apartments of His Royal Highness the President of the Royal Society, whilst speaking of certain men who, by means of peculiar apparatus for breathing, could walk about at the bottom of waters, and also of the pearl fishers, Sir Graves C. Haughton described to me an observation he had made, by the application of which a man could hold his breath about twice as long as under ordinary circumstances. It is as follows:—If a person inspire deeply, he will be able immediately after to hold breath for a time, varying with his health, and also very much with the state of exertion or repose in which he may be at the instant. A man, during an active walk, may not be able to cease from breathing for more than half a minute, who, after a period of rest on a chair or in bed, may refrain for a minute or a minute and a half, or even two minutes. But if that person will prepare himself by breathing in a manner deep, hard and quick, (as he would naturally do after running,) and, ceasing that operation with his lungs full of air, then hold his breath as long as he is able, he will find that the time during which he can remain without breathing will be double, or even more than double the former, other circumstances being the same. I hope that I have here stated Sir Graves C. Haughton's communication to me correctly; at all events whilst confirming his observation by personal experience, I found the results to be as above.

Whilst thus preparing myself, I always find that certain feelings come on resembling in a slight degree those produced by breathing a small dose of nitrous oxide; slight dizziness and confusion in the head are at last produced; but on ceasing to breathe, the feeling gradually goes off, no inconvenience results from it either at the time or afterwards, and I can hold my breath comfortably for a minute and a quarter, or a minute and a half, walking briskly about in the mean time.

Now this effect may be rendered exceedingly valuable. There are many occasions on which a person who can hold breath for a minute or two minutes, might save the life of another. If, in a brewer's fermenting vat, or an opened cesspool, one man sinks senseless and helpless, from breathing the unsuspected noxious atmosphere within, another man of cool mind would by means of this mode of preparation, which requires nothing but what is always at hand, have abundant time, in most cases, to descend by the ladder or the bucket, and rescue the sufferer without any risk on his own part. If a chamber were on fire, the difference in the help which could be given to any one within it by a person thus prepared, and another who goes in, perhaps, with lungs partially exhausted, and who, if he inhale any portion of the empyreumatic vapours of the atmosphere, is stimulated to inspire more rapidly, and is therefore urged to instant retreat into fresh air, is so great, that no one who has noticed what can be done in a minute or in two minutes of time can doubt the value of the preparation under such circumstances, even though from want of practice and from hurry and alarm it may be very imperfectly made. In cases of drowning, also, a diver may find his powers of giving aid wonderfully increased by taking advantage of Sir Graves Haughton's fact.

I have myself had occasion to go more than once or twice into places with atmospheres rendered bad by carbonic acid, sulphuretted hydrogen or combustion; and I feel how much I should have valued at such times the knowledge of the fact above stated. Hoping, therefore, that it may be useful, I will add one or two precautions to be borne in mind by those who desire to apply it.

Avoid all unnecessary action; for activity exhausts the air in the lungs of its vital principle more quickly, and charges it with bad matter. Go collectedly, coolly and quietly to the spot where help is required: do no more than is needful, leaving what can be done by those who are in a safe atmosphere (as the hauling up of a senseless body, for example,) for them to do.

Take the precautions usual in cases of danger in *addition* to the one now recommended. Thus, in a case of choke-damp, as in a brewer's vat, hold the head as high as may be; in a case of fire in a room, keep it as low down as possible.

If a rope is at hand, by all means let it be fastened to the person who is *giving* help, that he may be succoured if he should venture too far. It is astonishing how many deaths happen in succession in cesspools, and similar cases, for want of this precaution.

It is hardly needful to say, do not try to breathe the air of the place where help is required. Yet many persons fall in consequence of forgetting this precaution. If the temptation to breathe be at all given way to, the *necessity* increases, and the helper himself is greatly endangered. Resist the tendency and retreat in time.

Be careful to commence giving aid with the lungs *full* of air, not *empty*. It may seem folly to urge this precaution, but I have found so many persons who, on trying the experiment on which the whole is based, have concluded the preparation by closing the mouth and nostrils *after an expiration*, that I am sure the precaution requires to be borne in mind.

I have thought it quite needless to refer to the manner in which the preparation enables a person to increase so considerably the time during which he may suspend the operation of breathing. It consists, of course, chiefly in laying up for the time, in the cells of the lungs, a store of that vital principle which is so essential to life. Those who are not aware of the state of the air in the lungs during ordinary respiration, and its great difference from that of the atmosphere, may obtain a clearer notion from the following experiment. Fill a pint or quart jar with water over the pneumatic trough, and with a piece of tube and a forced expiration throw the air from the lungs in their *ordinary state* into the jar; it will be found that a lighted taper put into that air will be immediately extinguished.

A very curious fact connected with the time of holding the breath was observed by Mr. Brunel, jun., and has, I think, never been published. After the river had broken into the tunnel at Rotherhithe, Mr. Brunel descended with a companion (Mr. Gravatt, I think,) in a diving-bell, to examine the place: at the depth of about 30 feet of water, the bell touched the bottom of the river, and was over the hole; covering it, but too large to pass into it. Mr. Brunel, after attaching a rope to himself, inspired deeply, and sunk, or was lowered through the water, in the hole, that he might feel the frames with his feet, and gain further knowledge, if possible, of the nature of the leak. He remained so long beneath without giving any signal, that his companion, alarmed, drew him up before he desired; and then it was found that either of them could remain about twice as long under water, going into it from the diving-bell at that depth, as they could under ordinary circumstances.

This was supposed to be accounted for, at the time, by the circumstance that at the depth of 30 feet the atmosphere was of double pressure, and that the lungs, therefore, held twice as much air as they could do under common circumstances. It is, however, quite evident that another advantageous circumstance must have occurred, and that the air in the lungs was also better in quality than it would have been at the surface of the river, as well as denser; for supposing the deterioration by breathing to continue the same for the same time, it is clear that every inspiration passed into the lungs twice as much pure air as would have entered under common circumstances: the injured air must, therefore, have been removed more rapidly, and the quality of that at any one time in the lungs must have risen in consequence. When to this is added the effect of double quantity, it fully accounts for the increased time of holding the breath; and had the effect of the mode of preparation now described been also added, it is probable that the time would have appeared astonishingly increased.

I am, Gentlemen, yours, &c.

M. FARADAY.

# XLIV. *Some Observations on the Nature of Coal, and on the Manner in which the various Strata of the Coal-measures must probably have been deposited.* By GEORGE FAIRHOLME, *Esq.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

IN submitting the following observations to your notice, and to that of the readers of your very able and instructive periodical work, should you consider them worthy of a place in its pages, I am chiefly induced by the growing interest now so universally taken in geological subjects, and by the high importance which must always attach to such new facts, when they come to light, as bear forcibly upon the science of geology in general: and I feel persuaded that even a departure from received theories, if expressed with temperance, and supported by reasonable arguments, or by undeniable facts, will not have the effect of excluding from your pages opinions which, if unfounded, must thus become exposed to immediate refutation.

In the remarks which I propose to make upon the coal strata, I have no intention of entering upon the question which, at one period, occupied so much of the attention of geologists, with respect to whether that valuable substance was of *vegetable* or of *mineral* origin; for I imagine that it will be pretty generally admitted that this point has already been completely set at rest, by the discoveries of late years, both in geology and in chemistry, and that the vegetable origin of coal is now placed quite beyond dispute*. Everything, indeed, connected with coal, seems to tend to this important truth. Its immediate and invariable contact with stony strata, in which vegetable substances of every size, from the minutest grasses to the tallest trees, are so beautifully displayed; its bituminous

---

* I have lately had an opportunity of examining a great variety of coal, and have found a distinct vegetable texture in many different specimens; but the most obvious instance I have ever remarked is in the fine coal from Stobart's main near Sunderland, which exhibits in the cleavage, in every part, the appearance of crushed wood, like charcoal. From these and other specimens, I am led to conclude that the soiling quality of most coal is derived from the ligneous portions of it; and that, but for the existence of this substance, the clear and shining bituminous coal would be as clean in the hand as any other specimen of a mineral nature. In all the instances which I have observed, the transverse fracture was clear and brilliant, while between the laminæ the appearance of charcoal was displayed on the surface of each side.—[See our report of Mr. Hutton's paper on the structure and origin of coal, in the preceding volume, p. 302. —EDIT.]

character; its colour; its combustible nature, which is found in no other mineral; its frequently displaying a distinct ligneous texture; and, in corroboration of these, the conclusive experiments and reasoning of many able chemists;—all tend distinctly to prove that the arguments formerly maintained by some geologists, who considered it an original chemical formation, entirely unconnected with a vegetable origin, may now be classed amongst various other concessions which have, of late years, been made to the Wernerian theory.

Setting out, then, upon the principle that coal is, in every situation, *a mineralized vegetable substance*, and, consequently, that it derived its origin from successive depositions in water of the vegetable productions of former periods, it becomes a point of the highest interest to speculate upon the manner in which this deposition must have probably taken place; and upon the evidences which the attendant phænomena may exhibit, as to the period of time which was occupied in the process.

The first point which arrests our attention in the consideration of the coal-fields of every quarter of the world, is their being *invariably* situated in similar districts, and their exhibiting, on every scale of magnitude, the form of the *basin*. I am not aware of any exception to this fact in any part of the world in which coal has been discovered. In forming an idea, however, of those basin-shaped hollows in which the vegetable deposits have taken place, we must not be misled by attaching to them a great regularity, or roundness of form. On the contrary, the coal basins are found to be as diversified in form, as the various lakes and valleys now existing on the present surface of the earth. We find in some places such basins of not more than a mile in diameter, and which, in the hills of the West Riding of Yorkshire, are termed *swilleys*, filled like the larger basins with coal and its usual attendant strata. In other districts of greater extent the basin obtains the name of a *field*, extending over many miles of country, but differing in no other material degree from the smaller basins to which I have just alluded. These distinct basin-shaped deposits have greatly tended to support the theory of coal being a *lacustrine* formation, in the supposition that such basins were, at very remote periods, and for a prodigious lapse of years, filled with fresh water; and that the deposition of vegetable substances took place by a slow and very gradual process, and by the submersion of such vegetables as either grew on their shores, or were washed into them by rivers. This mode of accounting for the coal strata, which has long been considered as the most plausible by geologists, is open to insuperable objections, which must occur to the mind of every one who is adequate to the consideration of the present circumstances of inland lakes, even in the most thickly-wooded countries. But without dwelling upon these objections, I shall proceed to notice two facts which have but lately been brought to light, and which appear to me to be of the most conclusive nature, and utterly destructive of this long-received theory.

The first of these facts is the very recent discovery of extensive strata in the coal-fields, containing *sea shells* in great abundance, of which an interesting account has already appeared in your pages from the pen of Mr. J. Phillips, in your Number for November 1832. Nor are these marine strata so situated with respect to the beds of coal as to leave the smallest doubt of their having been actually deposited *by the sea.* They are found to extend over a very wide district, and it cannot therefore be for a moment supposed, that the sea-shells were, in a manner, *accidentally* introduced amongst what have hitherto been looked upon as fresh-water deposits. I have lately had presented to me specimens of sea-shells from a bed of coal shale near Wigan, in Lancashire; and as this locality is situated on the western margin of the same great coal-field which has been so ably traced by Mr. J. Phillips, as having an intermixture of marine strata, it appears probable that the specimens now in my possession have been derived from a continuation of the same beds; although I have not yet ascertained the particular situation in which they were found. These shells are bivalve, of about two inches in diameter, are much injured by pressure, but may still be distinctly defined. They appear to me to resemble most nearly the genus *Mactra*, and especially the *M. Lutraria* of Wood's Catalogue. So singular and conclusive a fact, although similar instances have not yet been brought to light in any great variety of cases, not only affects most materially the very foundation of the lacustrine theory, but even brings at least one portion of the coal strata distinctly within the catalogue of *marine* deposits; and when we consider that the existence of these marine strata has only lately become known, not in a new series of coal mines, but in a district supposed to be perfectly well known to geologists, we cannot but anticipate a speedy increase to our store of similar facts, as the lights of science begin to shed a more steady lustre on those who are most intimately connected with the coal districts.

The second class of facts to which I before alluded, have even a stronger bearing upon the *manner* of the coal deposits than these marine strata have upon their general character. I mean the existence of large entire trees, in various parts of the strata, *placed in a vertical position*, and intersecting, in many instances, a great variety of beds. It is scarcely necessary to enumerate the instances in which this remarkable position of the fossils has been observed. The facts connected with these vertical stems, *projecting through beds of coal, of shale, and of sandstone*, and assuming in a greater or less degree, the character of each bed with which they come in contact, must now be well known to all geologists; and it only appears surprising that the discovery of even one such fossil tree, in any well-defined coal district, should not have had the effect of utterly exploding from our systems the theory of a *slow and gradual deposition*, whether in salt or in fresh water. Such trees have sometimes been found with roots spreading, as it were, in their natural position, and they have in such cases been generally described as *in situ*, or as having originally *grown* where their stems are now found*. It seems altogether unnecessary to refute so extraordinary and unnatural an idea. For where, in the present course of things, are we to look for anything analogous on which to ground an argument? Where, in our existing lakes, are we to hope to find even the slightest indication of growing beds of coal *with intervening strata of sand or clay?* And even if such are to be found, where shall we find a tree of 50 or 60 feet in length, *in a growing state*, and enduring patiently the tardy process of *slow lacustrine deposition*, by which its lofty top shall be as well preserved for the inspection of future geologists, as the roots which are nourished in the loose sands which cover them?

Such considerations are, perhaps, sufficient to show the erroneous nature of our theories, with respect both to the *nature* and the *relative age* of the coal strata. We must of necessity either admit the *rapidity* of formation of such deposits as exhibit entire vertical trees intersecting from 50 to 70 feet of variously stratified rock, or we must produce, in the existing system of the world, some instances in the vegetable kingdom of *thousands of years' duration*, and so tenacious of life as to continue growing, and yet not materially increasing, while they become thus gradually covered up *in the bottoms of fresh-water lakes.*

But there is another most important consideration which belongs to this subject, and which militates with equal strength against the theory entertained by some, that deposits of coal have at all times been in progress on the earth, and must even

---

* For such a description, see the Annals of Philosophy for November 1820, where an account is given of a tree with roots discovered in the coal sandstone near Glasgow.—[See also a paper by Mr. Witham, in the Phil. Mag. and Annals, N.S., vol. vii. p. 23.—Edit.]

now be going on in the fresh-water lakes of every wooded region. If this had been the case in the very remote epochs assumed by many geologists, we never could have expected to have found the coal strata in the invariable position, with respect to other beds, in which they are actually placed. If, as some able writers have taught, the progress of nature has, in all past ages, been regular and uniform, fresh-water lakes must at all times have existed, vegetable deposits of coal must at all times have been in progress; and we should consequently have found such beds in every part, indiscriminately, of the surface of the earth. Such, however, is by no means the case; and no part of the geological system is more exactly defined than the nature of the districts in which coal may be expected to be found.

If we find, then, an insuperable argument against the theory of a *slow* deposition, in undefined periods of great extent, in these entire trees which intersect various parts of the coal-measures, to what species of action are we to attribute the *rapidity* of formation which these *carbonometers*, if I may so call them, so plainly indicate? Are we to ascribe this rapidity of action merely to the formation of the actual strata in which such trees have been found, or are we, on the contrary, to extend the principle, by fair analogy, to other portions of the series both *above* and *below* these interesting and instructive indexes? We may surely be permitted to reason from analogy, that if any one portion of an extensive series, exhibiting throughout a similarity of character, can be proved to demonstration to have been deposited in so short a space of time as to cover up and retain *in equal preservation* a vertical stem of 60 or 70 feet in length, the other portions of the same series must have been deposited in a manner extremely similar, if not strictly identical. If we have, then, a reasonable ground for such conclusion, can we continue to look upon the coal strata as lacustrine deposits, from fresh water, formed in the course of *thousands*, or as some think, of *millions* of years? It must be evident that either the facts to which I have alluded are erroneous, or the usual line of reasoning on the coal-measures must be unfounded. The facts, however, speak for themselves, and are fully open to the inspection of every one. It may therefore be fairly assumed that suspicion must rest upon the theories in question.

In the paper by Mr. J. Phillips to which I have already alluded, we find sections of the coal strata in the neighbourhood of Halifax and Leeds, in one instance amounting to about 50 yards, and in the other to upwards of 170. These sections, which are of the very same character as those of the mines of the North of England and the South of Scotland, contain no one stratum differing in any material degree from those through which tall and entire stems, of great diameter, have in numerous instances been found to penetrate *vertically*; and it is nearly certain, that if we could bring into one spot the various stems found at various depths in different parts of that coal-field, we should obtain a regular series of *measures* from the present surface of the ground down to the utmost depths of our coal mines. When we unite, therefore, the evidence adduced by these stems, and that of the *marine* strata in contact with the coal, we arrive at the natural conclusion, that instead of a long-continued and gradual process in the bosom of fresh-water lakes, these invaluable and interesting formations must have taken place *in the waters of the sea*, and by a *violent and rapid process*, at some period of unusual destruction in the vegetable kingdom.

Although no geological writer has yet, as far as I am aware, brought these *speaking witnesses* to bear with their full power upon the general theory of progressive formations, I find that my own opinion respecting them cannot be looked upon as singular; for Mr. Bakewell, in his very able "Introduction to Geology," makes the following remarks upon them, while treating of the coal-measures. "In some places where sections have been made in the sandstone strata accompanying coal, instances of fossil stems of large plants occur in *a vertical position*. In Burntwood quarry, at Althouse, near Wakefield in Yorkshire" (which is situated in the very same coal-field as Halifax and Leeds, where the *marine* strata have been remarked by Mr. J. Phillips,) "*several vertical stems of large magnitude* have been found. One stem which I measured in the quarry, was 9 feet long and 10 inches in thickness: but, what is very remarkable, this stem cut through three strata of sandstone *parted by regular strata seams*. It had therefore," observes this author, (not being aware, at the time he wrote, of the intermixture of *marine strata* amongst these very formations,)—"it had therefore probably *grown where it stood*; for it is difficult to believe that any vegetable stem could pierce through three strata of sandstone, the lower of which, at least, must have been partly *consolidated*. *This fact proves that the strata were deposited rapidly.*" p. 148. To the "*difficulty*" here mentioned by Mr. Bakewell, I shall only add the still greater one of believing that a living tree could be rapidly covered up *where it grew*, and its top imbedded in the very same substance in which its roots had before found nourishment. Had this strange idea been well founded, we must have discovered such fossil trees in many more instances than we do: they must have been almost always upright, and invariably furnished with *roots* and *branches*. This, however, is rarely the case; they lie in every degree of inclination from horizontal to vertical: they have not always roots, very rarely branches, and I have never heard of an instance with the smaller twigs and leaves. If this able geologist was deeply struck with a fossil stem of only *nine* feet, and piercing *three* strata of sandstone, what must he think of such stems as have since been frequently found (as in Craigleith quarry near Edinburgh,) of from 50 to 70 feet in length, *and piercing ten or twelve different and distinct strata* * ?

Before concluding these cursory remarks on the coal formations, I am also desirous of calling the attention of your scientific readers to another very remarkable fact, with regard to these carboniferous strata, which, I believe, has only been described by the same able writer whom I have just cited, and which also appears to me to offer a powerful resistance to our most received theories respecting them.

After describing the remarkable deposits of coal near Cologne, in which are imbedded "trunks of trees deprived of their branches, *which proves their having been transported from a distance*, and also nuts which are indigenous to *Hindostan* and *China*," Mr. Bakewell proceeds as follows: "But a still more remarkable formation occurs at Alpnach near the lake of Lucerne, in Switzerland, where a bed of coal is found at the depth of 280 feet from the surface. Over this coal there is *a stratum of limestone containing fluviatile*" (?) "*shells, and the bones and teeth of a species of Mastodon, and of other large land quadrupeds.* Notwithstanding the occurrence of the bones of large mammalia in this stratum over the coal, in this place, the coal approaches in character nearly to mineral coal; and *the strata of micaceous sandstones and shales above it, have a close resemblance to those of our English coal-fields:* but though from these organic remains we are *compelled* to place the coal of Alpnach amongst the *tertiary strata*, or else to admit the occurrence of an anomalous formation like the one at Stonesfield, still I believe the true geological position of this coal is problematical; and it deserves the particular attention of some

---

* [A notice of the fossil tree discovered at Craigleith in 1826 will be found in Mr. Witham's paper before referred to; but this tree, we have to remark, was found in a nearly horizontal position, corresponding with the dip of the strata.—Edit.]

English geologist well acquainted with the coal-fields of his own country, and the lignite formation in different parts of Europe." p. 173.

The singular anomaly here presented to the geologist powerfully supports the argument which naturally arises from the specimens of vertical trees, to which allusion has just been made. According to geological theories, such deposits of vegetable matter, *accompanied by micaceous sandstones and shales*, were formed *long previous* to the creation of such mammalia as are here described*; and yet we have only to suppose the highly probable existence of vertical trees in this coal basin of Alpnach, such as are elsewhere found in similar localities, to perceive the rapidity of this formation also, and that it took place at a period when the destruction of animal life was such as our upper diluvial deposits more usually demonstrate.

I must apologize for having thus trespassed upon your attention and that of your readers; but I cannot help thinking that the facts I have mentioned are well worthy of the deepest study by all true lovers of a consistent geology. My own line of reasoning upon these facts may, in the opinion of some, be open to many objections; but, be that as it may, it must be admitted that a scientific explanation of these phænomena, opposed as they are to the most approved geological theories, would be considered as an essential service done to this most interesting science, and that they loudly call for the learned interference of some of the great leaders of the geological world. I have the honour to be,

Gentlemen, yours, &c.

Ramsgate, June 17, 1833. GEO. FAIRHOLME.

---

* [We leave Mr. Fairholme's theory of the rapid production of the coal strata to the consideration of our geological readers and correspondents; but it seems requisite that we should offer a remark on his allusion to the coal of Alpnach. It is not "according to geological theories" (by which we mean the generalizations of facts which have been established by modern geologists,) to suppose that such strata as those of Alpnach here alluded to, were formed "*long previous*" to the creation of the mammalia in question: all that can be deduced from the occurrence of remains of the latter in the stratum overlying the coal, is that the entire formation belongs to the tertiary series, and probably the animals were contemporaneous with the plants which furnished the coal. It is now fully established that coal has been produced at many epochs subsequent to that of the Great Coal Formation; and we may also observe, that no geologist of the present day would infer the high antiquity of a formation containing coal, merely from the mineral characters of the accompanying strata.—EDIT.]

## XLV. *Experimental Researches in Electricity.—Third Series. By* MICHAEL FARADAY, *D.C.L. F.R.S. M.R.I. Fullerian Prof. Chem. Royal Institution, Corr. Mem. Royal Acad. of Sciences, Paris, Petersburgh, &c. &c.*

[Continued from p. 171.]

309. iii. *Chemical Decomposition.* THE chemical action of voltaic electricity is characteristic of that agent, but not more characteristic than are the laws under which the bodies evolved by decomposition arrange themselves at the poles. Dr. Wollaston showed* that common electricity resembled it in these effects, and "that they are both essentially the same;" but he mingled with his proofs an experiment having a resemblance, and nothing more, to a case of voltaic decomposition, which however he himself partly distinguished; and this has been more frequently referred to by others, on the one hand, to prove the occurrence of electro-chemical decomposition, like that of the pile, and on the other, to throw doubt upon the whole paper, than the more numerous and decisive experiments which he has detailed.

310. I take the liberty of describing briefly my results, and of thus adding my testimony to that of Dr. Wollaston on the identity of voltaic and common electricity as to chemical action, not only that I may facilitate the repetition of the experiments, but also lead to some new consequences respecting electro-chemical decomposition (376. 377.).

311. I first repeated Wollaston's fourth experiment†, in which the ends of coated silver wires are immersed in a drop of sulphate of copper. By passing the electricity of the machine through such an arrangement, that end in the drop which received the electricity became coated with metallic copper. One hundred turns of the machine produced an evident effect; two hundred turns a very sensible one. The decomposing action was however very feeble. Very little copper was precipitated, and no sensible trace of silver from the other pole appeared in the solution.

312. A much more convenient and effectual arrangement for chemical decompositions by common electricity, is the following. Upon a glass plate, fig. 2, placed over, but raised above a piece of white paper, so that shadows may not interfere, put two pieces of tinfoil *a*, *b*; connect one of these by an insulated wire *c*, or wire and string (301.) with the machine, and

---

* Phil. Trans. 1801, pp. 427, 434.

† Ibid. 1801, p. 429.

the other *g*, with the discharging train (292.) or the negative conductor; provide two pieces of fine platina wire, bent as in fig. 3, so that the part *d*,*f* shall be nearly upright, whilst the whole is resting on the three bearing points *p*, *e*,*f*; place these as in fig. 2; the points *p*, *n* then become the decomposing poles. In this way surfaces of contact, as minute as possible, can be obtained at pleasure, and the connexion can be broken or renewed in a moment, and the substances acted upon examined with the utmost facility.

Fig. 2.

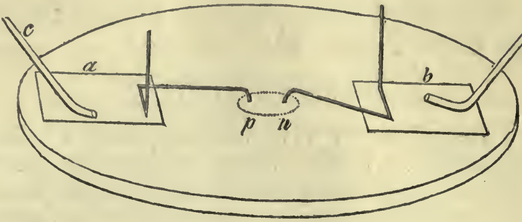
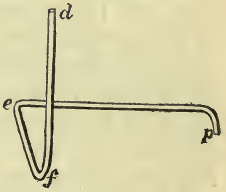


Fig. 3.



313. A coarse line was made on the glass with solution of sulphate of copper, and the terminations *p* and *n* put into it; the foil *a* was connected with the positive conductor of the machine by wire and wet string, so that no sparks passed: twenty turns of the machine caused the precipitation of so much copper on the end *p*, that it looked like copper wire; no apparent change took place at *n*.

314. A mixture of half muriatic acid and half water was rendered deep blue by sulphate of indigo, and a large drop put on the glass, fig. 2, so that *p* and *n* were immersed at opposite sides: a single turn of the machine showed bleaching effects round *p*, from evolved chlorine. After twenty revolutions no effect of the kind was visible at *n*, but so much chlorine had been set free at *p*, that when the drop was stirred the whole became colourless.

315. A drop of solution of iodide of potassium mingled with starch was put into the same position at *p* and *n*; on turning the machine, iodine was evolved at *p*, but not at *n*.

316. A still further improvement in this form of apparatus consists in wetting a piece of filtering paper in the solution to be experimented on, and placing that under the points *p* and *n*, on the glass: the paper retains the substance evolved at the point of evolution, by its whiteness renders any change of

colour visible, and allows of the point of contact between it and the decomposing wires being contracted to the utmost degree. A piece of paper moistened in the solution of iodide of potassium and starch, or of the iodide alone, with certain precautions (322.), is a most admirable test of electro-chemical action; and when thus placed and acted upon by the electric current, will show iodine evolved at *p* by only half a turn of the machine. With these adjustments and the use of iodide of potassium on paper, chemical action is sometimes a more delicate test of electrical currents than the galvanometer (273.). Such cases occur when the bodies traversed by the current are bad conductors, or when the quantity of electricity evolved or transmitted in a given time is very small.

317. A piece of litmus paper, moistened in solution of common salt or sulphate of soda was quickly reddened at *p*. A similar piece moistened in muriatic acid was very soon bleached at *p*. No effects of a similar kind took place at *n*.

318. A piece of turmeric paper, moistened in solution of sulphate of soda, was reddened at *n* by two or three turns of the machine, and in twenty or thirty turns plenty of alkali was there evolved. On turning the paper round, so that the spot came under *p*, and then working the machine, the alkali soon disappeared, the place became yellow, and a brown alkaline spot appeared in the new part under *n*.

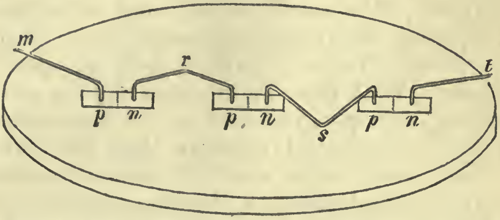
319. On combining a piece of litmus with a piece of turmeric paper, wetting both with solution of sulphate of soda, and putting the paper on the glass, so that *p* was on the litmus and *n* on the turmeric, a very few turns of the machine sufficed to show the evolution of acid at the former and alkali at the latter, exactly in the manner effected by a volta-electric current.

320. All these decompositions took place equally well, whether the electricity passed from the machine to the foil *a*, through water, or through wire only; by *contact* with the conductor, or by *sparks* there; provided the sparks were not so large as to cause the electricity to pass in sparks from *p* to *n*, or towards *n*; and I have seen no reason to believe that in cases of true electro-chemical decomposition by the machine, the electricity passed in sparks from the conductor, or at any part of the current, is able to do more, because of its tension, than that which is made to pass merely as a regular current.

321. Finally, the experiment was extended into the following form, supplying in this case the fullest analogy between common and voltaic electricity. Three compound pieces of litmus and turmeric paper (319.) were moistened in solution of sulphate of soda, and arranged on a plate of glass with

platina wires, as in fig. 4. The wire *m* was connected with the prime conductor of the machine, the wire *t* with the discharging train, and the wires *r* and *s* entered into the course of the electrical current by means of the pieces of moistened paper: they were so bent as to rest each on three points, *n*, *r*, *p*; *n*, *s*, *p*, the points *r* and *s* being supported by the glass, and the others by the papers, the three terminations *p*, *p*, *p* rested on the litmus, and the other three *n*, *n*, *n* on the turmeric paper. On working the machine for a short time only, acid was evolved at *all* the poles or terminations *p*, *p*, *p*, by which the electricity entered the solution, and alkali at the other poles *n*, *n*, *n*, by which the electricity left the solution.

Fig. 4.



322. In all experiments of electro-chemical decomposition by the common machine and moistened papers (316.), it is necessary to be aware of and to avoid the following important source of error. If a spark passes over moistened litmus and turmeric paper, the litmus paper (provided it be delicate and not too alkaline,) is reddened by it; and if several sparks are passed, it becomes powerfully reddened. If the electricity pass a little way from the wire over the surface of the moistened paper, before it finds mass and moisture enough to conduct it, then the reddening extends as far as the ramifications. If similar ramifications occur at the termination *n*, on the turmeric paper, they *prevent* the occurrence of the red spot due to the alkali, which would otherwise collect there; sparks or ramifications from the points *n* will also redden litmus paper. If paper moistened by a solution of iodide of potassium (which is an admirably delicate test of electro-chemical action,) be exposed to the sparks or ramifications, or even a feeble stream of electricity through the air from either the point *p* or *n*, iodine will be immediately evolved.

323. These effects must not be confounded with those due to the true electro-chemical powers of common electricity, and must be carefully avoided when the latter are to be observed. No sparks should be passed, therefore, in any part

of the current, nor any increase of intensity allowed by which the electricity may be induced to pass between the platina wires and the moistened papers, otherwise than by conduction; for if it burst through the air, the effect referred to ensues.

324. The effect itself is due to the formation of nitric acid by the combination of the oxygen and nitrogen of the air, and is, in fact, only a delicate repetition of Cavendish's beautiful experiment. The acid so formed, though small in quantity, is in a high state of concentration as to water, and produces the consequent effects of reddening the litmus paper, or preventing the exhibition of alkali on the turmeric paper, or, by acting on the iodide of potassium, evolving iodine.

325. By moistening a very small slip of litmus paper in solution of caustic potassa, and then passing the electric spark over its length in the air, I gradually neutralized the alkali, and ultimately rendered the paper red; on drying it, I found that nitrate of potassa had resulted from the operation, and that the paper had become touch-paper.

326. Either litmus paper or white paper moistened in solution of iodide of potassium, offers therefore a very simple, beautiful, and ready means of illustrating Cavendish's experiment of the formation of nitric acid from the atmosphere.

327. I have already had occasion to refer to an experiment (265. 309.) by Dr. Wollaston, which is insisted upon too much, both by those who oppose and those who agree with the accuracy of his views respecting the identity of voltaic and ordinary electricity. By covering fine wires with glass or other insulating substances, and then removing only so much matter as to expose the point, or a section of the wires, and by passing electricity through two such wires, the guarded points of which were immersed in water, Wollaston found that the water could be decomposed even by the current from the machine, without sparks, and that two streams of gas arose from the points, exactly resembling in appearance, those produced by voltaic electricity, and, like the latter, giving a mixture of oxygen and hydrogen gases. But Dr. Wollaston himself points out that the effect is different from that of the voltaic pile, inasmuch as both oxygen and hydrogen are evolved from *each* pole; he calls it " a very close *imitation* of the galvanic phænomena," but adds, that "in fact the resemblance is not complete," and does not trust to it to establish the principles, correctly laid down in his paper.

328. This experiment is neither more nor less than a repetition, in a refined manner, of that made by Dr. Pearson in

1797*, and previously by MM. Paets Van Troostwyk and Deiman in 1789 or earlier. That the experiment should never be quoted as proving true electro-chemical decomposition, is sufficiently evident from the circumstance, that the law which regulates the transference and final place of the evolved bodies (278. 309.) has no influence here. The water is decomposed at both poles independently of each other, and the oxygen and hydrogen evolved at the wires are the elements of the water existing the instant before in those places. That the poles, or rather points, have no mutual decomposing dependence, may be shown by substituting a wire, or the finger, for one of them, a change which does not at all interfere with the other, though it stops all action at the changed pole. This fact may be observed by turning the machine for some time; for though bubbles will rise from the point left unaltered, in quantity sufficient to cover entirely the wire used for the other communication, if they could be applied to it, yet not a single bubble will appear on that wire.

329. When electro-chemical decomposition takes place, there is great reason to believe that the quantity of matter decomposed is not proportionate to the intensity, but to the quantity of electricity passed (320.). Of this I shall be able to offer some proofs in a future part of this paper (375. 377.). But in the experiment under consideration, this is not the case. If, with a constant pair of points, the electricity be passed from the machine in sparks, a certain proportion of gas is evolved; but if the sparks be rendered shorter, less gas is evolved, and if no sparks be passed, there is scarcely a sensible portion of gases set free. On substituting solution of sulphate of soda for water, scarcely a sensible quantity of gas could be procured even with powerful sparks, and almost none with the mere current; yet the quantity of electricity in a given time was the same in all these cases.

330. I do not intend to deny that with such an apparatus common electricity can decompose water in a manner analogous to that of the voltaic pile; I believe at present that it can. But when what I consider the true effect only was obtained, the quantity of gas given off was so small that I could not ascertain whether it was, as it ought to be, oxygen at one wire and hydrogen at the other. Of the two streams one seemed more copious than the other, and on turning the apparatus round, still the same side in relation to the machine gave the largest stream. On substituting solution of sulphate of soda for pure water (329.), these minute streams were still

---

* Nicholson's Journal, 4to, vol. i. pp. 241, 299, 349.

observed. But the quantities were so small, that on working the machine for half an hour I could not obtain at either pole a bubble of gas larger than a small grain of sand. If the conclusion which I have drawn (377.) relating to the amount of chemical action be correct, this ought to be the case.

331. I have been the more anxious to assign the true value of this experiment as a test of electro-chemical action, because I shall have occasion to refer to it in cases of supposed chemical action by magneto-electric and other electric currents (336. 346.) and elsewhere. But, independent of it, there cannot be now a doubt that Dr. Wollaston was right in his general conclusion; and that voltaic and common electricity have powers of chemical decomposition, alike in their nature, and governed by the same law of arrangement.

332. iv. *Physiological Effects.*—The power of the common electric current to shock and convulse the animal system, and when weak to affect the tongue and the eyes, may be considered as the same with the similar power of voltaic electricity, account being taken of the intensity of the one electricity and duration of the other. When a wet thread was interposed in the course of the current of common electricity from the battery (291.) charged by eight or ten revolutions of the machine in good action (290.), and the discharge made by platina spatulas through the tongue or the gums, the effect upon the tongue and eyes was exactly that of a feeble voltaic circuit.

333. v. *Spark.*—The beautiful flash of light attending the discharge of common electricity is well known. It rivals in brilliancy, if it does not even very much surpass, the light from the discharge of voltaic electricity; but it endures for an instant only, and is attended by a sharp noise like that of a small explosion. Still no difficulty can arise in recognising it to be the same spark as that from the voltaic battery, especially under certain circumstances. The eye cannot distinguish the difference between a voltaic and a common electricity spark, if they be taken between amalgamated surfaces of metal, at intervals only, and through the same distance of air.

334. When the battery (291.) was discharged through a wet string placed in some part of the circuit away from the place where the spark was to pass, the spark was yellowish, flamy, having a duration sensibly longer than if the water had not been interposed, was about three fourths of an inch in length, was accompanied by little or no noise, and whilst losing part of its usual character had approximated in some degree to the voltaic spark. When the electricity retarded by water was discharged between pieces of charcoal, it was exceedingly luminous and bright upon both surfaces of the

charcoal, resembling the brightness of the voltaic discharge on such surfaces. When the discharge of the unretarded electricity was taken upon charcoal, it was bright upon both the surfaces, (in that respect resembling the voltaic spark,) but the noise was loud, sharp and ringing.

335. I have assumed, in accordance, I believe, with the opinion of every other philosopher, that atmospheric electricity is of the same nature with ordinary electricity (284.), and I might therefore refer to certain published statements of chemical effects produced by the former as proofs that the latter enjoys the power of decomposition in common with voltaic electricity. But the comparison I am drawing is far too rigorous to allow me to use these statements without being fully assured of their accuracy; and I have no right to suppress them, because, if accurate, they establish what I am labouring to put on an undoubted foundation, and have priority to my results.

336. M. Bonijol of Geneva* is said to have constructed very delicate apparatus for the decomposition of water by common electricity. By connecting an insulated lightning rod with this apparatus, the decomposition of the water proceeded in a continuous and rapid manner even when the electricity of the atmosphere was not very powerful. The apparatus is not described; but as the diameter of the wire is mentioned as very small, it appears to have been similar in construction to that of Wollaston (327.); and as that does not furnish a case of true polar electro-chemical decomposition (328.), this result of M. Bonijol does not prove the identity in chemical action of common and voltaic electricity.

337. At the same page of the *Bibliotheque Universelle*, M. Bonijol is said to have decomposed *potash*, and also chloride of silver, by putting them into very narrow tubes and passing electric sparks from an ordinary machine over them. It is evident that these offer no analogy to cases of true voltaic decomposition, where the electricity only decomposes when it is *conducted* by the body acted upon, and ceases to decompose, according to its ordinary laws, when it passes in sparks. These effects are probably partly analogous to that which takes place with water in Pearson's or Wollaston's apparatus, and may be due to very high temperature acting on minute portions of matter; or they may be connected with the results in air (322.). As nitrogen can combine directly with oxygen under the influence of the electric spark (324.), it is not impossible that it should even take it from the potassium of the potash,

---

* *Bibliotheque Universelle*, 1830, tome xlv. p. 213.

especially as there would be plenty of potassa in contact with the acting particles to combine with the nitric acid formed. However distinct all these actions may be from true polar electro-chemical decompositions, they are still highly important, and well worthy of investigation.

338. The late Mr. Barry communicated a paper to the Royal Society* last year, so distinct in the details that it would seem at once to prove the identity in chemical action of common and voltaic electricity, but that, when examined, considerable difficulty arises in reconciling certain of the effects with the remainder. He used two tubes, each having a wire within it passing through the closed end, as is usual for voltaic decompositions. The tubes were filled with solution of sulphate of soda, coloured with syrup of violets, and connected by a portion of the same solution, in the ordinary manner; the wire in one tube was connected by a *gilt thread* with the string of an insulated electrical kite, and the wire in the other tube by a similar *gilt thread* with the ground. Hydrogen soon appeared in the tube connected with the kite, and oxygen in the other, and in ten minutes the liquid in the first tube was green from the alkali evolved, and that in the other red from free acid produced. The only indication of the strength of the atmospheric electricity is in the expression, "the usual shocks were felt on touching the string."

339. That the electricity in this case does not resemble that from any ordinary source of common electricity, is shown by several circumstances. Wollaston could not effect the decomposition of water by such an arrangement, and obtain the gases in *separate* vessels, using common electricity; nor have any of the numerous philosophers, who have employed such an apparatus, obtained any such decomposition, either of water or of a neutral salt, by the use of the machine. I have lately tried the large machine (290.) in full action for a quarter of an hour, during which seven hundred revolutions were made without producing any sensible effects, although the shocks that it would then give must have been far more powerful and numerous than could have been taken, with any chance of safety, from an electrical kite-string; and by reference to the comparison hereafter to be made (371.), it will be seen that for common electricity to have produced the effect, the quantity must have been awfully great, and apparently far more than could have been conducted to the earth by a gilt thread, and at the same time only have produced the "usual shocks."

340. That the electricity was apparently not analogous to

---

* Philosophical Transactions, 1831, p. 165.

voltaic electricity, is evident, for the "usual shocks" only were produced, and nothing like the terrible sensation due to a voltaic battery, even when it has a tension so feeble as not to strike through the eighth of an inch of air.

341. It seems just possible that the air which was passing by the kite and string, being in an electrical state sufficient to produce the "usual shocks" only, could still, when the electricity was drawn off below, renew the charge, and so continue the current. The string was 1500 feet long, and contained two double threads. But when the enormous quantity which must have been thus collected is considered (371. 376.), the explanation seems very doubtful. I charged a voltaic battery of twenty pairs of plates four inches square and with double coppers, very strongly, insulated it, connected its positive extremity with the discharging train (292.), and its negative pole with an apparatus like that of Mr. Barry, communicating by a wire inserted three inches into the wet soil of the ground. This battery thus arranged produced feeble decomposing effects, as nearly as I could judge answering the description M. Barry has given. Its intensity was, of course, far lower than the electricity of the kite-string, but the supply of quantity from the discharging train was unlimited. It of course gave no shocks to compare with the "usual shocks" of a kite-string.

342. Mr. Barry's experiment is a very important one to repeat and verify. If confirmed, it will be, as far as I am aware, the first recorded case of true electro-chemical decomposition of water by common electricity, and it will supply a form of electrical current, which, both in quantity and intensity, is exactly intermediate between those of the common electrical machine and the voltaic pile.

[To be continued.]

## XLVI. *Experimental Contributions towards the Theory of Thermo-electricity. By Mr.* JOHN PRIDEAUX, *Member of the Plymouth Institution.*

[Concluded from p. 215.]

### V. *What are the electrical conditions of Homogeneous Metals brought into contact at different temperatures?*

19. TWO copper wires, $\frac{1}{16}$th of an inch in diameter, had a flat spiral, $\frac{3}{4}$ in diameter, turned in each, the central end of the wire being drawn out perpendicular to the spiral, to enter a cork, for a handle; the external end being continued in a line, nearly parallel with the face of the spiral, for 8

inches, and the point amalgamated. Thus the faces of the spirals could be pressed against each other, by means of the cork handles, the amalgamated ends entering the mercury boxes to communicate with the magnetest. One of the spirals being now heated, and (having placed the points in the mercury boxes,) pressed against the cold one, a deflection took place of 5°, showing an electric current from the hot spiral to the cold one. The heat employed was about 300°.

20. An iron pair, formed in the same way, being similarly employed, gave a deflection in the opposite direction, indicating the current *from* the *cold to* the *hot* spiral, which increased by increased heat till, on approaching redness, it reached 18°.

A pair, of tinned iron, being next employed gave the same result, but in a much greater degree. The mere warmth of the fingers communicated to one of the spirals produced deflections of 3° or 4°; and before the heat reached redness, it was 30°; the electric current being in this instance also from cold to hot.

21. Platinum, silver, lead, tin, and bismuth all corresponded with copper, in the currents passing from the hot to the cold metal. Bismuth could not, of course, be obtained in spirals; and therefore rods of the other metals were employed to compare with it. This property, in which the cold metal is positive to the hot (in the common thermo-electric sense*), may be called thermo-negative. Bismuth possesses it in the highest degree; then silver; next platinum, copper, tin. Lead, whether in wire or in bars, has only just enough of it to recognise.

22. Zinc and antimony correspond with iron, or are thermo-positive; that is, the hot metal is positive to the cold. But the experimenter will have some trouble, at first, in ascertaining the point.

Rolled zinc gives a current from hot to cold, when heated up to about 200°; between that and 250° is a neutral point; and from 400° up to the melting point the current is more lively, but reversed; *i. e.* from cold to hot, or thermo-positive. I have hitherto had some difficulty as to the temperature at which the change takes place. When heated up to the thermo-positive point, it seems to retain that character in cooling, down to a temperature considerably below that at which it first assumes it; and the direction of the heat, in the heated bar, seems to exercise an influence in the effect. This property of zinc explains the discrepancy respecting it in the tables of Becquerel and Cumming; the former having worked

---

* It must be noticed that the terms 'positive' and 'negative' have been fixed in thermo-electricity in the sense of electrics, not of conductors; positive here being that which takes, not that which gives, positive electricity.

below 200°, the latter much above that point: and in this thermo-electric change of the same metal, at such manageable temperatures, the secret seems to lie within narrow compass: it promises to contain the key by which the whole field may be laid open. Zinc bars were more troublesome, some being always negative to others, whichever is heated. A long bar, well cast, broken in the middle, and the contiguous ends used for the points of contact, generally act consistently. But even here the surfaces of contact must be filed, not hammered flat; for a few blows of the hammer destroy the consistency of action. The crystalline texture is pretty evidently concerned in this inconstancy.

Two slips of rolled zinc, cut side by side, from the same sheet, and the heads doubled, or trebled, to retain the heat, have always given me consistent results, so far as I have been able to understand them.

But it should be observed, that in this and other metals (except lead) cast rods are more active than rolled or wire-drawn pieces.

23. Antimony is still more embarrassing than zinc. It cannot be rolled or drawn, and is difficult to cast well. A tolerably well cast bar, broken in the middle, and used as described with zinc, was consistent as to direction of the current, but far otherwise as to its force, when the pieces were consecutively heated to the same degree, and applied one hot to the other cold. When heated together, one half was always positive to the other, as though the other had been of a less active metal. The method which I found to answer best, was, to take as many well cast bars as I could obtain, and classify them, by heating them together in pairs; putting the negative bars on one side, and the positive on the other; then, proceeding in the same manner, to separate the negative bars from each other; and so on, until a pair was obtained which gave no deflection when heated together. Such bars gave consistent results when heated separately, the current being always thermo-positive, in about the same degree as that of iron.

It is singular that bismuth, a very crystallizable metal, has never given me any embarrassment when acting in this way, although sufficiently capricious in single masses (26.).

24. Thus the metals resolve themselves into two classes:

1. Thermo-positive*; those which become increasingly positive by heating.—Antimony, iron, zinc above 250°.

2. Thermo-negative*; those which heat renders increas-

---

* These terms are not unobjectionable; but 'idio-positive' and 'idio-negative' would seem to apply rather to the cold than the hot bar; and 'thermo-electro-positive' is too complex for an English word.

ingly negative.—Silver, platinum, copper, tin, lead; and zinc below 200°.

Of the first class, the thermo-electric order (acting in pairs of different metals,) is nearly the reverse of that of conduction.

Of the second class, the thermo-electric order nearly corresponds with that of conduction.

| Tables of conduction from Mr. Forbes. | | Thermo-electric table from Prof. Cumming. |
|---|---|---|
| Heat. | Electricity. | |
| Gold. | Silver. | Antimony. |
| Silver. | Copper. | Iron. |
| Copper. | Gold. | Zinc*. |
| Iron. | Zinc. | Silver. |
| Zinc. | Iron. | Copper. |
| Platinum. | Platinum. | Gold. |
| Tin. | Tin. | Lead. |
| Lead. | Lead. | Tin. |
| Antimony. | Antimony. | Platinum. |
| Bismuth. | Bismuth. | Bismuth. |

Mr. Forbes considers the electrical table better authenticated than that for heat, and seems inclined to the opinion, that the order is really identical for the two.

| Thermo-positive class, in their thermo-positive order. | Order of conduction. | Order of thermo-electric reaction. |
|---|---|---|
| Antimony.<br>Iron†. | Zinc.<br>Iron. | Antimony. |
| | | Iron. |
| Zinc, above 250°. | Antimony. | Zinc. |
| Thermo-negative class, in their thermo-negative order. | | |
| Bismuth. | Silver. | Silver. |
| Silver. | Copper. | Copper. |
| Platinum. | Zinc. | Lead. |
| Copper. | Platinum. | Tin. |
| Tin. | Tin. | Platinum. |
| Zinc, below 200°. | Lead. | Bismuth. |
| Lead. | Bismuth. | |

---

* Becquerel brings zinc below silver, for reasons already adverted to (22.).

† Iron is well known to have its thermo-electric reaction reversed at a bright red heat, and to undergo the same change in its magnetic relations,—a remarkable analogy between the two. This would have been noticed above, but from the difficulty of the investigation having rendered my results hitherto inconstant. When the red-hot part is thin, its surface of contact loses its redness on touching the cold face; when substantial enough to prevent this, it is not easy to heat it high enough, without oxidation, and without the communication of some warmth to the points in contact with the mercury.

25. On comparing these tables, the thermo-electric reaction, in pairs of different metals, would seem to be compounded of the idio-thermo-electric force of each, and its conducting power.

In the thermo-positive class, the order of conduction is reversed: here iron and antimony differ little in thermo-positive quality; but antimony is the worst conductor, and stands highest in Cumming's table.

Zinc and iron differ little in conducting power; but iron is considerably more thermo-electric than zinc, and accordingly predominates in action when the metals are acting together.

In the thermo-negative class, the arrangement corresponds with the order of conduction; the conducting power tending to raise, the thermo-negative to lower, the metal in Cumming's table.

Silver is a better conductor than copper, but at the same time more thermo-negative, and their thermo-electric reaction is slight and uncertain; copper, though usually described as negative to silver, being sometimes positive, particularly at high temperatures: I have, indeed, most frequently found it so.

Copper is a better conductor than platinum, and much less thermo-negative; the one property tends to keep up the copper, the other to lower the platinum, which accordingly stands much below copper in Cumming's table.

Platinum is a little better conductor than tin, but much more thermo-negative; the latter quality accordingly predominates, and tin rises above platinum.

Lead, a worse conductor than either of these metals, is very much behind them in thermo-negative property, and both accordingly fall below it in the table of mutual reaction.

Bismuth, the worst conductor, and the strongest thermo-negative metal, has both properties coinciding to place it at the bottom of the table, and would, if the forces were measured, stand as far below platinum as that metal does (the temperature being alike,) below silver.

The place of zinc, in this class, cannot be so well settled, as it changes with the temperature.

To reduce these proportions to numbers would require more precise knowledge of the conducting powers than we yet possess, and a greater variety of experiments on the idio-thermo-electric powers than an individual is likely to make. The proximate cause of this peculiar faculty comes first in the order of inquiry.

VI. *Can the currents which pervade a mass of bismuth (and other metal), when heated at a point, be drawn off by conductors, so as to be traced up and connected with its thermo-negative property?*

26. Mr. Sturgeon found that a solid prism of bismuth, heated at a point near the end, gave out an electric stream, which flowed along the side where the heated point lay, ran over the edges before it reached the other end, and returned along the opposite side to the point of heat*.

I cast several slabs, prisms, and cylinders of this metal of various dimensions, some being cast flat, others on end, but could not obtain the regularity of circuit described by Sturgeon. In every case in which a current was detected from the heated point, another was found returning towards it; but it did not always happen that this was on the opposite side. Sometimes, on a slab 4 inches wide, it was on the lateral parts of the same face, more often on the edges: in several instances the current was towards the heated point, along the middle of the same face, and back again along the lateral parts or edges. In many cases the current took the same direction on the opposite sides, and returned along the edges. One slab, cast just at the melting point, in a cold mould, crystallized in granules; and in this no currents were detected.

Each piece was tried with a point of heat about the middle of each end of every face, allowing it to cool perfectly between the successive heatings. The heat was applied by the dart of the spirit blow-pipe, and at various degrees, a melted spot being produced in a few seconds. The bismuth was instantly raised close under the lower of a pair of short needles, not quite astatic, the needles being 2 inches apart. They were suspended by a fibre of unspun silk, within a glass shade, closed at the bottom with writing-paper, on which was a divided circle and a guide-cross as described (1.) p. 207, only the cross was here drawn on the paper, as the thickness of card between the bismuth and the needle would have been too great in some cases.

27. A cylindrical bar ($10 \times \frac{5}{8}$ inches) was filed up to a bright surface, and two copper wires made to slide upon it, the ends being pressed against it by a couple of card hoops, which slid with the wires. The other ends of the wires were amalgamated, and dipped into the mercury boxes of the magnetest. The bar being now heated at a given point, the direction of

---

* Phil. Mag. and Annals, N.S. vol. x. p. 15. I attribute this to Mr. Sturgeon, not having seen the description of Chevalier Yelin's experiments, and therefore being unable to say whether he anticipated this one or not.

the currents was traced by the needles last described (26.). The ends of the copper wires were now brought into the line of the current, (by turning and sliding the hoops,) in the hope that, by the superior conducting power of the copper, either the direct or return current might be taken up by the wire. But I could not succeed in obtaining this, or the vestige of any current, through the wire, until, coming in contact with a warm part of the bismuth, it assumed its proper thermo-electric action.

28. Two square bars, each connected at foot with the magnetest, and the head of one heated, were brought into contact at the upper ends: the current *always* set from the hot into the cold bar (21.), though in the majority of cases it would have gone down the heated face of the hot bar, and up the cold face.

29. On heating one of these bars at midlength, so that the heat should not readily reach either end, the current was always from the cold to the heated bar, although in that single bar (*i. e.* in either singly,) it would have been in different directions, according to the side heated.

30. Two bismuth rods, each 8 × ¼ inches, were tied together at top, the feet communicating with the magnetest: on directing the blow-pipe dart to the midlength of either, a current immediately set from the cold rod to the one so heated, as in (29.); but as the heat extended itself through the rod, the needle gradually returned to its station, and passed to the other side, as usual with two bars of that metal, one hot, the other cold, at the point of contact (21. 28.). I obtained no satisfactory evidence of any current analogous to (29. 30.), by heating the midlength of a pair of any uncrystallized metal.

31. No evidence, then, appears of any connexion between the currents induced in a mass of bismuth, and those pervading the same metal, when forming part of a circuit. The former seem related to the crystalline laminæ, the latter independent of the laminar direction, and generally analogous to those in other metals, the structure of which is not crystalline.

The changes which take place in zinc may probably offer fairer chance of success (22.); and it is for the purpose of inviting the attention of experimenters to them, that I offer this inquiry to the public in its present stage.

## VII. *Of the effects of extraneous contact on a thermo-electric circuit.*

32. It is quoted above from Becquerel (13.), that a continuous circuit of one metal, heated, and touched near the heated point with a cold piece of the same, gives a current from the hot point to the part in contact with the cold piece.

Having placed the thermo-electric pair described (9.) p. 211, in connexion with the magnetest, heat was applied to the middle of the copper leg instead of the twist. This soon communicated, through the good conducting power of the copper, to the point of contact, and proportionate deflection ensued. When the apparatus had cooled, heat was applied to the middle of the iron leg, which did not soon affect the needle. In the meanwhile it was touched, near the heated point, with a piece of iron; then of tinned iron; but still with little effect on the magnetest. Presently the heat was renewed, and a slip of sheet copper substituted for the iron, as a better conductor, being also bent double, to pinch the wire, and thus ensure good contact. A lively deflection now took place, but in direction contrary to that above stated, the current being from the part touched with copper to the point of heat.

33. Instead of the pair, a single wire of tinned iron was now taken, 18 by $\frac{1}{16}$th inches, bent in the form of the letter U, or forming a sort of wire staple. The points of this being set in communication with the magnetest, and the bend, or any part (distant from the mercury *) heated, gave a current, when pinched by copper, near the point of heat, from the part touched to the heated point.

34. A copper staple was now employed, and being pinched with tin, gave the same result; but tin plate being used, instead of tin, gave a current in the opposite direction, *i. e.* from the heated point toward the part touched. Two flakes of antimony, stuck on the ends of a slip of card, produced the same effect as tin plate.

Thus foreign metals, applied to the surface of the wire, affect the circuit. Is the thermo-electric action, then, superficial?

35. A copper staple was taken, one leg of which took three turns round a knob of antimony. Being connected with the magnetest, heat was applied to the copper, just by the antimony: strong deflection took place, as if the antimony had formed part of the circuit, the current flowing from the heated point to the part in contact with the antimony, and this to whichever side the heat was applied. Bismuth being substituted for the antimony, currents took place equally active, but in the converse direction; and the same with tin, when substituted for the bismuth. Hence the inside of a spiral is equally thermo-electric with the outside.

---

* Liquid mercury is an active thermo-electric; and care must be taken, wherever it is used for connexion, not to allow any heat to reach the point of contact with it. Many precautions are sometimes requisite to prevent this.

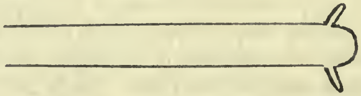
36. A staple was then made, having one leg a tube of tin plate, in which short cylinders of bismuth and tin were made to slide. When either of them approached a heated point in the tube, a current was driven back toward the heated point. Thus it acts inside a tube as well as outside a wire.

37. It is therefore evident that a foreign metal, brought into contact with a homogeneous circuit, near a heated point, enters into the thermo-electric connexion, and determines a current, according to the reaction between the two metals. Such current is, however, weaker than when the second metal intercepts or forms a distinct portion of the circuit, and is what might be expected, regarding the latter only as participating, with the homogeneous metal, in the calorific action on the portion to which it is applied.

38. Becquerel's magnetest was much more delicate than mine, and his results (13.), p. 213, coincide with the property of thermo-negative metals (21.). I have applied this mode of examination to zinc, heating a staple of polished zinc sheet at the bend, and pinching it with another slip from the same sheet, at different distances from the point of heat, consequently at different temperatures. The effects varied with the temperature, and also, apparently, with the direction in which heat was flowing; but they were not decided enough to particularize here.

## VIII. *In what consists the superior efficacy of tinned surfaces?*

39. It was noticed above (9.) that iron, instead of having its thermo-electric action weakened by tinning the surface, seemed to have it considerably augmented. To place this out of doubt, a staple of iron wire had two loops turned out near the bend; of these one was tinned, the other left clean, and polished bright. The points also being tinned and connected with the magnetest, the bend was heated nearly to redness, and the loops quickly became hot. The bright loop was then pinched successively with copper, tin, lead, and platinum, but without much effect on the needle. The same metals were then applied to the tinned loop, when the tin gave a deflection of 10°, and the others in proportion.



40. A platinum wire, 12 × $\frac{1}{12}$th inches, was then bent into a staple, and at ½ inch from the bend a bright iron wire, $\frac{1}{16}$ in diameter, was wound 16 turns round it, so as to inclose the platinum in an iron helix for an inch in length. At ½ inch on

the other side of the bend was wound a helix of *tinned* iron wire; the dimensions of the wire and of the helix being the same as the clean iron one. On heating the bend, a deflection of 10° took place, the current setting towards the tinned helix.

41. Equal lengths of tinned and untinned iron wire, of the same dimensions, were twisted together at one end, so as to form a pair. No deflection ensued on heating the twist; but turning the tinned leg round a knob of bismuth, as above (36.), the needle deviated, on heating the twist, 15°; whilst the same knob of bismuth, similarly bound in the clean leg, gave with the same heat only 4° deflection.

42. An iron wire was then cut into lengths of 16 inches, and bent into staples, which were coated as follows:—1, with tin; 2, bismuth; 3, lead; 4, fusible metal, all by heat; 5, with copper, by the humid process. They were heated successively at the bend to 140°, and the forceps (so we may denominate the doubled slip of metal employed to pinch them, as above (32. 33.),) applied at ½ inch from the point of heat. The results are expressed in the following table.

*Forceps.*

| | Tin. | Tinned iron. | Copper. | Iron. |
|---|---|---|---|---|
| Tin | +15 | +8 | +12 | +5 |
| Fus. metal | +14 | +6 | + 6 | +5 |
| Lead | +12 | 0 | + 8 | 0 |
| Bismuth | + 4 | 0 | 0 | −4 |

These numbers are evidently not precise; but, being the means of several experiments, are indications sufficient for the present purpose.

The sign + signifies that the coated wire was + to the forceps, *i. e.* that the current set from the point of contact toward the point of heat: the sign − indicates, of course, the converse direction. The copper coating differed little from naked iron; the tin exalted the thermo-electric power of the wire; the fusible metal did the same, in an inferior degree; the lead very slightly, if at all; but the bismuth reduced it. At the foot of the last column, iron coated with bismuth was − to bright iron.

43. Similar staples of the same iron wire were bound tightly with lead and tin foils, in single, double, and triple thicknesses. But in every case, and with whatever forceps, the wires so bound were inferior in action to clean iron wires.

The efficacy of copper wire was also increased by tinning and by amalgamation, but in a less degree than that of iron.

44. I am inclined to attribute the efficacy of tinning to the presentation of a soft and clean metallic surface, by which good

metallic contact is facilitated. Tinned iron seems neutral to clean iron when heated together (41.). Fusible metal acts nearly as well as tin. Lead is softer, but much more susceptible of tarnish, and does not take so well upon iron. Bismuth will not yield to pressure, and therefore will not facilitate contact, whilst its strong thermo-negative property can hardly be subdued. The inefficacy of a copper coating is what we should expect from this explanation.

From these experiments it seems probable,—

I. That thermo-electricity differs only in tension from that of the voltaic apparatus, or of the machine.

II. That it is not produced at the expense of caloric.

III. That the radiation of heat, or any kindred property, is not the proximate cause of its development.

IV. That no properties at present known of conduction, either for heat or electricity, are sufficient to account for it.

V. That the metals are resolved by thermo-electricity into two classes: 1. thermo-positive, or becoming electro-positive by heating; 2. thermo-negative, or becoming electro-negative by heating; the first class being always positive to the second when heated: and that their order in their respective classes is dependent on their conductive as well as thermo-electric faculty.

VI. That this property cannot be traced up to, or explained by, the currents produced by heat in single masses of bismuth or other metal.

VII. That foreign metals brought into contact with a homogeneous circuit near the point of heat, participate in the action, and tend to determine the current.

VIII. That the thermo-electric advantage gained to iron and some other metals by tinning, is due to the improved contact, occasioned by the soft and clean metallic surface thus produced.

These results are far from revealing an opening, even in the remote distance, to the theory of the relations between electricity and heat; but if others who have engaged in different branches of the investigation will likewise communicate their observations to the public as they occur, comparison, assisting the details of the note-book, may expedite the pursuit. By affording the means of such comparison, scientific periodicals are most effective agents in the advancement of science; and the general interest is much concerned in their extensive circulation.

## XLVII. *Contributions to the Geology of Northumberland and Durham.* *By* N. J. Winch, *Esq. F.G.S. & A.L.S.*

[Concluded from p. 204.]

### *Section of the Strata of one of the Pits at Blenkinsop near Toadholes, sunk in the year* 1826.

*Isabella Pit.*

| | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|
| SURFACE soil, clay, &c. ... ... ... | 3 | 1 | 0 | 0 |
| Plate or shale ... ... ... ... ... | 0 | 1 | 2 | 6 |
| Soft gray slaty sandstone ... ... ... | 1 | 0 | 1 | 0 |
| Plate ... ... ... ... ... ... ... ... | 5 | 0 | 2 | 3 |
| Hard white and yellow slaty sandstone | 6 | 1 | 0 | 6 |
| Plate ... ... ... ... ... ... ... ... | 3 | 1 | 1 | 6 |
| Limestone ... ... ... ... ... ... | 4 | 0 | 0 | 0 |
| Plate ... ... ... ... ... ... ... ... | 4 | 0 | 0 | 3 |
| Coal ... ... ... ... ... ... ... ... | 0 | 1 | 0 | 5 |
| | 29 | 1 | 2 | 5 |

The pit called the Deep Pit, at Blenkinsop, was 56 fathoms; the upper part all clay, the lower strata corresponding with the above section.

Dip of the coal seam 1 yard in 9 yards.

Regular dip to 10 o'clock A.M.

No whin dykes; there are up and down carts. An out-burst of the coal seam at Little Angerton, in the township of Blenkinsop, 4 feet 6 inches in height. The seam varies from 4 feet 5 inches to 4 feet 8 inches in thickness. The colliery is wrought at present (1830) by a drift or tram-way. Only one workable seam. There is a small seam of crow coal 10 inches thick, but not workable.

I now give a statement of the sinking of another pit at the same colliery (not now at work), called the John Pit.

| | *Fa.* | *Yds.* | *Ft.* | *In.* |
|---|---|---|---|---|
| Clay ... ... ... ... ... ... ... ... | 1 | 1 | 0 | 8 |
| Soft blue plate ... ... ... ... ... ... | 1 | 1 | 1 | 2 |
| Gray post or girdles ... ... ... ... | 1 | 0 | 1 | 2 |
| Soft gray post ditto with water ... ... | 2 | 0 | 1 | 0 |
| Soft gray beds ... ... ... ... ... ... | 2 | 1 | 2 | 8 |
| Blue plate ... ... ... ... ... ... ... | 3 | 1 | 2 | 0 |
| Limestone* ... ... ... ... ... ... | 8 | 0 | 2 | 0 |
| Crow coal ... ... ... ... ... ... | 0 | 0 | 0 | 10 |
| Gray thill ... ... ... ... ... ... ... | 0 | 0 | 0 | 8 |
| White post girdles ... ... ... ... ... | 0 | 1 | 1 | 0 |
| Blue plate ... ... ... ... ... ... | 2 | 0 | 1 | 0 |
| Coal ... ... ... ... ... ... ... ... | 0 | 1 | 0 | 4 |
| | 25 | 0 | 2 | 6 |

---

* A large kibbe or tub of fine lead ore was found in this stratum when sinking the pit.

The average of tonnage per day of the present working pit is 28¼ tons. The annual working in the year 1829 was 2525 score loads, each load containing 4½ imperial bushels.

Seams of coal, inferior in thickness to those belonging to the Newcastle coal formation, and interstratified with the encrinal limestone, as well as with sandstone and shale, are spread over most parts of Northumberland; but owing to these landsale collieries being generally inconsiderable in point of depth and extent of workings, the continuity of the beds of coal has never been accurately ascertained. Sections of coal mines in this formation are to be found in the fourth volume of the first series of the Geological Transactions, p. 60, where an account of Shilbottle Colliery, which supplies Alnwick with fuel, is given: and in the Transactions of the Natural History Society of Newcastle, in vol. i. pp. 126, 127, 128, 129, sections of the more important mines in the vicinity of Berwick-upon-Tweed, are inserted. The section above is of the colliery close to the old castle of Blenkinsop, 33 miles west of Newcastle, and close to the borders of Cumberland. The viewer at this place considered the position of the coal to be below the four-fathom limestone, and above the great limestone of the Alston Moor mining field, and that the bed of coal was the same as that worked in the more extensive mines on Tynedale Fell. From these collieries Carlisle derives its coal. At Angerton, close to Blenkinsop, a very deep quarry is worked in the encrinal limestone before mentioned (see the section below); but I would here remark, that it is next to impossible to trace and identify the various strata of limestones and sandstones to any great distance from the places where they are well known on Alston Moor by the lead miners, for as these beds range towards the north and north-east, they divide and admit others between them; and I have every reason to think that this is even the case with that well-defined rock known by the name of the millstone grit.

*Angerton Limestone Quarry, used for Lime, adjoining the present Working Pit (Height thereof) below the Coal.*

| | *Ft.* | *In.* |
|---|---|---|
| *First bad post or top stone ... ... | 1 | 0 |
| *Second ditto ... ... ... ... ... | 1 | 0 |
| *Third ditto ... ... ... ... ... | 1 | 0 |
| First or good top stone ... ... ... | 3 | 0 |
| *Damp bed ... ... ... ... ... ... | 0 | 8 |
| Second top stone ... ... ... ... | 3 | 0 |
| Carried forward ... | 9 | 8 |

| | *Ft.* | *In.* |
|---|---|---|
| Brought forward ... | 9 | 8 |
| *Damp bed ... ... ... ... ... ... | 0 | 6 |
| Thick blue stone ... ... ... ... | 3 | 0 |
| Small bed above the villies ... ... ... | 1 | 0 |
| *Damp ... ... ... ... ... ... | 1 | 0 |
| First villie ... ... ... ... ... ... | 2 | 0 |
| Second ditto ... ... ... ... ... | 1 | 0 |
| Third ditto ... ... ... ... ... | 1 | 0 |
| Tweddel's bed ... ... ... ... ... | 4 | 0 |
| *Damp ... ... ... ... ... ... | 0 | 6 |
| Three dunny beds, 1 foot 4 inches each | 4 | 0 |
| Three ditto 6 inches each | 1 | 6 |
| *Damp ... ... ... ... ... ... ... | 0 | 8 |
| Crotly bed ... ... ... ... ... ... | 1 | 2 |
| Curly ... ... ... ... ... ... ... | 3 | 0 |
| Coarse bed ... ... ... ... ... | 1 | 3 |
| Three Leonard beds, 5 inches each ... | 1 | 3 |
| Two true beds, 7 inches each ... | 1 | 2 |
| Middle thick stone ... ... ... ... | 2 | 6 |
| Yellow or sounding bed ... ... ... | 0 | 8 |
| Moll Harrison ... ... ... ... ... | 1 | 3 |
| Thick stone above the bottom ... ... | 1 | 3 |
| Cap above ditto ... ... ... | 0 | 6 |
| Bottom stone ... ... ... ... ... | 2 | 8 |
| Flag ... ... ... ... ... ... ... | 0 | 4 |
| | 43 | 2 |
| *Thickness of bad stone, not used, and damps | 5 | 10 |
| Height of stone (or quarry) used for lime | 37 | 4 |

To the eastward of Blenkinsop, coal is worked at Haltwhistle, Milkbridge, Barkham, Haydon Bridge, Fourstones, opposite Warmley and Acomb or Fallowfield. These places are all in the limestone country, and the coal is thought to be the Blenkinsop seam, though reduced at Milkbridge to nineteen inches in thickness, and at Barkham, at which place the shaft is thirty fathoms and a half deep, from twenty to twenty-five inches. At Hayton Bridge the seam is about twenty inches thick, but at Fourstones it is as thick as at Blenkinsop. The following rough account of the strata sunk through at Acomb was obtained on the spot from an intelligent workman.

| | *Yds.* | *Ft.* |
|---|---|---|
| Clay ... ... ... ... ... ... ... | 5 | 0 |
| Freestone (sandstone) ... ... ... ... | 1 | 1 |
| Plate (argillaceous shale) ... ... ... | 18 | 0 |
| Plate, white ... ... ... ... ... ... | 2 | 0 |
| Plate ... ... ... ... ... ... ... | 21 | 0 |
| Brown limestone ... ... ... ... | 7 | 0 |
| Brown post ... ... ... ... ... ... | 7 | 0 |
| Coal mixed with stone ... ... ... | 2 | 1 |
| | 66 | 2 |

This may convey some general idea of the rocky beds passed through, but evidently is not to be relied upon like the other sections, which were procured from gentlemen employed in the higher departments of mining.

At Guilsland in the Vale of Irthing, three miles to the west of Blenkinsop, the strata consist of limestone, sandstone, coal, and shale; the latter peculiarly rich in nodules and thin subordinate strata of clay ironstone. One peculiar bed of blue limestone, about half a mile below the Spa, is intimately blended with minute fragments of coal. A seam of coal, two feet thick, crops out in the cliffs on the Wardrew side of the river: it has a good roof of sandstone, and is worked at the surface by the farmers on the estate. Near Baron House, a mile and a half south-west of Wardrew, a seam of coal, three feet eight inches thick, crops out: from its situation, and the inclination of the strata in which it is imbedded, it must be lower in the series than the Blenkinsop seam. The course of the Irthing from Narworth to Guilsland is in the limestone formation; but at Leonard coast the new red sandstone of Cumberland makes its appearance. The limestone has been quarried on the banks of the river a little to the east of the bridge, and the red sandstone not far above it. The Abbey is chiefly built of this material, which, like the same description of stone at Melrose, seems, from its durability, well adapted to the purpose. Immense blocks of fine-grained gray granite are in this neighbourhood scattered over the face of the country, both on the encrinal limestone and on the new red sandstone. To return to the vicinity of Glenwhelt: a mass or irregular bed here crosses the rivulet, and is probably connected on the one hand with the well-known Walltown crags to the eastward, and on the other with the basalt quarried on the top of Windy-law Hill, close to the Carlisle turnpike road, to the westward. In the quarry the basalt assumes a rude columnar structure, and beautiful crystals of purple amethystine quartz are occasionally found in its interstices. In the vicinity of

Thirlwall Castle a bed of encrinal limestone reposes on the basalt, and, as is usually the case when in contact with that rock, has become crystalline in texture, and phosphorescent if laid on red-hot iron: its colour is also changed from dark blue to yellowish white.

Newcastle-upon-Tyne, Dec. 18, 1832.

---

## XLVIII. *On* Bernoulli's *Solution of the Problem of Shortest Twilight. By* T. S. Davies, *Esq. F.R.S. L. & E., F.R.A.S., &c.*

[Concluded from p. 185.]

BEFORE we proceed, however, to these supplementary theorems, we may make one or two other remarks upon the result just obtained.

By the theory of equations, if $\rho'$ and $\rho''$ denote the values of $\rho$ in the last equation, $\rho'$ referring to the minimum, and $\rho''$ to the maximum cases, we have

$$\cos\rho' \cos\rho'' = \cos^2\lambda \quad \text{..................} \quad (10)$$

which is independent of the almacantars between which the star moves. Also taking the difference,

$$\begin{aligned}\cos\rho' - \cos\rho'' &= \cos\lambda \, \frac{\cos^2 \tfrac{1}{2}\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} - \cos^2 \tfrac{1}{2}\overline{\rho_{\prime} + \rho_{\prime\prime}}}{\cos\tfrac{1}{2}\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} \cos\tfrac{1}{2}\overline{\rho_{\prime} + \rho_{\prime\prime}}} \\ &= \cos\lambda \, \frac{\tfrac{1}{2}\{1 + \cos\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} - 1 - \cos\overline{\rho_{\prime} + \rho_{\prime\prime}}\}}{\tfrac{1}{2}(\cos\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} + \cos\overline{\rho_{\prime} + \rho_{\prime\prime}})} \\ &= \cos\lambda \, \frac{\cos\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} - \cos\overline{\rho_{\prime} + \rho_{\prime\prime}}}{\cos\overline{\rho_{\prime} \backsim \rho_{\prime\prime}} + \cos\overline{\rho_{\prime} + \rho_{\prime\prime}}} \\ &= \cos\lambda \tan\rho_{\prime} \tan\rho_{\prime\prime} \quad \text{........................} \quad (11)\end{aligned}$$

which, when $\rho_{\prime}$ and $\rho_{\prime\prime}$ (the zenith distances of the almacantars) are taken the complements of each other, the difference of the cosines of the polar distances of the sun for the maximum and minimum time is constant.

Again, from the same equation (9), we have

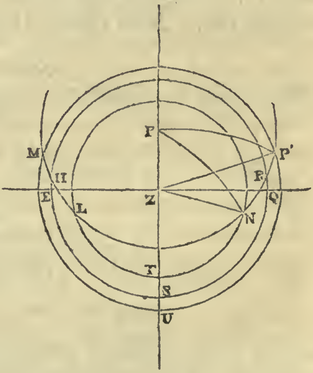
$$\cos\rho' + \cos\rho'' = 2\cos\lambda \, \frac{1 + \cos\rho_{\prime}\cos\rho_{\prime\prime}}{\cos\rho_{\prime} + \cos\rho_{\prime\prime}} \quad \text{.........} \quad (12)$$

and by division, we have

$$\frac{\cos\rho'}{\cos\rho''} = \frac{\cos^2\tfrac{1}{2}\overline{\rho_{\prime} \backsim \rho_{\prime\prime}}}{\cos^2\tfrac{1}{2}\overline{\rho_{\prime} + \rho_{\prime\prime}}} \quad \text{............} \quad (13)$$

The question actually resolved is,—what declination of the sun would cause the time of passing from one given almacantar to another to be a maximum or a minimum? The actual path of the sun is no part of the data; and hence D'Alembert's difficulty here arose from *tacitly* introducing a new condition into the *solution* of the problem, which had not been introduced into the process for finding the *equation* of the problem. It is true that under the physical circumstances which were known to exist (but which were unknown in the problem in the aspect under which he viewed it as a mathematician,) there was an obstacle to the maximum answer taking place actually in certain latitudes; but in other given latitudes the maximum might, with the present position of the ecliptic, be actually attained. His showing that the maximum could not be attained in certain particular cases, did not show that it was unattainable in all: and hence his inference, as a general one, that the second answer did not refer to the maximum case of the mathematical problem which he had solved, was in all respects inaccurate. It is important to keep in mind the fact, that the *mathematical* problem which we have *solved* is not always identical with the *physical* problem which we had *proposed*.

Delambre has given as a remarkable property of the azimuths at the beginning and end of twilight, in the case of the minimum, that they are supplementary; but this is not confined to the case in which the horizon is one of the almacantars, as the following investigations show:



1. Let us take $\rho_{,}+\rho_{,,}$. Then

$$\cos \mathrm{PZN} = \frac{\cos\rho - \cos\lambda\cos\rho_{,}}{\sin\lambda\sin\rho_{,}}$$

$$= \cot\lambda\,\frac{1+\cos\rho_{,}\cos\rho_{,,} - \sin\rho_{,}\sin\rho_{,,} - \cos^2\rho_{,} - \cos\rho_{,}\cos\rho_{,,}}{\sin\rho_{,}\,(\cos\rho_{,}+\cos\rho_{,,})}$$

$$= \cot\lambda\,\frac{1-\sin\rho_{,}\sin\rho_{,,} - (1-\sin^2\rho_{,})}{\sin\rho_{,}\,(\cos\rho_{,}+\cos\rho_{,,})}$$

$$= \cot\lambda\,\frac{\sin\rho_{,} - \sin\rho_{,,}}{\cos\rho_{,}+\cos\rho_{,,}}$$

$$= \cot\lambda\tan\tfrac{1}{2}\,\overline{\rho_{,}-\rho_{,,}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

And in the same way we find

$$\cos \mathrm{PZR} = \frac{\cos \rho - \cos \lambda \cos \rho_{\prime\prime}}{\sin \lambda \ \sin \rho_{\prime\prime}} = \cot \lambda \tan \tfrac{1}{2} (\rho_{\prime\prime} - \rho_{\prime})$$

$$= - \cot \lambda \tan \tfrac{1}{2} (\rho_{\prime} - \rho_{\prime\prime}) \ldots (15)$$

And by a comparison of (14) (15) we find at once that PZN + PZR $= \pi$, or the azimuths PZN, PZR are supplementary.

2. Take $\overline{\varrho_{\prime} \backsim \rho_{\prime\prime}}$. Then

$$\cos \mathrm{PZN} = \frac{\cos \rho - \cos \lambda \cos \rho_{\prime}}{\sin \lambda \sin \rho_{\prime}} = \cot \lambda \tan \tfrac{1}{2} (\rho_{\prime} + \rho_{\prime\prime}) \ldots (16)$$

$$\cos \mathrm{PZR} = \frac{\cos \rho - \cos \lambda \cos \rho_{\prime\prime}}{\sin \lambda \ \sin \rho_{\prime\prime}} = \cot \lambda \tan \tfrac{1}{2} (\rho_{\prime} + \rho_{\prime\prime}) \ldots (17)$$

Hence in this case the azimuths are equal; or the points in which the sun crosses the two almacantars are in the same vertical great circle,—a remarkable property.

To the case of the shortest twilight problem, the $\rho_{\prime} + \rho_{\prime\prime}$ applies, and gives the same value as found by Delambre and others: but as it depends upon the respective values of $\rho_{\prime}$ and $\rho_{\prime\prime}$ whether the + or ∽ designates the minimum time between the almacantars, we cannot say that the supplemental or the equal relation of the azimuths belongs either to the maximum or to the minimum only.

In the supplementary case we may readily find the difference of the azimuths as follows :—

Let $\xi_{\prime}$ and $\xi_{\prime\prime}$ denote the azimuths: then by the common properties of angles, we have

$$\cos \xi_{\prime} + \cos \xi_{\prime\prime} = 2 \cos \tfrac{1}{2} (\xi_{\prime} + \xi_{\prime\prime}) \cos \tfrac{1}{2} (\xi_{\prime} - \xi_{\prime\prime}) \ldots\ldots \text{(a)}$$

$$-\cos \xi_{\prime} + \cos \xi_{\prime\prime} = 2 \sin \tfrac{1}{2} (\xi_{\prime} + \xi_{\prime\prime}) \sin \tfrac{1}{2} (\xi_{\prime} - \xi_{\prime\prime}) \ldots\ldots \text{(b)}$$

But equation (a) is $= 0$, and in equation (b) we have

$$2 \sin \tfrac{1}{2} (\xi_{\prime} + \xi_{\prime\prime}) = 1, \text{ and hence also}$$

$$-\cos \xi_{\prime} + \cos \xi_{\prime\prime} = 2 \sin \tfrac{1}{2} (\xi_{\prime} - \xi_{\prime\prime}) \ \ldots\ldots\ldots \ (18)$$

But by (14) (15) we have

$$-\cos \xi_{\prime} + \cos \xi_{\prime\prime} = - 2 \cot \lambda \tan \tfrac{1}{2} \overline{\rho_{\prime} - \rho_{\prime\prime}}, \text{ and hence}$$

$$\sin \tfrac{1}{2} (\xi_{\prime} - \xi_{\prime\prime}) = - \cot \lambda \tan \tfrac{1}{2} \overline{\rho_{\prime} - \rho_{\prime\prime}} \ \ldots\ldots \ (19)$$

In the other case, or that in which azimuths are equal, we have also

$$\sin \tfrac{1}{2} (\xi_{\prime} - \xi_{\prime\prime}) = \cot \lambda \tan \tfrac{1}{2} \overline{\rho_{\prime} + \rho_{\prime\prime}} \ \ldots\ldots\ldots \ (20)$$

Delambre, after Cagnoli and some other authors, shows that the angles at the sun are equal in the case of a minimum twilight. They are also equal or supplementary in all cases.

1. Take $\rho_{\prime}-\rho_{\prime\prime}$: then

$$\cos \mathrm{PNZ} = \frac{\cos\lambda - \cos\rho\cos\rho_{\prime}}{\sin\rho\,\sin\rho_{\prime}}$$

$$= \frac{\cos\lambda\left\{1 - \dfrac{1+\cos\rho_{\prime}\cos\rho_{\prime\prime}+\sin\rho_{\prime}\sin\rho_{\prime\prime}}{\cos\rho_{\prime}+\cos\rho_{\prime}}\cos\rho_{\prime}\right\}}{\sin\rho\,\sin\rho_{\prime}}$$

$$= \frac{\cos\lambda\{\cos\rho_{\prime}+\cos\rho_{\prime\prime}-\cos\rho_{\prime}-\cos^2\rho_{\prime}\cos\rho_{\prime}-\cos\rho_{\prime}\sin\rho_{\prime}\sin\rho_{\prime\prime}\}}{\sin\rho\,\sin\rho_{\prime}\,(\cos\rho_{\prime}+\cos\rho_{\prime\prime})}$$

$$= \frac{\cos\lambda\,\sin\overline{\rho_{\prime}-\rho_{\prime\prime}}}{\sin\rho\,(\cos\rho_{\prime}+\cos\rho_{\prime\prime})} = \frac{\cos\lambda}{\sin\rho}\cdot\frac{\sin\frac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}}{\cos\frac{1}{2}\overline{\rho_{\prime}+\rho_{\prime\prime}}} \quad\ldots\ldots\ldots\ldots (21)$$

In a similar way, we find

$$\cos \mathrm{PRZ} = \frac{\cos\lambda\,\sin\frac{1}{2}\overline{\rho_{\prime\prime}-\rho_{\prime}}}{\sin\rho\,\cos\frac{1}{2}\overline{\rho_{\prime\prime}-\rho_{\prime}}}. = -\frac{\cos\lambda}{\sin\rho}\cdot\frac{\sin\frac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}}{\cos\frac{1}{2}\overline{\rho_{\prime}+\rho_{\prime\prime}}} \ldots (22)$$

And it follows at once that $\mathrm{PNZ}+\mathrm{PRZ} = \pi$, or the angles at the sun are supplementary of one another.

2. Take $\overline{\rho_{\prime}+\rho_{\prime\prime}}$: then,

$$\cos \mathrm{PNZ} = \frac{\cos\lambda\left\{1 - \dfrac{1+\cos\rho_{\prime}\cos\rho_{\prime\prime}-\sin\rho_{\prime}\sin\rho_{\prime\prime}}{\cos\rho_{\prime}+\cos\rho_{\prime\prime}}\cos\rho_{\prime}\right\}}{\sin\rho\,\sin\rho_{\prime}}$$

$$= \frac{\cos\lambda}{\sin\rho}\cdot\frac{\sin\frac{1}{2}\overline{\rho_{\prime}+\rho_{\prime\prime}}}{\cos\frac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}} \quad\ldots\ldots\ldots\ldots\ldots\ldots (23)$$

And in the same way, we find

$$\cos \mathrm{PRZ} = \frac{\cos\lambda}{\sin\rho}\cdot\frac{\sin\frac{1}{2}\overline{\rho_{\prime\prime}+\rho_{\prime}}}{\cos\frac{1}{2}\overline{\rho_{\prime\prime}-\rho_{\prime}}} \quad\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

Hence, since $\cos\frac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}} = \cos\frac{1}{2}\overline{\rho_{\prime\prime}-\rho_{\prime}}$, these angles are equal.

We may here remark, that Delambre's proof is insufficient to justify his inference of the equality of these angles, in the case he has considered. His argument is,

$$\text{since } \sin \mathrm{ZNP} = \sin \mathrm{PZN}\,\frac{\sin\lambda}{\sin\rho},$$

$$\sin \mathrm{ZRP} = \sin \mathrm{PZN}\,\frac{\sin\lambda}{\sin\rho},$$

$$\text{and } \sin \mathrm{PZN} = \sin \mathrm{RZN};$$

hence also $\mathrm{ZNP} = \sin \mathrm{ZRP}$, and *therefore* the angles ZNP, ZRP are themselves equal. But manifestly *this does not show* *that they might not be supplemental instead of equal.* Hence his deduction is not authorized. It is, however, true, as may be seen by putting the corresponding values $\frac{\pi}{2}$ and $\frac{\pi}{2} + 2a$ for $\rho_{\prime}$ and $\rho_{\prime\prime}$ in the above equations: *vide* Leybourn's Edition of the Diaries, *ut supra*, or Delambre's *Histoire de l'Astronomie Ancienne.*

It has been objected to the solution of Bernoulli, by Delambre, that it does not give the time of duration of the shortest twilight, but the declination of the sun when the twilight is shortest. By referring, however, to Bernoulli's own words, we shall find that he proposed to determine "*le jour* de plus petit crépuscule," and not to find the *duration* on that day. As an objection, then, Delambre's amounts to this—that Bernoulli, having proposed to himself one problem, did not substitute the solution of another *instead* of the one he had proposed! This is travelling out of the way to find imperfections, most assuredly. It would, indeed, at first sight seem difficult to account for such an insignificant objection being urged at all; but doubtless it originated in the somewhat exaggerated expressions of admiration bestowed upon Bernoulli's solution by Montucla, and the fact of the historian of mathematics having greatly undervalued the original solution of Nunez. It is a fact, however, that cannot have escaped the notice of every one who has had occasion to consult Delambre's Histories, that there is a feeling not altogether friendly displayed by him towards both Montucla and Bailly; and that points of comparative insignificance are often dwelt upon at very incommensurable length, where he has discovered, or believes he has discovered, those authors to be in error. The present is one of them. Bernoulli did not, indeed, solve the other problems that were connected with the one he chose to attempt; but having solved that one, all the others might have been followed out without difficulty,—of which Bernoulli, of course, was well aware. Nor is it more difficult in the general case.

For $$\cos(\xi_{\prime}-\xi_{\prime\prime}) = 1 - 2\sin^2\tfrac{1}{2}(\xi_{\prime}-\xi_{\prime\prime})$$
$$= 1 - 2\cot^2\lambda\tan^2\tfrac{1}{2}\,\overline{\rho_{\prime}-\rho_{\prime\prime}}$$

But taking RN as the arc of a great circle joining the points R, N, we have $\cos \mathrm{RN} = \cos\rho_{\prime}\cos\rho_{\prime\prime}+\sin\rho_{\prime}\sin\rho_{\prime\prime}\cos(\xi_{\prime}-\xi_{\prime\prime})$

$$\sin^2\tfrac{1}{2}(\theta_{\prime\prime}-\theta_{\prime}) = \frac{1-\cos \mathrm{RN}}{2\sin^2\rho}$$

$$= \frac{1-\cos\rho_{\prime}\cos\rho_{\prime\prime}-\sin\rho_{\prime}\sin\rho_{\prime\prime}+2\sin\rho_{\prime}\sin\rho_{\prime\prime}\cot^2\lambda\tan^2\tfrac{1}{2}\,\overline{\rho_{\prime}-\rho_{\prime\prime}}}{2\sin^2\rho}$$

$$= \frac{1-\cos\overline{\rho_{\prime}\backsim\rho_{\prime\prime}}+2\sin\rho_{\prime}\sin\rho_{\prime\prime}\cot^{2}\lambda\tan^{2}\tfrac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}}{2\sin^{2}\rho}$$

$$= \frac{\sin^{2}\tfrac{1}{2}\overline{\rho_{\prime}\backsim\rho_{\prime\prime}}+\sin\rho_{\prime}\sin\rho_{\prime\prime}\cot^{2}\lambda\tan^{2}\tfrac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}}{\sin^{2}\rho}$$

$$= \frac{\tan^{2}\tfrac{1}{2}\overline{\rho_{\prime}\backsim\rho_{\prime\prime}}}{\sin^{2}\lambda\sin^{2}\rho}\left\{\cos^{2}\tfrac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}\sin^{2}\lambda+\cos^{2}\lambda\right\}$$

$$= \frac{\tan^{2}\tfrac{1}{2}\overline{\rho_{\prime}\backsim\rho_{\prime\prime}}}{\sin^{2}\lambda\sin^{2}\rho}\left\{1-\sin^{2}\lambda\sin^{2}\tfrac{1}{2}\overline{\rho_{\prime}-\rho_{\prime\prime}}\right\}\ldots\ldots\ldots\ldots\ldots \quad (25)$$

Substituting in (25) the values of $\rho$ adapted to the two cases of $\rho_{\prime}\backsim\rho_{\prime\prime}$ and $\rho_{\prime}+\rho_{\prime\prime}$, we shall have expressions for the corresponding times. It is altogether unnecessary to consider them here, or to enter upon a discussion of any other analogies between the properties, which Delambre has collected together, of the diagram employed, and those which belong to the more general problem discussed in this paper; since they do not all hold true, and where they do hold true they are mere matters of mathematical curiosity,—at the same time that they offer no real difficulties to any one who may be tempted to enter upon their investigation.

Bath, August 8, 1833.

⁂ Mr. Skene, in the prefatory remarks to his solution, mentions an analytical one by Fontana; but he does not say whether it was a separate publication or inserted in any of the foreign scientific Transactions. I have sought it without success. A solution by means of the Stereographic Projection of the figure was given by M. Dandelin of Liege, in vol. ii. of Quetelet's *Correspondance Mathématique et Physique*; but it offers nothing novel in principle to call for special remark. Several neat solutions may also be seen in the Gentleman's Diary for 1817; but they also differ more in form than in principle, from others which had been previously published.

## XLIX. *On a Difficulty in the Theory of the Attraction of Spheroids.* *By* J. MacCullagh, *F.T.C.D.*[*]

An approximate theorem discovered by Laplace, and relating to the attraction of a solid slightly differing from a sphere on a point placed at its surface, has given rise to many disputes. It has engaged the attention of Lagrange, Ivory,

---

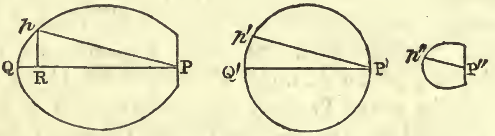
[*] Communicated by the Author.

and Poisson*. I hope the following remarks will make the matter clear.

Let us consider the function which expresses the sum of every element of a solid divided by its distance from a fixed point, and let us denote it, as Laplace has done, by the letter V. It is necessary to find the value of V for a pyramid of indefinitely small angle, the fixed point being at its vertex. Calling $\varphi$ the small solid angle of the pyramid (or the area which it intercepts on the surface of a sphere whose radius is unity and centre at the vertex), it is manifest that the element of the pyramid at the distance $r$ from the vertex is $\phi r^2 dr$; dividing, therefore, by $r$, and integrating, we have $\frac{1}{2}\phi r^2$, or $\phi$ multiplied into half the square of the length, for the value of V.

Again, supposing the force to vary inversely as the square of the distance,—the only hypothesis which can be of use in the present inquiry,—the attraction of the same pyramid on a point at its vertex, and in the direction of its length, is manifestly equal to $\varphi r$.

Let us now consider a solid of any shape, regular or irregular, terminated at one end by a plane to which the straight line PQ is perpendicular at the point P; and let there be a sphere of any magnitude, whose diameter P′Q′ is parallel to PQ. Let P″ be a fixed point, and from the points P, P′, P″, draw three parallel straight lines P$p$, P′$p'$, P″$p''$, the first two terminated by the surfaces of the solid and of the sphere, the third P″$p''$ in the same direction with them and equal to their difference, without regarding which of them is the greater, and suppose all the points $p''$ taken according to the same law, to trace the surface of a third solid. Let P$p$, P′$p'$, P″$p''$, be edges of three small pyramids with their other edges proceeding from P, P′, P″, parallel, and having of course the same solid angle which we shall call $\varphi$, denoting by $r$, $r'$, $r''$, their respective lengths, and by V, V′, V″, the values of the function V for each of them. Drawing $p$R perpendicular to PQ, the attraction of the pyramid P$p$ in the direction of PQ will be



---

* See Pontécoulant, vol. ii. p. 380; Foreign Quarterly Review, vol. v. p. 248.

equal to $\phi \times \mathrm{PR}$; call this attraction A, and let $a$ be the radius of the sphere.

Since $r''$ is the difference of $r$ and $r'$, we have $r^2 + r'^2 - r''^2 = 2rr' = 2\,\mathrm{PR} \times \mathrm{P'Q'}$, and multiplying by $\frac{1}{2}\phi$ we find $\frac{1}{2}\phi r^2 + \frac{1}{2}\phi r'^2 - \frac{1}{2}\phi r''^2 = 2a\phi \times \mathrm{PR}$, that is $\mathrm{V} + \mathrm{V}' - \mathrm{V}'' = 2a\mathrm{A}$. The same thing is true for any other three pyramids similarly related to each other, throughout the whole extent of the three solids which are exhausted by them at the same time; and hence, if we now denote by V, V′, V″, the *whole* values of the function V for the three solids, and by A the *whole* attraction of the first of them parallel to PQ on a point at P, we shall still have $\mathrm{V} + \mathrm{V}' - \mathrm{V}'' = 2a\mathrm{A}$.

To express this general theorem in the notation of Laplace, we have merely to observe that the attraction A is synonymous with $-\left(\frac{d\mathrm{V}}{dr}\right)$, and that the quantity V′ for the sphere is equal to $\frac{4}{3}\pi a^2$. Substituting these values, we find

$$\mathrm{V} + 2a\left(\frac{d\mathrm{V}}{dr}\right) = -\tfrac{4}{3}\pi a^2 + \mathrm{V}'';$$

an exact equation, differing from the approximate one of Laplace only in containing the quantity V″, and totally independent of the nature of the surface or the magnitude of the sphere, the only things supposed being that all the lines drawn from P meet the surface again but once, and that no part of it passes beyond a plane through P at right angles to PQ.

With respect to the limit of the quantity V″, it is obvious that if a hemisphere be described from P″ as a centre with a radius equal to the greatest difference $\delta$ between the lines P$p$, P′$p'$, the solid P″$p''$ will lie wholly within this hemisphere, and consequently V″ will be less than the value of V for the hemisphere, that is, less than $\pi\delta^2$; for here all the little pyramids from the centre have the same length $\delta$, and their bases are spread over the hemispherical surface; wherefore $\mathrm{V}'' = 2\pi \times \frac{1}{2}\delta^2 = \pi\delta^2$. All this is independent of anything but the suppositions just mentioned.

If now PQ be supposed to be a spheroid of any sort, slightly differing from the sphere P′Q′, and such that the line PQ, perpendicular to the surface at P, passes nearly through the centre, then all the differences, of which $\delta$ is the greatest, being of the first order, the quantity V″, which is less than $\pi\delta^2$, will be of the second order; and therefore neglecting, as Laplace has done, the quantities of that order, we get the theorem in question.

It may be well to apply the general theorem to the simple case in which the first solid is a sphere of the radius $a'$, because both Lagrange and Ivory have used it to show that the reasonings of Laplace are incorrect. In this case, then, the surface described by the point $p''$ is that of a sphere whose radius is the difference between $a$ and $a'$; and the values of V, V′, V″ and A, are $\frac{4}{3}\pi a'^2$, $\frac{4}{3}\pi a^2$, $\frac{4}{3}\pi(a'-a)^2$, and $\frac{4}{3}\pi a'$, respectively.

Substituting these values in the equation $V+V'-V''=2a\,A$, and omitting the common factor $\frac{4}{3}\pi$, the resulting equation

$$a'^2+a^2-(a'-a)^2=2\,a\,a$$

ought to be identical;—and so it manifestly is.

---

## L. *On a New Principle in Statics, called the* PRINCIPLE OF LEAST PRESSURE. *By the Rev.* H. MOSELEY, *B.A. Professor of Natural Philosophy in King's College, London*[*].

LET there be conceived a system of forces, of which a certain number are given in magnitude and direction, and the rest are supplied by the resistances of as many fixed points.

Also let the points of application of all the forces of the system be supposed to be given.

Now to the complete determination of any force in magnitude and direction, its point of application being given, it is necessary that we know its resolved parts in the directions of three rectangular axes.

To ascertain, therefore, completely, the magnitudes and directions of the resistances on the different fixed points of the system we have supposed, we must have at least three times as many equations between the resolved parts of the forces and resistances which compose it, as there are points of resistance.

The known conditions of equilibrium supply, at most, but six such equations. If there be more than two points of resistance, these equations are therefore insufficient. And it remains to establish some other relation between the resistances, their several points of application, and the other forces of the system, as shall enable us to determine the former, in terms of the others, of which they are manifestly functions.

The following principle is sufficient for this determination. It is believed to constitute a new principle in statics. *If there be any number of forces in equilibrium among which there enters a system of resistances, then are these resistances such, that their sum is a* MINIMUM; *each being considered a function of the*

---

[*] Communicated by the Author.

*coordinates of its point of application, taken with a positive sign, and subjected to the conditions imposed by the equilibrium of the whole.*

Let A designate the *given* forces of the system, B the resistances, and C *any* other system of forces which being applied to the same points with the forces of the system B, would maintain the equilibrium. Also let the system C be supposed to replace the system B.

Now each force of the system C, under these circumstances, *just* sustains and is equivalent to the pressure propagated to its point of application by the forces of the system A; or it is equivalent to that pressure *together with* the pressure propagated to its point of application by the other forces of the system C.

In the former case, it is identical with the corresponding *resistance* of the system B. In the latter case it is *greater* than it.

The sum of the forces of the system B, each being considered *a function of the coordinates of its point of application, &c. &c.*, is therefore a minimum.

Let P represent any force of the system B; $x, y, z$ its coordinates; and $\alpha, \beta, \gamma$ the angles it makes with the axes of these, respectively. Let $M_1, M_2, M_3$ represent the sums of the resolved parts of the forces of the system A, and $N_1, N_2, N_3$, the sums of their moments;

$$\therefore \left.\begin{aligned} \Sigma P \cos\alpha &= M_1 \\ \Sigma P \cos\beta &= M_2 \\ \Sigma P \cos\gamma &= M_3 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\left.\begin{aligned} \Sigma P\,(y\cos\alpha - x\cos\beta) &= N_1 \\ \Sigma P\,(x\cos\gamma - z\cos\alpha) &= N_2 \\ \Sigma P\,(z\cos\beta - y\cos\gamma) &= N_3 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Also $\alpha_1, \beta_1, \gamma_1, \alpha_2, \beta_2, \gamma_2$, &c. representing the values of $\alpha, \beta, \gamma$, for different points of the system B, we have

$$\left.\begin{aligned} \text{Cos}^2\alpha_1 + \cos^2\beta_1 + \cos^2\gamma_1 &= 1 \\ \text{Cos}^2\alpha_2 + \cos^2\beta_2 + \cos^2\gamma_2 &= 1 \\ \&\text{c.} \qquad\quad \&\text{c.} \qquad &= \end{aligned}\right\} \quad \ldots\ldots \quad (3)$$

Now the relations existing by reason of the nature of the system between the coordinates of the several points of application of the forces P may be expressed by the equations

$$\left.\begin{aligned} u_1 &= 0 \\ u_2 &= 0 \\ u_3 &= 0 \\ \&\text{c.} &= 0 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Also $\Sigma P = \text{minimum} = V \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$

Differentiating the above equations, P being considered a function of $x, y, z$; multiplying the differentials of equations (1) by the indeterminate quantities $A_1, A_2, A_3$, respectively,

(2) by $B_1, B_2, B_3$,
(3) by $\mu_1, \mu_2, \mu_3, \mu_4$, &c. &c. &c.,
(4) by $\lambda_1, \lambda_2, \lambda_3, \lambda_4$, &c. &c. &c.,

and adding the resulting equations (all whose right-hand members disappear) to the differential of equation (5), which is

$$\Sigma \left\{ \frac{d\,\mathrm{P}}{d\,x}\,\delta\,x + \frac{d\,\mathrm{P}}{d\,y}\,\delta\,y + \frac{d\,\mathrm{P}}{d\,z}\,\delta\,z \right\} = \delta\,\mathrm{V},$$

we shall obtain an equation in which the coordinates of the several points of resistance $x_1, y_1, z_1, x_2, y_2, z_2$, &c. &c., and $\alpha_1, \beta_1, \gamma_1, \alpha_2, \beta_2, \gamma_2$, &c. &c., may be considered as independent variables; so that by the condition $\mathrm{V} =$ a minimum, the coefficients of $\delta\,x$, $\delta\,y_1$, $\delta\,z_1$, $\delta\,x_2$, $\delta\,y_2$, $\delta\,z_2$, &c. &c. $\delta\,\alpha_1$, $\delta\,\alpha_2$, &c. $\delta\,\beta_1$, $\delta\,\beta_2$, &c. $\delta\,\gamma_1$, $\delta\,\gamma_2$, &c. &c., respectively equal nothing. We thus obtain, in respect to each point of resistance, six equations, reduced to four, by the elimination of the indeterminate quantities $\lambda$ and $\mu$, which are different for the different points of resistance. Of these four equations, two, involving partial differential coefficients of P, from which one of the variables $x, y, z$ may be eliminated by means of the equation $u = 0$, are equivalent to one complete differential equation between the other two variables, so that on the whole there are three equations determining the quantities P, $\alpha$ and $\beta$ in terms of the coordinates $x, y, z$, and the indeterminate quantities $A_1, A_2, A_3, B_1, B_2, B_3$ (which are the same for all the different points of resistance), whilst these are in their turn determined, by substituting the resulting values of $P_1, \alpha_1, \beta_1$, $P_2, \alpha_2, \beta_2$, &c. in the equations (1) and (2).

Thus the values of P, $\alpha$, and $\beta$, that is, the amount and direction of the pressure upon any fixed point of the system, are completely determined.

The various analytical operations indicated above, are in their nature too elaborate to be *here* brought under the eye of the reader. Those conversant with the methods of analysis will, however, readily supply the deficiency.

It may be observed that in the case in which the points of resistance are all in the same plane*, the pressure upon any

---

* This particular case of the general proposition has formed the subject of a paper by the illustrious Euler, entitled, "*De Pressione Ponderis in Planum cui incumbit*," Mem. Ac. Pet. Novi Commentarii, vol. xviii. His discussion of the question is most ingenious and elaborate. It is impossible, however, to admit the *hypothesis* on which he has grounded it.

point whose coordinates in that plane are $x$ and $y$, is ascertained to come under the formula

$$\frac{C}{1+Ax+By},$$

A, B and C being constants, dependent upon the number and positions of the points of support, and upon the forces impressed upon the system.

From this formula it follows, that there is a certain line, distant from the origin by a quantity equal to $\frac{1}{\sqrt{A^2+B^2}}$, and inclined to the axis of $x$ at an angle whose tangent is $\frac{A}{B}$; about which the moments of all the pressures are the same. This line may be properly called the *axis of least pressure*, as the principle whence its existence and properties have been deduced, may be designated the *principle of least pressure*.

Where the points of support are in the same line, this axis resolves itself into a point; and it follows that the moments of the resistances about a certain point in the line in which they act, are all equal;—a result which is verified by the known conditions of the pressure upon two points of support.

## LI. *Notice respecting certain Changes of Colour in the Choroid Coat of the Eyes of Animals.* *By Sir* David Brewster, *LL.D. F.R.S.*

IN the Number of this Journal for August last, (p. 87) Mr. Fielding has published some interesting experiments respecting certain changes of colour induced by chemical and other agents on the membrane lining the choroid coat of the eye; and he has particularly described an experiment which shows that when the colours have disappeared by drying, they may be revived by simple immersion in water.

In the chapter on the colours of natural bodies in the article Optics in the Edinburgh Encyclopædia, I have brought forward this fact as illustrating and supporting Sir Isaac Newton's Theory of the Colours of Natural Bodies, and I am induced to mention this at present, not only for the purpose of giving to Dr. Drummond of Belfast, the merit of having first made this curious experiment, but also of making some further observations upon it in reference to its connexion with the theory of Newton. The following is the passage in which it is mentioned.

"Dr. Drummond of Belfast observed, that the *membrane* behind the retina of the dog, and other animals which produce those *blue* and *green* and sometimes *red* reflections, which often shine with such brilliancy in the living animal, loses the power of reflecting these tints when it is dry, and becomes entirely black. Upon learning this fact from Dr. Drummond, we prepared several eyes that reflected these colours with great vivacity, and invariably found that they became *black* when *dry*, and *blue* and *green* when softened with water. After some of them had remained *four or five years in a dry state*, they still possessed the property of developing their colours by moisture. It is worthy of remark, that the *black* passed instantly into a brilliant *blue*, the *blue* into *green*, and the *green* into a *greenish yellow**."

After this paragraph was written, I had occasion to repeat the experiment on one of the eyes just mentioned, and I found that the colours could be revived in the membrane ten or twelve years after it had been taken from the animal.

I do not recollect to have anywhere seen it stated that the brilliant colours which appear in the eyes of animals have been noticed in the human eye; but I had occasion many years ago to observe them in the most distinct manner, and to examine them repeatedly in the eye of a boy about ten years of age. The colour was a *bright red*, with a purplish tinge; but it is not in my power to ascertain now whether or not this colour varied with an increase of years. On this point Mr. Fielding remarks, " As regards the human eye, I have had very little opportunity for investigation; and though I have proved its [the new membrane's] existence, *I cannot say that it ever presented any distinctly coloured appearance*."

Having just succeeded in finding one of the prepared specimens of the tapetum of an ox's eye, mentioned in a preceding paragraph, and which has been preserved for nearly twenty years, I find that when dry, it is as black as charcoal; and that the blue and green colours of the membrane above referred to, could be revived in all their original brightness by immersion in water.

It is a curious circumstance in the colours thus produced, that though they are apparently those of thin plates, they advance immediately from black to blue and green of the second order, all the intermediate colours of the first order being omitted. The same phænomenon occurs in the peacock's tail, in the plumage of different birds, and in Labrador felspar. In another communication I hope to be able to give a satisfactory explanation of this remarkable interruption of continuity.

Belleville, by Kingusie, Sept. 18, 1833.

---

* Edinb. Encycl. vol. xv. p. 623.

## LII. *Proceedings of Learned Societies.*

### ROYAL ASTRONOMICAL SOCIETY.

AGREEABLY to the intention expressed in our last Number, we now give abstracts of two of the most important communications read on June 14th.

Notice of the Elliptic Orbit of $\xi$ *Boötis*, with a further Approximation to the Orbit of $\gamma$ *Virginis*. By Sir John Herschel.

The elements of the orbit of $\xi$ *Boötis* are given for the first time; those of $\gamma$ *Virginis* are recalculated by the aid of observations made in the current year, by Sir J. Herschel and others, which differ materially from the Ephemeris published in the Supplement to the Nautical Almanac for 1832. Comparisons of the calculated results, with observations, are given in both cases.

The elements are as follow :—

$\xi$ *Boötis.*

| | | | |
|---|---|---|---|
| Semiaxis major......... | $a = 12''{\cdot}56$ | Inclination to the plane of the sky | $\gamma =$ 80° 5′ |
| Excentricity............ | $e =$ 0 ·59374 | Position of node ... | ☊ = 359° 59′ |
| Pos. of perihelion...... | $\varpi =$ 138° 24′ | Period in tropical years........... | P = 117·14 |
| Angle between lines of nodes and apsides ............... | $\lambda =$ 100° 59′ | Mean motion......... | $n = -3^{\circ}{\cdot}0733$ |

Perihelion passage, Dec. 17, 1779.

"These elements are interesting in several respects. In the first place, the period they indicate fills up an intermediate and wanting link between the short periods of $\eta$ *Coronæ*, $\xi$ *Ursæ*, &c., and the much longer ones of *Castor*, $\sigma$ *Coronæ*, 61 *Cygni*, $\gamma$ *Virginis*, &c. establishing (so far as we can at present rely on such determinations,) a connected scale of periods, from less than half a century to upwards of six centuries. The great amount of the excentricity of the orbit in question strengthens the induction which already begins to assign, in no unequivocal manner, orbits rather of a cometary than a planetary character to the binary stars generally. This orbit, moreover, is the most oblique to the line of sight which has yet been calculated; and as the apparent position of the projected perihelion is not very far from making a right angle with the line of nodes, the longer axis of the real ellipse is violently fore shortened, and the whole character of the apparent ellipse completely distorted, as seen in projection, from what it is in reality."

$\gamma$ *Virginis.*

| | |
|---|---|
| Major semiaxis.................................. | $a = 12''{\cdot}090$ |
| Excentricity....................................... | $e =$ 0·8335 |
| Perihelion projected .......................... | $\varpi =$ 36° 40′ |
| Perihelion from node on the orbit ........ | $\lambda =$ 282° 21′ |
| Inclination to heavens......................... | $\gamma =$ 67° 2′ |
| Node.................................................. | ☊ = 97 23 |
| Period in tropical years ...................... | P = 628·90 |
| Mean annual motion ......................... | $n = -0^{\circ}{\cdot}57242$ |
| Perihelion passage ............................ | $\tau =$ 1834·63 |

On the Adoption of a Standard of Optical Power by Observers. By the Rev. W. R. Dawes.

"Almost from the first invention of telescopes to the present day, the eclipses of *Jupiter's* satellites have afforded matter of interest to the astronomer, and to all who are anxious for the improvement of geographical science. Unhappily, however, notwithstanding all which has been done to improve this most simple method of determining differences of terrestrial longitude, there are few observations whose results are less satisfactory. Nor will this excite surprise, if it be considered, that the instant when any of these phænomena is observed is greatly influenced by the circumstances under which it is witnessed. When observed at different places, the results may be affected by diverse states of the atmosphere, and altitudes of the planet; besides the varieties existing in the *instruments* employed, and the *eyes* which use them. But though it is beyond our power to control the state of the atmosphere, or to alter the situation of the planet, we may, I conceive, do much to remove the enormous discrepancies arising from the differences in the optical power and acuteness which are brought to bear on this interesting class of phænomena.

"It might be supposed, perhaps, that a sufficient agreement of optical power might be obtained by fixing on a certain aperture, and a suitable magnifying power, as a standard to be adopted by all observers who are desirous of determining differences of longitude by means of these eclipses. And, no doubt, a much nearer approach to what is desirable would be thus obtained, than can be expected while some are employing telescopes possessed of immensely greater illuminating power than those used by others for the same purpose. However important in other respects observations may be, made in well determined stations, with large instruments, they are obviously not comparable with the results obtained by such instruments as are usually possessed by private individuals of astronomical taste, and to whom this species of observation is commonly very interesting, and would be more so were its results less unsatisfactory. Yet, were we to agree to cut down the larger instruments to a certain aperture, we should still leave two sources of disagreement unprovided against, which however are within our control. First, the instruments thus *apparently* placed on a footing would differ much in excellence, and consequently in the time when they would render an immerging or emerging satellite only just visible. Secondly, even could this point be adjusted, there would remain the very great variety which exists in different individuals in respect of *acuteness of vision*. This I believe to be much greater than is generally supposed; for I know it to be such, in some instances, as to render the 42-inch achromatic telescope as efficient an instrument to one observer in discerning minute points of light, as a 5-feet achromatic is to another; each instrument having its usual aperture, and being of corresponding excellence. In further proof of this, I may advert to the fact, that in every instance in which Captain Smyth and myself have witnessed the same *emersion*, the satellite appears to have been first discerned by me;

the instrument used at Bedford being, as I understand, the excellent $8\frac{1}{2}$-feet achromatic of nearly 6 inches aperture, and consequently possessing an illuminating power of between two and three times greater than that of my 5-feet achromatic. Hence it is manifest that some plan must be devised for equalizing the optical powers of the different *observers and their instruments*, the *eye* and the *telescope* being viewed as one compound optical machine. And this being attained, the varying condition of the atmosphere would alone be uncontrollable; for I imagine the differences of the planet's altitude might be very nearly allowed for by a corresponding alteration in the aperture or power generally used.

"I would therefore earnestly recommend the adoption of some celestial object as a *standard* of the optical power to be employed; and I know of none possessing so many advantages as the minute companion of *Polaris*. It is readily found, is visible throughout the year, and preserves nearly the same altitude. Let each observer then ascertain, by a series of experiments on several clear nights, what is the *minimum aperture* with which his instrument will enable him, on an average of such nights, to keep this delicate object *just steadily* in view. Perhaps it would be proper to fix the power employed at about 80. This power is very usually attached to the $3\frac{1}{2}$-feet achromatic, the aperture of which instrument will, I imagine, to most eyes, admit of a little diminution to bring it to the proposed standard. This telescope is, moreover, not an uncommon one among observers; yet I am disposed to regret, that the object I have selected as on the whole the best, is not sufficiently visible with the usual 30-inch achromatic. For, the greater the number of observers engaged, the more interesting and useful are the results likely to prove.

"It appears to me, that by the adoption of this plan, all the observers of these phænomena would be placed as nearly as possible on an equal footing, and every source of uncertainty within our control would be removed. I am not, indeed, prepared to suggest precisely the best mode of meeting the differences of the planet's altitude, as seen from different places; but this will not vary enormously in the British Isles; and if the plan should meet with the approbation of observers within these limits, and by them be subjected to a fair trial during the next apparition of *Jupiter*, further details and improvements may be brought forward, should the method be thought worthy of general adoption.

"It would, of course, be highly desirable that the same mode of observation should be pursued (in respect at least of *one* instrument and observer) at the principal observatories, whose longitude is accurately settled, as the results thus obtained would have great influence in determining the question of its practical utility.

"I need not dwell on the importance of distinctly specifying the *atmospheric circumstances* under which these observations are made, as otherwise it will be impossible to judge of their comparability. It might also conduce to further improvement of the method, if the planet's *hour-angle* or *estimated altitude* were recorded, and it would be convenient were the same *denomination* of time employed in registering the observations; or if both the sidereal and mean time were given, as in the Greenwich Observations.

"Should this subject be found to possess sufficient interest to engage a few careful observers in thus watching for the eclipses of *Jupiter's* satellites during the present year, the results might be communicated to the Society, so as to appear in one of their Monthly Notices during the session of 1834; and thus evidence would be had, at one view, of the degree of advantage to be expected from the adoption of such a plan of simultaneous and uniform observation."

## ZOOLOGICAL SOCIETY.

June 11.—A specimen of the *Patagonian Penguin*, *Aptenodytes Patachonica*, Gmel., recently presented to the Society by Lady Rolle, was exhibited. Mr. Yarrell availed himself of the opportunity to point out on it the proofs which it afforded of the statement made by him at the Meeting on March 12, that the *woolly Penguin* of Dr. Latham is the young condition of this species.

A specimen was exhibited of a *Goose* from the Sandwich Islands, being one of a pair recently living at the Society's Gardens, to which they were presented by Lady Glengall. Mr. Vigors characterized it as a species of *Barnacle Goose*, by the name of *Bernicla Sandvicensis*, and pointed out its distinguishing marks. He also observed on the general resemblance in the distribution of colouring which occurs in the species of *Bernicla* and in those of many other groups of *Birds*.

Numerous skins of *Birds* were exhibited, which had recently been obtained by the Society from California. They formed part of the collection, the *Mammalia* of which were brought under the notice of the Society by Mr. Bennett on March 26 (see page 66). Mr. Vigors remarked on them generally as regarded the geographical distribution of many of them; and pointed out, as apparently hitherto undescribed, an *Ortyx*, a *Falco*, two species of *Coccothraustes*, and a *Psittacara*. Among the known birds were several of those first described by Mr. Swainson in the 'Fauna Boreali-Americana,' and a specimen of *Ortyx Montezumæ*, Vig.

Dr. Grant directed the attention of the Meeting to a fine entire skull of the *round-headed Grampus*, (*Delphinus globiceps*, Cuv.,) from the North Pacific Ocean, presented to the Society by Capt. Delvitte, R.N., Corr. Memb. Z.S. He availed himself of the opportunity of entering into some details regarding the osteology of the head of the *Grampus* and other predaceous *Cetacea*.

Specimens were exhibited of two *Monkeys*, forming part of the Society's Museum, which Mr. Bennett characterized as SEMNOPITHECUS *Nestor* and CERCOPITHECUS *pogonias*. The former may be assumed to be a native of India; the latter is from the vicinity of Fernando Po.

A specimen was exhibited of the *black Lemur, Lemur niger,* Geoff., which had recently been added to the Society's Menagerie. In calling the attention of the Society to it, Mr. Bennett stated his belief that this was the first individual of the species which had fallen under the observation of zoologists since the days of Edwards, its original describer, who saw and figured one which was living in 1755 in the possession of a surgeon in London. The description and figure given by Edwards have consequently been hitherto the only proofs of the existence of such an animal. Mr. Bennett added that the *black Lemur* is the type of the *Lemur Macaco*, Linn.; and that the *Vari,* to which the name of *Lem. Macaco* has been applied by modern authors, is given by Linnæus as the Var. d. of that species. Custom having, however, transferred the specific name to the variety, he deemed it better to acquiesce in the use which has obtained, leaving to the *Vari* the name of *Lem. Macaco*, and to the *black Lemur* that of *Lem. niger*.

Specimens were exhibited of various *Mammalia*, *Birds*, and *Reptiles*, from the continent of India, which had been recently presented to the Society by Thomas Heath, Esq. Mr. Bennett observed on the several objects, pointing out especially the more interesting among them. They included an individual apparently referrible to the *Semnopithecus cucullatus*, Isid. Geoff. St.-Hil., although darker in all its markings than is indicated in the description given by the original observer of the species. They also included a species of *Felis*, of a size intermediate between the larger and the smaller animals of that genus, and having in its gray colour and longitudinal striping a general external resemblance to some of the *Viverræ*. This Mr. Bennett regarded as new to science, and proposed to designate it

FELIS VIVERRINUS. *Fel. fulvo-cinereus, subtùs albescens; capite, nuchá, dorso, genis, guláque nigro vittatis; lateribus, ventre, pedibusque nigro maculatis.*

Long. *corporis* cum capite, 33 unc.; *caudæ* mutilæ, 7; *auriculæ*, 1½.

The prevailing colour of the upper surface is a rather deep yellowish gray, the separate hairs being dusky at the base, yellowish in the middle, and having short black tips. The black lines and spots are formed of hairs destitute of yellow, and having the black tips of much greater length. A longitudinal black band passes on each side, from the inner *canthus* of the eye above the ear nearly to the shoulder; a second, more internally, passes to the same distance backwards, and is somewhat interrupted anteriorly; and between this and its fellow on the *vertex* is the vestige of a median line, which on the forehead is broken up into a double row of spots; these and the two adjoining lines subdivide in front into numerous very small spots between the eyes. Two black lines pass downwards obliquely on either side from below the eye, over the angle of the jaw; and from their terminations on each side there passes a transverse band across the throat: the space between these lines is nearly white, as is also a stripe over each eye, and the whole of the under jaw and chin. There is a large black spot surrounding the base of the ear posteriorly, and the ear is also tipped with black. The long, linear markings of the back are disposed in about five interrupted, longitudinal bands, and some of the spots on the sides assume a linear form.

Of these the most remarkable are, one on each side of the neck, and an oblique wavy band on the shoulder. The spots on the sides generally approach a rounded shape, and form, posteriorly, four or five interrupted longitudinal rows. Those of the under surface are larger, and are arranged without order. On the fore limbs the spots are small externally, and internally there are on each two large transverse black patches. On the hinder limbs the spots are arranged so as to form interrupted transverse bands on both surfaces. The hairs of the soles of the feet are dusky brown. The tail is spotted above in the same manner as the sides; its colour beneath is uniform. The spots are throughout numerous. The whiskers are white, and take their origin from three black lines on either side.

The species is nearly allied to *Felis Serval*, Schreb., but will readily be distinguished by the characters above given, by the comparative shortness and strength of its limbs, and by the locality whence it was obtained.

Specimens were exhibited of three species of *Toucan*, hitherto apparently undescribed, which form part of the Society's Museum. At the request of the Chairman, Mr. Gould pointed out their distinguishing characteristics. He described them as RAMPHASTOS *Swainsonii*, RAMPH. *culminatus*, and PTEROGLOSSUS *hypoglaucus*.

The exhibition was resumed of the new species of *Shells*, forming part of the collection made by Mr. Cuming on the western coast of South America, and among the islands of the South Pacific Ocean. Those exhibited on the present occasion were accompanied by characters by Mr. G. B. Sowerby, which are given in No. VI. of the Society's "Proceedings." Their names were as follows:

TRITON *clathratus*, *nitidulus*, *distortus*, *reticulatus*, *Mediterraneus*, (from the coast of Sicily, but nearly resembles the preceding species, which is from the Gallapagos,) *Ceylonensis*, *lineatus*, and *decollatus*, (the first seven, Mr. Sowerby remarks, may be regarded by some as mere varieties of *Trit. maculosus* of Lamarck, but he is fully satisfied that they are perfectly distinct species;) BULINUS *discrepans*, *calvus*, *ustulatus*, *pallidior*, *Luzonicus*, *conspersus*, *albus*, *striatulus*, *decoloratus*, *unicolor*, *Jacobi*, and *scabiosus*.

Specimens were also exhibited from the same collection, of two species of *Cirripedes*, apparently hitherto undescribed. They were characterized by Mr. Sowerby as POLLICIPES *ruber* and *polymerus*, their characters also being given in the "Proceedings."

Preparations were exhibited of the stomach and *cæcum* of two species of SEMNOPITHECUS, F.Cuv., SEMN. *Entellus* and *fascicularis*. They were obtained from individuals which recently died in the Society's Gardens. Mr. Owen called the attention of the Society to these preparations in illustration of a Paper which he read "On the Sacculated Form of the Stomach in the *Monkeys* of the Genus *Semnopithecus*, F. Cuv." He referred to M. Otto as the first observer of this peculiar structure among the *Monkeys*, that eminent anatomist having described and figured it in the "Nova Acta Academiæ Cæsareæ" (tom. xii. p. 511.), as it exists in a species to which he gave the name of *leucoprymnus*, placing it doubtingly among the

*Cercopitheci,* although it now seems by general consent to be regarded as a *Semnopithecus.* From its existence in M. Otto's species, and in the only two species of *Semnopithecus* which Mr. Owen has had opportunities of dissecting, the latter gentleman is disposed to consider it as appropriated to the genus, which may consequently be now regarded as established on anatomical as well as on zoological and geographical grounds.

Col. Sykes reminded the Society that, in submitting his Catalogue of the *Mammalia* observed in Dukhun, East Indies, he took occasion (Phil. Mag. and Annals, N. S. vol. x. p. 307,) to comment on the popular error respecting the ferocious and untameable disposition of the *common Hyæna, Hyæna vulgaris,* Cuv. His opinions were founded partly on observation of a cub which he had domesticated, and partly on facts communicated by his friends. He went on to state as follows:

"Two years have elapsed since I placed in the Gardens of the Society the above-mentioned cub (a female), which has now attained its full growth, and I am happy to be enabled to confirm the opinions I formerly advanced. In India it was allowed to run about my house, and on board ship it was released from its cage two or three times a day, to play with the sailors and gambol with the dogs. It early recognised my person and voice, and would obey when called; and in general was as playful and good-humoured as a puppy. My visits to it in the Gardens have been rare, and at long intervals, nor have I ever carried it food; I anticipated, therefore, that it would outgrow its early associations, and that I should be to it as any other stranger; but it has always greeted me not only as an acquaintance, but as an old friend; and if I am to judge from its agitation and peculiar cries, the animal's recognition is that of affection.

"On Sunday last it was asleep in its cage when I approached. On calling to it by its name it looked up, distinguished me in the crowd, started on its legs, and on my applying my hand to its mouth to smell to, it threw itself down against the bars, rubbed its head, neck, and back against my hand, and then started on its legs and bounded about its cage, uttering short cries. On ceasing to speak to it, and moving away, it stopped, and looked wistfully after me, nor resumed its motions until I addressed it again. Its manifestations of joy were so unequivocal, as to excite the surprise of a great number of bystanders. As these pleasing traits in the disposition of a calumniated animal appeared so new to those who surrounded me on that occasion, they may possibly be deemed of sufficient interest to be worthy of extended promulgation by record in our Proceedings.

"I take occasion to repeat my conviction, that association with man, constant kindness, and abundance of food, will suffice not only to modify, and indeed eradicate, the worst traits in the disposition of any animal of the higher classes, but give birth to others of which their natures were not deemed susceptible."

June 25.—Extracts were read from a letter addressed to the Secretary by W. Willshire, Esq., Corr. Memb. Z.S., dated Mogadore, May 5, 1833. It referred to various animals of Marocco which Mr. Willshire is in expectation of procuring for the Society. It also stated the opinion of the writer that "the *M'horr Antelope* [recently described by Mr. Bennett as a distinct species, as noticed in Lond. & Edinb. Phil. Mag. vol. ii. p. 477,] will be found to be of the same race as the *Nanguer* of Senegal;" Mr. Willshire "having traced the existence of the *M'horr* to Whadden (or Hoden on the maps), and even further to the southward, thus approaching near to Senegal." Mr. Willshire adds that he considers that "the *Antilope Leucoryx* is almost beyond a doubt the *Bekker-al-wash* of the Arabs of this neighbourhood."

Mr. Willshire forwarded at the same time the following account of the method practised in dressing skins in Marocco, the results of which are excellent as regards the preservation and colour of the fur and the flexibility of the pelt.

"Wash the skin in fresh water to deprive it of the salt; as soon as this is done scrape the flesh off; when take

"2 lbs. alum,

"1 quart buttermilk,

"2 or 3 handfuls barley meal,

"which mix well together, and lay on the fleshy side of the skin equally; fold up and press it together carefully, and let it lie two days. On the third day take it to the sea side, wash the skin well, and when clean and free from the mixture, hang it up to let the water run from it: then take 2 lbs. rock [Roche] alum finely powdered, and throw or spread it equally on all parts of the skin; again fold up as before, and allow it to lie three days, when it will be in a proper state to dry in the sun, laid flat without taking away the powder. When it is dry, take a pint or two of fresh water and sprinkle it upon the skin, and again fold it up carefully for about two hours to imbibe the water; then lay it on a table, and after scraping it free from the mixture and flesh, take a sand stone (rather rough) and rub the skin well until it becomes soft and pliable, then hang it in the shade to dry. The process is then complete.

"When the skin is perfect, having the head, horns, &c., take off the horns and fill their cavity with a mixture of equal parts of powdered alum and ashes of charcoal, dissolved in water, and expose them two days to the sun. Saturate the trunks of the horns with 8 ounces of alum dissolved in water, and fold up with the skin, and apply the same on each occasion when employed in curing the skin. The flesh on the head and jaws to be carefully taken off, filling the same with powdered alum. It should remain in the sun until perfectly dry.

"In addition to the foregoing description of the mode used in this country in dressing skins, as related by the person employed by me, it may be well to observe that the process does not take so long here, as I have often received back skins of the *Aoudad* and *Leopard* from the dresser, on the third or fourth, and never exceeding the fifth day, perfectly cured. Allowance has been made by the dresser, in the foregoing description, for the difference in the climate of London.

"The skins of smaller animals must not be subjected to so lengthened a process, or they will become harsh, and the pelt impoverished.—W. W."

A brief description was read of a pair of *Doves*, now living at the Society's Gardens, which had been pointed out by Mr. Vigors as representatives of a species hitherto undescribed. It was characterized as COLUMBA *Princeps*, Vig.

Dr. Grant exhibited a preparation of the *cloaca* of a female *Condor*, *Sarcorhamphus Gryphus*, Dum., which recently died at the Society's Gardens. He entered into a series of observations on the subject, demonstrating the differences of structure and appearance existing in its several parts, and the several orifices opening into it. He adverted to the imperfect development of the right oviduct and ovary in the class of *Birds*, and considered it as probably dependent on the position of the *aorta* in that class. To the position of the *aorta* in the *Mammalia* he was also disposed to attribute the inferior powers of the left side of the animals composing that class, an inferiority which is very striking in the cranial structure of the *Cetacea*, to which he had occasion to refer at the last Meeting of the Society. He dwelt particularly on the *bursa Fabricii*, remarkably evident in this large bird, and explained the several uses which had been attributed to that organ by its discoverer and by subsequent anatomists. With M. Geoffroy-Saint-Hilaire he regarded it as the analogue of Cowper's glands in the *Mammalia*, and adduced various reasons in favour of this view.

Mr. F. D. Bennett exhibited a dried preparation of the upper *larynx* and adjoining parts of the *Albatross*, *Diomedea exulans*, Linn., for the purpose of demonstrating the existence in that bird of an *epiglottis*.

Having demonstrated this and the adjacent parts on the preparation exhibited by him, Mr. F. D. Bennett added that as it had been the opinion of naturalists in all ages that no bird possesses an *epiglottis*, the structure which he had brought under the notice of the Society appeared to him highly interesting. So fixed was the opinion to which he had adverted that when Warren showed the existence in the *Ostrich*, *Struthio Camelus*, Linn., of a structure which he regarded as an *epiglottis*, the denomination was generally rejected even in this anomalous *bird*, and the part was considered as a mere elevation at the base of the tongue, a rudiment, but without the function, of the organ. In the *Albatross*, however, the function is that of an *epiglottis*; and the size, though small, is sufficient for the protection of that portion of the *rima glottidis* which cannot be closed in the manner usual in *Birds* by the apposition of its margins. With a peculiar structure of the *glottis* there exists an apparatus equally peculiar in the class, as a provision against the inconvenience which might otherwise result from the deviation from the normal structure.

Mr. F. D. Bennett also exhibited several specimens of a species of *Pyrosoma* captured by him, on the 6th September 1832, at sea, in lat. 1° 41′ N., long. 11° 56′ W. Between 2 and 4 A.M. the sea, having been two hours before less luminous than usual, presented one mass of bright phosphoric light extending to a considerable distance around the vessel. The extensive field of bright luminous matter emitted so powerful a light as to illuminate the sails, and to permit a book of small print to be read with facility near the windows of the stern cabins. Above this luminous field numerous sea fowl were hovering in search of their prey. The light appeared to be entirely owing to the *Pyrosomata.*

Specimens taken from the sea and placed in a vessel containing sea water, ceased altogether to emit light, or emitted it but sparingly while they remained at rest. On the water, however, being agitated, or when one of the masses of animals was taken into the hand, the whole mass became instantly illuminated by myriads of bright dots, much resembling in hue the points on the *elytra* of a *diamond Beetle, Curculio imperialis,* Fab.

The *Pyrosoma,* thus enveloped throughout its whole extent in a flame of bright phosphorescent light gleaming with its peculiar hue, presented a most splendid spectacle; the light shed by it was sufficient to render objects distinctly visible in every part of an otherwise dark room. If long retained in the hand, or returned to a quiescent state in the water, the luminous spots gradually faded, and no light was visible until the animal was again disturbed, when the illumination instantly returned with all its vivid splendour. After death it emitted no light.

The mass of *Pyrosoma,* of the usual cylindrical form and gelatinous substance, was about 4 inches in length and 1½ in circumference. The tube, passing along its middle, is described as being open at both ends; the orifice at the broader extremity being much better defined in its circular form, larger, and more distinct than that of the opposite end. The surface of the mass appeared to be studded with numerous prominent rigid and pearly tubercles intermingled with small specks of a brown or red colour. In these latter the power of emitting light appeared chiefly to be seated, these being frequently bright while the remainder of the body exhibited only its natural white or yellowish white hue; a hue which changed after death into a red tinge. The brown specks, when removed from the body, did not emit light.

A "Description, with Additional Particulars, of the *Apteryx Australis* of Shaw," by Mr. Yarrell, was read. It described in greater detail than the communication made by the author on February 12, the external structure of this singular bird. It also observed on its probable habits, and on its place in the natural series in immediate relation with the *Struthionidæ.* Following up the history of our acquaintance with it, which commenced with the possession by Dr. Shaw of a single perfect skin (hitherto unique and brought under the observation of the Society by the kindness of the President, of whose collection it now forms part), Mr. Yarrell referred to the incidental notices of it by Captain Cruise, M. Lesson, M. Duperrey, and M. Gaimard, and from the evidence thus collected pointed out its locality to be Mount Ikou-Rangui, near East Cape, New Zealand, and its native name to be *Kiwi*, frequently doubled, according to the custom of the natives, into *Kiwi-Kiwi.* With this information it is hoped that some of our enterprising countrymen in that quarter may, ere long, succeed in acquiring additional specimens and additional knowledge, as regards both the habits and the structure of this curious race.

July 9.—A letter was read, addressed to the Secretary by Charles Telfair, Esq., Corr. Memb. Z.S., and dated Port Louis, February 25, 1833. It gave an account of the history of a gigantic living specimen of the *Indian Tortoise, Testudo Indica*, Linn., which has recently been presented to the Society by Lieut. General Sir Charles Colville, late Governor of the Mauritius. The specimen is one of those which were brought from the Seychelles Islands to the Isle of France in 1766, by the Chevalier Marion du Fresne; and is believed to have since remained unchanged in size and appearance. Its length, measured along the curve of the back, is 4 feet 4¼ inches; its breadth, taken in the same manner, 4 feet 9 inches; the length of its *sternum*, 2 feet 8 inches; the breadth of its *sternum*, 2 feet 1½ inch. Its weight is 285 pounds.

An extract was read from a second letter from Mr. Telfair, of the date of Feb. 26, referring to an animal known in the interior of Madagascar by the name of *Sokinah*. Mr. Telfair regards it as an undescribed species of *Tenrec, Centenes*, Ill. A specimen of a very young individual, which was transmitted in spirit by Mr. Telfair, was exhibited, and compared with young specimens of the *European Hedge-hog, Erinaceus Europæus*, Linn., and of the *half-spiny Tenrec, Centenes semi-spinosus*, Ill. Its extreme youth, however, precluded the possibility of satisfactorily characterizing it. It was born in confinement, and lived for seventeen days; its parents having escaped from their cage on the night of its birth.

A letter was read, addressed to the Secretary by R. J. Bourchier, Esq., Corr. Memb. Z.S., dated Malta, June 8, 1833. It contained an account of two *Vultures, Vultur Kolbii*, Daud., (the *Chasse-fiente* of Le Vaillant,) which have recently been presented to the Society's Menagerie by Sir Thomas Reade, Corr. Memb. Z.S., His Majesty's Consul at Tunis. Mr. Bourchier also adverted to his attempts to procure for the Society living *Bustards* from Northern Africa. Although the birds are secured without much difficulty, his attempts have been hitherto unsuccessful, owing to the impossibility of keeping them alive in confinement for any considerable length of time, so inveterately sulky is their nature. He proposes to endeavour to obtain them at a very early age; or, if possible, to procure their eggs and have them hatched under a *domestic Turkey*.

A specimen was exhibited of the Indian variety of the *Nilotic Crocodile, Crocodilus vulgaris*, Cuv., obtained in Vellore, and presented to the Society by Alexander Bain, Esq. At the request of the Chairman, Dr. Harlan explained the structure of the heart and the course of the circulation in the *pike-headed Alligator, Alligator Mississippensis*, which he had described in detail in the 'Journal of the Academy of Natural Sciences of Philadelphia.'

Specimens of various objects of zoology, collected by George Bennett, Esq., Corr. Memb. Z.S., during his late voyage to New South Wales and in that colony, were exhibited. They were transmitted by Mr. G. Bennett to the Royal College of Surgeons, and the exhibition was made with the permission of the Board of Curators of the College Museum. They included a portion of a *Flying-fish*, to a parasite on which several *Barnacles* (*Cineras*, Leach,) were attached: several *Mollusca*: a river *Lobster*: portions of the *Death Adder*, &c. &c. They also included the *uterus* of a *Kangaroo*, "showing the fœtus with a *placenta* attached, contained within it." Mr. Owen, by whom the preparations were brought under the notice of the Society, and who remarked on each of them as they were severally presented, observed on this that he had not yet examined it sufficiently to determine the structure of the umbilical appendage visible in the preparation. It was accompanied by sketches by Mr. G. Bennett of the fœtal *Kangaroo in utero*, which were exhibited.

The preparations were accompanied by a letter addressed by Mr. G. Bennett to Mr. Owen, and dated Sydney, New South Wales, February 4, 1833, from which several extracts were read. Among them was the following:

"I have a section of one female *Ornithorhynchus* which I shot, in which the milk gland is very large; and I can now inform you from actual observation that milk is secreted from it: it comes out (as your mercury did when you injected the ducts,) in small drops on the surface of the skin. I intend sending you a further account of this; but you can mention it to the Zoological Society as a decided fact; and which had also been seen by some intelligent gentlemen in this country;—but I was not satisfied to assert it until I became an eye-witness of the fact. I wish you to show the specimens to the Zoological Society, with some brief comments in my name, stating also that I am about to send home a detailed account of the habits and œconomy of the *Ornithorhynchus* and *Kangaroo*."

The exhibition was resumed of the new species of *Shells* contained in the collection made by Mr. Cuming on the western coast of South America, and among the Islands of the South Pacific Ocean. Those brought on the present evening under the notice of the Society were accompanied, as on previous occasions, by characters by Mr. Broderip and Mr. G. B. Sowerby. They comprehended the following species of the genus CARDIUM: CARD. *Cumingii*, *procerum*, *Orbita*, *planicostatum*, *obovale* (remarkable for the peculiarity of its general form; its length and breadth being equal, and its height much greater), *elatum* (*long.* 4·, *lat.* 3·5, *alt.* 4·5 *poll.*; being the largest species of the genus with which Mr. Sowerby is acquainted, its dimensions sometimes far exceeding these), *senticosum*, *multipunctatum*, *unimaculatum*, *Consors*, *laticostatum*, *maculosum*, *Panamense*, *aspersum*, and *multistriatum*.

Dr. Grant communicated the following extract from a letter which he had received from Dr. Coldstream, of Edinburgh:—

"Torquay, (Devon,) Nov. 10, 1832.—Today I examined the *ova* of *Sepia officinalis*. A group of eighteen was attached (each by a ring formed of its semigelatinous coats) to a leaf of *Zostera marina*. They were of an elongated oval shape, about 1 inch in length and $\frac{4}{10}$ths in breadth; colour black, shining; consistence soft. Tunics of the *ovum* very numerous, of various thickness, arranged concentrically. When these tunics were removed in succession until the *ovum* became transparent, I saw distinctly the contained fœtus and its yelk within the inner coat. I could see it move and respire. When the egg was gently pressed, it moved briskly. I succeeded in getting the inner membrane with the contained fœtus out of the egg entire. I kept one in this state in sea-water for many hours, at the end of which time no change had taken place. Others I opened, and let out the fœtus; at first preserving it in its own fluid. Its only evident motion was that of respiration performed with more or less activity, according to the degree of disturbance given to it. When at rest, the respirations were thirty two per minute. The sac was dilated, and the funnel raised as in the adult; and from the transparency of the mantle, I could see plainly the motions of the lateral valves. The surface was marked with several spots; proportionally, not so numerous as in the adult. These seemed to me to become larger after the removal from the egg; but I saw no contraction and dilatation similar to what occurs in the adult. The yelk at first adhered to the front of the body, being placed between the arms; but I could not see how it was attached. In a short time it dropped off. It seemed to consist of a very thin membrane, inclosing a homogeneous transparent jelly. The lateral fin was broad, and, when the animal moved, had much wavy motion. When touched, before the yelk separated, the sac was contracted, raised, and a sharp expiration took place. The same, after separation of the yelk, was sufficient to make the animal move backwards a short distance. When salt-water was mixed with the fluid in which the fœtus floated, the animal, at first, appeared uneasy, drew its mantle over its eyes, and breathed quickly. This agitation, however, soon subsided, and there seemed to be additional vigour imparted. Viewed ventrally, the ink bag's silvery coats were seen shining through the mantle; and when the animal was touched, it twice or thrice ejected minute streams of ink. Whole length of the fœtus $\frac{4}{10}$ths of an inch. The eyes were very large proportionally. The suckers on the arms appeared only as minute tubercles. The shape of the yelk was nearly spherical; diameter about $\frac{2}{10}$ths of an inch.

"Nov. 12.—The fœtus taken out of its egg on the 10th instant was, on the same evening, put into salt water, which happened to be muddy; it continued to respire, and appeared well all the evening; but afterwards its sac contracted so as to allow the lateral valves to be seen outside, and it was languid: next morning it was dead. Today I dissected it. The shell was found loosely imbedded in the mantle. It was $\frac{2}{10}$ths of an inch in length; white; in shape ovate; thickest at the narrow end, where it was almost opaque; composed of five concentric layers; outermost very thin, translucent, spotless; others marked with variously shaped spots; near the margin of the shell these were simple [roundish, oval, or oblong]; towards the centre more complex [elongated and variously but slightly branched]. Internally, I found the gills distinctly, and, to all appearance, perfectly formed. The ink bag contained a considerable quantity of very deep-coloured ink. The inferior pair of arms were very broad at their base, and furnished with a fin-like expansion.

" The fœtus which I laid aside (in salt water), covered with the inner coat only (that membrane being entire), I found this morning outside of it and dead. I opened others of the group of eggs, and found every fœtus dead. Some had ejected part of their ink within the egg. In some the amniotic fluid was, in part, gelatinous. The spots were distinctly visible on the skin of the mantle, head, and arms ; yellowish brown beneath ; darker above."

Mr. Cox read a Paper " On the Circumstances which modify the Existence of Animals in Northern Regions." He dwelt on the migrations of these animals, chiefly in search of food, which in the countries they usually inhabit could scarcely be obtained during the winter months. When the spring returns, and the supply of nutriment becomes abundant, plethora and consequent disease would probably result; but this, the author conceives, is provided against partly by the expenditure of the animal forces for the purposes of generation, and, in the *Ruminants* with deciduous horns at least, by the extra supply of blood required for the renovation of these organs. The horns of the several species of *Deer*, Mr. Cox remarked, appear to be large proportionally with the extent to which the variation in the deficiency and abundance of food at different seasons of the year prevails; those of the extreme north being much more heavy and branched than those of the animals of more temperate regions; and the branching being at its minimum in the *Deer* of India. In still warmer countries and in tropical regions, *Deer* almost cease to exist, their place being occupied by *Antelopes*, *Ruminants* with persistent horns; a provision quite in accordance with the assumed law that the growth of horn is designed to employ superabundant blood produced by excess of nourishment at one period of the year, these animals in which the horns are continually growing having constantly at their disposal food in sufficient and nearly equable quantity.

## ROYAL SOCIETY OF EDINBURGH.

" Experimental Researches regarding certain Vibrations which take place between Metallic Masses having different Temperatures." By James D. Forbes, Esq. Professor of Natural Philosophy in the University of Edinburgh.*

The vibrations here referred to are those which, with their accompanying sounds, were first observed by Mr. Arthur Trevelyan, and communicated to this Society in a paper published in the 12th volume of their Transactions. The author of the present paper undertook

---

* The paper of which the above is an abstract, was read before the Royal Society of Edinburgh on the 1st of April, 1833.—Edit.

the inquiry as soon as the remarkable fact was announced by Mr. Trevelyan, and was induced to prosecute it to a considerable extent experimentally, in consequence of being dissatisfied with the only plausible explanation yet offered,—that of the successive expansions of the cold metal by the hot one at the point of contact, at each successive vibration, which was conceived to afford the necessary impulse or maintaining power.

In this paper the phænomena of sound are first discussed, which, with Mr. Faraday, the author imputes solely to the number of vibrations taking place in a given space of time. This seems completely proved by observation; and the note depends upon the frequency of the oscillations, which have been observed as high as between 700 and 800 in a second, and must often be greatly more frequent. The phænomena of vibration are next considered, as affected by the nature of the metals, by the form of the masses, and by temperature. The order of the metals as vibrators is the following,—meaning that the cold metal must always stand lower in the list than the hot one, and that the force or intensity of vibration is, generally speaking, proportional to the space intervening between two metals on the list:—*silver, copper, gold, zinc, brass, platinum, iron, tin, lead, antimony, bismuth.* Antimony and bismuth are placed at the bottom of the list, because no other metal is capable, under any circumstances which have been examined, of producing vibrations in conjunction with those two metals: they are the only metals yet observed which, when heated, do not vibrate on cold lead.

From experiments detailed at considerable length in the paper, the author is led to the following practical conclusions, which, whatever may be the fate of the hypothesis which he is disposed to found upon them, will, he conceives, be viewed as valuable in themselves:—1. As far as has been observed, the vibrations never take place between substances of the same nature. 2. Both substances must be metallic. 3. The vibrations take place with an intensity proportional, within certain limits, to the difference of the conducting powers of the metals for *heat* (or *electricity*), the metal having the least conducting power being necessarily the *coldest.* 4. The time of contact of two points of the metals (between which the oscillations take place) must be longer than that of the intermediate portions. 5. The impulse is received by a distinct and separate process at each contact of the bar with the block, and in no case is the connexion of these points in any way essential. 6. The intensity of vibration is (with certain exceptions) proportional to the difference of temperature of the two metals.

From these data the author first endeavours to show that the hypothesis of expansion is untenable, by tracing closely the process of communication of heat, and proving that it must lead to several conclusions totally at variance with experiment, and particularly that, as far as conducting power for heat is concerned, both the hot and the cold metal should possess it in the highest degree. The author is led by the striking analogy of the powerful repulsive action of electricity in passing from a good to a bad conductor, to infer a similar property in heat, which, without entering into any speculations as to the nature of those principles, appear to have a repulsive character in common, indicated by a tendency to diffusion and equilibrium. He conceives, that while some very delicate experiments in France have given indications of the actual force exerted by heat equally diffused through two adjoining masses, the energy in this case is produced by the accumulated repulsive power in the last particles of the good conductor, the current (without meaning anything hypothetical by the term,) being suddenly cut short by the resistance opposed to its passage by the inferior conductor. The destructive energy of electricity indicative of its repulsive force is never exerted in a state of equilibrium, but by the accumulation of separate repulsive energies which takes place in the transition from a good to a bad conductor, or during its passage through the latter.

## ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

### *Twentieth Annual Report of the Council.*

"The Fourth Volume of Transactions, reported at the last Meeting as being in the press, has since been published; and the Council have great pleasure in stating that it has attracted considerable attention, and has been most favourably noticed by several distinguished geologists. Its leading feature, Dr. Boase's paper on the Geology of the County generally, adduces many facts at variance with the prevailing theories, and advances some peculiar notions, which have given rise to much discussion, and awakened a novel interest in the investigations of Primary Geology. The Council, therefore, earnestly hope that Dr. Boase will be induced to prosecute, in all its details, a subject which forms so important a part of the objects of this Society. The Volume also contains much additional and curious information on the recent deposits of Cornwall.

"Mr. Henwood's progress in the survey of the mines has been retarded by the duties of an office in the Duchy, obtained for him by the application of the Society to their patron, His Most Gracious Majesty. He has, however, already examined the principal mining districts, and made a variety of experiments on the electro-magnetism of veins, and on the intensity of terrestrial magnetism: their results have brought to light some additional facts, by the accumulating of which alone, we may expect to arrive at any satisfactory conclusions on these obscure but interesting phænomena.

"Several donations of mineralogical and geological specimens have been received by the Society during the past year, which will be particularized in the Curator's Report. Since Mr. Carne's list of the minerals found in St. Just was published in our Second Volume, a considerable number have been discovered, not before known to exist there, of which he has now given a descriptive account: and the Council rejoice that he is still labouring in that field which he has hitherto so successfully cultivated.

"These numerous contributions have so nearly filled the cabinets, that it cannot be long before some additional accommodation will be required, which may be obtained by the enlargement of the present rooms, without incurring any considerable expense.

"It is impossible for a cursory observer to form an idea of the extent of the geological collection; for several series, and among them Mr. Henwood's specimens of veins and veinstones, exceeding a thousand in number, are deposited in drawers.

"Since the last Meeting, Dr. Boase's numerous and instructive specimens of Cornish rocks have been labelled and arranged: and the Council have the satisfaction to state, that measures are about to be taken to place the classification of the remaining geological series on the same respectable footing as that on which the mineralogical collection stands, through the able and zealous exertions of Mr. Giddy, who, they are sorry to announce, has, through indisposition, been under the necessity of tendering his resignation as Secretary, but has kindly consented to continue his valuable services as Curator."

(By Order) E. C. Giddy,
August 30th, 1833. Secretary.

The following papers have been read since the last Report:—1. On the Progress and Prospects of the Society. By Henry S. Boase, M.D. &c.—2. Additional Contributions to the Mineralogy of the Parish of St. Just. By Joseph Carne, Esq. F.R.S. F.G.S. M.R.I.A. &c. Treasurer of the Society.—3. Report of further Progress made in the Geological Survey of the Mines of Cornwall. By W. J. Henwood, Deputy Assay Master of the Duchy of Cornwall, F.G.S. London and Paris, Hon. M.Y.P.S. &c. Member of the Society.—4. Preliminary Observations on the Coast of the Land's-end District. By the Rev. George Pigott, Member of the Society.—5. An Attempt to elucidate the Nature of the Primary Strata, and more particularly that of Quartz Rock. By H. S. Boase, M.D.—6. On the Occurrence of the Earthy Phosphate of Iron in a Metalliferous Vein. By Joseph Carne, Esq. &c.—7. Observations on the Intensity of Terrestrial Magnetism, on Carn-Brea Castle, on the surface of Dolcoath Mine, and at 210 fathoms deep in the same Mine. By W. J. Henwood, F.G.S. &c.—8. Notice of a Granitic Elvan in the Granite at Pedn-merer-mere, near St. Levan. By the Rev. George Pigott.—9. On the Nature and Origin of the indigenous and transported Deposits of Cornwall, belonging to the Modern Geological Epoch. By H. S. Boase, M.D.—10. On some curious Intersection of Veins in Dolcoath Mine. By W. J. Henwood, F.G.S. &c.—11. An Account of the Quantity of Tin produced in Cornwall and Devon, in the year ending with Midsummer Quarter 1833. By Joseph Carne, Esq. &c.—12. An Account of the Quantity of Copper produced in Cornwall, and in Great Britain and Ireland, in the year ending the 30th June, 1833. By Alfred Jenkin, Esq.

*Curator's Report: Donations to the Museum and Library.*—Eighty-five specimens of Fossil Plants from the Shale of the Jarrow Colliery, near Newcastle. Presented by the Natural History Society of Newcastle-on-Tyne.—Specimens of Sussex Marble and Malm-rock; and also of a Copper-lode in Poldice Mine. By Davies Gilbert, Esq. &c. &c.—Numerous specimens of Minerals, Rocks, and Organic Remains, from various localities. By J. Mitchell, LL.D. Esq. &c., London.—Specimens of Graham Island in the Mediterranean. Presented by John Davy, M.D. F.R.S. &c. &c.—A Fossil Fish, referred to by Professor Sedgwick in his paper on the Magnesian Limestone of the northern part of England. By George T. Fox, Esq., Durham.—A fine specimen of Gray Copper-ore from Wheal Perran Mine. By R. S. Scott, Esq.—A curious pseudomorphous formation of Carbonate of Iron, and of Iron Pyrites, from Virtuous Lady Mine, near Tavistock. By Edward Pearse, Esq.—Another specimen of the same. By Mr. William Longmaid.—Specimens illustrative of the Stream-work near Marazion Bridge; and four hundred specimens of Cornish Rocks. By W. J. Henwood, F.G.S. &c.—One hundred and fifty additional specimens of the Cornish Rocks. By H. S. Boase, M.D.—Specimens of Woodstone from Hobart Town, Van Dieman's Land; and Silver and Copper-ore from South America. By Edward Leah, Esq.

At the Anniversary Meeting, held on the 30th August, 1833, Davies Gilbert, Esq. F.R.S. &c., *President*, in the chair;—the Report of the Council being read, it was resolved, That it be printed and circulated among the Members;—That the Council be empowered to nominate Students, who, under certain regulations, may be permitted to enjoy gratuitously the benefits of the Library and Museum; and that the management of this department be entirely entrusted to the Council;—That the thanks of the Society be presented to the authors of the various papers, to the officers, &c. The President then announced that the Council had come to the determination of recommending to the Society to present a piece of plate to Dr. Boase for his valuable services during the last four years; and he was sure that the proposal would be carried by acclamation: it was therefore resolved, That a piece of plate be presented to Dr. Boase.

The following gentlemen were elected Members of the Society:—*Honorary Members:* Roderick Impey Murchison, Esq. F.R.S. &c. &c.; Henry T. De la Beche, Esq. F.R.S. &c. &c.; Charles Lyell, Esq. F.R.S. &c. Professor of Geology, King's Coll. London.—*Ordinary Members:* John J. A. Boase, Esq.; Mr. Charles Parry; the Rev. Thomas Pascoe; Edward H. Rodd, Esq.; Mr. Richard Rule; the Rev. Thomas H. Vyvyan.—*Associate:* Mr. William Petherick, of Dolcoath.

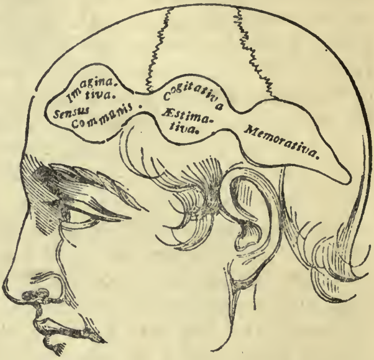
Officers and Council for the present year:—*President:* Davies Gilbert, Esq. F.R.S. &c. &c.—*Vice-Presidents:* George S. Borlase, Esq. F.R.S. &c.; John Paynter, Esq.; Sir Charles Lemon, Bart. M.P. F.R.S. &c.; John Hearle Tremayne, Esq.—*Secretary:* Henry S. Boase, M.D.—*Treasurer:* Joseph Carne, Esq.—*Librarian:* the Rev. George Pigott.—*Curator:* Edward C. Giddy, Esq.—*Assistant Curator:* W.J. Henwood, F.G.S. &c.—*Council:* J. J. A. Boase, Esq.; T. Bolitho, Esq.; Wm. Cornish, Esq.; Stephen Davey, Esq.; Robert W. Fox, Esq.; Day P. Le Grice, Esq.; George D. John, Esq.; Rev. Canon Rogers; Wm. M. Tweedy, Esq.; John Williams, jun., Esq.

The Quarterly Meetings of the Society for the ensuing year will be held on Wednesdays,—the 23rd October, the 15th January, the 16th April, and the 23rd July.

## LIII. *Intelligence and Miscellaneous Articles.*

### EARLY ANTICIPATION OF PHRENOLOGY.

THE Rev. W. D. Conybeare, F.R.S. &c., has favoured us with the following notice of a curious anticipation of the modern Phrenological System, bearing date as early as 1503: it occurs in an old Encyclopædical kind of Work, entitled *Margarita Philosophica*, printed at Friburg in that year. The author speaking of the mental functions, says, "Sensus interiores numero quinque sunt: Sensus Communis, Imaginativa, Æstimativa, Cogitativa, et Memorativa. *Horum Organa in substantiâ cerebri* subtilissimis secernuntur pelliculis; quæ primum totum cerebrum tribus distinguunt ventriculis, quorum anterior et medius rursus bipartiuntur:—1ma portio anterioris organum est Sensus Communis; 2da, Imaginativa. 1ma, autem ventriculi medii attribuitur Æstimativæ; 2da, Cogitativæ; posterior vero ventriculus totus Memorativæ deputatur." This is illustrated by the sketch of a head divided just like one of Gall or Spurzheim's models, a part of which is copied in the annexed.



### COMPOSITION OF PHOSPHURETTED HYDROGEN.

M. Rose published some years since researches on the composition of phosphuretted hydrogen gas, which, he observes, do not agree with those published at the same time by Dumas and by Buff: he has since repeated his experiments, both upon the spontaneously inflammable gas, and that obtained from hydrated phosphorous acid.

*Spontaneously inflammable Gas.*—M. Rose does not state the composition of this gas by weight; but states that he considers it as composed of 1 atom of phosphorus and 3 atoms of hydrogen, or, by calculation, of $\frac{1}{2}$ a volume of vapour of phosphorus $+ 1\frac{1}{2}$ volume of hydrogen gas, condensed to 1 volume. Now as neither the absolute weights of the constituents of the gas, nor those of the atoms are given, we are compelled to make them out indirectly. M. Rose finds that hydriodic acid combines with phosphuretted hydrogen, atom to atom, and 100 parts are stated to consist of 78·73 acid +21·27 phosphuretted hydrogen. Assuming the atomic weight of the acid to be 127, that of phosphuretted hydrogen will, of course, be 34·30 (78·73 : 21·27 : : 127 : 34·30). Subtracting then $3 = 3$

atoms of hydrogen from 34·30, we have phosphuretted hydrogen

| | |
|---|---|
| composed of 3 atoms of hydrogen | 3· |
| 1 atom of phosphorus | 31·30 |
| Weight of atom | 34·30 |

Now whether we admit 15·7 as the atomic weight of phosphorus, as stated by Dr. Turner, or 16, as given by Dr. Thomson, we may consider phosphuretted hydrogen as composed of

| | | | |
|---|---|---|---|
| 3 atoms of hydrogen | 3· | or | 3· |
| 2 atoms of phosphorus | 32· | | 31·4 |
| | 35· | | 34·4 |

It is therefore a sesquihydruret.

M. Rose procured the gas by heating hypophosphite of lime: the gas contains variable proportions of hydrogen: the volume of the gas obtained was accurately measured, and remained for thirty-six hours exposed to a weak solution of sulphate of copper, deprived by long boiling of atmospheric air: the phosphuretted hydrogen gas was completely absorbed, and the hydrogen only left. M. Rose states that the specific gravity of phosphuretted hydrogen by calculation should be 1·1846; that which was procured from phosphite of lead was of sp. gr. 1·205.

M. Rose proved by several experiments, that the spontaneously inflammable phosphuretted hydrogen gas, does not lose this property, when kept over either mercury or water. He states also that it is requisite to dry the gas perfectly by means of chloride of calcium, as without this precaution it may contain vapour of phosphorus, which would increase the weight of the gas; and he thinks that is the only way in which the different sp. gr. found by himself and M. Dumas can be explained.

*Phosphuretted Hydrogen from Phosphorous Acid.*—This gas was obtained by heating the hydrated phosphorous acid in green glass retorts: white ones must not be used, as the acid readily attacks them: a phosphite is formed with the alkali of the glass, which, by the action of heat, becomes a phosphate, and disengages hydrogen gas. The gas received was dried over chloride of calcium, and the latter portions of it rejected. The gas obtained is a mixture of varying proportions of hydrogen and phosphuretted hydrogen. Much depends upon the degree of heat employed: when it was quick and intense, the gas was much richer in phosphorus.

M. Rose found the action of the inflammable and uninflammable gases to be perfectly similar on different substances; and they have both the property of being converted, one into uninflammable and the other into inflammable phosphuretted hydrogen: on these accounts M. Rose considers them as isomeric compounds.—*Ann. de Chim. et de Phys.* tom. li. p. 1.

On referring to Dr. Dalton's New System of Chemistry, vol. ii. p. 182, it will appear that he had several years since arrived at the same conclusion as M. Rose, with respect to the similarity of the two kinds of phosphuretted hydrogen.

"It may be proper," he observes, "to advert more particularly to the hydrophosphoric gas of Davy. That this gas is the same as that we have been describing, can hardly admit of a doubt. Their near agreement in sp. gr., in their absorbability by water, in the quantity of oxygen requisite for their combustion, in their moderate expansion by burning with a minimum of oxygen, and in their combustibility in oxymuriatic acid, are circumstances sufficient to warrant their identity."

Dr. Dalton states the sp. gr. of the spontaneously inflammable gas to be nearly 1·1, which much more nearly approximates to 1·1846, Rose's calculated statement, than the sp. gr. given by Dumas, viz. 1·761. It may be further observed that Dr. Dalton's analysis does not widely differ from that of Rose: he states the gases to be composed of 1 hydrogen + 9 phosphorus, which will give

| | |
|---|---|
| Hydrogen . . . . . . | 3·5 |
| Phosphorus . . . . . | 31·5 |
| | 35·0 |

R. P.

## METALLIC PHOSPHURETS.

M. Rose obtained phosphuret of copper by passing a current of hydrogen gas over heated phosphate of copper. This salt became at first yellow by the conversion of the peroxide into protoxide, and afterwards, at a higher temperature, it became gray phosphuret of copper, water being formed at the same time. It consisted of

| | | | | |
|---|---|---|---|---|
| Copper . . . | 65·09 | or nearly | 1 atom of copper . . . | 64 |
| Phosphorus . | 34·91 | | 2 atoms of phosphorus | 32 |
| | 100 | | | 96 |

*Phosphuret of Cobalt.*—A current of hydrogen gas, directed upon phosphate of cobalt, gave very pure phosphuret: water only was given out. This compound is gray, powdery, and gives no phosphoric flame with the blowpipe.

When exposed to a current of dry chlorine, and moderately heated, strong ignition occurred; chloride of phosphorus sublimed, and chloride of cobalt crystallized. Its composition was found to be

| | | | | |
|---|---|---|---|---|
| Cobalt . . . | 73·47 | or nearly | 3 atoms of cobalt . . | 90 |
| Phosphorus | 26·53 | | 2 atoms of phosphorus | 32 |
| | 100· | | | 122 |

*Phosphuret of Nickel.*—This phosphuret may be obtained, as well as those of copper and cobalt, by decomposing the muriate with phosphuretted hydrogen gas. It is black and insoluble in muriatic acid; but dissolved by nitric acid, it burns under the blowpipe with a phosphoric flame. Phosphuret of nickel may also be obtained from the phosphate by hydrogen gas.

*Phosphuret of Iron.*—This was procured by the action of phosphuretted hydrogen gas upon sulphuret of iron, at a gentle heat.

It is powdery, insoluble either in concentrated or dilute muriatic acid, but dissolved by aqua regia and nitric acid. It burns when heated by the blowpipe with a phosphoric flame.

*Phosphuret of Chromium.*—The decomposition of anhydrous crystallized chloride of chromium is not effected by phosphuretted hydrogen below a red heat, which occasions the gas to deposit phosphorus. The phosphuret of chromium preserves the form of the chloride: it is black, insoluble in muriatic acid, and very slightly dissolved by nitric acid and aqua regia: it burns with the blowpipe, giving a phosphoric flame. It is composed of

| | | | |
|---|---|---|---|
| Chromium . . . | 64·5 | or 1 atom of chromium . . | 29 |
| Phosphorus . . | 35·5 | 1 atom of phosphorus . . | 16 |
| | 100· | | 45 |

In attempting to convert other metallic chlorides and sulphurets into phosphurets by means of phosphuretted hydrogen, satisfactory results were not obtained. Though at first combined with phosphorus, it was lost by continuing the heat necessary for the decomposition of the chlorides or sulphurets.

Phosphuretted hydrogen gas very readily decomposes chloride of silver, but metallic silver only is obtained; chloride of lead is not so quickly decomposed, but the results are similar. Muriatic acid gas is disengaged, and phosphorus is deposited in the cool parts of the apparatus. Chloride of mercury, decomposed by the gas, produces a phosphuret. There is a very violent disengagement of muriatic acid gas, but the combination is destroyed by heat.

Chloride of zinc may be converted into phosphuret, but the quantity obtained was too small for examination. Chloride of manganese also gives a phosphuret by the action of phosphuretted hydrogen: it has a metallic lustre, but does not give a phosphoric flame with the blowpipe. Protosulphuret of tin is very slowly decomposed at a low temperature by phosphuretted hydrogen gas; sulphuretted hydrogen gas is disengaged and phosphorus sublimes. No phosphorus was discoverable in the residue, but it still contained sulphur: it dissolved entirely in muriatic acid with disengagement of sulphuretted hydrogen gas.

Sulphuret of bismuth is also reduced by the action of phosphuretted hydrogen gas to the metallic state, and so also is sulphuret of antimony; phosphorus is deposited; sulphuretted hydrogen is given out: it is, however, remarkable that the greater part of the antimony sublimes, although the temperature is not raised to the degree at which the metal volatilizes *per se.—Ann. de Chim. et de Phys.* tom. li. p. 47.

## ON ARICINA, SANTALINE, SARCOCOLINE, &C. BY M. PELLETIER.

*Aricina.*—This is an organized salifiable and crystallizable base, accidentally discovered by MM. Pelletier and Coriol in examining some bark, which had the characters of yellow bark, but which it was stated did not yield any quina. Aricina, when combined with sulphuric acid, forms a compound which is more soluble in hot than in cold water, and gelatinizes on cooling, provided the solution is perfectly neutral when examined by litmus paper: if, however, excess of acid be added, another sulphate is formed which crystallizes in flat needles; cinchonia, on the other hand, crystallizes with sulphuric acid in neutral solutions.

The following is the composition of this substance:

| | By direct Analysis. | Atomic Constitution. | Calculated Results. |
|---|---|---|---|
| Carbon | 71·00 | 20 | 70·93 |
| Hydrogen | 7·00 | 24 | 6·95 |
| Azote | 8· | 2 | 8·21 |
| Oxygen | 14· | 3 | 13·96 |

Estimating the atomic constitution according to the weights generally adopted in England, the atoms of hydrogen and azote in this statement, and the following analyses, will be reduced to one half the above numbers. M. Pelletier remarks, that if the analysis of aricina be compared with those of cinchonia and quina by Liebig, it will be seen that they may be represented as consisting of a common radical, united with 1, 2, 3 atoms of oxygen; this radical being $C^{20}\ H^{24}\ Az^{2}$, we shall have

$$(C^{20}\ H^{24}\ Az^{2}) + O = \text{Cinchonia.}$$
$$(C^{20}\ H^{24}\ Az^{2}) + O^{2} = \text{Quina.}$$
$$(C^{20}\ H^{24}\ Az^{2}) + O^{3} = \text{Aricina.}$$

M. Pelletier is of opinion, however, that cinchonia contains two atoms more of hydrogen than were found by M. Liebig. M. Pelletier observes that cinchonia, quina and aricina will then be considered as three degrees of oxidizement of the same substance, which explains the fact that aricina requires more acid to saturate it than the other two; and it will explain how two salifiable bases, as he discovered with respect to quina and cinchonia, may exist in the same bark.

*Santaline.*—This is the colouring matter of red saunders wood (*Plerocampus santalinus*). An account of this substance has been read before the Academy of Sciences, to which the author refers; but he mentions a curious circumstance respecting it. Sulphuric æther does not immediately dissolve santaline; the process takes place slowly, and the solution, instead of being red, as in alcohol, is orange or even yellow. By the spontaneous evaporation of the æther, exposed to the air, the colouring matter is obtained of a superb red; if the æther be quickly evaporated *in vacuo*, the colour is much less intense, often it is even quite yellow. It is further remarked, that deprived of water, as the æther employed may be, and although the santaline may have been perfectly dry, water always remains after the evaporation of the æthereal tincture: it sometimes even happens that ice is obtained when the æther is rapidly evaporated under the receiver of the air-pump. M. Pelletier seems inclined to believe that while dissolving in the æther, the santaline loses a portion of its oxygen, which forms water with the hydrogen of the æther, and that afterwards, the santaline, by exposure to the air, regains its colour by absorbing oxygen.

M. Pelletier states, that some chemists consider santaline as a resinous matter; he is however more inclined to rank it with acid colouring matters, on account of its affinity for salifiable bases.

Its composition is

| | By direct Analysis. | Atomic Constitution. | Calculated Results. |
|---|---|---|---|
| Carbon | 75·03 | 16 | 75·36 |
| Hydrogen | 6·37 | 16 | 6·15 |
| Oxygen | 18·60 | 3 | 18·48 |

*Sarcocoline.*—This substance was discovered by Dr. Thomson in sarcocol, the concrete juice of the *Pœnea mucronata.* It is obtained by treating sarcocol with sulphuric æther to remove the resinous matter; the sarcocol is then to be dissolved in absolute alcohol, which is to evaporate spontaneously.

Sarcocoline is soluble in water, and more so when it is hot; the solution made in boiling water becomes milky on cooling; it is soluble in alcohol, insoluble in æther, and does not crystallize under any circumstance. When treated with nitric acid, it is converted into oxalic acid. The results of the analyses are

| | By direct Analysis. | Atomic Constitution. | Calculated Results. |
|---|---|---|---|
| Carbon | 57·15 | 13 | 57·39 |
| Hydrogen | 8·34 | 23 | 7·94 |
| Oxygen | 34·5 | 6 | 34·65 |

*Piperine.*—Piperine is a peculiar crystalline substance found in several species of the fruits of the genus *Piper*. It was discovered by Œrsted. In order to obtain piperine, the method proposed by M. Pelletier or M. Poutet, may be employed; the latter process gives the piperine more free from fatty matter.

The composition is

| | By direct Analysis. | Atomic Constitution. | Calculated Results. |
|---|---|---|---|
| Carbon | 70·41 | 20 | 70·54 |
| Hydrogen | 6·80 | 24 | 6·91 |
| Azote | 4·50 | 1 | 4·08 |
| Oxygen | 18·28 | 4 | 18·45 |

It contains one atom more of oxygen and one less of azote than aricina. [To be continued.]

### PREPARATION OF FORMIC ACID.

The following is the method of preparing formic acid, adopted by M. Döbereiner.

"I dissolve one part of sugar in two parts of water, mix the solution in a copper alembic, with 2½ to 3 parts of peroxide of manganese, well powdered; I heat the mixture to about 140° Fahr. and carefully stirring with a wooden rod, I add 3 parts of sulphuric acid, previously mixed with an equal weight of water. On the addition of the first third of the diluted acid, so strong an effervescence is produced, that the mixture would overflow the vessel, if it were not fifteen times larger than required to hold the mixture; along with carbonic acid, very pungent vapours of formic acid are given out; the head of the alembic must then be put on and communication made with the refrigeratory to condense the vapours. As soon as the action of the acid is over, the remaining two thirds of the acid are put into the boiler; the mixture is to be well agitated, and distillation carried on almost to dryness, in order that all the formic acid produced may pass into the receiver. A limpid liquid acid is obtained which has a penetrating odour; it is composed of water, formic acid, and an æthereal matter. It is to be neutralized with a carbonate, (chalk answers best,) and evaporated; this last operation ought to be performed in a retort with a receiver adapted to it: if it be wished to separate the æthereal matter, which evaporates with the water and remains dissolved in it, it may be effected by distilling the aqueous product from chloride of calcium. A pound of sugar furnishes formic acid enough to saturate 5 or 6 ounces of carbonate of lime. The residue is protosulphate of manganese, artificial malic acid, and a kind of extractive matter. The sulphate of manganese may be employed in dyeing instead of sulphate of iron, to deoxidize indigo. If concentrated formic acid or formic æther be required, the formic acid produced from the sugar is to be saturated with carbonate of soda; the solution is to be evaporated to dryness, and 7 parts of the dry salt, reduced to powder, are to be distilled either with 10 parts of sulphuric acid and 4 of water, or with a mixture of 10 parts of concentrated sulphuric acid, and 6 parts of perfectly rectified spirits of wine. The formic æther produced in the latter case ought to be agitated, if it is acid, with a little calcined magnesia; it may be separated from alcohol by agitating it with a little water, and it is deprived of the water by distilling it with chloride of calcium.

"The properties of this æther are well known; one of the most remarkable is, that when put in contact with water, the bodies composing it are reproduced, namely, alcohol and formic acid. When it is mixed with dilute alcohol, it suffers no alteration; hence a mixture of 1 part of formic æther and 3 parts of rectified spirit may be preserved, (*spiritus formico-æthereus*)."—*Ann. de Chim. et de Phys.* tom. lii. p. 105.

---

## EXPERIMENTS ON THE ACTION OF LIME ON CERTAIN SOLUTIONS OF CARBONATE OF POTASH. BY HENRY HOUGH WATSON.

Among the Miscellaneous Articles in the London and Edinburgh Philosophical Magazine and Journal of Science for September 1832, will be found an extract from *Ann. de Chim. et de Phys.* xlix. p. 142, in which M. Liebig states that "if one part of carbonate of potash be dissolved in four parts of water, and the solution be boiled with slaked lime, the potash does not lose the smallest quantity of carbonic acid; it does not become caustic, even though lime be added to any extent, or however long the boiling may be continued." Now, as the first part of this statement is considerably at variance with the one which I should give, as founded on the result of my own inquiries, without further premise I venture to lay before the readers of the Philosophical Magazine a few experiments lately made on the same subject.

*Exp.* 1. 50 grains of pure dry carbonate of potash, prepared by exposing the bi-carbonate to a red heat, are dissolved in 200 grains of water (4 times the weight of the carbonate); and to the solution are added 70 grains of proto-hydrate of lime. The mixture is heated to boiling as quickly as possible, the whole heating operation only lasting two minutes. The liquor is filtered while hot and undiluted, and a part of it treated with sulphuric acid, sp. gr. 1·135, of which 60 grain measures are required before effervescence takes place, and only 20 more for saturation; consequently ¾ths of the carbonate are decomposed by the lime.

The boiling point of the mixture is about 220°; but I find that a very material decomposition of the carbonate takes place even when a like mixture is exposed only to 150° for a quarter of an hour, being briskly agitated all the time.

*Exp.* 2. 61·4 grains of pure dry carbonate of potash = 1 atom, are dissolved in 320 grains of water = 40 atoms, or about 5⅙ times the weight of the carbonate; and to the solution are added 90 grains of hydrate of lime: 50 grains more water are also added to the mixture as an allowance for the loss in boiling. It is now heated up to boiling in 1½ minute, and kept boiling another 1½ minute, when it is found by weighing that the additional 50 grains of water have evaporated.

The liquor is filtered while hot and undiluted, and part of it treated with sulphuric acid, such as before, of which 100 grain measures are required before effervescence takes place, and only 5 more for saturation. In this case, therefore, the lime has only left $\frac{1}{21}$ part of the carbonate undecomposed.

*Exp.* 3. 61·4 grains of pure dry carbonate of potash = 1 atom, are dissolved in 480 grains of water = nearly 8 times the weight of the carbonate, and to the solution are added 90 grains of hydrate of lime: 50 grains more water are also again added to the mixture. It is boiled as before, until the additional 50 grains of water are evaporated.

The liquor is filtered while hot and undiluted, and a part of it found to require 105 grain measures of the sulphuric acid for saturation; only a few minute bubbles of carbonic acid being given out.

It therefore appears that to obtain caustic potash, not fewer than about 53 atoms of water (besides what is combined with the lime to constitute the hydrate,) are sufficient for each atom of the carbonate.

The atomic weights here made use of are those of Dr. Dalton.

How M. Liebig arrives at the conclusion that carbonate of potash loses no carbonic acid when dissolved in only 4 times its weight of water, and boiled with slaked lime, I am not aware, except it is from the entertainment of some theoretical views. He explains the matter upon the fact that concentrated potash takes carbonic acid from lime. Though that may be the case, it is very evident, from the result of my first experiment, that the solution employed is not sufficiently strong to do so.

Considerable time has now elapsed since the statement in question was announced; but as nothing contradictory has, as far as I know, hitherto been given, the above experiments and observations will not, I trust, be regarded as too late, when it is considered that the real intent of their publication is the correction of error.

Little Bolton, July 13th 1833.

## PROPOSED MODIFICATION OF THE PATENT LAWS.

The following paper has been privately circulated; and at the present time, when the attention of many persons is directed to the law of patents, it may prove interesting to some of our readers.

*Proposed Definition of the Subject Matter of Patents for Inventions.*—That His Majesty is hereby empowered to grant letters patent, of exclusive privilege, for limited periods of time, as hereinafter provided, to the inventor or inventors, or to the introducer from abroad, of any manufacture, which, at the time of lodging application for such letters patent, shall be new in the United Kingdom of Great Britain and Ireland; which new manufacture shall consist, either in a new saleable thing made, or in some new means or process, employed in the working, making, or preparing of a saleable thing: and such letters patent shall confer on such inventor or inventors, or on such introducer from abroad, and their executors, administrators, and assigns, the exclusive privilege of making and selling such new manufacture, so far as the same shall consist in a new saleable thing made, and the exclusive privilege of using and practising such new manufacture, so far as the same shall consist in some new means or process, employed in the working, making, or preparing of a saleable thing; always provided, that no such privilege shall interfere with any privilege conferred by previously granted letters patent.

That any manufacture shall be accounted new at the time of application being lodged for letters patent for the same, when the said manufacture has not been openly made or sold, nor openly used or practised, during the whole, or any part of the *fifteen* years immediately preceding the lodging of such application; although such manufacture has been openly made or sold, or openly used or practised, prior to the said *fifteen* years, or although such manufacture has been secretly made or sold, or secretly used or practised, during some part of the said *fifteen* years; always provided, that the said open making or selling, or open using or practising prior to the said *fifteen* years, or the said secret making or selling, or secret using or practising during some part of the said *fifteen* years, has been unknown to the person making application for letters patent, at the time of lodging such application, and that the said secret making or selling, or secret using or practising has been abandoned before lodging such application. But no manufacture shall be accounted new in the United Kingdom of Great Britain and Ireland, at the time of application for letters patent for the same being lodged, when the said manufacture has been described, either in some printed publication made in the said United Kingdom, during the *thirty* years immediately preceding the lodging of such application, or in any specification of the letters patent for the whole, or for any part or parts of the said United Kingdom, granted during the said *thirty* years, but expired, or made void; always provided, that in such publication, or in such specification, the said manufacture has been so described, as to enable manufacturers, or intelligent operatives employed by them, to make, or to use and practise, the said manufacture.

That any manufacture, which may otherwise be accounted new, according to the foregoing description, shall be so accounted, although the novelty shall consist only in a new combination of previously known parts, or only in a new improvement; but, in such cases, the exclusive privilege shall be confined to the new combination, or to the new improvement.

## DEATH OF THOMAS ALLAN, ESQ., OF LAURISTON, F.R.S. L. & E. F.L.S. &C. &C.

The friends of Mr. Allan will receive with deep regret, and those who saw him so lately at the Cambridge Meeting of the British Association, not without surprise, the intelligence of his death; for though evidently declining in health, yet there was nothing then to indicate that the termination of his earthly career was so near at hand. After returning to Edinburgh, he again left that city early in September, attended by some members of his family; and when on a visit to his friend Mr. Bigge, of Linden Hall, Northumberland, was suddenly attacked with apoplexy, and died there, on the 12th ult., in the 57th year of his age.

The claim of Mr. Allan to be honourably remembered by the cultivators of science, rests mainly on his extensive and accurate knowledge of mineralogy, and on his contributions to its advancement. He was thoroughly acquainted with the system of external characters, and most skilful in applying them to the discovery of those minute resemblances and differences on which the classification of minerals is founded. Instances of his skill must be in the memory of those who intimately knew him. It may be sufficient to notice his sagacious discrimination from Gadolinite, of the mineral to which the name of *Allanite* was afterwards given by the eminent chemist who analysed it*. The collection formed by Mr. Allan, though by no means the largest, was undoubtedly the best-selected and the most instructive in the kingdom. It was also admirably arranged, partly by himself and partly by Mr. Haidinger; and the latter derived, for his Work explanatory of the System of Mohs, many of his descriptions and figures from the fine specimens in Mr. Allan's cabinet. These treasures Mr. Allan delighted to lay open, not for the gratification of vanity (with which no man was ever more entirely unstained), but for the higher purposes of communicating knowledge, and of receiving information in return.

Mr. Allan was one of those who early espoused the Huttonian Theory of the Earth. He was struck with the beauty of that happy

---

* Dr. Thomson.

generalization, and warmly admired the creative genius of which it was the offspring. But he did not adopt it till he had himself tried its conformity with actual phænomena; and even then he admitted that it was by no means free from difficulties. In the course of this scrutiny, several new observations occurred to him, which are detailed in a series of memoirs published in the Transactions of the Royal Society of Edinburgh. His only separate Work is an octavo volume on Mineralogical Nomenclature, which passed through two editions, and which it would now be desirable to reprint, with the additions rendered necessary by the present state of the science.

The mind of Mr. Allan was one of considerable original power and of great and general activity. " In every sense of the word" (as it has been expressed by one who knew him well,) " he was an eminent citizen of Edinburgh." During the last twenty years, his name has been associated with every scheme for the improvement of that beautiful city; and on this subject he was completely an enthusiast, devoting a large portion of his time and thoughts to the public good. Of the various Institutions of Edinburgh, whether for charitable or other purposes, there was scarcely one to which he had not rendered important services; and those, more particularly, intended for the promotion of science, were the objects of his constant and fostering care. At the meeting of the British Association in Edinburgh during the ensuing year, to which he looked forward with great delight, the loss of his zealous cooperation and of his kind attentions and friendly offices will be felt as a serious calamity.

The following is a list (probably incomplete) of Mr. Allan's publications :—1. " On the Rocks in the Vicinity of Edinburgh :" Transactions of the Royal Society of Edinburgh, vol. vi.—2. " Remarks on the Transition Rocks of Werner :" Ditto, vol. vii.—3. " An Account of the Mineralogy of the Faroe Islands :" Ditto.—4. "Description of a Vegetable Impression found in the Quarry of Craigleith :" Ditto.—5. " Observations on Chalk Strata, and on the Construction of Belemnites."—6. " On a Mass of Native Iron from the Desert of Atacama in Peru."—7. " Remarks on a Mineral from Greenland, supposed to be Crystallized Gadolinite."—8. " An Account of the Geology of the Environs of Nice."—A few Articles in Dr. Brewster's Encyclopædia.
W. H.

## DESCRIPTION OF A NEW AND INTERESTING OBJECT FOR THE MICROSCOPE. BY C. GOULD.

Having occasion to prepare some of the scales from different fish for the microscope, in viewing one as an opake object, in a drop of water, I observed a very curious phænomenon; which was, a number of minute shining particles in motion, moving in all directions, appearing and disappearing, and when on the surface reflecting the most brilliant prismatic colours, producing a beautiful microscopic effect. I have examined them with various forms of the microscope, particularly under a fine achromatic belonging to Mr. Joinville; and they have every appearance of animalcula. Several of my microscopic friends who have seen them are of the same opinion, particularly the above gentleman, who has paid great attention to microscopic pursuits. Whether they are living animalcula or not, I am at a loss to determine, and must leave it for the investigation of our microscopic friends. The readiest way of examining them is as follows:—Take a single scale from any fish (say a fresh herring); put it on a flat piece of glass, and cover it with a drop of pure water; press the scale to make it lie flat on the glass; place it under the microscope with a piece of black paper, or the black ivory stage-piece of the microscope, as it must be viewed as a perfect opake object, or the effect is not seen: by means of a condenser throw a strong light upon it from a lamp or candle; and you will observe a multitude of minute bodies in motion on the scale: but they are much more visible in that part of the drop of water which the scale does not occupy, forming a most beautiful and interesting microscopic object.

## LUNAR OCCULTATIONS FOR OCTOBER AND NOVEMBER.

*Occultations of fixed Stars by the Moon, visible at Greenwich in the Year* 1833. *Computed by* Thomas Maclear, *Esq.; and circulated by the Astronomical Society.*

*⁎* The *angles* are reckoned *from* the northernmost point, and also *from* the vertex, *towards* the right hand, round the circumference of the Moon's image, as exhibited in an inverting telescope.

An Asterisk (*) annexed to the time of the phænomenon is intended to denote that the Star is *on*, or *near to*, the meridian, at that time.

| 1833. | Stars' Names. | Magnitude. | Ast. Soc. Cat. No. | Immersions. | | | | Emersions. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sidereal time. | Mean time. | Angle from | | Sidereal time. | Mean time. | Angle from | |
| | | | | | | North Pole. | Vertex. | | | North Pole. | Vertex. |
| | | | | h m | h m | ° | ° | h m | h m | ° | ° |
| Oct. 7 | 33 Cancri | 6 | 1037 | 2 2 | 12 56 | 140 | 99 | 2 36 | 13 31 | 214 | 172 |
| | 38 *o* Cancri | 7 | 1048 | 5 34 | 16 27 | | | a near | approa. | | |
| | 39 Cancri | 6 | 1050 | 5 5 | 15 59 | 72 | 38 | 6 16 | 17 9 | 272 | 247 |
| | 40 Cancri | 6 | 1051 | 5 9 | 16 3 | 63 | 28 | 6 18 | 17 11 | 279 | 254 |
| | (136) Cancri | 7 | 1058 | 6 3 | 16 56 | 53 | 27 | 7 9 | 18 2 | 285 | 274 |
| 13 | 88 Virginis | 7 | 1571 | 17 16 | 3 48 | 109 | 137 | 18 1 | 4 33 | 201 | 235 |
| 18 | 24 Sagittar. | 6·7 | 2141 | 20 23 | 6 36 | 25 | 39 | 20 55 | 7 7 | 337 | 359 |
| 22 | 29 *x* Aquarii | 6 | 2613 | 21*25 | 7 21 | 54 | 47 | 22 8 | 8 4 | 352 | 355 |
| 28 | (155) Arietis | 7 | 284 | 1 18 | 10 50 | 114 | 111 | 2 37* | 12 9 | 304 | 314 |
| | 85 Ceti .... | 6 | 286 | 1 52 | 11 24 | 141 | 135 | 3 6* | 12 37 | 277 | 285 |
| 31 | 123 ζ Tauri | 3·4 | 684 | 11 53 | 21 11 | 17 | 57 | 12 7 | 21 25 | 347 | 26 |
| Nov. 1 | (338) Tauri | 6·7 | 759 | 22 44 | 8 1 | | | a near | approa. | | |

*Meteorological Observations made by Mr.* THOMPSON *at the Garden of the Horticultural Society at Chiswick, near London; by Mr.* GIDDY *at Penzance, and Mr.* VEALL *at Boston.*

| Days of Month, 1833. | Barometer. | | | | | Thermometer. | | | | | Wind. | | | Rain. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | London. | | Penzance. | | Boston 8½ A.M. | London. | | Penzance. | | Bost. 8½ A.M. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
| | Max. | Min. | Max. | Min. | | Max. | Min. | Max. | Min. | | | | | | | |
| Aug. 1 | 30·394 | 30·379 | 30·292 | 30·286 | 29·83 | 67 | 45 | 71 | 56 | 61 | N. | NE. | N. | ... | ... | ... |
| 2 | 30·372 | 30·326 | 30·298 | 30·292 | 29·83 | 65 | 52 | 67 | 55 | 58·5 | N. | NE. | calm | ... | ... | 0·05 |
| 3 | 30·349 | 30·292 | 30·298 | 30·278 | 29·75 | 67 | 45 | 67 | 53 | 60 | N. | E. | NE. | ... | ... | ... |
| 4 | 30·351 | 30·223 | 30·304 | 30·298 | 29·82 | 74 | 45 | 67 | 55 | 60 | NE. | NE. | calm | ... | ... | ... |
| 5 | 30·111 | 30·100 | 30·204 | 30·098 | 29·50 | 70 | 43 | 68 | 51 | 62 | NW. | E. | N. | ... | ... | ... |
| 6 | 30·153 | 30·135 | 30·104 | 30·098 | 29·14 | 70 | 36 | 67 | 53 | 57 | NE. | E. | calm | ... | ... | ... |
| 7 | 30·134 | 30·077 | 30·084 | 30·048 | 29·54 | 75 | 45 | 67 | 50 | 58 | NE. | NE. | calm | ... | ... | ... |
| ☾ 8 | 30·076 | 30·058 | 30·054 | 30·018 | 29·48 | 76 | 51 | 68 | 51 | 61·5 | NE. | NW. | calm | ... | ... | ... |
| 9 | 30·055 | 30·006 | 30·105 | 30·004 | 29·44 | 79 | 44 | 68 | 53 | 60 | SW. | NW. | calm | ... | ... | ... |
| 10 | 30·017 | 29·978 | 30·001 | 29·998 | 29·39 | 78 | 44 | 69 | 52 | 62·5 | W. | NW. | NW. | 0·04 | ... | ... |
| 11 | 30·117 | 29·985 | 29·998 | 29·998 | 29·39 | 78 | 37 | 68 | 52 | 58 | W. | NE. | calm | ... | ... | ·03 |
| 12 | 30·188 | 30·037 | 30·054 | 30·048 | 29·67 | 74 | 48 | 68 | 53 | 57 | NE. | NE. | calm | ... | ... | ... |
| 13 | 29·839 | 29·669 | 29·901 | 29·698 | 29·25 | 70 | 48 | 64 | 52 | 58·5 | S. | NE. | calm | ... | ... | ... |
| 14 | 29·679 | 29·639 | 29·698 | 29·654 | 29·16 | 70 | 40 | 63 | 51 | 57 | NE. | NE. | NW. | ... | ... | ·12 |
| ● 15 | 29·859 | 29·757 | 29·804 | 29·757 | 29·27 | 70 | 46 | 64 | 48 | 55 | N. | NE. | calm | ... | 0·100 | ... |
| 16 | 29·905 | 29·791 | 29·904 | 29·804 | 29·27 | 69 | 40 | 65 | 51 | 54·5 | NW. | N. | calm | ... | ... | ... |
| 17 | 29·913 | 29·843 | 29·904 | 29·904 | 29·36 | 75 | 44 | 64 | 52 | 59 | W. | N. | W. | ... | ... | ·25 |
| 18 | 29·822 | 29·773 | 29·854 | 29·851 | 29·21 | 74 | 56 | 67 | 52 | 58 | W. | NW. | calm | ·11 | ... | ... |
| 19 | 29.929 | 29·742 | 29·904 | 29·854 | 29·17 | 72 | 48 | 68 | 53 | 62·5 | W. | NW. | W. | ... | ... | ·05 |
| 20 | 29·979 | 29·915 | 30·018 | 30·004 | 29·24 | 74 | 60 | 67 | 55 | 61 | W. | NW. | NW. | ... | ... | ... |
| 21 | 29·891 | 29·691 | 29·998 | 29·898 | 29·24 | 77 | 48 | 67 | 58 | 61 | W. | SW. | W. | ... | ·050 | ·04 |
| ☽ 22 | 29·771 | 29·679 | 29·884 | 29·858 | 29·10 | 71 | 48 | 66 | 53 | 58 | W. | W. | W. | ... | ·095 | ·06 |
| 23 | 29·803 | 29·654 | 29·898 | 29·804 | 28·94 | 71 | 47 | 65 | 53 | 59 | W. | NW. | W. | ... | ... | ... |
| 24 | 30·011 | 29·948 | 29·998 | 29·954 | 29·33 | 74 | 47 | 64 | 54 | 58 | SW. | NW. | NW. | ... | ·100 | ·15 |
| 25 | 30·279 | 30·127 | 30·148 | 30·004 | 29·59 | 65 | 62 | 65 | 55 | 57 | SW. | NE. | calm | ... | ... | ·07 |
| 26 | 30·305 | 30·235 | 30·207 | 30·198 | 29·67 | 75 | 40 | 65 | 50 | 58 | NE. | NE. | calm | ... | ... | ... |
| 27 | 30·244 | 30·178 | 30·204 | 30·198 | 29·60 | 78 | 45 | 67 | 48 | 62 | W. | W. | NW. | ... | ... | ... |
| 28 | 30·244 | 30·198 | 30·204 | 30·198 | 29·59 | 80 | 44 | 67 | 52 | 62 | W. | NW. | calm | ... | ... | ... |
| 29 | 30·158 | 29·927 | 30·151 | 30·048 | 29·43 | 80 | 51 | 67 | 52 | 64·5 | SW. | NW. | W. | ... | ... | ... |
| ○ 30 | 29·893 | 29·266 | 29·951 | 29·354 | 29·21 | 70 | 45 | 65 | 55 | 58 | W. | SW. | W. | ·86 | ·790 | ·16 |
| 31 | 29·333 | 28·985 | 29·704 | 29·460 | 28·25 | 55 | 46 | 60 | 47 | 50 | NW. | NW. | N. | ·92 | ... | 1·04 |
| | 30·394 | 28·985 | 30·304 | 29·354 | 29·37 | 80 | 36 | 71 | 47 | 58·9 | | | | 1·93 | 1·135 | 2·02 |

**Remarks.**

*London.* — August 1. Cloudy and cool. 2, 3. Overcast. 4. Very dry. 5. Cloudy and fine. 6. Cold and dry: fine. 7—9. Fine. 10. Fine: lightning and rain at night. 11—14. Fine. 15. Heavy dew: fine. 16, 17. Fine. 18. Overcast. 19—21. Fine. 22. Fine: strong gale at night. 23. Dry and windy. 24—27. Fine. 28. Very dry. 29. Slight haze: fine. 30. Fine: heavy rain with strong wind at night. 31. Very boisterous with heavy rain. On the afternoon of the 4th, about 4 P.M., a whirlwind swept through the garden from north to south: four large sashes were lifted by it and dashed to pieces; one of them was tossed over a low wall to the distance of twenty yards.

*Penzance.*—August 1. Clear: fair. 2. Clear. 3. Clear: fair. 4—12. Clear. 13. Fair. 14. Clear. 15. Clear: rain at night. 16. Fair. 17, 18. Clear: light shower. 19, 20. Fair. 21, 22. Fair: evening rain. 23. Fair. 24. Fair: rain at night. 25. Fair. 26, 27. Clear. 28, 29. Fair. 30. Clear: heavy rain. 31. Fair: a shower.

*Boston.*—August 1. Cloudy. 2. Cloudy: rain early A.M. 3. Cloudy. 4. Fine. 5. Cloudy. 6, 7. Fine. 8. Cloudy. 9, 10. Fine. 11. Cloudy: rain early A.M. 12. Cloudy. 13. Cloudy: rain A.M. 14. Cloudy. 15. Foggy. 16. Cloudy: rain A.M. and P.M. 17. Fine. 18. Cloudy. 19. Fine. 20. Fine: rain A.M. 21. Cloudy: rain P.M. 22, 23. Stormy. 24. Fine. 25. Cloudy: rain early A.M. 26—28. Fine. 29. Fine: rain P.M. 30. Fine. 31. Rain and stormy: blew a hurricane all day; ships wrecked, orchards stript, and trees blown up by the roots.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

NOVEMBER 1833.

## LIV. *On the Vibration of heated Metals. By* ARTHUR TREVELYAN, *Esq.*; *including a Letter on the same Subject by Dr.* W. KNIGHT.*

AS it is always interesting to know the accidental circumstances which lead to the discovery of any new fact in natural science, I shall begin by relating the manner in which I was led to observe the vibrations of heated metals. On the 9th of February 1829, I was about to spread with a plaster-iron some common pitch, when the iron being at too high a temperature, I placed it in a slanting direction against a block of lead, the handle resting on the table: shortly after doing so I heard a shrill high tone, which much resembled a note produced on the chanter of the smaller Northumberland pipes, an instrument played on by my father's gamekeeper. Not knowing the cause of the sound, I thought he might be practising out of doors. The room being on the ground floor, I went outside, when the sound was no longer heard; and seeing no person, returned again to the room, when I was surprised at still hearing the sound as shrill as before. After looking about for a few minutes, I at last approached closer to the iron, perceived the vibration, and thence found the immediate cause of the sound. I was much surprised and pleased; but at that time, not having studied any branch of natural philosophy connected with the subject of heat, I was not aware that it was a fact which had not been before observed (although it struck me so at the time). I came to Edinburgh in November 1830, and attended Dr. D. B. Reid's class of

---

* Communicated by the Author. Part of this paper was read before the Section of Physics of the British Association, meeting at Cambridge, June 27, 1833.

Practical Chemistry. Having mentioned the circumstance and shown him the experiments, he informed me that the fact was new, and recommended me to make further experiments, and prepare a paper on the subject for the Royal Society of Edinburgh. I took his advice, and during the winter session had the honour of having two papers read before that Society, which were illustrated by experiments.

Since that time I have made numerous additional experiments, and have succeeded in obtaining vibration with most metals, many of which I failed with previously, from the apparatus not being sufficiently delicate.

On the opposite page is a Table of the different metals in which I have observed vibration.

The experiments were repeated several times before I was satisfied with the results.

I have not yet observed any effect with bismuth, although I have with pale solder, which is an alloy of that metal.

The gold was in too small a piece to try cold, with the hot bar placed on it. The results with it and with platinum would probably have been more numerous, if I could have obtained better-shaped pieces of those metals.

Bars of tin, lead, bismuth, antimony, block tin, solder, tin-solder and pale solder, produced no effect, when heated and placed on cool blocks, or rings, of all the different metals mentioned in the Table.

Cold bars of lead, bell-metal, tin-solder and pale solder, when placed on heated iron or brass, produced vibration and tone. The cold lead block, placed on the heated polished bar of a fire-grate, sounds loudly, and vibrates rapidly.

The vibration continues in the exhausted receiver of an air-pump.

The bars begin to vibrate on lead at a temperature below 212° Fahr., but on harder metals they require a higher temperature.

A cool brass bar, 5 inches long, 2 inches wide and $\frac{3}{8}$ths of an inch thick, placed on a cool lead cylinder $\frac{1}{2}$ an inch thick, 2 inches in height and $4\frac{1}{4}$ inches in diameter, with a spirit-lamp placed under the bar, produced vibration and tone in 6 minutes 15 seconds, and continued sounding for 5 hours and 55 minutes: when I removed the lamp, it ceased vibrating in 6 minutes, but might probably be continued, by the continued application of the lamp, for any length of time. The block had arrived at so high a degree of temperature, that it was too hot to hold with the naked hand: the vibration was only kept up by the brass bar being so superior to lead in its power of conducting caloric. From the small size of the bar, it soon fell to the same temperature as the lead, and then of course the vibration ceased.

| Bars. | Simple Metals. | | | | | | | | | | Alloys. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. Platinum. | 2. Gold. | 3. Silver. | 4. Copper | 5. Iron. | 6. Cast Iron. | 7. Zinc. | 8. Tin. | 9. Antimony. | 10. Lead. | 1. Fine Brass. | 2. Com. Brass. | 3. Gun Metal. | 4. Bell Metal. | 5. Cock Metal. | 6. Block Tin Solder. | 7. Tin Solder. | 8. Pale Solder or Fusible Metal. |
| Platinum ....... | | | | | | | + | + | | + | | | | + | + | + | | |
| Gold ............ | | | | | | | | | | + | + | + | | + | + | | | |
| Silver............ | + | | | | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Copper.......... | + | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Iron............. | | | | | | | + | + | + | + | | | | + | | + | + | + |
| Cast Iron ...... | | | | | | | | + | | + | | | | | | | | |
| Zinc............. | | | | | | | | + | + | + | | | | + | | | + | + |
| Fine Brass...... | | | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Common Brass | | | | | | | + | + | | + | | + | + | + | + | + | + | |
| Gun Metal...... | | | | | | | | + | | + | | | | + | | + | + | |
| Bell Metal...... | | | | | | | | | | + | | | | | | | + | |
| Cock Metal..... | | | | | | | | | | + | | | | + | | | | |

The crosses denote that vibration took place when the heated bar was placed on the cold metal named at the top of the column. The names of metals at the side of the Table are those of the bars which were heated and placed on the cold metal.

When the brass bar at a high temperature is placed on the cool lead, the vibration seldom fails taking place instantly and spontaneously.

A bar 5 inches long, 2 inches wide, and $\frac{3}{8}$ths of an inch thick, vibrated when supporting a weight of 12 pounds.

However near the bar and block may be brought to each other, no apparent phænomenon takes place until they are in actual contact.

By balancing the bar in a horizontal position on a narrow lead block (fig. 1. p. 332), rounded on the part on which the bar rests, the vibration is well exhibited, the bar moving vertically and laterally at the same time. A rod 10 or more inches long, flattened in the centre to prevent its slipping, with a ball on each end (fig. 5), when placed across a heated vibrating bar (fig. 6), increases the arc of motion, rendering the movements much more conspicuous.

A thick ring of copper, 5 inches in diameter, when heated, and hung on a lead bar, vibrates backwards and forwards; and when laid on a narrow lead block, upwards and downwards.

The heated bar vibrated on a piece of thin sheet lead, either placed loosely or soldered on brass, and on a lead block burnished with gold-leaf.

A heated copper bar vibrated on the bottom of a glass tumbler. This is an experiment which the late Professor Leslie tried with me, but it is very uncertain and difficult to obtain.

The bars vibrate best when placed on blocks of lead with the surface somewhat rough: both metals also should be kept clean, and free from oxidation, which impairs the vibration.

A bar of heated copper was placed on an iron block rounded on the surface, and being nicely balanced on the centre of the rounded part, showed the vertical motion.

The shape or size of the bars and blocks is of little consequence, except for the more delicate experiments with the hard metals: on lead the hard metal almost of any form will vibrate when heated.

Mr. K. T. Kemp, the skilful electrician and chemist, informed me that after casting some bismuth, whilst it was cooling, after being taken out of the mould, he heard a sound proceed from it; when cool he again heated it, but could not reproduce the sound.

The bars I use to show the experiments are of different sizes: a bar about 5 inches long, $1\frac{1}{4}$ inch wide, and $\frac{3}{8}$ths of an inch thick, will produce considerable tone; a rod of small wire 6 inches long, must be attached at one end, to serve as a handle. A ridge is formed along the centre of one side of the broad part, by its being bevelled off towards each edge; the other side is hollowed out down the centre so as to throw the weight on each side, which assists the vibration: the longitudinal ridge is the part that rests on the block, (figs. 3 & 4.).

A hollow lead cylinder about ½ an inch thick, with the diameter in proportion to the length of the bar, is the best form for showing the vibrations and producing the tone.

An inequality or unequal notch on the lead cylinder increases the sound. When the bar at a high temperature is first placed on the cold lead, the tone is very harsh and undefined; but when the lead has acquired a certain proportion of heat, it becomes clear, full and mellow.

Pressure on the bar alters the note: the greater the pressure the higher is the note. Pressure also applied to the sounding-board or table on which the vibrating bar may happen to be placed, or even walking across the room, by altering the position of the bar, changes the tone.

A common poker heated and placed on a lead block vibrates, producing deep tones. If the vibrating bar be placed on a piano-forte, and certain notes be struck on the instrument, the vibration of the bar, and consequently the tone produced by it, is altered, and sometimes suddenly stopped.

Vibration is prevented by rubbing the surface of the lead with mercury, oil, plaster of Paris, or by oil gilding; also if a piece of thin tissue paper, or of wire-gauze, be interposed between the bar and the block.

The vibrations have not been produced with any substances besides metals, except in the instance of the glass tumbler already mentioned.

To try whether there was any attraction between the hard and soft metals when heated, I had two pieces of brass, about the size of an ounce weight, with a wire attached to them, and then hung on a delicate scale beam: having heated the brass weights, blocks of lead were placed under them and tried at various distances, but without producing the slightest effect.

To try whether electricity caused the phænomenon or made any alteration whilst the bar was vibrating, a hole was drilled in a bar and filled with mercury, a wire was soldered to the lead cylinder on which it was placed, and a galvanic battery of 150 plates, 4 inches square, being charged, the wire from the cylinder was placed in one end of the battery, whilst from the other end a wire was brought to the mercury contained in the cavity of the bar, which was heated, and in motion, previous to completing the circle. We also tried other methods, but with none of them did we succeed in producing any change either in the tone or in the vibration.

A Leyden phial was charged with electricity, and applied to the same bar and block, without producing any effect.

Spirit of wine, or æther, evaporated off the heated bar when in motion, produced no effect.

Air blown with a pair of bellows on the heated bar when vibrating does not affect the tremors.

If the heated bar be ground smooth, on the resting part, and the block of lead be also very smooth, no vibration takes place.

When the bar and block become of the same temperature, the vibration and sound cease.

A cylinder, 5 inches long, with a thick side bevelled off, leaving a flat ridge in the centre, similar to the former bars, when heated and placed on lead, produced no change of tone.

From the above-related experiments it appears:

1st, That in order to produce the vibrations, metals must be employed, either of the same kind or different, for both the bars and blocks; with the single exception of the glass tumbler.

2nd, That the difference of temperature between the two metals must be considerable, although some require a much higher temperature than others: the vibrations on zinc and bell-metal succeed with a lower temperature than others of the hard metals.

3rd, That the surface of the block must have some degree of unevenness, for when rendered quite smooth, the vibration does not take place; but the bar cannot be too smooth.

4th, That the interposition of any matter prevents vibration, with the exception of a burnish of gold-leaf, the thickness of which cannot amount to the 200,000dth part of an inch.

5th, That the air has no share in the production of the vibratory movements, however much its presence is essential to the production of sound.

6th, That it has no connexion with galvanism or electricity, the vibration and tone not being affected by passing a current through the bar when in action. Professor Forbes found no appearance of thermo-electricity after trying a number of experiments.

7th, That all the metals, both simple and alloys, produce vibration and sound, when one is heated and the other cool, on being brought into contact, (with the exception of bismuth,) but with some we find much greater difficulty in obtaining vibration than in others, as it depends on the temperature, but more particularly on the mode of placing the one on the other, which with some requires great nicety.

8th, Although all the metals are not found to vibrate on each other, or on metals of the same kind,—and I have not been able produce vibration with other substances,—yet I do not despair but that hereafter, when this subject is better understood, we shall be able to produce vibration with all the metals, and with all other matter either solid or liquid, when heat is applied to a cool substance, or *vice versâ.*

The following theory, which is partly derived from the late Professor Leslie's mode of accounting for the vibration, and appears the most probable, (and experiments hitherto made strengthen this view,) ascribes the vibratory movements to the usual mechanical changes which caloric occasions in passing from one substance into another,—I mean the expansion and contraction which accompany alternations of temperature.

It appears that some degree of roughness of one metal is essential to the success of the operation. This slight asperity arises from numberless points or ridges projecting from the mass of metal.

When the heated bar is laid upon the cool lead, the caloric passes into these prominences; and as their power of conduction is not great, it does not rapidly diffuse itself through the rest of the mass: of course they instantly expand and elongate, and by that sudden elongation they give an impulse to the incumbent bar. Soon, however, the caloric moves into the adjoining mass, and the prominences contract, and at the same time come into a state ready to admit a renewed accession of caloric from the bar: they receive that caloric, again expand, and give a second impulse to the bar. This goes on incessantly, and though the first impulse be infinitely small, and altogether inadequate to produce any sensible movement of the bar, yet by incessant repetition an accumulation of effect takes place, and the movements gradually reach a sufficient magnitude to become easily discernible.

As soon as the bar and block arrive within a certain limit of difference of temperature, the impulses become feebler and feebler, and at length the bar comes to rest. It has been mentioned that the smoother the bar is so much greater is the effect: I conceive that this smoothness operates by increasing the celerity with which the surface possessed of it communicates the caloric to the projecting points of the block, and thereby the elongation which gives the impulse to the bar is increased both in quickness and extent.

It is obvious that had the bar any considerable degree of asperity, the points of contact between the two metals would be fewer, and the passage of caloric between them more tardy.

When the two surfaces are highly polished, the experiment does not succeed: no tremors occur. This result proceeds probably from the circumstance, that the caloric enters into every part of the surface of the block equally, and is more quickly diffused through the mass, and hence there are none of those partial and sudden expansions which give the tremor-causing impulse.

The rocking on the narrow lead block may be induced by two causes, either by some slight inequality in the weight of the portions of the bar on the two sides of the ridge, or some difference in the condition of the surface of that part of the block which the ridge of the bar touches; and may be thus explained:

1st, If the first-mentioned inequality exist, as soon as the bar receives an upward heave, the greater weight of the one side will cause it to incline to that side; and as soon as that heave ceases, and the contraction succeeds, the bar approaches its original position, but will not remain in it, for the inclination given to the preponderating side will, on its return, of course, cause the bar to incline to the opposite side. The impulses which the bar receives, in this position, from the renewed expansion and elongation, will not only renew the upward heave, but also incline it again to the preponderating side, and thus increase the lateral movement, which, like the vertical, though altogether insensible at first, by incessant frequent repetition accumulates and increases till the rocking becomes conspicuous, and is rendered much more so by the transverse rod.

2ndly, If there exist any difference in regard to asperity in the condition of the surface of that part of the block upon which the ridge of the bar rests, it must necessarily follow, that the impulse given to the bar on that side which is most rough will be greater than on the other, and consequently the upward heave will be so modified as to create an inclination to one side. The bar thus thrown off its balance to the right on ascending, will incline as far to the left on descending, and there receiving the expansive impulse, it will be driven back, and thus the principle of rocking will be created. The sound depends upon the rapidity of the vibrations; for when slow, no tone is heard.

I think from the above-related experiments, and the conclusions and theory drawn from them, that the hitherto unknown causes of many sounds are now accounted for.

The sounds described by Humboldt as heard at sunrise by those who sleep on certain granite rocks on the banks of the Orinoco, also the sounds at sunrise produced by the statue of Memnon, and the twang, like the breaking of a string, heard by the French naturalists, as if proceeding from a mountain at Carnac, are probably caused by the pyrometric expansions and contractions of the heterogeneous material of which the statue and the mountain consist. Similar sounds, and from the same cause, are emitted, when heat is applied to any connected mass of machinery, and the snapping heard in a fire-grate affords a familiar example. We have often heard of a poker producing tone when heated and the point rested on a knot in a fir board in the floor of a room; also the singing in a tea-kettle is another example. In distilleries, shortly after the fire is put to the cool coppers, a very loud note is given out, and continues until the liquor boils*.

John Robison, Esq., Secretary to the Royal Society of Edinburgh, informed me that he once let a heated bar fall from his hand: it alighted on a painted shelf of wood, when he was surprised at hearing sounds; but they soon ceased.

The following theory of the cause of earthquakes and volcanic eruptions strikes me as being not at all unlikely. Earthquakes, and the sounds accompanying them, may be caused by vibration, occasioned by heat generated far below the surface of the earth, in some enormous metallic mass, which being in contact with some cool substance, not a very good conductor of heat, the latter is violently agitated, thus producing the vibration felt in earthquakes. By its intensity chasms are opened on the face of the earth; and below, caverns filled with condensed combustible matter and liquid lava are torn open, and the contents, by their enormous expansion, and having found an egress more easily upwards, rise to a great height above the surface of the earth.

The following interesting remarks on the vibration of heated metals are copied from a letter received by my brother from Dr. W. Knight, Professor of Natural Philosophy in Marischal College, Aberdeen, dated June 8, 1833.

"I regret that I have not written sooner in reply to your letter of the 9th ult., but I waited until I should find a convenient opportunity for repeating many of the experiments which I hinted the general nature of to you in my letter of the 19th of April. These opportunities have unfortunately not occurred yet, from myself being engaged with a daily class here, and my family at a country residence at some distance; nor are they likely to occur soon, so that I must content myself with

---

* The sounds from the statue of Memnon and the mountain at Carnac, and those from machinery and a fire-grate, have already been explained, nearly in the above words, by Sir John Herschel, (see Lond. and Edinb. Phil. Mag. vol. i. p. 221,) but without reference, however, to the new phænomena of vibrating metals, with the cause of which, indeed, contrary to Mr. Trevelyan's opinion, we apprehend that they are not essentially connected. The sounds heard on the granite rocks of the Orinoco are attributed by Sir J. Herschel, in the same letter, to sonorous vibrations of the air passing through small orifices, either subterranean or communicating with the atmosphere. The singing in a tea-kettle, and the note given out by stills, are referrible, we conceive, to another order of causes, connected with the rapid condensation of vapour, and quite distinct from all the former as well as from those concerned in the vibration of heated metals.—Ed.

sending you a shorter account than I could wish of the new trials made on the vibrations of metallic bodies in the end of March and beginning of April last.

" Having frequently failed as well as succeeded with the iron pokers and masses of lead, &c., and not being always able to account for the failures, a simple plan of producing vibrations occurred to me, which in no instance yet fails upon the greater number of metals employed. This consists in placing a quantity of a melted metal (as tin, lead, fusible metal, bismuth, &c.) in a hemispherical, or, better, in a parabolic conoidal cup of copper, or iron, or brass, lying above a piece of lead or other metal. The oscillations of the cup thus resting upon a small surface continue long after it has become solid, indeed until the cup and its contents have fallen to a temperature not much above that of the metal upon which they rest. I have employed in many trials cups of iron, brass and copper, of various sizes, from 2 to 6 inches in diameter at the top; and of melted metals, from an ounce to some pounds, of bismuth, tin, lead, zinc, &c. (In case of pouring the melted metal too rapidly from the ladle into the cups, and thus overturning the latter, it may be steadied by a small pair of forceps for a few seconds.) No vibrations could be produced *above* any other bodies than metals: they are most striking *above* lead, tin, zinc, antimony; more feeble above silver, gold, platina, brass, copper. Above wrought and cast-iron, I could not observe them. They are very distinct above slabs of the metal of reflecting telescopes, and above fusible metal. The smoothness of the ingots above which the vibrations are performed lessens the effect greatly, or prevents it.

" Among the most interesting trials are:

" 1st, 3 or 4 ounces of lead, melted and poured into the parabolic cup of copper, resting above the ingot of 1 pound of tin with uneven surface. The tremors loud, quick and large; *a peculiar crackling noise* is heard, which I cannot distinguish in character from the noise of the same kind which ensues on bending a piece of block tin held close to the ear. On compressing the tin ingot with the fingers, the sound does not cease, but assumes a sort of stifled character: on removing the fingers, the former crackling noise is resumed. The fingers feel distinctly the vibration communicated to the ingot by the heated cup.

" 2nd, The same placed on an ingot of 1 pound of zinc. The vibrations commenced immediately on pouring out the lead: they were small, rapid and equal, (not of an unequal sort like those above antimony): the sounds louder than above any other metal. They cease on pressing the ingot between the fingers; when resumed, there seemed some difference of tone: the stopping at the end sudden and distinct.

"3rd, The vibrations of the cups above a platina coin were very slow, and did not commence until after the lead had become solid: they soon ceased;—as if connected with the bad conducting power of platina?

"4th, The solidifying of the melted metals in the cup, and their crystallization when made to solidify during their vibrations, offered several singular phænomena, particularly with bismuth, lead and tin. As far as trials have yet gone, the crystallizing property seemed to be more conspicuous when solidifying during the vibrations, than when the same quantities of metals were not vibrating.

"These observations, like those of your brother, seem to connect this subject closely with the arcana of cohesion. On seeing the copy of your brother's paper, which you were so good as to send me, on the 19th of April, I was naturally much interested in the perusal, and cannot but think his theory the true one. An extensive field seems to be opened for examining the passage of heat through metallic bodies, in connexion with the structure of their atoms in cohesion. I could wish much that he or you would repeat some of the above experiments. I do not know when I shall find time to resume them. I found indeed, soon after beginning, that I could not advance without one of the small metallic Breguet's thermometers, with which the temperature of the ingots might be approximated to. I omitted to mention that the cups themselves will vibrate, if heated above a gas flame; but the other mode of pouring from a ladle some melted metal is more convenient, and increases the range of the phænomena; or hot mercury may be poured in, but the fumes are disagreeable.

"P.S. If you try any of the experiments, it will give me great pleasure to hear of your success. I have tried them so very often that I am quite sure you will not lose your trouble."

At one of the meetings of the Royal Society of Edinburgh this spring, Professor Forbes, of the Edinburgh University, read an able paper, and one that showed great research, on the vibration of metals; he also produced tables showing the difference of metals in the conduction of heat and electricity, and for showing the vibrations: there was great similarity in the position of the different metals in the three columns of the table, showing the difference of power in producing the three various effects*.—In the Literary Gazette for May 17, 1831, Mr. Faraday is mentioned to have shown the experiment of a curved silver plate vibrating and sounding when placed on cold iron, and to have stated that this effect had long been known to working silversmiths.

---

* An abstract of Prof. Forbes's paper will be found in our last Number, p. 303.—Edit.

## *Description of the Figures.*

Fig. 1. Is the lead block on the rounded surface of which the bar rests, by that means the vibrations being more distinctly seen: this block is screwed to a flat brass plate, having three small flat knobs to rest on.

Fig. 2. Shows the ring on which the bar is to be placed to produce the tone: it is better to have an unequal notch for the bar to rest on, thus 

Fig. 3. Is the back part of the bar, showing the ridge on which it ought to rest when placed on the lead.

Fig. 4. Is the upper side of the bar, hollowed out in the centre so as to bring the gravity more to each side.

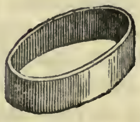
Fig. 5. Is the bar with a ball at each end, to be laid across the vibrating bar, so as to cause it to move through a larger arc.

Fig. 6. Shows how the bars ought to be arranged for exhibiting both the vertical and lateral motion.

Fig. 7. Shows the bar as placed for producing the tone.

Fig. 1.

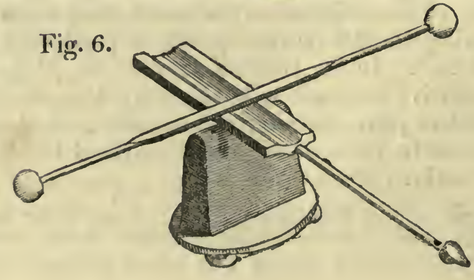
Fig. 2.



Figs. 3. 4. 5.

Fig. 7.

Fig. 6.

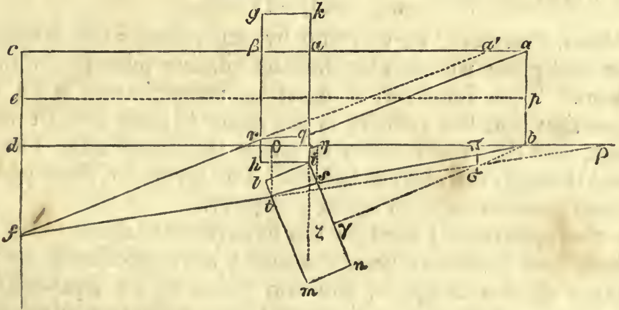


# LV. *Particulars of a Series of Experiments and Calculations undertaken with a View to determine the Velocity with which Light traverses Transparent Media.* *By* R. Potter, *Jun., Esq.**

BEFORE entering on the immediate subject of the essay, I must be excused a few remarks on Professor Airy's last paper, in the Phil. Mag. for June (vol. ii. p. 451). He does not inform us on what ground he came to the conclusion, that the locus of interference for any one band after prismatic refraction was exactly in the theoretical direction. His adjusting the wooden bar on which his eye-piece slided, so that a certain interference band might be seen on the wire, is not sufficient, unless the angle between the bar and the incident pencils is known, together with other data needful in a calculation which would require some nicety. This intricacy would have been avoided by using a criterion furnished by the experiment itself, such as the position of a band with respect to the diffracted fringes given by the edges of one of the mirrors, being the method which I employed. But Professor Airy does not inform us that he used any such expedient, nor that he found an aplanatic lens needful for such experiments.

To proceed to the subject of the paper; if *a b*, fig. 1, be two luminous points from which luminiferous surfaces depart simultaneously, then the locus of the central band of interference will be always on the line *p e*, bisecting perpendicularly the line joining *a* and *b*. In this we suppose the whole path of the light to be in air. But if any other medium such as a plate of glass with parallel surfaces were placed as at *g h i k*, perpendicularly to *p e*, the place of central interference would not be altered. If, however, another pate of the

Fig. 1.



---

* Communicated by the Author.

same glass be placed as at $lmni$, and inclined to the direction of the incident light, then very frequently (that is, when the apparatus used is properly adjusted and applied,) there is another set of bands seen at $f$. In this case it will be seen that the upper ray $aqrf$, will have passed through a greater distance in air than the lower ray $bstf$. But on account of the glass $lmni$ being more inclined to the ray passing through it than the glass $ghik$ to the ray $aqrf$, it will be seen that the lower ray will have passed through a greater distance in glass. Or the sum of the distances $aq$ and $rf$ is greater than the sum $bs$ and $tf$, and the distance in glass $st$ is greater than $qr$.

Now, putting $d$ = the distances in air $aq + rf$
and $d_{\prime}$ = ———————— $bs + tf$
and putting $D$ = the distance in glass $qr$
$D_{\prime}$ = ———————— $st$

Then, when the interference at the point $f$ is produced between rays which have set out *simultaneously* from $a$ and $b$, putting $T$ = the whole time of passing from $a$ or $b$ to $f$, and
$v$ = the velocity of light in air
$w$ = ———————— in glass,

we have
$$T = \frac{d}{v} + \frac{D}{w} = \frac{d_{\prime}}{v} + \frac{D_{\prime}}{w}$$

from which we find
$$\frac{v}{w} = \frac{d - d_{\prime}}{D_{\prime} - D}.$$

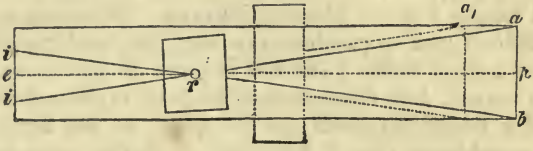
When, therefore, we can find by experiments the distances in air and glass, we can also find the relative velocities of light in them. This, however, it must be remembered, is on the supposition that the velocity is the same in glass for all incidences, and that the velocity in air is the same after having passed through the glass as before. The former of these points we shall have to refer to again presently.

In the apparatus I used for the experiments about to be described, the luminous points $a$ and $b$ were produced by reflections of the image of the sun given by an equi-convex lens of crown glass of $\frac{1}{10}$th inch focus, from two mirrors of speculum metal. These mirrors were set in a frame, and so that their contiguous edges could be adjusted by means of four fine-threaded screws. The glasses $ghik$, $lmni$, were produced by dividing a piece from one plate, which had been examined very carefully to see that the surfaces were flat and truly parallel. The mode of examining the parallelism of the surfaces which I adopted, was that of viewing the reflected images they gave of a narrow line of light in the following manner.—Standing in a room facing the window through which the light from the sky came directly, and at the distance of a few yards from this window, I held up before me the plate (a small one) with a piece of black velvet behind it; then holding a piece of fine platinum wire (a very fine steel needle would answer as well,) directly before the pupil of one of my eyes, I viewed with the same eye the images, produced by the surfaces of the glass, of the fine line of light which was shown by the platinum wire. When the surfaces are even very slightly inclined to each other, it is immediately detected by their two images being distinctly separated; but when both surfaces are accurately perpendicular to the same incident rays, the two reflected images become blended into one. Knowing it to be a very difficult task to produce two such flat and parallel surfaces on a small scale, I did not attempt to grind and polish a plate myself, but chose rather to avail myself of the kindness of a friend, to select a small plate, to suit my purpose; and I considered myself fortunate in finding *one* amongst a large number of plates in which no inclination of the surfaces could be detected in any direction. One of the best methods for examining the truth of flat surfaces, I find to be that of pressing together alternately the surfaces of the two pieces of glass, when, if there be any appretiable curvature, it will be detected by an appearance of Newton's rings; care must, however, be had that the curvature does not arise from a too great degree of pressure.

My two pieces of glass from the plate just mentioned were attached, the one to the pivot of a divided circle, and the other to the arm turning on this pivot, which carried the reading microscope. The circle was something less than 18 inches in diameter; and from the examination I made of the values of the divisions, I think the angles, in the experiments which were deduced from the divisions for even tens of degrees, could not be wrong more than five or six seconds. For the other divisions it is possible the error might be several times as much, but nothing, as I have proved, which could affect fundamentally the results. The heliostat I used was the one I have described in a former number of the Magazine, (Lond. and Edinb. Phil. Mag. and Journal, vol. ii. p. 6,) and the lens and two mirrors were attached to it, so that the line *e p*, fig. 1, might be horizontal. The plane of the circle was adjusted accurately to be parallel to this line, and perpendicular to the horizon, by three screws forming the feet of its support. The two glasses being cemented to plates of brass were also adjusted by three screws each, so as to be perpendicular to the plane of the circle. The distance *ef* in the figure was measured by means of a chased steel screw set accurately in a brass frame; this screw was set perpendicular to the horizon, and it carried up or down, when turned, a piece of hard wood, to which was attached the eye-lens with a needle-point in its focus. By means of an index and a divided card, the motion of the screw was read off to the 200dth part of a revolution.

The distance of the points *a* and *b* was determined by the method used in a similar case by M. Fresnel, namely, by placing a piece of tin-plate, so that a circular perforation in it might be on the line *e p*, as in fig. 2. A series of coloured rings round a centre, also coloured, but well defined, was in this manner seen for each luminous point *a* and *b*, and the distance *i i* of these centres was very easily and accurately determined with the screw carrying the eye-glass; from which the distance *a b* was easily deduced, when the distances *e r* and *r p* had been measured.

Fig. 2.



There are many points that require great attention in conducting the experiment, with which I must not trespass longer on the reader's patience, but will merely state that they arise from the necessary smallness of the distance *a b*, the diffracted fringes of the edges of the glasses *h i*, *l i*, the peculiar adjustments required for the mirrors, the positions of the mirrors with respect to the original luminous point, and the positions of the glasses with respect to the points *e*, *f* and *a*, *b*.

The *final* adjusting of the apparatus often required all the sun-light I could obtain, for one or two days before the experiment could be proceeded with; and this occurring every time the apparatus was altered so as to experiment under different circumstances, prevented me, even during the long succession of fine weather we had this spring, from obtaining more numerous measures. The alterations of the apparatus were to produce different values for the distance *a b*, and the proper places of the edges *h i*, *l i*, for the different angles between the glasses. For all the measures in which the glasses were inclined to each other *more* than 10 degrees, the two sets of fringes at *e* and *f* were seen, and afforded the means of taking the distances of these points with great accuracy. In the others, one set only could be seen at once, so that the lower glass had to be brought up to a parallel position with the upper one for every measure; the lower pencil passing in this case through the lower glass, for both sets of fringes. The light I used was a red obtained by extracting the colouring matter of alkanet root in oil of turpentine, and then transferring it, when filtered, by solution and quick evaporation, to Canada balsam. This coloured balsam, placed between two plane glasses and cemented round with sealing-wax, furnished a convenient way of getting light of any required purity: that which I used was such as to cause rather more than twenty bright and twenty dark bands to be visible at once; and yet in this number there was no difficulty, with a little practice, in determining with certainty which was the central one.

The following are the measures I have taken, and the results which they give.

On March 30th 1833, the angle between the glasses ($\zeta i \gamma$) being 14° 1′ 7″,

the distance $ef$ was found to be ·29290 inch.

When the angle ($\zeta i \gamma$) was 15° 0′ 15″,

$ef$ was found to be ·34320.

For both the above $i\,i$, fig. 2. = ·10126
$e\,r$ — = 12·15 inches
$r\,p$ — = 19·65 inches
whence $a\,b$ = ·1637661.

The thickness of the glass plates was found to be ·1375 inch. Taking the refractive index of the glass ($\mu$) at 1·495, these measures give

$$\frac{d-d_{,}}{D_{,}-D}=\frac{\cdot 002812115}{\cdot 001743651}=1\cdot 612.$$

The second one for the angle 15° 0′ 15″ I have not calculated.

On the 6th of April, I obtained the following:

Angle $\zeta i \gamma$, fig. 1 = 18° 59′ 17″
$ef$ — = ·540276
$i\,i$ fig. 2. = ·104012
$e\,r$ — = 12·15
$r\,p$ — = 19·9375
whence $a\,b$ = ·170678

from which we find when $\mu$ is taken = 1·495

$$\frac{d-d_{,}}{D_{,}-D}=\frac{\cdot 0051619}{\cdot 0030902}=1\cdot 6704.$$

On the 21st of April, I got the following measures:

Angle $\zeta i \gamma$, fig. 1. = $5^\circ\ 0'\ 6''$
$ef$ — = ·0337193
$ii$ fig. 2. = ·1125248
$er$ — = 12·10
$rp$ — = 20·04

This value of $ii$ being taken without removing the glasses, on account of the great labour required to re-adjust the apparatus, requires to be considered as for the distance $rp$ corrected by $aa$, fig. 2, which I calculated in the experiments taken at and after this date from the expression:

$$a a_{\prime} = \text{thickness of glass} \times \left(\frac{\mu-1}{\mu}\right)$$

whence $ab$ = ·1859400 and for $\mu = 1{\cdot}495$

$$\frac{d-d_{\prime}}{D_{\prime}-D} = \frac{{\cdot}00037980}{{\cdot}00024464} = 1{\cdot}552.$$

On the same day, I obtained the following also:

Angle $\zeta i \gamma$, fig. 1. = $9^\circ\ 59'\ 42''$
$ef$ — = ·1240136
$ii$ fig. 2. = ·11339
$er$ — = 12·10
$rp$ — = 20·04

whence $ab$ = ·1873696, and when $\mu = 1{\cdot}495$

$$\frac{d-d_{\prime}}{D_{\prime}-D} = \frac{{\cdot}001419883}{{\cdot}00092721} = 1{\cdot}531.$$

On the 8th of May, I obtained as follows:

Angle $\zeta i \gamma$, fig. 1. = $5^\circ\ 0'\ 6''$.
$ef$ — = ·047953687
$ii$ fig. 2. = ·0776168
$er$ — = 12·05
$rp$ — = 20·28

whence $ab$ = ·1303349, and taking $\mu = 1{\cdot}405$

$$\frac{d-d_{\prime}}{D_{\prime}-D} = \frac{{\cdot}00037257}{{\cdot}00023757} = 1{\cdot}568.$$

On May 9th, I obtained the following:

Angle $\zeta i \gamma$, fig. 1. = $5^\circ\ 0'\ 6''$
$ef$ — = ·04641225
$ii$ fig. 2. = ·0803153
$er$ — = ·12·05
$rp$ — = ·20·26

whence $ab$ = ·1347321, and taking here $\mu = 1{\cdot}492$

$$\frac{d-d_{\prime}}{D_{\prime}-D} = \frac{{\cdot}00037475}{{\cdot}00023915} = 1{\cdot}567.$$

On May 18th, I obtained the following:

Angle $\zeta i \gamma$, fig. 1. $= 17^\circ\ 0'\ 55''$
$ef$ — $= \cdot 4131553$
$i i$ fig. 2. $= \cdot 11176437$
$er$ — $= 12 \cdot 08$
$rp$ — $= 20 \cdot 23$

Another set,

Angle $\zeta i \gamma$, fig. 1. $= 16^\circ\ 0'\ 23''$
$ef$ — $= \cdot 44349222$
$i i$ fig. 2. $= \cdot 09132167$
$er$ — $= 12 \cdot 08$
$rp$ — $= 20 \cdot 23$

On re-examining the adjustments, after taking these two sets, I found the glasses had got slightly moved. It is probable that this had occurred in taking the measures of $er$ and $rp$, and therefore would not influence the others; but I have not calculated them.

On May 22nd, I obtained the following:

Angle $\zeta i \gamma$, fig. 1. $= 19^\circ\ 59'\ 39''$
$ef$ — $= \cdot 70650$
$i i$ fig. 2. $= \cdot 0397189$
$er$ — $= 12 \cdot 08$
$rp$ — $= 20 \cdot 25$

whence $ab = \cdot 1500612$; and when $\mu = 1 \cdot 492$,

$$\frac{d-d_{,}}{D_{,}-D} = \frac{\cdot 00576170}{\cdot 00334260} = 1 \cdot 7237.$$

On May 23rd, I obtained the following:

Angle $\zeta i \gamma$, fig. 1. $= 19^\circ\ 59'\ 39''$
$ef$ — $= \cdot 6719927$
$i i$ fig. 2. $= \cdot 09218843$
$er$ — $= 12 \cdot 08$
$rp$ — $= 20 \cdot 29$

whence $ab = \cdot 1544955$, and

$$\frac{d-d_{,}}{D_{,}-D} = \frac{\cdot 00568722}{\cdot 00335378} = 1 \cdot 6958.$$

when the refractive index $\mu$ is taken $= 1 \cdot 495$.

When we take $\mu = 1 \cdot 492$, we find

$$\frac{d-d_{,}}{D_{,}-D} = \frac{\cdot 00570817}{\cdot 00336775} = 1 \cdot 6949.$$

The reason of my having used two values of the refractive index is this. The circle being engaged with the other part of the experiments, and as I possessed no other divided instrument fit for determining the refractive power of the glass, I had recourse to Dr. Wollaston's instrument, with which I deduced 1·495 as the refractive index. When the circle was at liberty, I found this to be rather too high for the red light with which I had been experimenting, and that 1·492 was about the true refractive index for it. On going, however, through the calculation again for the experiment of the 23rd of May, the difference was so small in the results, that I have not thought it needful to re-calculate the others, and particularly as the labour is considerable.

It will be seen in fig. 1, that to find the true value of the angle $q\,a\,e$, from knowing the distances $c\,f$, $c\,a$ and the thickness of the glass $\beta\,\alpha$, it is necessary to find the distance $a\,a_{,}$ from the formula $a\,a_{,} = t\left(1-\frac{\cos\phi}{\mu\cos\phi'}\right)$, where $t = \beta\,\alpha$ $\phi =$ the angle of incidence $q\,a\,e$, and $\varphi' =$ the angle of refraction. By repeating this process, we at length find the angle $q\,a\,e$ to any required correctness, and then easily find $d$ and D.

For the lower ray, supposing a perpendicular $(b\,\gamma)$ to be let fall upon the lower glass, $\sigma\,b$ is first found by the same formula as $a\,a_{,}$, and then from it $\sigma\,\tau$ or $b\,\varrho$, as may be most convenient to use. After one or two approximations in this manner, the values of the angles $s\,b\,d$ and $s\,b\,\gamma$ may be found with every accuracy that the logarithmic tables to 7 figures admit of. Knowing the angle $s\,b\,\gamma$, we soon find $t\,s = \mathrm{D}_{,}$, then from it we obtain the value of $\theta\,\eta$, and finally, $d_{,} = s\,b + f\,t = (d\,b - \theta\,\eta) \times \text{secant } s\,b\,d$.

In the calculations, I have used the logarithmic tables to 7 figures, excepting for the secants of the angles $q\,a\,e$ and $s\,b\,d$, in which, from the largeness of the values of $d$ and $d_{,}$ compared with their differences, I found it necessary to calculate these secants from the formula, secant $= \sqrt{1+\tan^2}$, to 10 places of decimals.

According to the undulatory hypothesis, we should have for all incidences

$$w : v :: (\mathrm{D}-\mathrm{D}_{,}) : (d-d_{,}) :: 1 : \mu$$

$$\text{or,} \quad \frac{v}{w} = \frac{d-d_{,}}{\mathrm{D}_{,}-\mathrm{D}} = \mu.$$

We see that this is not supported by the preceding experiments, and that they deviate the more from it as the angle of incidence on the lower glass is greater. This leads us at first to suppose the velocity of light in glass to be variable for different incidences. Before concluding finally on our results, we shall find it wise on this, as on many other occasions, to doubt the infallibility of the undulationists. They tell us, it is true, that the image of the sun's disk, produced by a lens of short focal length, may be used instead of a luminous body, in *all* experiments in which it is wished to produce a series of waves diverging from a point. And the measurements hitherto taken, which have been supposed by some to demonstrate the undulatory theory, have been made with common lenses, without its being imagined there was any need of achromatic, aplanatic glasses for these delicate purposes.

Without attempting to clear the foregoing results of the effects of aberration, we may still convince ourselves by a simpler procedure, that their discordance with the hypothesis, —that the velocity of light in passing through transparent bodies is inversely as their refractive indices,—is more apparent than real.

The experiments appear to show that the velocity ($w$) of the light in the glass was slower as the incidence was increased, making the fraction $\frac{v}{w}$ of larger value. Then the light must also have moved more slowly in the lower glass than in the upper one, on account of its greater incidence upon it.

Let us, therefore, instead of

$$T = \frac{d}{v} + \frac{D}{w} = \frac{d_{\prime}}{v} + \frac{D_{\prime}}{w}$$

take the $w$ in the denominator on the second side equal to $z\,w$, and we have

$$T = \frac{d}{v} + \frac{D}{w} = \frac{d_{\prime}}{v} + \frac{D_{\prime}}{z\,w}$$

and $$z = \frac{\frac{v}{w} D_{\prime}}{(d - d_{\prime}) + \frac{v}{w} D}$$

In applying this to the experiments of the 9th of May, let us assume, as the experiments warrant us in doing, that the velocity in the glass at a perpendicular incidence is to the velocity in air in the inverse ratio of their refractive indices. We find for $z$ the following:

$$z = {\cdot}999912$$

and from this $$\frac{v}{z\,w} = 1{\cdot}49213$$

which is nearly, as we supposed it, at a perpendicular incidence, namely, 1·492.

For another example, the experiment of May 23rd gives

$$z = {\cdot}996759$$

$$\text{and} \qquad \frac{v}{z\,w} = 1{\cdot}49685.$$

Or, the ratio of the velocities appears still to be, when fully considered, nearly 1·492, as we have taken it to be, at an incidence nearly perpendicular.

These experiments, then, give no adequate ground for maintaining the incorrectness of the hypothesis that the velocity in refracting bodies is inversely as their refractive indices.

On a careful re-examination of the thickness of the glass, of the value of the threads of the screw by which were measured the distances $i\,i$ and $e\,f$, and of the other parts of the apparatus, I could find no ground to suppose the results I had obtained were influenced materially by any other imperfection besides the aberration at the focus of the lens.

I shall consider it exceedingly important to determine whether, when an achromatic lens of short focus is used to form the luminous point, the central band of direct interference given by two mirrors is black, as it has appeared to me, and to several friends to whom I have shown it, when adequately tried with a common lens,—contrary to what the undulationists would have us believe it to be. If the central band shall still be found black, I shall submit to those who are not perfectly wedded to the undulatory theory, that it *must fall.* If, however, when adequately tried, the experiment shall exhibit the central band white, I shall consider *one of my greatest* difficulties to receiving the undulatory theory to be removed.

## LVI. *Descriptions of several new British Forms amongst the Parasitic Hymenopterous Insects. By* J. O. Westwood, *F.L.S. &c.*[*]

[Continued from vol. ii. p. 445.]

### 25. *Streblocera*, Westw.

*ALYSIÆ* affinis. Caput anticè bituberculatum. Antennæ ferè longitudine corporis 16-articulatæ, articulo 1mo longo (capite longiori) subtùs dente valido armato, 2do brevi apice prioris obliquè inserto, 3tio paullò majori, 4to etiam obliquè inserto, hoc et reliquis filiformibus. Collare angustum. Abdomen subrhomboideum pedunculo brevi. Alæ anticæ stigmate magno, areolâ 1 marginali brevi, areolâ 1mâ submarginali cum discoidali effusâ.—*Strebl. fulviceps*, Westw. Piceo-nigra, nitida, capite fulvo, oculis ocellisque nigris, antennis fuscis, articulis 3 basalibus fulvis, pedibus fuscis, femoribus

---

[*] Communicated by the Author.

fulvescentibus; alarum stigmate nervisque pallidè fuscis. Long. Corp. lin. 1. Coombe, Aug. 1833.

### 26. *Basalys*, Westw.

*Aneurhynchum* (antennis) cum *Spilomicro* (alis) arctè conjungens. Os haud rostratum. Antennæ ♂ 14-articulatæ, articulis 2 et 3 brevibus, 4to magno, externè producto, reliquis subæqualibus tenuibus. Alæ magnæ nervis duobus subcostalibus tertiam alæ partem accedentibus, nervo transverso illorum apicem connectente cum nervo ex illorum medio exeunti areolam triangularem formantibus stigmate magno internè retro-producto, nervisque quibusdam longitudinalibus ferè obliteratis.—*Bas. fumipennis*, Westw. Niger, nitidus, pilis longis ornatis, alis fuscescentibus, stigmate nervoque transverso nigris, nervis reliquis fuscis, apice femorum tibiarumque piceo, tibiis piceo-nigris. Long. lin. 1¾. Prope Londinum. R. Lewis.

### 27. *Elasmus*, Westw.

Ex *Eulopho typicali* differt antennis ♂, articulis 3, 4 et 5 brevissimis ferè coalitis (singulo ramum longum emittenti), 6to longo, reliquis clavam formantibus; ♀ ut videtur 10-articulatæ, 3 et 4 annuliformibus, 5, 6, 7 oblongis, 8, 9, 10 clavam formantibus, metathorax (♂ ♀) utrinque ad latera in laminam magnam concavam posticè productus.—Alæ angustissimæ. Pedes longissimi femoribus magnis.—*Eulophus flabellatus.* Fonscol. Ann. Sc. Nat., Jul. 1832. (Descr. antennarum vitiosa). Coombe, Aug. 1833.

### 28. *Stenomesius*, Westw.

*Euplectro* affinis. Caput lutiusculum. Antennæ longiores, ♂ graciles, ♀ subincrassatæ, 9-articulatæ, articulo 2do 3tio dimidio breviori, clavâ 3-articulatâ. Thorax anticè collari attenuatus; abdomen pedunculo brevi, ♂ parvum spatuliforme, ♀ majus, ovatum. Alæ magnæ. Pedes sat elongati tibiis intermediis, ♂ attenuatis, apice subclavatis.—1. *Sten. pulchellus*, Westw. ♂. Capite nigro, antennis nigris, basi subtùs pallidis, collari et mesothorace fulvo-testaceis, parapteris nigris metathorace nigro, abdomine nigro, basi maculâ magnâ fulvâ, pedibus fulvis, anticorum femoribus basi tibiisque apice fuscis, intermediorum tibiis apice tarsisque totis nigris; alis immaculatis. Variat collari scutelloque plùs minùsve nigro notatis. Long. lin. ⅔. Exp. Alar. 1⅔. Prope Londinum et Cantabrigiam.—2. *Sten. maculatus*, Westw. ♀, Capite fulvo maculâ occipitali lineâque pone oculos nigris, antennis nigris articulo basali fulvo, thorace ut in præcedenti colorato, abdomine nigro basi fasciâ tenui lineâque brevi fulvis, pedibus fulvis, tarsorum apice fusco, alis maculâ centrali fuscescenti. An ♀ præcedentis? Long. lin. 1. Exp. Alar. 1⅞. Prope Londinum. R. Lewis.

### 29. *Cheiloneurus*, Westw.

*Encyrtum* (pedibus) cum *Eupelmo* (alis) conjungens. Caput sat magnum. Mandibulæ 3-dentatæ. Antennæ prope os insertæ, ferè thoracis longitudine, versus apicem subclavatæ, 11-articulatæ, articulo 2do 3tio majori. Thorax oblongo-quadratus, anticè collari attenuato, scutello posticè fasciculato; abdomen ovatum depressum posticè acuminatum. Alæ anticæ nervo stigmaticali brevissimo à loco conjunctionis nervi subcostalis cum costâ paullò remoto. Pedes ut in Encyrto.—*Cheil. elegans*, Dalm. (*Encyrtus* et *Eupelmus*). Capite obscurè æneo, oculis antennisque nigris; his basi et apice pallidioribus, thorace cinerascenti-æneo, scutello flavo, abdomine nigro, cupreo nitenti, alis fuscis, in medio obscurioribus, basi atque prope et sub stigmata albis, pedibus pallidè testaceis, femoribus tibiisque posticis obscuris, tibiarum 4 posticarum basi albo. Long. Corp. lin. ⅚. Expans. Alar. lin. 1⅓. Richmond Park, Aug. 1833.

30. *Ectroma*, Westw.

*Encyrtum* (pedibus) cum *Theocolace* (habitu) conjungens. Caput crassum mandibulis 3-dentatis. Antennæ inter partem inferiorem oculorum insertæ, ferè corporis longitudine, sensim incrassatæ, 9-articulatæ, articulo 3tio 2do minori, 9no 8vo haud majori. Thorax oblongo-quadratus collari acuminato. Alæ rudimentales.—*Ectr. fulvescens*, Westw. Capite thoraceque pallidè fulvis, æneo submicantibus, abdomine obscurè testaceo metallico, oculis et antennis nigris, his basi subtùs, apiceque articuli terminali pallidis pedibus fulvis, tarsorum apice nigro. Long. lin. ⅔. Coombe, Aug. 1833.

31. *Pteroptrix*, Westw.

*Agonioneuro* affinis. Corpus brevissimum, latum, depressum. Caput transversum oculis magnis pilosis. Antennæ 8-articulatæ, articulis 2 et 3 æqualibus, 4to paullò minori, 5, 6, 7 multò majoribus, 8vo minutissimo. Thorax ferè quadratus. Scutellum magnum. Alæ magnæ, apice longè pilosæ, nervo stigmaticali brevi angulum acutum formante. Abdomen sessile, brevissimum, apice mucronatum. Tarsi 4-articulati.—*Pter. dimidiatus*, Westw. Piceo-niger, scutello albido, antennis flavis, articulo 7mo obscuriori, alarum dimidio basali fusco, pedibus pallidis, femoribus tibiisque basi fuscis. Long. Corp. lin. ¼. In quercu, Richmond Park, Aug. 1833.

32. *Coccophagus*, Westw.

*Agonioneuro* affinis, differt antennis 8-articulatis, articulo 2do 3tio minori, hoc et duobus sequentibus ferè æqualibus, ultimis 3iis clavam, vix articulo præcedenti crassiorem, formantibus. Tarsi 5-articulati; nervus stigmaticalis brevis apice conoideus. Habitat in Coccis.—Sp. 1. *Entedon scutellaris*, Dalm. Sw. Tr. 1825. 365*.—Sp. 2. *Cocc. pulchellus*, Westw. Pallidè flavus, oculis, thorace anticè abdomineque nigris, antennarum flagello thoracisque lateribus obscurioribus, pedibus flavis, tarsorum apice fusco. Long. lin. ½. Exclusus e *Cocc. aceris*, Jun. 1833.—Sp. 3. *Cocc. obscurus*, Westw. Niger, abdomine nitido, antennis fuscescentibus, pedibus sordidè albidis, tarsorum apice fusco, femoribus intermediis basi, posticis totis, tibiisque posticis basi fuscis. Alarum nervo fusco. Long. lin. ⅔. Habitat cum præcedenti. Sp. 4. *Entedon insidiator*, Dalm. l. c. 371.

## LVII. *Characters of some undescribed Genera and Species of* Araneidæ. *By* JOHN BLACKWALL, *Esq. F.L.S. &c.*†

### *Tribe*, INEQUITELÆ, Latreille.

Genus, *Neriene*, } mihi.
*Neriene bicolor*, }

CEPHALOTHORAX inversely heart-shaped, convex above, and glossy, with an indentation in the medial line of the posterior region. Mandibles robust, conical, perpen-

---

* Dalman observes upon this species, "Dubii facile generis, Entedoni proximus, sed ad Encyrtum quoque accedere videtur," a remark which applies both to *Coccophagi* and *Agonioneuri*. Were, however, the latter genus synonymous with *Aphelinus*, Dalman would doubtless, from the intimate affinity of the two genera, have placed *Ent. scutellaris* with *Aphelinus*. The number of joints in the antennæ is also different in *Agonioneurus* and *Aphelinus*.

† Communicated by the Author.

dicular, and furnished with teeth on the inner surface. Maxillæ enlarged at the apices, and slightly inclined towards the lip. Pectus heart-shaped. In structure and relative length the legs and palpi are similar to those of *Neriene marginata.* The colour of these parts is red-brown, the pectus, lip, maxillæ, and margins of the cephalothorax being the darkest; and the eyes are placed on black spots. Abdomen oval, convex above, projecting over the base of the cephalothorax, thinly clad with hair, glossy, and of a brownish-black colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{5}$th of an inch; length of the cephalothorax $\frac{1}{12}$; breadth $\frac{1}{16}$; breadth of the abdomen $\frac{1}{12}$; length of an anterior leg $\frac{1}{4}$.

The male, though rather smaller than the female, resembles it in colour and in the relative length of its legs: but the anterior part of the cephalothorax is supplied with slender bristles curved forwards. The third and fourth joints of the palpi are short; the former is terminated by a fine bristle in front, and the latter, which is the stronger, has a small protuberance on the outer side of the upper part, fringed with long bristles; the fifth joint has a large, obtuse apophysis near its articulation with the fourth; it is of an oval form, convex externally, concave within, comprising the sexual organs, which are highly developed, complicated in structure, and of a dark red-brown colour.

This species abounds in the plantations about Crumpsall Hall, constructing in the long grass under the trees a web similar to that of *Neriene marginata.* It is of frequent occurrence also under stones.

### *Neriene rufipes.*

This species has the cephalothorax of an oval form; it is convex above, and glossy, with the anterior part about the region of the eyes rounded and somewhat depressed, and in the medial line of the posterior part a small indentation occurs. Mandibles powerful, conical, provided with teeth on the inner surface, and inclined a little towards the pectus, which is heart-shaped. Maxillæ enlarged at the apices, and inclined towards the lip. The legs and palpi are similar in structure and relative length to those of *Neriene bicolor*. These parts are of a light red-brown colour, the mandibles, pectus, lip, and maxillæ, being the darkest, and the eyes are placed on black spots. Abdomen oval, slightly convex above, projecting over the base of the cephalothorax; it is rather hairy, glossy, and brownish-black. Plates of the spiracles large, and of a yellowish-white colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{3}{20}$ths of an inch; length of the cephalothorax $\frac{1}{12}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{16}$; length of an anterior leg $\frac{1}{3}$; length of a leg of the third pair $\frac{1}{6}$.

Though somewhat smaller, the male resembles the female in colour, and in the relative length of its legs. The second joint of the palpi is enlarged at its anterior extremity; the third and fourth joints are short; the former, which is the larger, is provided with a few long bristles in front of its anterior extremity, and the latter has an obtuse apophysis on the under side of the upper part; the fifth joint is oval, with a small protuberance or apophysis on the inner side, near its articulation with the fourth joint; it is convex externally, concave within, and comprises the sexual organs, which are complicated with spiny processes, highly developed, and of a dark red-brown colour.

Specimens of this spider were obtained in the autumn of 1832, under stones and on rails in the township of Crumpsall.

*Tribe*, ORBITELÆ, } Latreille.
Genus, *Linyphia*, }

### *Linyphia marginata.*

In colour and design this spider bears a close resemblance to *Neriene marginata*, but in external structure it is decidedly a *Linyphia*. Cephalothorax oval, prominent before, glossy; sides and posterior part depressed, the former having several slight furrows extending from the carina to the margins, and the latter a large indentation in the medial line. Mandibles strong, conical, armed with two rows of teeth on the inner surface, and inclined towards the pectus, which is heart-shaped. Maxillæ robust and somewhat quadrate, having the exterior angle at the extremity curvilinear. Lip short, prominent at the apex, and semicircular. These parts are of a very dark brown colour, the pectus, which is the darkest, being almost black. Eyes unequal in size, disposed in two transverse rows on the anterior part of the cephalothorax; the intermediate eyes of both rows form a trapezoid whose anterior side is considerably the shortest, and the lateral ones are placed obliquely in pairs, each pair being seated on a small eminence and geminated; the posterior eyes of the trapezoid are much the largest, and the anterior ones are the smallest of the eight. Legs long and slender, furnished with numerous, fine, erect spines; their colour is yellowish-brown with brownish-black bands. Each tarsus has three claws at its extremity; the two superior ones are pectinated, and the inferior one is inflected near its base, where there are one or two very minute teeth. The palpi resemble the legs in colour; they are provided with slender spines, and are terminated by a slightly curved claw, having a series of very small teeth extending about a third of its length from the base. Abdomen oval, convex above, projecting over the base of the cephalothorax, and sparingly covered with short hairs; upper part brownish-black bordered by a broad, irregular, dentated, brown band, which passes above the spinners, but whose continuity is interrupted in front by a black streak intersecting it at right angles; this band is very thickly spotted with white anteriorly, the white spots on the posterior portion being fewer, smaller, and intermixed with some of a blackish hue; an indistinct series of curved, angular lines of a brown colour extends along the middle; their convexity is towards each other, and their apices are directed forwards; above the spinners are several small, yellowish-white spots; the sides are brown minutely spotted with white, and a curved, brownish-black band extends from the anterior part of each nearly half way towards the spinners; under side of the abdomen dark-brown, with four minute, yellowish-white, compound spots forming a large quadrangle. Sexual organs prominent, cylindrical, and brownish-black. Plates of the spiracles of a brown colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{4}$th of an inch; length of the cephalothorax $\frac{1}{10}$; breadth $\frac{1}{13}$; breadth of the abdomen $\frac{1}{8}$; length of an anterior leg $\frac{9}{20}$; length of a leg of the third pair $\frac{3}{10}$.

The abdomen of the male is more slender than that of the female and darker-coloured, but the relative length of the legs is the same; the absolute length of these organs, however, is greater, an anterior leg measuring $\frac{11}{20}$ths of an inch. The third and fourth joints of the palpi are short, the latter, which is much the stronger, being fringed with long bristles on the outer side of the upper part; the fifth joint is oval, convex externally, concave within, comprising the sexual organs; they are highly developed, complex with spiny processes, and are of a dark reddish-brown colour.

I discovered this species in the autumn of 1832, in the plantations about Crumpsall Hall, and in the ensuing year I met with it in the woods at Oakland, in the month of May, at which season it pairs. In its habits, and in the construction of its web, which is usually fabricated among coarse herbage or low bushes, it resembles the other species of the genus. If it be compared with *Neriene marginata*, it will be seen immediately how easy the transition is from the *Nerienæ* to the *Linyphiæ*.

### *Linyphia annulipes.*

Cephalothorax oval, prominent before, glossy, with an indentation in the medial line of the posterior region; it is of a pale yellowish-brown colour, with a fine line of black on each of the lateral margins, immediately above which is a longitudinal row of triangular, black spots, and along the middle extends a black band bifid in front. Eyes placed on black spots, their disposition and relative size being the same as in the other species of the genus. Mandibles long, conical, armed with two rows of teeth on the inner surface, and inclined towards the pectus, which is heart-shaped and of a pale yellowish-brown colour. The maxillæ and lip have the same form as those of the *Linyphiæ* generally; their colour, and that of the mandibles, is yellowish-brown, the maxillæ being the palest. Legs long and slender, provided with a few upright spines; they are of a pale yellowish-brown colour with brownish-black bands. Each tarsus has three claws at its extremity; the two superior ones are pectinated, and the inferior one is inflected near its base, where there are one or two very minute teeth. The palpi have numerous long, erect spines, particularly on their ultimate and penultimate joints, and are terminated by a single claw slightly curved, and minutely dentated about a third of its length; their colour is similar to that of the legs. Abdomen oval, convex above, projecting over the base of the cephalothorax; upper part greenish white reticulated with fine, yellowish-green or greenish-brown lines, and having along the middle a series of greenish-brown bands of an angular form, whose vertices are directed forwards. A curved, black band, comprising four white spots in front, extends from the anterior part of the abdomen, contiguous to the cephalothorax, rather more than half its length along the sides, and from each of its extremities a black line stretches obliquely upwards and forwards; between the extremities of the curved band and the spinners are two, oblique, black streaks united near the middle, and below the band and streaks are numerous yellowish-white spots. Inferior part of the abdomen reddish-brown marked with a few minute, yellowish-white spots. Above the exterior margin of the spiracles, which are of a pale yellowish-white colour, a black streak occurs. A long, depressed process of a red-brown colour, directed backwards, is in connexion with the sexual organs.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{6}$th of an inch; length of the cephalothorax $\frac{1}{14}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{12}$;

length of an anterior leg $\frac{1}{3}$; length of a leg of the third pair $\frac{1}{5}$.

The male, though smaller than the female, resembles it in colour, and in the relative length of its legs; but their absolute length is greater, an anterior one measuring $\frac{2}{5}$ths of an inch. The third and fourth joints of the palpi are short, the latter, which is the stronger, being very convex on the outer side; the fifth joint is somewhat oval with a pointed apophysis, curved outwards, near its articulation with the fourth joint; it is convex externally, concave within, comprising the sexual organs, which are highly developed, complex with spiny processes, the largest curving over the upper part of the fifth joint, and are of a red-brown colour.

I obtained specimens of this species in September 1833, on the posts and rails of stages erected for the purpose of drying oak-bark in the woods at Oakland.

## *Linyphia fuliginea.*

Cephalothorax of the male of an elongated oval form, having a large indentation in the medial line of the posterior region. Maxillæ straight, enlarged at the extremities. Lip semicircular, prominent at the apex. Mandibles long, powerful, conical, armed with two rows of minute teeth on the inner surface, and inclined towards the pectus, which is heart-shaped. The colour of these parts is dark brownish-black. Legs long, slender, and of a light red-brown colour. Each tarsus is terminated by three claws; the two superior ones are pectinated, and the inferior one is inflected near its base. Colour of the palpi the same as that of the legs, with the exception of the ultimate and penultimate joints which are brownish-black; third and fourth joints short, the latter being much the stronger, particularly at its anterior extremity; fifth joint of an oblong oval figure pointed at its termination; it is convex above, concave within, comprising the sexual organs, which are highly developed, complicated in structure, with a long, slender, prominent spine curved upwards and somewhat outwards in a circular form; they are of a brownish-black colour tinged with red. Abdomen nearly cylindrical, of a brownish-black colour with a white spot on each side of the medial line, on the upper part near the cephalothorax. Plates of the spiracles dark-brown.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{3}{20}$ths of an inch; length of the cephalothorax $\frac{1}{12}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{22}$; length of an anterior leg $\frac{3}{10}$; length of a leg of the third pair $\frac{1}{5}$.

I procured specimens of this spider in the spring of 1833, in the woods at Oakland, but they were all males, and I have not yet discovered the female.

### Genus, *Nephila*, Leach.

### *Nephila Turneri.*

I have seen the female only of this spider. Its cephalothorax is nearly quadrilateral, the major axis being in the direction of the abdomen; it is notched behind, and the posterior region is depressed, with a deep indentation in the medial line; the anterior part is rather narrower, and convex; the lateral margins are rough with minute tubercles, and two very conspicuous ones occur near its middle; the whole of the upper surface is black, thinly covered with short hairs of a silvery lustre. Eyes disposed in two transverse rows on the anterior part of the cephalothorax; the four intermediate ones, which are seated on an eminence, form a square, the two in front being rather the largest of the eight, and the other four are in pairs placed obliquely on abrupt tubercles, one on each side of the square. Mandibles robust, conical, perpendicular, black, and furnished with teeth on the inner surface. Maxillæ straight, powerful, and enlarged at their extremities which are rounded. Lip rather longer than broad, and subacuminated at the apex. These organs are black, the inner margins of the former, and the tip of the latter being of a red-brown colour. Pectus heart-shaped with three pointed projections in front, two lateral, and one intermediate, the last situated immediately below the lip; its colour is yellow finely bordered with black, an oblong black spot occupying the medial line of the posterior region, on each side of which is a smaller one placed on the hinder part of a prominence contiguous to the insertion of each leg of the third pair. Legs long and without brushes or tufts of hair; first pair the longest, then the second, the third pair being the shortest; they are black, the thighs excepted, which are yellow with black extremities; the first joint of the tarsi is very long, and the last or terminal one remarkably short, comparatively; the two superior tarsal claws are pectinated, and the inferior one is inflected near its base; each of the coxæ has a rounded, glossy protuberance on the under side, near its articulation with the pectus, those on the last pair being the largest, and those on the anterior pair the least apparent. Palpi black, terminated by a small claw and some strong spines; the third joint is very short. Abdomen long, somewhat cylindrical, projecting over the base of the cephalothorax, of a yellow-brown colour.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, 1 inch and $\frac{3}{20}$ths; length of the cephalothorax $\frac{1}{2}$; breadth $\frac{2}{5}$; length of an anterior leg $2\frac{3}{4}$; length of a leg of the third pair $1\frac{7}{20}$.

The specimen from which the foregoing description was taken is from the Gold Coast, Upper Guinea, on the western coast of Africa. It was obligingly submitted to my inspection by Mr. J. A. Turner, of Manchester, a zealous and skilful entomologist, in compliment to whom I have named the species.

### *Tribe*, TUBITELÆ, Latreille.

### Genus, *Agelena*, Walckenaër.

### *Agelena brunnea.*

Cephalothorax oval, compressed before, convex above, rather hairy, with depressed sides marked with furrows diverging from the upper part towards the margins; it is of a red-brown colour bordered by a fine, black line; on each side are black lines forming several diverging narrow triangles, whose vertices are directed towards the upper part of the cephalothorax, the small area inclosed by each being red-brown. Eyes disposed on the anterior part of the cephalothorax in two transverse, curved rows, whose convexity is directed backwards; the eyes of the anterior row are somewhat larger than those of the posterior row, the two intermediate ones being the largest of all. Mandibles strong, conical, vertical, rather prominent at the base, and armed with a few teeth on the inner surface. Maxillæ short, powerful, convex underneath, rounded at the extremity, and inclined towards the lip, which is short and nearly square, being rather narrower at the apex than the base. Pectus heart-shaped. Legs and palpi moderately long and robust, and provided with hairs and spines. These parts are of a red-brown colour, the lip being the darkest. Fourth pair of legs the longest, then the first, the third pair being the shortest. Each tarsus is terminated by two pectinated claws, and the palpi have a single pectinated claw at their extremity. Abdomen oval, rather larger at its posterior than its anterior extremity, projecting over the base of the cephalothorax; its colour is yellow-brown, with indistinct, angular lines of a lighter shade, whose vertices are directed forwards, extending along the middle of the upper part, which, with the sides, is obscurely spotted with black, an irregular spot of a larger size occurring on each side of the spinners; on the under side are three very faint, longitudinal bands of a dull brown colour, which meet at the spinners. Plates of the spiracles yellow. Spinning mammulæ small.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{5}$th of an inch; length of the cephalothorax $\frac{1}{10}$; breadth $\frac{1}{13}$; breadth of the abdomen $\frac{1}{12}$; length of a posterior leg $\frac{2}{5}$; length of a leg of the third pair $\frac{1}{4}$.

This species, which appears to have a closer affinity with the *Agelenæ* than with the spiders of any other genus, occurs in the woods at Oakland; it is found occasionally under stones, but is by no means common. I am at present ignorant of its œconomy, and the male has not yet fallen under my observation.

Oakland, Denbighshire, Sept. 30, 1833.

## LVIII. *On* Mr. Talbot's *Proposed Method of ascertaining the greatest Depth of the Ocean.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

HAVING been absent from England, your Number for August last has only just come to hand, which will account for the delay of my present notice of one of Mr. H. F. Talbot's proposed experiments. My object in sending the following remarks is for the purpose of inducing any person who may be inclined to try his second experiment, to pause before they commence such a trial as he proposes. I admit, with Mr. Talbot, that it would be very desirable, *if possible*, to reduce the problem respecting the greatest depth of the ocean to the test of actual experiment; but I must most decidedly object to his proposed method. The *primâ facie* part of his principle is, that there must be ground, (a point that is not admitted by every one,) or his shell will never explode: but without mooting this point, if there is any credit to be placed on Mr. Perkins's experiments, (and I believe no one doubts them,) Mr. Talbot's shell would *float* long before it could reach the bottom, as it is now pretty well ascertained that at a certain depth the sea is specifically heavier than any body which we are acquainted with, consequently a cast-iron shell could not penetrate it.

As to the danger of the experiment, there could be none; for supposing it did reach the bottom and exploded, it should be borne in mind that miners and others who have occasion to blast rocks under water, find that about 3 or 4 fathoms is quite sufficient to protect them from any injury.

Again, supposing that the experiment could be tried as Mr. Talbot proposes, it seems to have escaped his recollection that no body, in a *moving* current of water, can fall perpendicularly; and also that at certain depths there are various currents running, all which would tend to give erroneous results.

With respect to the explosion of the shell being audible at a great depth, the experiment at Geneva is not any proof; for if I recollect aright, that was *superficial* sound, not perpendicular *sound*,—a difference of considerable consequence.

Palace Yard, Sept. 23, 1833. T. R. F.

## LIX. *Experimental Researches in Electricity.—Third Series. By* Michael Faraday, *D.C.L. F.R.S. M.R.I. Fullerian Prof. Chem. Royal Institution, Corr. Mem. Royal Acad. of Sciences, Paris, Petersburgh, &c. &c.*

[Concluded from p. 262.]

### III. *Magneto-Electricity.*

343. *Tension.*—THE attractions and repulsions due to the tension of electricity have been well observed with that evolved by magneto-electric induction. M. Pixii, by using an apparatus, clever in its construction and powerful in its action[*], was able to obtain great divergence of the gold leaves of an electrometer[†].

344. *In motion:* i. *Evolution of Heat.*—The current produced by magneto-electric induction, can heat a wire in the manner of ordinary electricity. At the British Association of Science at Oxford, in June of the present year, I had the pleasure, in conjunction with Mr. Harris, Professor Daniell, Mr. Duncan, and others, of making an experiment, for which the great magnet in the museum, Mr. Harris's new electrometer (287.), and the magneto-electric coil described in my first paper (34.), were put in requisition. The latter had been modified in the manner I have elsewhere described[‡], so as to produce an electric spark when its contact with the magnet was made or broken. The terminations of the spiral, adjusted so as to have their contact with each other broken when the spark was to pass, were connected with the wire in the electrometer, and it was found that each time the magnetic contact was made and broken, expansion of the air within the instrument occurred, indicating an increase, at the moment, of the temperature of the wire.

345. ii. *Magnetism.*—These currents were discovered by their magnetic power.

346. iii. *Chemical Decomposition.*—I have made many endeavours to effect chemical decomposition by magneto-electri-

---

[†] *Annales de Chimie*, l. p. 322. [†] Ibid. li. p. 77.

[‡] Phil. Mag. and Annals, N.S. 1832, vol. xi. p. 405.

city, but unavailingly. In July last I received an anonymous letter (which has since been published *,) describing a magneto-electric apparatus, by which the decomposition of water was effected. As the term "guarded points" is used, I suppose the apparatus to have been Wollaston's (327. &c.), in which case the results did not indicate polar electro-chemical decomposition. Signor Botto has recently published certain results which he has obtained†; but they are, as at present described, inconclusive. The apparatus he used was apparently that of Dr. Wollaston, which gives only fallacious indications (327. &c.). As magneto-electricity can produce sparks, it would be able to show the effects proper to this apparatus. The apparatus of M. Pixii already referred to (343.) has however, in the hands of himself‡ and M. Hachette§, given decisive chemical results, so as to complete this link in the chain of evidence. Water was decomposed by it, and the oxygen and hydrogen obtained in separate tubes according to the law governing volta-electric and machine-electric decomposition.

347. iv. *Physiological Effects.*—A frog was convulsed in the earliest experiments on these currents (56.). The sensation upon the tongue, and the flash before the eyes, which I at first obtained only in a feeble degree (56.), have been since exalted by more powerful apparatus, so as to become even disagreeable.

348. v. *Spark.*—The feeble spark which I first obtained with these currents (32.), has been varied and strengthened by Signori Nobili and Antinori, and others, so as to leave no doubt as to its identity with the common electric spark.

### IV. *Thermo-Electricity.*

349. With regard to thermo-electricity, (that beautiful form of electricity discovered by Seebeck,) the very conditions under which it is excited are such as to give no ground for expecting that it can be raised like common electricity to any high degree of tension; the effects, therefore, due to that state are not to be expected. The sum of evidence respecting its analogy to the electricities already described, is, I believe, as follows:—*Tension.* The attractions and repulsions due to a certain degree of tension have not been observed. *In currents:* i. *Evolution of Heat.* I am not aware that its power of raising temperature has been observed. ii. *Magnetism.* It was discovered, and is best recognised, by its magnetic powers.

---

* Lond. and Edinb. Phil. Mag. and Journ. 1832, vol. i. p. 161.

† Ibid. 1832, vol. i. p. 441.

‡ *Annales de Chimie,* li. p. 77.

§ Ibid. li. p. 72.

iii. *Chemical Decomposition* has not been effected by it. iv. *Physiological Effects.* Nobili has shown* that these currents are able to cause contractions in the limbs of a frog. v. *Spark.* The spark has not yet been seen.

350. Thus only those effects are weak or deficient which depend upon a certain high degree of intensity; and if common electricity be reduced in that quality to a similar degree with the thermo-electricity, it can produce no effects beyond the latter.

### V. *Animal Electricity.*

351. After an examination of the experiments of Walsh †, Ingenhousz ‡, Cavendish §, Sir H. Davy ||, and Dr. Davy ¶, no doubt remains on my mind as to the identity of the electricity of the torpedo with common and voltaic electricity; and I presume that so little will remain on the minds of others as to justify my refraining from entering at length into the philosophical proofs of that identity. The doubts raised by Sir H. Davy have been removed by his brother Dr. Davy; the results of the latter being the reverse of those of the former. At present the sum of evidence is as follows:—

352. *Tension.*—No sensible attractions or repulsions due to tension have been observed.

353. *In motion:* i. *Evolution of Heat*; not yet observed: I have little or no doubt that Harris's electrometer would show it (287. 359.).

354. ii. *Magnetism.*—Perfectly distinct. According to Dr. Davy**, the current deflected the needle and made magnets under the same law, as to direction, which governs currents of ordinary and voltaic electricity.

355. iii. *Chemical Decomposition.*—Also distinct; and though Dr. Davy used an apparatus of similar construction with that of Dr. Wollaston (327.), still no error in the present case is involved, for the decompositions were polar, and in their nature truly electro-chemical. By the direction of the magnet, it was found that the under surface of the fish was negative, and the upper positive; and in the chemical decompositions, silver and lead were precipitated on the wire connected with the under surface, and not on the other; and when these wires were either steel or silver, in solution of common salt, gas (hydrogen?) rose from the negative wire, but none from the positive.

356. Another reason for the decomposition being electro-

---

* *Bibliotheque Universelle*, xxxvii. p. 15.

† Phil. Trans. 1773, p. 461.

‡ Phil. Trans. 1775, p. 1.

§ Ibid. 1776, p. 196.

|| Ibid. 1829, p. 15.

¶ Ibid. 1832, p. 259.

** Ibid. 1832, p. 260.

chemical is, that a Wollaston's apparatus constructed with *wires*, coated by sealing-wax, would most probably not have decomposed water, even in its own peculiar way, without the electricity rising high enough in intensity to produce sparks in some part of the circuit; whereas the torpedo was not able to produce sensible sparks. A third reason is, that the purer the water in Wollaston's apparatus, the more abundant is the decomposition: and I have found that a machine and wire points which succeeded perfectly well with distilled water, failed altogether when the water was rendered a good conductor by sulphate of soda, common salt, or other saline bodies. But in Dr. Davy's experiments with the torpedo, *strong* solutions of salt, nitrate of silver, and superacetate of lead were used successfully, and there is no doubt with more success than weaker ones.

357. iv. *Physiological Effects.*—These are so characteristic, that by them the peculiar powers of the torpedo and gymnotus are principally recognised.

358. v. *Spark.*—The electric spark has not yet been obtained, or at least I think not; but perhaps I had better refer to the evidence on this point. Humboldt, speaking of results obtained by M. Fahlberg, of Sweden, says, "This philosopher has seen an electric spark, as Walsh and Ingenhousz had done before him at London, by placing the gymnotus in the air, and interrupting the conducting chain by two gold leaves pasted upon glass and a line distant from each other*." I cannot, however, find any record of such an observation by either Walsh or Ingenhousz, and do not know where to refer to that by M. Fahlberg. M. Humboldt could not himself perceive any luminous effect.

Again, Sir John Leslie, in his dissertation on the progress of mathematical and physical science, prefixed to the seventh edition of the *Encyclopædia Britannica*, Edinb. 1830, p. 622, says, "From a healthy specimen" of the *Silurus electricus*, meaning rather the *gymnotus*, "exhibited in London, vivid sparks were drawn in a darkened room;" but he does not say he saw them himself, nor state who did see them; nor can I find any account of such a phænomenon; so that the statement is doubtful†.

359. In concluding this summary of the powers of torpedinal electricity, I cannot refrain from pointing out the enormous absolute quantity of electricity which the animal must

---

* Edinburgh Phil. Journal, ii. p. 249.

† Mr. Brayley, who referred me to these statements, and has extensive knowledge of recorded facts, is unacquainted with any further account relating to them.

put in circulation at each effort. It is doubtful whether any common electrical machine has as yet been able to supply electricity sufficient in a reasonable time to cause true electro-chemical decomposition of water (330. 339.), yet the current from the torpedo has done it. The same high proportion is shown by the magnetic effects (296. 371.). These circumstances indicate that the torpedo has power (in the way probably that Cavendish describes,) to continue the evolution for a sensible time, so that its successive discharges rather resemble those of a voltaic arrangement, intermitting in its action, than those of a Leyden apparatus, charged and discharged many times in succession. In reality, however, there is *no philosophical difference* between these two cases.

360. The *general conclusion* which must, I think, be drawn from this collection of facts is, that *electricity, whatever may be its source, is identical in its nature.* The phænomena in the five kinds or species quoted, differ not in their character, but only in degree; and in that respect vary in proportion to the variable circumstances of *quantity* and *intensity** which can at pleasure be made to change in almost any one of the kinds of electricity, as much as it does between one kind and another.

*Table of the experimental Effects common to the Electricities derived from different Sources.*

| | Physiological Effects. | Magnetic Deflection. | Magnets made. | Spark. | Heating Power. | True chemical Action. | Attraction and Repulsion. | Discharge by Hot Air. |
|---|---|---|---|---|---|---|---|---|
| 1. Voltaic Electricity | × | × | × | × | × | × | × | × |
| 2. Common Electricity | × | × | × | × | × | × | × | × |
| 3. Magneto-Electricity | × | × | × | × | × | × | × | |
| 4. Thermo-Electricity | × | × | ? | | ? | | | |
| 5. Animal Electricity | × | × | × | ? | | × | | |

---

* The term *quantity* in electricity is perhaps sufficiently definite as to sense; the term *intensity* is more difficult to define strictly. I am using the terms in their ordinary and at present accepted meaning.

## § 8. *Relation by Measure of common and voltaic Electricity.*

361. Believing the point of identity to be satisfactorily established, I next endeavoured to obtain a common measure, or a known relation as to quantity, of the electricity excited by a machine, and that from a voltaic pile; for the purpose not only of confirming their identity (378.), but also of demonstrating certain general principles (366. 377, &c.), and creating an extension of the means of investigating and applying the chemical powers of this wonderful and subtile agent.

362. The first point to be determined was, whether the same absolute quantity of ordinary electricity, sent through a galvanometer, under different circumstances, would cause the same deflection of the needle. An arbitrary scale was therefor attached to the galvanometer, each division of which was equal to about 4°, and the instrument arranged as in former experiments (296.). The machine (290.), battery (291.), and other parts of the apparatus were brought into good order, and retained for the time as nearly as possible in the same condition. The experiments were alternated so as to indicate any change in the condition of the apparatus and supply the necessary corrections.

363. Seven of the battery jars were removed, and eight retained for present use. It was found that about forty turns would fully charge the eight jars. They were then charged by thirty turns of the machine, and discharged through the galvanometer, a thick wet string, about ten inches long, being included in the circuit. The needle was immediately deflected five divisions and a half, on the one side of the zero, and in vibrating passed as nearly as possible through five divisions and a half on the other side.

364. The other seven jars were then added to the eight, and the whole fifteen charged by thirty turns of the machine. The Henley's electrometer stood not quite half as high as before; but when the discharge was made through the galvanometer, previously at rest, the needle immediately vibrated, passing *exactly* to the same division as in the former instance. These experiments with eight and with fifteen jars were repeated several times alternately with the same results.

365. Other experiments were then made, in which all the battery was used, and its charge (being fifty turns of the machine,) sent through the galvanometer: but it was modified by being passed sometimes through a mere wet thread, sometimes through thirty-eight inches of thin string wetted by distilled water, and sometimes through a string of twelve

times the thickness, only twelves inches in length, and soaked in dilute acid (298.). With the thick string the charge passed at once; with the thin string it occupied a sensible time, and with the thread it required two or three seconds before the electrometer fell entirely down. The current therefore must have varied extremely in intensity in these different cases, and yet the deflection of the needle was sensibly the same in all of them. If any difference occurred, it was that the thin string and thread caused greatest deflection; and if there is any lateral transmission, as M. Colladon says, through the silk in the galvanometer coil, it ought to have been so, because then the intensity is lower and the lateral transmission less.

366. Hence it would appear that *if the same absolute quantity of electricity pass through the galvanometer, whatever may be its intensity, the deflecting force upon the magnetic needle is the same.*

367. The battery of fifteen jars was then charged by sixty revolutions of the machine, and discharged, as before, through the galvanometer. The deflection of the needle was now as nearly as possible to the eleventh division, but the graduation was not accurate enough for me to assert that the arc was exactly double the former arc; to the eye it appeared to be so. The probability is, that *the deflecting force of an electric current is directly proportional to the absolute quantity of electricity passed*, at whatever intensity that electricity may be*.

368. Dr. Ritchie has shown that in a case where the intensity of the electricity remained the same, the deflection of the magnetic needle was directly as the quantity of electricity passed through the galvanometer †. Mr. Harris has shown that the heating power of common electricity on metallic wires is the same for the same quantity of electricity whatever its intensity might have previously been ‡.

369. The next point was to obtain a *voltaic* arrangement producing an effect equal to that just described (367.). A platina and a zinc wire were passed through the same hole of a draw-plate, being then one eighteenth of an inch in diameter; these were fastened to a support, so that their lower ends

---

* The great and general value of the galvanometer, as an actual measure of the electricity passing through it, either continuously or interruptedly, must be evident from a consideration of these two conclusions. As constructed by Professor Ritchie with glass threads (see Philosophical Transactions, 1830, p. 218, and Quarterly Journal of Science, New Series, vol. i. p. 29.), it apparently seems to leave nothing unsupplied in its own department.

† Quarterly Journal of Science, New Series, vol. i. p. 33.

‡ Plymouth Transactions, page 22.

projected, were parallel, and five sixteenths of an inch apart. The upper ends were well connected with the galvanometer wires. Some acid was diluted, and, after various preliminary experiments, that adopted as a standard which consisted of one drop strong sulphuric acid in four ounces distilled water. Finally, the time was noted which the needle required in swinging either from right to left or left to right: it was equal to seventeen beats of my watch, the latter giving one hundred and fifty in a minute. The object of these preparations was to arrange a voltaic apparatus, which, by immersion in a given acid for a given time, much less than that required by the needle to swing in one direction, should give equal deflection to the instrument with the discharge of ordinary electricity from the battery (363. 364.); and a new part of the zinc wire having been brought into position with the platina, the comparative experiments were made.

370. On plunging the zinc and platina wires five eighths of an inch deep into the acid, and retaining them there for eight beats of the watch, (after which they were quickly withdrawn,) the needle was deflected, and continued to advance in the same direction some time after the voltaic apparatus had been removed from the acid. It attained the five-and-a-half division, and then returned swinging an equal distance on the other side. This experiment was repeated many times, and always with the same result.

371. Hence, as an approximation, and judging from *magnetical force* only, at present (376.), it would appear that two wires, one of platina and one of zinc, each one eighteenth of an inch in diameter, placed five sixteenths of an inch apart, and immersed to the depth of five eighths of an inch in acid, consisting of one drop oil of vitriol and four ounces distilled water, at a temperature about 60°, and connected at the other extremities by a copper wire eighteen feet long and one eighteenth of an inch thick (being the wire of the galvanometer coils), yield as much electricity in eight beats of my watch, or in $\frac{8}{150}$ths of a minute, as the electrical battery charged by thirty turns of the large machine, in excellent order (363. 364.). Notwithstanding this apparently enormous disproportion, the results are perfectly in harmony with those effects which are known to be produced by variations in the intensity and quantity of the electric fluid.

372. In order to procure a reference to *chemical action*, the wires were now retained immersed in the acid to the depth of five eighths of an inch, and the needle, when stationary, observed; it stood, as nearly as the unassisted eye could decide, at $5\frac{1}{3}$ division. Hence a permanent deflection to that extent

might be considered as indicating a constant voltaic current, which in eight beats of my watch (369.) could supply as much electricity as the electrical battery charged by thirty turns of the machine.

373. The following arrangements and results are selected from many that were made and obtained relative to chemical action. A platina wire one twelfth of an inch in diameter, weighing two hundred and sixty grains, had the extremity rendered plane, so as to offer a definite surface equal to a circle of the same diameter as the wire; it was then connected in turn with the conductor of the machine, or with the voltaic apparatus (369.), so as always to form the positive pole, and at the same time retain a perpendicular position, that it might rest, with its whole weight, upon the test paper to be employed. The test paper itself was supported upon a platina spatula, connected either with the discharging train (292.), or with the negative wire of the voltaic apparatus, and it consisted of four thicknesses, moistened at all times to an equal degree in a standard solution of hydriodate of potassa (316.).

374. When the platina wire was connected with the prime conductor of the machine, and the spatula with the discharging train, ten turns of the machine had such decomposing power as to produce a pale round spot of iodine of the diameter of the wire: twenty turns made a much darker mark, and thirty turns made a dark brown spot penetrating to the second thickness of the paper. The difference in effect produced by two or three turns, more or less, could be distinguished with facility.

375. The wire and spatula were then connected with the voltaic apparatus (369.), the galvanometer being also included in the arrangement; and a stronger acid having been prepared, consisting of nitric acid and water, the voltaic apparatus was immersed so far as to give a permanent deflection of the needle to the $5\frac{1}{3}$ division (372.), the fourfold moistened paper intervening as before*. Then by shifting the end of the wire from place to place upon the test paper, the effect of the current for five, six, seven, or any number of the beats of the watch (369.) was observed, and compared with that of the machine. After alternating and repeating the experiments of comparison many times, it was constantly found that this standard current of voltaic electricity, continued for eight beats of the watch, was equal, in chemical effect, to thirty turns of the machine; twenty-eight revolutions of the machine were sensibly too few.

376. Hence it results that both in *magnetic deflection* (371.)

---

* Of course the heightened power of the voltaic battery was necessary to compensate for the bad conductor now interposed.

and in *chemical force,* the current of electricity of the standard voltaic battery for eight beats of the watch was equal to that of the machine evolved by thirty revolutions.

377. It also follows that for this case of electro-chemical decomposition, and it is probable for all cases, that the *chemical power, like the magnetic force* (366.), *is in direct proportion to the absolute quantity of electricity* which passes.

378. Hence arises still further confirmation, if any were required, of the identity of common and voltaic electricity, and that the differences of intensity and quantity are quite sufficient to account for what were supposed to be their distinctive qualities.

379. The extension which the present investigations have enabled me to make of the facts and views constituting the theory of electro-chemical decomposition, will, with some other points of electrical doctrine, be almost immediately submitted to the Royal Society in another series of these Researches.

Royal Institution, Dec. 15, 1832.

Note.—I am anxious, and am permitted, to add to this paper a correction of an error which I have attributed to M. Ampere in a former series of these Experimental Researches. In referring to his experiment on the induction of electrical currents (78.), I have called that a disc which I should have called a circle or a ring. M. Ampere used a ring, or a very short cylinder made of a narrow plate of copper bent into a circle, and he tells me that by such an arrangement the motion is very readily obtained. I have not doubted that M. Ampere obtained the motion he described; but merely mistook the kind of mobile conductor used, and so far I described his *experiment* erroneously.

In the same paragraph I have stated that M. Ampere says the disc turned "to take a position of equilibrium exactly as the spiral itself would have turned had it been free to move;" and further on I have said that my results tended to invert the sense of the proposition "stated by M. Ampere, *that a current of electricity tends to put the electricity of conductors near which it passes in motion in the same direction.*" M. Ampere tells me in a letter which I have just received from him, that he carefully avoided, when describing the experiment, any reference to the direction of the induced current; and on looking at the passages he quotes to me, I find that to be the case. I have therefore done him injustice in the above statements, and am anxious to correct my error.

But that it may not be supposed I lightly wrote those passages, I will briefly refer to my reasons for understanding them in the sense I did. At first the experiment failed. When re-made successfully about a year afterwards, it was at Geneva, in company with M. A. de la Rive: the latter philosopher described the results[*], and says that the plate of copper bent into a circle which was used as the mobile conductor "sometimes advanced between the two branches of the (horse-shoe) magnet, and sometimes was repelled, *according* to the direction of the current in the surrounding conductors."

I have been in the habit of referring to Demonferrand's *Manuel d'Electricité Dynamique,* as a book of authority in France; containing the general

---

[*] *Bibliothcque Universelle,* xxi. p. 48.

results and laws of this branch of science, up to the time of its publication, in a well arranged form. At p. 173, the author, when describing this experiment, says, "The mobile circle turns to take a position of equilibrium as a conductor would do in which the current moved in the *same direction* as in the spiral;" and in the same paragraph he adds, "It is therefore proved *that a current of electricity tends to put the electricity of conductors, near which it passes, in motion in the same direction.*" These are the words I quoted in my paper (78.).

*Le Lycée* of 1st of January 1832, No. 36, in an article written after the receipt of my first unfortunate letter to M. Hachette, and before my papers were printed, reasons upon the direction of the induced currents, and says, that there ought to be "an elementary current produced in the same direction as the corresponding portion of the producing current." A little further on it says, "therefore we ought to obtain currents, moving in the *same direction*, produced upon a metallic wire, either by a magnet or a current. M. Ampere *was so thoroughly persuaded that such ought to be the direction of the currents by influence*, that he neglected to assure himself of it in his experiment at Geneva."

It was the precise statements in Demonferrand's *Manuel*, agreeing as they did with the expression in M. de la Rive's paper, (which, however, I now understand as only meaning that when the inducing current was changed, the motion of the mobile circle changed also,) and not in discordance with anything expressed by M. Ampere himself where he speaks of the experiment, which made me conclude, when I wrote the paper, that what I wrote was really his avowed opinion: and when the Number of the *Lycée* referred to appeared, which was before my paper was printed, it could excite no suspicion that I was in error.

Hence the mistake into which I unwittingly fell. I am proud to correct it, and do full justice to the acuteness and accuracy which, as far as I can understand the subjects, M. Ampere carries into all the branches of philosophy which he investigates.

Finally, my note to (79.) says that the *Lycée*, No. 36, "mistakes the erroneous results of MM. Fresnel and Ampere for true ones," &c. &c. In calling M. Ampere's results erroneous, I spoke of the results described in, and referred to by the *Lycée* itself; but *now* that the expression of the direction of the induced current is to be separated, the term *erroneous* ought no longer to be attached to them.

*April* 29, 1833. M. F.

## LX. *Reviews, and Notices respecting New Books.*

*Elements of Plane and Spherical Trigonometry, with its Applications to the Principles of Navigation and Nautical Astronomy;* by J. R. YOUNG[*]: *to which are added some original Researches in Spherical Geometry,* by T. S. DAVIES, Esq. F.R.S.L.&E., F.R.A.S.,&c.

OUR old-fashioned elementary works on mathematical science, though less erudite in appearance than their modern substitutes, were characterized by some excellences which we rarely find in recent treatises on the same class of subjects. One of these excellences was, the close connexion that was constantly kept in view

---

[*] We were gratified to learn, since this review was written, that this distinguished mathematician has been elected *Professor of Mathematics in the Royal Belfast Institution.*

between the arithmetical operation and the formula which closed the algebraical investigation. The *purposes* of an investigation were never lost sight of, and the mere transformations of an equation were only considered valuable as they tended to a more facile determination of the numerical result. Algebra was viewed as a universal arithmetic, only because the laws of its changes were identical with those of arithmetic, and because it thereby became, in fact, a part of the process of finding the solution of an arithmetical problem.

We do not deny that this arithmetical purpose, as the *final* one, of algebraical research, may be productive of confined views of the nature and purposes of that most extraordinary instrument of the human mind, nor do we wish to see any of the delicate and subtle abstractions that characterize our modern algebra, less valued than they are in our own day; but we must enter our protest against the almost universal neglect of the numerical part of the processes that have been derived from algebraical investigations (in our elementary works on almost every branch of physical and mathematical science) which is becoming every succeeding day more and more prevalent. If formulæ be intended to exhibit the curious and diversified relations of figure or number, then, indeed, the derivation of the formulæ may properly be considered the final object,—and we think that in pure mathematics there cannot be a more interesting employment than this; but if the investigation relates to the phænomena of nature or the actual value of the unmeasured parts of measured figures, we hold that the method of conducting the whole investigation, from its measured parts to the determination of the calculable parts, ought to be clearly and completely taught in every elementary book on those particular subjects. How imperfectly this is done in our most modern *elementary* treatises on Trigonometry, Mechanics and Physical Astronomy, we need not particularly specify; nor can it be doubted that the many excellences transplanted from our foreign mathematical cotemporaries, have been much diminished in their real value by our servile imitation of them in keeping aloof from the vulgarity of numerical application. The time to acquire these habits of numerical accuracy and expedition is, when the method of deriving the rules is first acquired; and it is to the neglect—the culpable neglect—of this practice, in our modern systems of mathematical education, that we owe the discreditable fact,—the too frequent incompetency of our most distinguished academic youth, to proceed from the observed elements to the numerical result of a physical problem, if that problem but very little exceeds the most common degree of difficulty. A parade of symbolic abstraction and a fondness for algebraical conundrums, are too prevalent amongst the mathematicians of our own day,—infesting our seats of learning to a degree that almost defeats the *useful* purposes which mathematics as a branch of *general education* is calculated to afford. "More in sorrow than in anger" do we mention this; but we cannot shut our eyes to the melancholy fact, nor yet to the melancholy consequences that must flow from it. The total and speedy decline of mathematical science will be the inevitable result.

These reflections have originated in a comparison of Mr. Young's excellent treatise on Trigonometry with some other works that have made their appearance within the last ten or twelve years, and a comparison of all these with the standard works that preceded them. We have more than once taken occasion to express the opinion we were led to form of this gentleman's course of analytical mathematics *; and though in some respects the nature of the work itself affords less scope for the exercise of that happy faculty which Mr. Young possesses for exposing the paralogisms and supplying satisfactory solutions of the elementary difficulties of science,—yet in many parts we see traces of that same peculiar attention to logical and philosophical accuracy which distinguished his former writings. The great value of this work, we conceive, consists in its unity of purpose, the continuity of its plan, and the very close attention paid to the student's power of completing the whole series of processes which are involved in the solution of the problem under consideration. Though a sufficient number of examples is always a desideratum in every elementary book, the clear development of the whole process is greatly more important; but in Trigonometry, examples are so easily formed, and the results so easily verified, that we think there is less necessity for this kind of amplification than in any other branch of elementary mathematics. We therefore think Mr. Young has done judiciously in rather giving examples of *completely-worked* questions under each head, than in adding a great number of unwrought questions, merely as an exercise for the student in performing operations for which he has no model, nor, to him, an intelligible rule. Having done this, we think the number of exercises given in the present work, will furnish ample practise for the most unapt of his readers.

The manner of considering the signs of the trigonometrical lines is, though not new, yet very happily developed ; and the derivation of the formulæ of plane trigonometry, altogether, is exceedingly well chosen. No one expects to find much in the way of novelty of method in this branch of the science; and all that can be expected is, a neatly condensed selection from the various writings already extant, and a systematic connexion between these several component parts. We could have wished, however, that the very elegant formulæ for one case of plane triangles, which was first given by Mr. Anthony Thacker, (editor of the Gentleman's Diary,) in his Mathematical Miscellanies (1743), and which has been subsequently used with great effect by Professor Wallace in the Edinburgh Transactions, vol. x. p. 168, had found a place in Mr. Young's book. We trust that in a second edition he will comply with this hint.

In the Spherical Trigonometry, the fundamental theorems are laid down with great clearness and perspicuity, and the subsequent formulæ are derived both briefly and elegantly. This forms the second part; and it is confined to that portion of spherical trigonometry which has direct and immediate reference to the practical solu-

---

* See Phil. Mag. & Annals, N.S. vol. x. p. 287, &c.

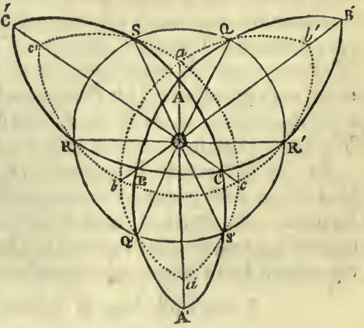
tion of the triangle defined by the conditions of the question. The third part contains a summary of the principles of Navigation and Nautical Astronomy. We think that sufficient is here taught to answer the purposes of most men who enter upon the study; and it is certainly taught in a way to enable the student to see the reason of the complicated rules that occur in the practice of navigation—a property belonging to few books that have been published on the subject.

The fourth part consists of a series of miscellaneous trigonometrical inquiries, such as are commonly to be found in the most recent continental and English works on trigonometry, and they are all conducted in the most simple and general manner. Amongst them we see some formulæ from De Gua for the spherical excess, which we think have not been before given in any English work. The chapter on the "Relations between the corresponding variations of the parts of a Triangle" is taken from Professor Airy's Trigonometry, in the *Encyclopædia Metropolitana*, which forms the best treatise on this branch of the subject that we are acquainted with.

The remaining part of the work consists of three supplementary chapters, containing some original speculations upon Spherical Geometry and Trigonometry, from the pen of Mr. Davies, which, together with other numerous productions of that accomplished mathematician, are well deserving the attention of geometers, as well for the novel views they afford as for the striking results they furnish in what may be termed *spherical analysis*,—a subject to which he has been long, and we believe, successfully, devoting his attention. We regret that we cannot find room for a complete analysis of these researches, and that we must content ourselves with a very brief account of the several chapters.

The first of these is devoted chiefly to the demonstration of certain properties of spherical triangles, having remarkable analogies to those of plane triangles. The second chapter is employed in establishing the properties of *associated triangles*, a term which we must explain, and we shall do so by giving a short account of the whole of the terminology which Mr. Davies has employed in this supplement

When a spherical triangle A B C is formed, we may, by producing its sides till they meet, two and two, form three others, A B′ C, C A′ B, B C′ A. These four triangles form what Mr. Davies calls an *associated system of triangles*. The triangle A B C (not necessarily the central one) is called the *fundamental triangle* of the associated system, and the other three the *supplemental* ones. When a new triangle, *a b c*, whose poles are A B C, is described, this, it is well known, is denominated the *polar triangle*;



and the author has shown, that if the associated system of which $a\,b\,c$ is the fundamental triangle be formed, these are *polar triangles to the primary associated system*, each to each. He also establishes a considerable number of curious and interesting relations between them. We shall transcribe one: If the sides of the primary and polar triangles intersect in R R′, S S′, Q Q′, these six points will all lie in the same great circle of the sphere; and if the arcs A $a$, B $b$, C $c$, be drawn, they will intersect in the same point, O, which will also be the pole of the circle Q R S Q′ R′ S′.

Another property that struck us is, that if the tangents of all the radii of the circles inscribed in and circumscribed about the eight triangles forming the two associations are multiplied together, their product is unity. A considerable number of other properties of these radii, for the most part new, is given in this second chapter, but we have not room to enumerate them.

The third and last chapter relates to the spherical excess, and exhibits this function in terms of data which we believe to be new. A new and concise investigation of Lhuillier's theorem is also given; but the majority of the inquiries are directed to the results which flow from the application of that celebrated theorem to the eight triangles above mentioned. There is also a curious analogy to that theorem exhibited in the following property, expressing one fourth of the perimeter in terms of the angles of the triangle:—

$$\tan^2\frac{a+b+c}{4} = \tan\frac{A+B+C-\pi}{4}\tan\frac{A+B-C+\pi}{4}$$
$$\tan\frac{A-B+C+\pi}{4}\tan\frac{-A+B+C+\pi}{4}$$

which analogy will be seen more distinctly by giving to the factors of Lhuillier's theorem their unabbreviated form, thus

$$\tan^2\frac{A+B+C+\pi}{4} =$$
$$\tan\frac{a+b+c}{4}\tan\frac{a+b-c}{4}\tan\frac{a-b+c}{4}\tan\frac{-a+b+c}{4}$$

where $\pi$ always connects itself with the angles and never with the sides. *Vide* page 245.

One or two other curious analytical expressions may be here mentioned: thus, if we denote by E the spherical excess of ABC, by $E_{\prime}E_{\prime\prime}E_{\prime\prime\prime}$ the excesses of BA′C, CB′A, AC′B; and by $E'E'_{\prime}E'_{\prime\prime}E'_{\prime\prime\prime}$ the excesses of the triangles respectively polar to these; then (pp. 249, 250)

$$\tan\frac{E'}{4}\tan\frac{E'_{\prime}}{4}\tan\frac{E'_{\prime\prime}}{4}\tan\frac{E'_{\prime\prime\prime}}{4} = \tan\frac{E}{4}\tan\frac{E_{\prime}}{4}\tan\frac{E_{\prime\prime}}{4}\tan\frac{E_{\prime\prime\prime}}{4}$$

and again

$$\tan\frac{E}{4}\tan\frac{E'}{4} = \tan\frac{E_{\prime}}{4}\tan\frac{E'_{\prime}}{4} = \tan\frac{E_{\prime\prime}}{4}\tan\frac{E'_{\prime\prime}}{4} = \tan\frac{E_{\prime\prime\prime}}{4}\tan\frac{E'_{\prime\prime\prime}}{4}$$

But we must close our extracts, which we shall do with the following new expression for the area of a spherical triangle in terms of its sines. It is not adapted in its present form to logarithmic calculation, but we believe it to be the first expression which has been given in terms of the *sines*.

$$\text{Cot}\,\frac{E}{2}=\frac{-\text{cosec}\,s+\text{cosec}\,\overline{s-a}+\text{cosec}\,\overline{s-b}+\text{cosec}\,\overline{s-c}}{-\sin s+\sin\overline{s-a}+\sin\overline{s-b}+\sin\overline{s-c}}\left\{\sin s\sin\overline{s-a}\sin\overline{s-b}\sin\overline{s-c}\right\}^{\frac{1}{2}}$$

To some copies of this work Mr. Young has added a set of logarithmic and other tables; but as we have already occupied so much of our space, we can only add that we like the arrangement of these tables and certain contrivances employed in them very much. Of their accuracy it is not easy to offer an opinion; but we feel it proper to state that we have lately dipped into them, at hazard, and with others of established reputation on our desk for comparison, about two hundred times, and in no one of these cases did we detect an error.

We hope, therefore, that the account we have been able to offer of this unpretending work will have the effect—of calling the attention of younger students (and still more of professional tutors) to it, as a book eminently calculated to ensure an early intimacy with the practice as well as the principles of trigonometry,—and of attracting the notice of geometers generally to the curious results that appear in the supplemental chapters, and inducing them to attempt the extension of a branch of science, which apparently admits of almost unlimited cultivation.

## LXI. *Proceedings of Learned Societies.*

### GEOLOGICAL SOCIETY.

May 15.—A PAPER was first read entitled "Observations on the Cliffs in the Neighbourhood of Harwich, made in December 1832," by James Mitchell, Esq., LL.D., F.G.S.

The principal object of this paper is to give a detailed description of the beds of London clay, as they appeared in the Harwich cliffs at the time the author visited the spot. After pointing out the physical features of the line of coast, the effects which the sea has produced upon the cliffs, and the means which have been taken to defend them, he proceeds to give an enumeration of the beds presented in a cliff which begins about 300 yards to the south of the lighthouse, and extends for rather more than a mile.

The author next gives a description of the cement stone; the history of its first discovery by the late Rev. Dr. Parker in the year 1796; a list of the localities where it is found in the greatest abundance; then points out the difference between the cement stone of Harwich and Sheppey, and lastly, advances an opinion on the probable period at which the supply will fail.

"A Memoir on the Valley of the River Medway and the adjacent Country," by R. Dadd, Esq., and communicated by James Mitchell, Esq., F.G.S., was then read.

The country described by the author lies in the immediate vicinity of Chatham and Rochester, and is characterized by the passage of the river Medway through a narrow, winding gorge bounded by chalk hills. It exhibits six different deposits, viz.—Lower chalk, Upper chalk, Plastic clay, London clay, Diluvium, and Alluvium. An abstract of the paper is given in the "Proceedings" of the Society.

A memoir was afterwards read "On a Fossil in the Bristol Museum, and discovered in the Lias at Lyme Regis," by Dr. Riley, and communicated by Charles Stokes, Esq., F.G.S., &c.

After stating the different opinions which had been given by those naturalists who had seen the specimen, and alluding to their apparent incorrectness, the author states that he is induced to consider the fossil as the remains of a cartilaginous fish, having many points of resemblance to the Rays, but differing from them in several important characters. He then proceeds to give a minute description of the anatomical structure of the fossil, commencing with the head. He states that the jaws are very much elongated; that he could discover in the upper no traces of respiratory canals or openings; that it appears to have fitted into a central groove in the lower jaw; that there are no signs of any cavities for the reception of teeth; but that there are lying near the jaws many spines with radiate bases similar to the spines of rays and other cartilaginous fishes. The orbits are stated to be of immense size, surrounded by an elevated edge or ridge, and the space on each side of the median line and within these ridges and corresponding to the parietal and frontal bones, to be flat and depressed not unlike that of a Saurian; but the author considers that this depression between the orbits may be better accounted for by the fact of this part of the cranium being nothing more than a thin membrane, as in some of the Chondropterygii.

The vertebral column is said to be less injured than the other parts of the animal. The processes have disappeared, but the bodies of the vertebræ are perfect; they are circular and very numerous, amounting to about 260, 28 of which are cervical, 143 dorsal, and 90 caudal. From the slight groove for the reception of the spinal marrow, and the separated condition of the cervical vertebræ, the author is inclined to consider the spine as having a nearer resemblance to that of a Squalus than of any other of the cartilaginous fishes.

The thoracic and pelvic members are stated to be greatly injured; but from the characters which they present, it is inferred, that they afford additional proofs that the fossil belonged to a cartilaginous fish.

In conclusion, the author conceives himself justified in considering the specimen as the type of a new genus, and therefore assigns to it the appellation of *Squalo-raia Dolichognathos.*

May 29th.—A paper "On the Oolitic Formation and its Contents, as occurring in a Quarry at Bearfield, near Bradford, Wilts," by J. Chaning Pearce, Esq., F.G.S., was first read.

The principal object of the author is to describe the organic remains which he found in a quarry situated at the summit of the hill to the north-west of the town of Bradford in Wilts, and in the same range of hills with that called Farleigh Down, near Bath. The following is a section of the beds, in descending order:—

| | | Ft. | In. |
|---|---|---|---|
| A. | Clay above the oolite | 10 | 0 |
| B. | Debris of shells, &c. | 0 | 6 |
| C. | Firestone | 15 | 0 |
| D. | Rag | 30 | 0 |
| E. | Yellow clay | 1 | 0 |
| F. | Soft freestone | 12 | 0 |
| G. | Rubbly freestone | | |

The organic remains are found principally in two of the strata, namely, in the shelly bed B, which lies directly on the surface of the great oolite (C. &c.), and in the yellow clay, marked E, which lies within the oolite. The fossils of the bed B, are Aviculæ in abundance, numerous species of Terebratulæ and Ostreæ, with several other species of univalve and bivalve shells, Corals, Asteriæ, Echini, vertebræ and teeth of fishes, Crustaceæ, *Pentacrinus vulgaris, Eugeniacrinites pyriformis* (Goldfuss), and three species of Apiocrinites, viz. *Apiocrinites globosus, A. intermedius,* and *A. elongatus.* The author observes that where the undulations of the great oolite rise above the level of half a foot, the debris of shells are wanting. He also remarks that the columns of the Apiocrinites are never found erect, but appear to have been thrown into their present, horizontal position by the superincumbent weight of clay at the moment of deposition. He supports this opinion by the fact that the columns, though in general separated from the roots, have their terminations almost invariably directed towards them,—an arrangement which he believes could not have occurred, had they been broken off and swept from their pedicles by a strong current.

The fossils contained in the yellow clay bed E, are Terebratulæ, Ostreæ, Echini, palatal bones, numerous small corals, and the three species of Apiocrinites already mentioned. The remains of the latter are abundant, but in this bed, as in the stratum B, the *Apiocrinites elongatus* is the most rare.

The author next proceeds to draw the distinctive characters of the genus Apiocrinites, and afterwards those of the three species above enumerated. The memoir was illustrated by drawings and very fine specimens of the fossils.

"A paper upon some tertiary deposits in the province of Granada, and part of that of Sevilla, and along the line of coast from Malaga to Cartagena, in the South of Spain," by Col. Charles Silvertop, F.G.S., was then read.

In this paper, an abstract of which is given in the "Proceedings," various widely scattered remnants of tertiary formations are described, which afford proofs of the great extent of an ancient sea in this southern portion of the Peninsula, and of the violent manner in which the deposits have been acted upon by igneous and aqueous agents.

June 12.—A paper entitled "A Notice on some Specimens from the Coal Shale of Kulkeagh, and the subjacent Limestone in the

County of Fermanagh," by Sir Philip de Malpas Grey Egerton, Bart., F.G.S., was first read.

After alluding, in terms of commendation, to Mr. Griffith's account of the Connaught coal-field, the author states that his principal object is to describe the organic remains which he obtained, in conjunction with Lord Cole, from the beds of shale forming part of the lowest division of the coal series. This shale deposit is stated to be 600 feet thick; to be covered by 70 feet of sandstone, and to be separated, in the northern division of the district, from the subjacent or mountain limestone by another system of sandstone strata about 40 feet thick. It is described as being composed principally of frequent alternations of beds of shale, more or less indurated, and of clay-ironstone. In the upper part of the series, several beds of black argillaceous limestone and a thin stratum of micaceous sandstone are stated to occur, and in the lower a bed of finely grained ferruginous sandstone. The shale is said to differ considerably in aspect, colour and structure at the superior and inferior portions of the deposit, but that the distinctive characters pass into each other by insensible gradations. The whole of the beds are stated to be replete with organic remains, entirely different from those found in the subjacent limestone. In the upper strata the prevailing fossils enumerated in the Memoir, are Ammonites and Orthocerata, associated, though in less abundance, with Producta and Calamites; and in the lower, crinoidal remains and corals of the genus Calamopora.

The author then describes the subjacent sandstone; the phænomena which accompany the streams engulfed by the mountain limestone, and the fossils he procured from that formation; and lastly, he details the characters of a bed of shale which occurs at the bottom of the limestone system, and abounds with fossils, some of which are stated to be peculiar to it.

A paper "on the Osseous Cave of Santo Ciro, about two miles to the S.E. of Palermo," by Samuel Peace Pratt, Esq., F.G.S., F.L.S., was then read *.

The author first describes the circumstances which led to the discovery of the bones, and then the position of the cave and the phænomena it presents. He states that it is situated rather more than a mile from the sea, in a projecting hill, forming part of the ridge of secondary limestone, which nearly traverses the northern portion of Sicily, and about 50 feet above the foot of the promontory. A gently inclined plain extends from the base of the ridge to the shore, and is composed of nearly horizontal strata of limestone and sand, containing shells analogous to those now inhabiting the Mediterranean. When discovered, the cave was filled to the level of the entrance with bones, more or less rolled, and in different states of decay, but cemented together by carbonate of lime. Associated with them, though in much less quantity, were pebbles and fragments

---

* When the author of this paper made his observations, he was not aware of the Memoir on Sicily by the late Dr. Turnbull Christie, read before the Society in November 1831. [See Phil. Mag. & Annals, N.S. vol. x. p. 433.]

of limestone. The bones which have been found, belong principally to the Hippopotamus; but tusks and teeth of the Elephant, as well as teeth of a large carnivorous animal, have been discovered. An osseous breccia extends around the mouth of the cave to the distance of many yards but differs from that within, in the greater abundance of fragments of limestone and pebbles, and in the bones having undergone greater attrition. The cave has been excavated to the depth of 20 feet, and its irregular sides appear to have been worn by water into polished hollows, perforated by the Lithodomus. Marks of the action of water, though to less extent, are visible much higher than the mouth of the cave, but the labours of the Lithodomus appear to have been confined to the surface below its level. The bottom of the cave was found to be covered with comminuted shells mixed with numerous well preserved specimens. Four other caves are mentioned as occurring at higher levels in the face of the hill. No bones have been discovered in them, though they bear the same proofs of the action of water, and their walls are perforated in the same manner. In conclusion, the author infers, from the evidence presented by the caves, and the known habits of the Lithodomus, that this part of the coast of Sicily was successively elevated to its present level, subsequently to the Mediterranean being inhabited by the existing species of Testacea, and he speculates on the changes which may have been produced at the same time in the physical outline of the country.

A communication from Capt. Colquhoun, and addressed to Roderick Impey Murchison, Esq., F.G.S., descriptive of masses of meteoric iron found in Mexico and Potosi, was next read.

The mass of iron principally noticed in this communication was formerly in the street of San Domingo, at Zacatecas in Mexico. It was about $4\frac{1}{2}$ feet long and $1\frac{1}{2}$ broad. On one side it was marked with deep indentations. The other masses were found at Charcas and Pablazon near Catorce.

A letter was lastly read, from Mr. Gardner, Geographer, to Roderick Impey Murchison, Esq., F.G.S., "On the relative position of land and water with respect to the Antipodes."

This letter was accompanied by a map of the world, on which was delineated, by colours, the antipodes of the existing dry land: and the writer of it states that he had ascertained by measurement that only $\frac{1}{27}$ part of the present continents and islands has land opposite to it; that the antipodes of the eastern hemisphere are confined to South America, with the exception of about the $\frac{1}{800}$ part, situated principally in New Zealand; and that the reciprocal antipodes of the western hemisphere fall on part of China and the Eastern Archipelago.

## ZOOLOGICAL SOCIETY.

July 23.—A letter was read, addressed to the Society by W. Williamson, Esq., dated Scarborough, July 2, 1833. It contained a full description of a specimen of the *garrulous Roller, Coracias garrula,* Linn., which was shot in the previous week in a limestone quarry near that place. The description was that of a female in nearly adult plumage.

A specimen was exhibited of the *Irish Hare,* recently presented to the Society by Mr. Yarrell, who pointed out the characters by which it is distinguished from the *common Hare* of England and the Continent of Europe. Its head is shorter and more rounded; its ears still shorter than its head; and its limbs less lengthened. The fur also differs essentially from that of the *common Hare,* and is useless as an article of trade. Mr. Yarrell added, that he had lately brought a specimen of it under the notice of the Linnean Society.

At the request of the Chairman, Dr. Stark exhibited the skeleton of the *edible Frog, Rana esculenta,* Linn., and stated that this species is found in the neighbourhood of Edinburgh, whence his specimen was obtained. He pointed out some of the differences between its osseous structure and that of the *common Frog, Rana temporaria,* Linn.

Dr. Stark also stated that he had obtained in the neighbourhood of Edinburgh specimens of a species of *Stickleback, Gasterosteus,* Linn., not previously known to exist in Great Britain.

In answer to a question on the subject, Dr. Stark described the changes produced in the colour of various *Fishes,* both of fresh and salt water, but especially in *Minnows, Leuciscus Phoxinus,* Cuv., in consequence of their being kept in water contained in vessels of different colours; the tendency of the fish being to assume the colour of the vessel in which it is kept.

The stomach and *cæcum* of a *Squirrel Monkey, Callithrix sciureus,* Geoff., which recently died at the Society's Gardens, were exhibited. At the request of the Chairman, Mr. Martin read his notes of the dissection of the animal, which are given in No. VII. of the Society's Proceedings.

Colonel Sykes exhibited several specimens of *Loligo sagittata,* var. $\beta$, Lam., which came on board the Lady Feversham on his passage to England in 1831. He read the following extracts respecting them from his journal.

"Monday, April 3, 1831.—Lat. 22° 20′ S., long. 1° 52′ E.—Three specimens of *Loligo sagittata* leaped on board at sun-set on the forecastle, which the men saw, the trade wind being so light at the time as to threaten a calm.

"Two days afterwards, in lat. 18° 6′ S., long. 3° 12′ W., several other individuals of the same species were found at daylight on the poop, having come on board during the night, the wind having been steady and the sea smooth."

Col. Sykes stated that his object in bringing the specimens under the notice of the Society, was to point out the locality from which they were obtained, the habitats given by Lamarck being the European and American seas; and to direct particular attention to the leaping powers of the animal, which he believed to have been hitherto unobserved. He added that he was unable to satisfy himself as to the organization by which it was enabled to throw itself above the surface of the sea.

Mr. Owen mentioned as an additional instance of the existence of this power in the *Loligo sagittata*, that two specimens were preserved in the Museum of the Royal College of Surgeons, to which they were presented by Dr. Henderson as having leaped on board a vessel in the Mediterranean.

Dr. Grant again called the attention of the Society to his specimen of *Loligopsis guttata*, Grant, and to specimens of *Sepiola vulgaris*, Leach, for the purpose of explaining more fully the anatomical structure of these species, which he had exhibited, with *Sepiola stenodactyla*, Grant, at the Meetings on February 12 and March 26. He gave a detailed account of their anatomy, which he illustrated by reference to an extensive series of diagrams prepared by himself. These diagrams have been engraved on a reduced scale for publication in the Society's Transactions.

In the *Loligopsis* the *parietes* of the mantle are remarkably thin and loose, excepting where they are supported by the dorsal transparent *lamina*, and by two thin cartilaginous *laminæ* extending from the free edge of the mantle about half-way down the sides, and placed rather towards the ventral surface of the animal. These lateral *laminæ* present an appearance anomalous in *Cephalopods*. Each of them sends out twelve or thirteen conical tubercles, about a line in diameter at their base, and projecting to the distance of a line beyond the general surface of the mantle.

The *viscera* occupy but a small portion of the cavity of the mantle, in which they are placed far backwards, the *branchiæ* themselves not extending forwards beyond the middle of the sac. The liver is divided, as in *Nautilus*, into four principal lobes, which are quite separate from each other; but the lobules which compose these lobes are not, as in the *Testaceous Cephalopod*, detached from each other. The branchial arteries are surrounded, before entering the auricles, by a spherical cluster of vesicles, like those which open into these vessels in *Nautilus*; but the auricles are not, as in *Nautilus*, wanting: they are, however, destitute of those singular *appendices* usually found attached to these muscular sacs in the *Naked Cephalopods*. The *branchiæ* are single on each side, and are proportionally the smallest which Dr. Grant has yet met with. The systemic ventricle is very muscular, and of a lengthened fusiform shape: it has an aortal trunk at each end. On the large dorsal or descending *aorta* there is, as in *Nautilus*, a distinct bulbous enlargement, probably the commencement of a *bulbus arteriosus*.

In *Sepiola*, in addition to the usual dorsal *lamina*, which is thin and short, there exist, external to the mantle and supporting the fins, two firm crescentic cartilaginous plates, like *scapulæ*, playing freely on the outer surface of the mantle, and furnished with an outer and an inner layer of muscles, passing in the form of minute white *fasciculi*, from the middle of the dorsal part of the mantle: by this structure, great extent and effect are given to the motions of these powerful dorsal arms, which have thus a singular resemblance in their mode of attachment to the anterior extremities of *Vertebrata*.

The cavity of the mantle is comparatively small, and its whole extent is occupied by the *viscera*, which are largely developed, particularly the digestive organs, the ink gland, and the two glands of the oviducts. The ink gland is remarkable for its form as well as its magnitude. It consists of three longitudinal lobes placed transversely, and extending more in that direction than lengthwise. The two lateral lobes are kidney-shaped; the third or middle lobe is smaller, and from its upper part the duct arises*.

August 13.—A letter was read, addressed to the Secretary by E. W. A. Drummond Hay, Esq., Corr. Memb. Z. S., and dated Tangier, July 5, 1833. It referred to various animals which Mr. Drummond Hay has obtained for the purpose of forwarding them to the Society's Menagerie; and adverted to others which he is in hopes of procuring.

On the subject of the *Bakra 'l whash*, in the plural *Bakkar el whash*, Mr. Drummond Hay states that this term, as well as *Mahats* and *Targeea*, (all signifying *wild Cow*,) appears to be applied by the Arabs to *Antilope Leucoryx*. It is, however, possible that the same name may be applied to large *Ruminants* of different species; although to any having the general appearance of an *Antelope* it is likely that the Arabs would give the term, generic as it were, *Gazal*.

The skins were exhibited of a *Cayman*, and of the *Coyote* or *Mexican Jackal*, the latter being apparently the *Prairie Wolf*, *Canis latrans*, Say. They were obtained in Mexico by Captain Colquhoun, by whom they were presented to the Society; as were also the horns, which were similarly exhibited, of the *Berenda*, a *prong-horned Antelope*.

The stomach was exhibited of the *Pekan* or *Fisher Marten*, *Mustela Canadensis*, Schreb.; and Mr. Martin, at the request of the Chairman, read his notes of the dissection of the animal, which are given in the "Proceedings" of the Society.

Its length from the nose to the origin of the tail was 21 inches. An immense deposition of fat loaded the cellular tissue, as well as the *omentum* and intestines.

Mr. Bell exhibited specimens of two *Reptiles*, forming part of his collection, which he regarded as the types of two genera hitherto undescribed. He stated his intention of publishing, in the 20th Number of the "Zoological Journal" shortly about to appear, descriptions and figures of them.

To one of them he gave the generic name

Anops.—*Pedes* nulli. *Annuli thoracici* completi. *Rostrum* porrectum, scutello arcuato compresso tectum. *Oculi* sub scutellis latentes. *Linea lateralis* depressa. *Cauda* breviuscula. *Pori præanales* nulli.

Anops Kingii.—*An. corpore suprà fusco, infrà albido.* Long. 8 unc. 5 lin.; *capitis*, 4 lin.; *caudæ*, 1 unc. 2 lin. *Hab.* in Americâ Australi.

---

* We defer till our next Number the remaining proceedings of July 23, in order to make room for the notice, under August 13, of Mr. Bell's discovery that the *three-toed Sloth* possesses only the normal number of cervical vertebræ.

This genus is referrible to the *Amphisbænidæ*, with which it agrees in general form, in the structure and arrangement of the scales, the concealed eyes and ears, and the short obtuse tail. From the other genera of the family it is distinguished by the form of its *rostrum* and of its singular compressed frontal plate, which considerably resembles that which characterizes the genus *Typhlops*.

The second of these *Reptiles* belongs to the family *Scincidæ*. It is characterized by Mr. Bell as follows:

Lerista.—*Caput* scutatum; *palpebræ* nullæ; *aures* sub cute latentes. *Corpus* gracile; *squamæ* læves æquales. *Pedes* quatuor: *anteriores* exigui, brevissimi, didactyli; *posteriores* longiores, tridactyli. *Anus* simplex, semicircularis; *pori præanales* et *femorales* nulli.

Lerista lineata. *Ler. æneo-viridescens, subtùs pallidior; lineis binis dorsalibus et binis lateralibus nigris. Hab.* in Australiâ.

This new genus of *Scincidæ* agrees with *Gymnophthalmus*, Merr., and *Ablepharus*, Fitzing., in the absence of eyelids; but differs from both in the number of its toes: the former having 4–5, and the latter 5–5, while *Lerista* has only 2–3. In addition to this difference in the structure of the feet, it is remarkably distinguished by the want of external ears, and by its elongated and anguiform body; characters in which it agrees with *Saiphos*, Gray. The last-named genus, however, possesses eyelids, and differs also in the number of its toes from *Lerista*.

Mr. Bell also read a paper, entitled "Observations on the Neck of the *three-toed Sloth*, *Bradypus tridactylus*, Linn., demonstrating that this Animal possesses only the Normal Number of Cervical *Vertebræ*."

By all preceding anatomists since the days of Hermann the number of the cervical *vertebræ* in the *three-toed Sloth* has been considered to be nine; and the animal has consequently been regarded as deviating in this respect from the other *Mammalia*, in which class seven is the normal number of these parts,—a number which exists equally in the short interval between the head and the *thorax*, scarcely deserving the name of a neck, of the *Cetacea*, and in the long flexile neck of the *Camel* and the *Giraffe*. It was natural that so marked a deviation from a general law should attract considerable attention, and numerous skeletons of the animal in which it was stated to occur have accordingly been examined by Cuvier, Meckel, and others, who have all, with the exception of the last-named anatomist, concurred in the statement that nine cervical *vertebræ* exist; Meckel alone hinting at the probability that what had been previously regarded as the ninth cervical might, in truth, be a first dorsal *vertebra*. On what grounds M. Meckel was induced to offer this suggestion does not appear; it is probable that he was led to it by the form of the *vertebra* itself, which is altogether that of a dorsal *vertebra*; or he may have been guided by a statement made by Cuvier that in a young individual examined by him the transverse processes of the ninth cervical *vertebra*, as he described it, were not united to the *vertebra* itself, whence Cuvier was induced to inquire, May not this be a small vestige of a rib? Cuvier does not appear to have noticed this detached portion of bone in any but this young individual, nor as connected with any but that which he continued, even in his latest work, to regard as the ninth cervical *vertebra*.

In two skeletons, however, which Mr. Bell possesses, one of a young individual and the other adult, there are bony detached appendages on each side both of the eighth and ninth *vertebræ*, reckoning from the *cranium*, and Mr. Bell is therefore disposed to regard these *vertebræ* as being rather the first and second dorsal than the eighth and ninth cervical, and to consider the seven *vertebræ* craniad of them as constituting the normal set. The transverse processes of these *vertebræ* are longer and narrower than the preceding ones, and each is terminated by a perfect articular surface, which is slightly depressed. To these articular surfaces are attached the heads of the rudimentary ribs. The first of these rudiments is small and slender, about four tenths of an inch in length, having a distinct rounded head at the articular extremity, then becoming abruptly smaller, and tapering to the *apex*. The second is considerably larger and assumes more of the character of a short rib. It is about 6 lines in length and nearly 2 in breadth. Its head is oblong and rounded; and there is a tubercle on the upper and anterior side. Towards the extremity it becomes broader and flatter, with an excavated surface inwards, and a convex rough prominence on the outer side, apparently the point of muscular attachment. Immediately behind and beneath the head of the bone is a minute *foramen* for the passage of intercostal vessels.

The character of the transverse processes of the two *vertebræ* differs very materially from that of the true cervical. In the superior *vertebræ* this process is transverse and slightly bifid. In the seventh cervical it stands obliquely forwards, and its *apex* is broad and oblong. In the first dorsal each transverse process is completely divided into an anterior flattened process which is turned forwards, and a true lateral or transverse one which supports the little rudimentary rib: the transverse process is smaller, but considerably longer than those of the true cervical *vertebræ*, and stands more in a lateral or transverse direction. In the second dorsal *vertebra* the anterior process does not exist, and the body assumes the form of the succeeding ones. The transverse processes are simple and obtuse, and the articular surface is slightly excavated.

Mr. Bell exhibited, in illustration of his paper, the two skeletons referred to; that of the young individual being natural, and preserved with its connecting ligaments in spirit. The paper was also accompanied by drawings of the structure described in it.

A paper was read, entitled "Remarks on the Nature of the Respiratory Organs in certain Littoral *Mollusca* of Madeira: by the Rev. R. T. Lowe, A.M., Corr. Memb. Z.S." It referred to certain experiments published by the author in the 19th Number of the "Zoological Journal," which were instituted with the view of ascertaining, by the duration of their life when deprived by immersion in water of the access of free air, whether the animals of *Melampus*, *Tornatella*, &c., are pectinibranchiate or pulmoniferous. Mr. Lowe, in his present paper, intended for publication in the same Journal, is anxious to guard against the too strict adoption of his conclusion that animals which continue to exist for a long time immersed in water cannot be lung-breathing; as he conceives it to be possible that in animals so comparatively low in organization as *Mollusca*, the quantity of oxygen required for the aëration of the blood may be so small as to be furnished even by sea-water to lung-bearing races; or, in the second place, the lungs being supposed to be inactive during the immersion, that some compensating power may exist, as in the skins of the *Batrachia*, which may enable existence to be prolonged for a considerable time without the access of free air to animals whose organization is adapted for breathing it.

August 27.—A letter was read, addressed to the Secretary by the Rev. R. T. Lowe, Corr. Memb. Z.S., and dated Madeira, June 25, 1833. It accompanied an extensive series of the land and freshwater *Shells* of that island, which the writer presented to the Society's Museum, and which were exhibited. With one exception, they have been described by Mr. Lowe in a paper published, with figures, in the 'Transactions of the Cambridge Philosophical Society.'

In another letter, of the same date, Mr. Lowe states, "We have no native *Mammalia* (except a few *Seals* now and then on the coast,) existing on the Island, at least in its present state. The common *brown Rat* and the *Mouse* abound, of course introduced; and the *Ferret* is said to have become wild in one part of the island, though I have not myself seen it. The *Rabbit* is pretty common: it abounds in the *desertas*. As we have neither *Hares*, *Foxes*, *Shrews*, *Moles*, nor *Weasels*, so of the *Birds* we have no *Crows* nor *Rooks*, *Daws*, *Magpies*, *Sparrows*, (*Fringilla Petronia*, Linn., takes the place of the latter, at least in Porto Santo,) no *Titmice*, *Yellow-hammers*, &c."

A letter was read, addressed to Mr. Vigors by James Prinsep, Esq., and dated Calcutta, March 9, 1833. It accompanied a list of numerous zoological specimens forwarded to the Society by B. H. Hodgson, Esq., Corr. Memb. Z.S., Resident in Nepâl; and also of a large collection of living *Pheasants*, *Partridges*, &c., obtained by that gentleman at the request of the Council for transmission to England. On this list Mr. Prinsep had noted the condition of the various articles at the time of their arrival in Calcutta, by which it appeared that many of the birds had died during their journey from the interior. Of the *Monâl* or *Impeyan Pheasant*, only two remained alive from among seventeen sent; and of these two, one was reported to be dying.

The gizzard, liver, *duodenum*, and adjacent parts, and the *cloaca*, were exhibited of the young *concave Hornbill*, *Buceros cavatus*, Lath., which recently died at the Society's Gardens; and Mr. Owen read his "Account of the Anatomy" of the bird, an abstract of which forms part of the "Proceedings."

Mr. Owen concluded this paper by some remarks on the affinities of the *Hornbill* as deducible from its anatomy. Its nearest approach is to the *Toucan*. The *Toucan*, however, in the want of a gall-bladder agrees with the *Parrots*; the presence of that organ in the *Hornbill*, places the bird in more immediate relation with the *Crows*. The disposition of the intestines in long and narrow loops also agrees with the *Raven*. The tongue, so remarkably varied in form and use among the *Scansores*, resembles, in the *Hornbill*, that of the carnivorous *Birds*. The individual examined was observed to be more attached to animal than to vegetable food, and would quit any other substance if a dead mouse were offered to it. This it would swallow entire, after squeezing it twice or thrice with the bill: and no castings were noticed. Petiver, however, has borne testimony to its regurgitating habits.

The communication was accompanied by drawings of the organs of nutrition; of the *cloaca*; and of the bill and its muscles.

A "Description of *Alepisaurus*, a new genus of *Fishes*," by the Rev. R. T. Lowe, A.M., Corr. Memb. Z.S., was read. It was contained in a letter addressed to the Secretary, and was accompanied by a coloured drawing of the *Fish*, which was exhibited, as was also a specimen, preserved in spirit, which had been presented to the Society by Mr. Lowe in the summer of 1832.

Mr. Lowe refers the genus in question to that family of the *Acanthopterygii* to which Cuvier has given the name of *Tænioides*. Its generic characters may be thus expressed.

Alepisaurus. *Caput* compressum, anticè productum; *rictu* magno, pone oculos longè diducto; dentibus uniseriatis, validis, retrorsum spectantibus, quibusdam prælongis.

*Corpus* elongatum, attenuatum, cum capite omnino nudum.

*Pinnæ dorsales* duæ; *prima* alta, a nuchâ longè per dorsum producta; *secunda* parva, trigona, adiposa: *ventrales* mediocres, abdominales: *analis* mediocris, anticè elevata: *caudalis* magna, furcata.

*Membrana branchiostega* 6–7 radiata.

Alepisaurus ferox. *Hab.* in Mari Atlantico Maderam alluente, rarissimus.

In its habit, shape of body, smoothness of skin, compressed head, wide gape, and long formidable teeth, *Alepisaurus* agrees with *Trichiurus* and *Lepidopus*; but in the former of these genera the ventral fins are wanting, and in the latter they are rudimentary only and pectoral: *Trichiurus* is also destitute of a caudal fin. In both of them, moreover, the anal fin is anormal and the dorsal is single. The two dorsal fins of *Alepisaurus* are remarkable among the *Fishes* with which it is most nearly related; and the small adipose second dorsal evidently indicates a curious relation of analogy to the *Salmonidæ* among the *Malacopterygii*.

## ROYAL SOCIETY OF EDINBURGH.

April 1st.—A paper on "The Employment of Coordinates traced upon the surface of the Sphere, in the determination of Spherical Loci," by T. S. Davies, Esq., F.R.S., L. & E., was read.

This was intended as the completion of a paper already printed in the Society's Transactions (vol. xii.), and of which an account was given in this Magazine for February 1832. Instead of considering the curves traced upon a spherical surface, as is usually done, as the line of intersection of two curve surfaces, one of which is the sphere itself, and of referring each curve surface to *their rectilinear coordinate axes*, Mr. Davies refers that curve to *two coordinate axes*, situated upon the spherical surface itself. The system which the author has already developed, is that in which points are defined by the common geographical method of reference to latitude and longitude, or else to polar distance and polar angle: he had before given all the requisite formulæ for facilitating the use of these systems, so far as that could be done without the employment of differential coefficients, and had also applied them to a number of the most celebrated problems that had engaged the attention of mathematicians by other methods. In the present, or complementary paper, he gives the formulæ which result from the use of differential coefficients, such as the tangent and normals, evolutes, and radii of curvature. He gives the *equation* of the great-circle tangent to a curve at any point, and likewise that of the normal, in terms of the *polar coordinates* of the current point of the tangent and normal, and of the differential coefficients to the curve at the point of contact or of normal section. He is also led by this, *and the remarkable analogy which is found to subsist between the plane and spherical equations,* to give the equation of the tangent and normal of plane curves, in terms of *polar coordinates*, and to suggest that the properties of such curves can often be more elegantly investigated by such means than by an equation between the radius vector and perpendicular upon the tangent, which has been hitherto universally employed. He considers, indeed, that the investigation of spherical loci is now reduced to principles quite as simple, and to operations quite as easy, as that of plane loci is, or perhaps ever will be.

Mr. Davies gives a few specimens of the use of these formulæ, in the case of the spherical conic sections (defined by the equality of the sum or difference of arcs drawn from two given points to the points of the curve), in which very slight modifications of the verbal enunciation are found to express corresponding properties *in plano* and *in sphæro*. A curve which, from the form of its equation and the mode of its genesis, Mr. Davies calls the *spherical logarithmic* or the *spherical equi-subtangential curve*, is also examined at some length. It is such a one that the great-circle tangent to any point shall cut off a constant arc upon the equator, reckoned from the meridian of the point of contact. Amongst its properties are:—

1. That its *gnomonic* projection upon the polar tangent-plane is a *logarithmic spiral.*

2. That its *gnomonic* projection on the equatorial cylinder becomes, when the cylinder is developed, a *logarithmic curve.*

3. That if another equal sphere be described, having the pole of the logarithmic for its centre, then the *gnomonic* projection of the logarithmic upon this second sphere, is the *loxodrome;* and the

rhomb of the loxodrome is measured by the constant intercepted arc of the equator on the first sphere.

4. Conversely, if an equal sphere be described about the pole of the loxodrome, and the *loxodrome be stereographically* projected upon it, then the projection is the *spherical logarithmic*, whose constant subtangent measures the angle of the rhomb in the projected loxodrome.

At the close of his paper Mr. Davies announces that another system of coordinates, having the same relation to the plane-rectangular system that the system he has already treated of has to the plane polar system, will be discussed in No. 25 of Leybourn's Mathematical Repository, and in the subsequent Numbers of that work.

## LXII. *Intelligence and Miscellaneous Articles.*

### ANALYSES OF VEGETABLE SUBSTANCES. BY M. PELLETIER.

[Continued from p. 313.]

*CARMINE.*—This is the colouring principle of cochineal, and was first obtained in a separate state by Pelletier and Caventou, in 1808. Carmine, procured by the process described by these authors in their original paper, was subjected to analysis after being dried *in vacuo*, and at a moderate heat, to deprive it of all traces of alcohol and æther. Its composition was determined by burning with peroxide of copper. It yielded

| | by direct Analysis. | | Atomic Composition. | | Calculated Results. |
|---|---|---|---|---|---|
| Carbon ............ | 49·33 | .... | 16 | .... | 49·43 |
| Hydrogen .......... | 6·66 | .... | 26 | .... | 6·65 |
| Azote ............ | 3·56 | .... | 1 | .... | 3·57 |
| Oxygen ............ | 40·45 | .... | 10 | .... | 40·42 |

M. Pelletier expresses, however, some doubt as to the true composition of carmine, and thinks it possible that the specimen analysed contained some water.

*Chlorophylle.*—This name was given by M. Pelletier to the substance from which the colour of the leaves and young stalks of vegetables appeared to be derived, and which was formerly called the green matter of vegetables, green resin, &c. Later researches have however convinced M. Pelletier that wax enters into the composition of chlorophylle, which, however, does not entirely consist of it. This wax may be obtained colourless and friable when it is separated from the green oil with which it is combined in the green matter of leaves; he has not however yet ascertained whether the green colour is essential to the oil, or whether it is derived from a green substance which it holds in solution. For the reasons above stated M. Pelletier has not given any analysis of chlorophylle.

*Olivile.*—This is a peculiar vegetable product discovered by M. Pelletier in 1816, in a concrete juice which exudes from the trunks of olive trees in the most southern parts of Italy. It was known to the ancients, and employed by them as an application to wounds.

It is obtained by exhausting the gum of the olive with sulphuric æther, which removes a resinous matter; the undissolved portion is then treated with absolute alcohol, which dissolves the olivile only; it is obtained in irregular crystals by evaporating the alcohol. It yielded

| | by direct Analysis. | Atoms. | Calculated Results. |
|---|---|---|---|
| Carbon | 63·84 | 6 | 63·91 |
| Hydrogen | 8·06 | 9 | 7·85 |
| Oxygen | 28·10 | 2 | 27·99 |

*Anchusic Acid.*—M. Pelletier gives this name to the colouring matter of alkanet root (*Anchusa tinctoria*). This substance was first obtained in 1818: its acid properties are very distinctly marked. It is of a red colour by itself, but all its combinations are of a blue colour, the tint of which is variable, and in some cases it is magnificent.

Anchusic acid is a sort of fat acid, which is soluble in alcohol and in æther; but it is very remarkable in forming neutral compounds with the alkalies and earthy oxides, which are soluble both in alcohol and in æther. The anchusate of magnesia is remarkable for this property, and according to M. Pelletier, it is the only acid which forms salts with the earths that are soluble in æther. Another property not noticed in M. Pelletier's original paper is, that the anchusic acid, when cautiously heated, gives violet-coloured vapours, somewhat resembling those of iodine: these vapours are extremely pungent, and call to mind those of burning selenium; on cooling they condense into very light flocks. It is, however, to be observed, that there is but little difference between the temperature at which the acid sublimes and decomposes, so that it is difficult to sublime it in considerable quantity.

This volatility of anchusic acid places it in the same rank as indigo and alizarine. It is composed of—

| | by direct Analysis. | Atomic Composition. | Calculated Results. |
|---|---|---|---|
| Carbon | 71·178 | 17 | 71·23 |
| Hydrogen | 6·826 | 20 | 6·84 |
| Oxygen | 21·996 | 4 | 21·91 |

*Ann. de Chim. et de Phys.* tom. li. p. 182.

---

### ON AMBREINE, AMBREIC ACID, AND CHOLESTERIC ACID.

M. Chevreul discovered in biliary calculi a peculiar substance of a fatty nature, to which he gave the name of cholesterine: it is distinguished from other fatty matters by neither forming a soap nor suffering decomposition by the action of the alkalies.

MM. Pelletier and Caventou have since discovered in ambergris a peculiar substance, which they term *ambreine*, similar to cholesterine in resisting the action of alkalies, but sufficiently distinguished from it by the difference of their fusing points, that of ambreine being 97° Fahr., while that of cholesterine is 278° Fahr. There are also some other properties in which they differ. Ambreine is composed of—

| | by direct Analysis. | Atomic Composition. | Calculated Results. |
|---|---|---|---|
| Carbon | 83·37 | 33 | 83·38 |
| Hydrogen | 13·32 | 65 | 13·30 |
| Oxygen | 3·31 | 1 | 3·32 |

If the analysis of ambreine, as here stated, be compared with that of cholesterine by M. Chevreul, it will appear that the former contains a little more hydrogen, which may explain its greater solubility in alcohol.

As in this analysis, in which M. Gay Lussac's method was adopted, the oxygen is determined by inference, the slightest loss in estimating the carbonic acid and water would occasion the disappearance of the small portion of oxygen, and the ambreine would be reduced to a peculiar carburetted hydrogen; but the analogy existing between cholesterine and ambreine, and the circumstance that naphtha in which ambreine is dissolved, is unfit for the preservation of potassium, renders such an opinion improbable.

Cholesterine and ambreine, when treated with nitric acid, give rise to two different acids, which have been described by MM. Pelletier and Caventou. The cholesteric acid was particularly examined, and the salts which it forms with strontia carefully analysed. The results were—

| | by direct Analysis. | Atomic. Composition. | Calculated Results. | |
|---|---|---|---|---|
| Carbon | 54·93 | 13 atoms | = 993·694 | 54·99 |
| Azote | 4·71 | 1 | = 88·518 | 4·89 |
| Hydrogen | 7·01 | 20 | = 124·800 | 6·96 |
| Oxygen | 33·35 | 6 | = 600·012 | 33·20 |

Atomic weight = 1807·024

Ambreic acid differs from cholesteric acid in several properties, which have been pointed out; and they differ in composition, as will appear by the following statement of the composition of the former:

| | by direct Analysis. | Atomic Composition. | Calculated Results. |
|---|---|---|---|
| Carbon | 51·942 | 21 | 51·96 |
| Azote | 8·505 | 3 | 8·59 |
| Hydrogen | 7·137 | 35 | 7·07 |
| Oxygen | 32·416 | 10 | 32·37 |

The existence of azote in acids derived from the action of nitric acid upon organized substances which do not contain any, is a remarkable and entirely new fact. Hitherto the few known azotized acids derived from the action of nitric acid upon organic matter were formed from substances which contained azote, so that in these cases it could not be said that azote was transferred from the nitric acid to the vegetable matter; but in this case, as the animal matter contains no azote, it is evidently derived from the nitric acid. M. Couerbe, indeed, has lately found an acid, resulting from the action of nitric acid upon meconine, which crystallizes in fine needles, and possesses peculiar properties; but he has not remarked that his acid was an exception to the general rule.—*Ann. de Chim. et de Phys.* tom. li. p. 187.

---

## ON THE IODIDES OF PLATINA AND THEIR COMPOUNDS.

### BY M. LASSAIGNE.

This paper has already been slightly noticed (Lond. and Edinb. Phil. Mag., vol. ii. p. 197.): we shall now give a further account of its contents.

*Protiodide of Platina.*—Protochloride of platina was prepared by first obtaining a solution of the perchloride by dissolving the metal in aqua regia: this was evaporated to dryness. The perchloride obtained was gently heated in a porcelain capsule till it ceased to disengage chlorine: the resulting protochloride was of a yellowish green colour. Any perchloride which might remain was gently heated in alcohol of specific gravity ·827: a yellow coloured solution of perchloride was obtained by repeated washings.

The purified protochloride was treated with a moderately strong solution of iodide of potassium. No action occurred till the mixture had been heated for about a quarter of an hour; decomposition then gradually took place, and a precipitate was obtained of the following properties: it was black, heavy, finely divided, and adhered to the fingers like charcoal; it had neither taste nor smell. Neither water nor alcohol acted upon it at any temperature, and it was unalterable in the air. When heated it was decomposed, vapour of iodine rising and spongy platina remaining. It may be heated to above 482° Fahr. without decomposing, but the vapour of iodine begins to rise at about the temperature of boiling mercury.

Neither nitric, sulphuric, nor muriatic acid has any action upon it either hot or cold: the solution of potash or of soda gradually decomposes it, and converts it into protoxide of platina, part of which precipitates in the form of a black powder, and the rest remains in solution in the excess of alkali with the subiodide formed. Ammonia, digested in this iodide, gradually converts it at common temperatures into a dull yellowish green matter; this, after washing and drying, is decomposed by heat, yielding ammonia, iodine, ioduretted hydriodate of ammonia, and platina. It was found to be a compound of protoxide of platina and iodide of platina, and ammonia. The protiodide of platina decomposed by heat gave as the mean of two experiments

| | |
|---|---|
| Iodine .. | 56·05 |
| Platina .. | 43·95 |
| | 100·00. |

A compound of 1 atom of iodine = 126 + 1 atom platina = 96 would consist of

| | |
|---|---|
| Iodine .. | 56·76 |
| Platina.. | 43·24 |
| | 100·00. |

M. Lassaigne observes that this iodide contains exactly half as much iodine as that which he first prepared in 1829 by treating perchloride of platina with iodide of potassium. (*Journal de Chimie Médicale.*) That iodide, of course consisted of

| | |
|---|---|
| One atom of iodine .. | 126 |
| Two atoms of platina | 192 |
| | 318. |

*Action of Iodide of Potassium upon Protiodide of Platina.*—Dissolve iodide of potassium in six parts of water, and put some protiodide of platina into the solution; suffer them to remain at the temperature of the air, with occasional stirring, for twenty-four hours: the solution becomes of a light orange colour, and the greater part of the iodide remains undissolved. When heated in a water bath nearly to ebullition, for several hours, the solution becomes of a deeper colour, but the greater part of the iodide of platina remains undissolved. There appears to be formed a double iodide of potassium and platina, which crystallizes, by slow evaporation, in rectangular tables of a lemon-yellow colour. As it is impossible to separate this salt from a portion of free iodide of potassium, it has not been analysed.

*Hydriodic Acid and Protiodide of Platina.*—Hydriodic acid of sp. gr. 1·038, when mixed with protiodide of platina at common temperatures, gradually decomposes and converts it into bi-iodide, which dissolves in the acid and produces a red compound, and metallic platina, which appears on the surface of the liquid, in the state of a steel-gray pellicle.

*Bi-iodide of Platina* is very easily prepared, by adding a solution of iodide of potassium to one of bichloride of platina diluted with water. At the moment these liquors are mixed, an orange red colour is produced, which soon becomes deeper and of a wine red-colour, without the formation of any precipitate; but if the mixture be heated it becomes brown, turbid, and when boiling deposits a flaky or crystalline black powder, according to the strength of the solutions. During precipitation vapour of iodine is given out, owing to the decomposition of a portion of iodide of potassium by an excess of acid, which remains mixed with the bichloride of platina; when this excess of acid is avoided as much as possible, no vapour of iodine is evolved. The bi-iodide of platina, after washing with boiling water, may be dried over sulphuric acid or by a water bath.

This iodide, like the protiodide, is a black powder, similar to powdered charcoal, and stains the fingers like it; sometimes it has a crystalline appearance, resembling powdered peroxide of manganese. It is inodorous, insipid, unacted upon by water, suffering no decomposition even when boiled in it. It is more easily decomposed by heat than the protiodide, giving out iodine at 268° Fahr. It is soluble in cold alcohol, but more so in hot; the solution is of a greenish yellow colour: it is not decomposed by water, and by evaporation to dryness it leaves a brownish residue, which is insoluble in water and has the properties of protiodide of platina. When iodine is triturated with water holding a portion of bi-iodide of platina in solution, it is not dissolved: a strong solution of chlorine decomposes a small portion of the bi-iodide, the results being bichloride of platina and of iodine, or perchloride of iodine, according to the quantity of chlorine employed. Cold sulphuric acid does not act upon it, but when heated it expels a portion of iodine.

This bi-iodide being decomposed by heat was found to consist of

| | | | |
|---|---|---|---|
| Two atoms iodine 126 × 2 | = 252 | .... | 72·42 |
| One atom platina | = 96 | .... | 27·58 |
| | 348 | | 100·00 |

Bi-iodide of platina combines readily with other iodides, and produces crystallizable double compounds of determinate proportions.

*The bi-iodide of Platina and Potassium* may be prepared by direct means: it is of a fine wine-red colour when dissolved in water. It crystallizes by spontaneous evaporation, in small rectangular parallelograms, sometimes terminated with four-sided pyramids; in this state of aggregation it is deep black, with a metallic lustre. It is always mixed with a small portion of uncombined iodide of potassium, which is easily separated by washing with alcohol. This salt is unalterable in the air, soluble in water, and imparting a fine deep red colour to it; it is nearly insoluble in alcohol. Cold sulphuric acid has no effect upon it, which is remarkable, because it acts strongly at common temperatures upon iodide of potassium when uncombined; the same occurs with the chloride of platina and potassium, which is not altered by cold sulphuric acid.

The double iodide of platina and potassium is composed of

| | | | |
|---|---|---|---|
| One atom of bi-iodide of platina .. | 348 | .... | 67·7 |
| One atom of iodide of potassium .. | 166 | .... | 32·3 |
| | 514 | | 100·0 |

*Bi-iodide of Platina and Sodium.*—This salt, obtained by a process like the preceding, crystallizes by exposure to the air in fine prismatic striated needles: it is of lead gray colour, very soluble in water and alcohol, and the solution is of a wine-red colour. As it was found impossible to free it from a portion of free iodide of sodium, it was not analysed.

*Bi-iodide of Platina and Barium.*—This salt has nearly the same properties as the last-mentioned, being deliquescent, but not in so great a degree.

*Bi-iodide of Platina and Zinc.*—This compound is prepared by saturating, cold, a solution of iodide of zinc, with bi-iodide of platina: it is very difficult to procure it regularly crystallized, irregular crystals forming in a red syrupy mass: it is very soluble in water, and attracts it strongly from the air; it has a strong styptic taste, like the other preparations of zinc.

*Hydriodate of Ammonia and Platina.*—This double salt, which is analogous to the muriate of ammonia and platina, is prepared by digesting, either cold or in a gentle heat, bi-iodide of platina, in a solution of hydriodate of ammonia: the red liquor obtained, when carefully evaporated, deposits small square crystals, of a black colour having also a metallic lustre.

This salt is unalterable in the air, insoluble in alcohol, slightly soluble in water, to which it imparts a wine-red colour; it contains no water of crystallization. When heated in a retort it yields ammonia, azote, vapour of iodine, iodiduretted hydriodate of ammonia, and leaves spongy platina to the amount of 23 per cent.

It was found to consist of

| | | | |
|---|---|---|---|
| Two atoms of bi-iodide of platina .. | 348 × 2 = | 696 .. | 82·86 |
| One atom of hydriodate of ammonia | = | 144 .. | 17·14 |
| | | 840 | 100·00 |

*Hydriodate of Bi-iodide of Platina.*—This is prepared by digesting, cold, bi-iodide of platina in a dilute solution of hydriodic acid. The acid becomes gradually of a fine red colour by saturation with the bi-iodide, and produces a double compound, which may be obtained, regularly crystallized, by evaporation under a bell-glass containing lime. The crystals are small, black and acicular, placed obliquely, somewhat similar to fern leaves. It is inodorous, has an acerb and rather styptic taste, but not at all an acid one. The crystals become slightly moist and of a reddish colour by exposure to the air, and water dissolves them readily.

It decomposes very slowly *in vacuo*, and may be repeatedly evaporated by heat without altering; at a higher temperature it decomposes, giving out ioduretted hydriodic acid and vapour of iodine; platina is left in powder, but in the form of the crystals before calcination.

This compound, analogous in formation to the hydriodate of bi-iodide of mercury, described by M. Boullay, Jun., appears to be composed of

| | | |
|---|---|---|
| One atom of hydriodic acid .. | 127 .... | 26·73 |
| One atom of bi-iodide of platina | 348 .... | 73·27 |
| | 475 | 100·00 |

This hydriodate of iodide of platina is decomposed by the alkaline oxides, and converted into a double iodide.—*Ann. de Chim. et de Phys.*, tom. li. p. 113.

## PEROXIDE OF BISMUTH.

M. Stromeyer observes that this oxide is but very little known, being scarcely mentioned in chemical works, though long since discovered by MM. Bucholz and Brandes, while analysing an ore of bismuth. Having occasion to separate a mixture of silica and oxide of bismuth, they fused it with potash, and on treating it with water, there remained a powder of an ochre yellow colour, which disengaged chlorine with muriatic acid, but dissolved in it without effervescence after calcination, which diminished its weight: by heating in a crucible with charcoal it was reduced to metallic bismuth. Although these experiments evidently prove the existence of a peroxide of bismuth incapable of forming combinations with acids, the composition stated by the discoverers was very improbable, and not in accordance with that of the yellow oxide: they fixed 50 as the quantity of oxygen contained in 100 of the peroxide, stating at the same time that when reduced to the protoxide by calcination it lost 33 per cent. As the protoxide contains about 10 per cent. of oxygen, the 67 remaining parts would contain 6·7, which would give a total of 39·7, differing 10 from their analysis.

When the yellow oxide of bismuth is moderately heated with potash, the mixture becomes brown, and after washing, a brownish powder remains, which gives chlorine with muriatic acid. As, however, by this process but little of the peroxide is obtained, the following process is recommended instead of it by M. Stromeyer: Heat the oxide obtained by calcining the subnitrate with a solution of chloride of potash or soda, which is readily prepared by decomposing chloride of lime with the alkaline carbonates. When cold but little action takes place, and even when heated the process goes on but slowly, so that the ebullition must be continued for some time. The oxide of bismuth assumes at first a fine ochre yellow colour, and at length becomes deep brown. It is then to be well washed, and in order to separate the protoxide which may remain, it is to be treated with cold nitric acid, diluted with 9 parts of water; it is to be added in excess to prevent the formation of subnitrate of bismuth. It is then to be washed, at first with weak acid, and then with water, and to be dried by a gentle heat.

The peroxide thus prepared is a heavy deep-brown powder, strongly resembling peroxide of lead. When exposed to a temperature near that of boiling mercury, it is decomposed, yellow oxide remaining and oxygen gas being evolved. When mixed with powdered charcoal, and heated, it burns vividly; the mixture may be fired by a live coal, and it continues to burn like amadou: the residue is a mixture of metal and protoxide. Hydrogen, at a moderate temperature, reduces it to protoxide, and at a higher one to the state of metal. When heated with sulphur it is quickly converted into sulphuret: it forms no compounds with acids: muriatic acid evolves chlorine, hydriodic acid converts it into a fine brown iodide, and the liquor becomes yellow owing to free iodine. Cold sulphuric acid expels oxygen, but if dilute, heat is requisite, and phosphoric acid acts in the same way. Cold nitric acid, containing no nitrous acid, acts but feebly upon it, but when heated it evolves oxygen. The acetic, oxalic, tartaric, and citric acids, do not act upon it, even when heated. The fixed alkalies and ammonia have no effect upon this peroxide: its composition is readily determined by ascertaining the loss of weight it suffers by heat; 12·12 parts lost 0·59 of oxygen, consequently 100 parts are composed of 95·141 protoxide and 4·859 oxygen. According to the experiment of Lajerhielm, the protoxide is composed of an atom of bismuth = 71, and an atom of oxygen = 8; in the 95·141 of protoxide there are then 85·507 metal + 9·634 oxygen, that is to say, nearly double the quantity expelled by heat. The peroxide is thus composed of 2 atoms metal and 3 of oxygen.

Neither the subnitrate nor the hydrate answers so well for preparing the peroxide as the pure protoxide.—*Ann. de Chim. et de Phys.*, tom. li. p. 267.

## SEPARATION OF BISMUTH AND LEAD.

M. Stromeyer observes that M. H. Rose in his work on analytical chemistry, advises that the oxides of these metals should be treated with sulphuric acid, which, when added in sufficient quantity, completely dissolves the sulphate of bismuth. But this method, as he has himself remarked, does not give very exact results, because the sulphate of lead is not totally insoluble; to this may be added the fact, that if the operation is not quickly performed, sulphate of bismuth is deposited in crystals, even from a very dilute solution.

M. Stromeyer proposes the use of potash as a better method. In many treatises on chemistry it is stated, that oxide of bismuth is soluble in the alkalies, but this is an error. When the oxide is boiled in potash, soda, barytes, or lime water, not the smallest trace of it is dissolved. The alkaline carbonates dissolve carbonate of bismuth; but this solution is decomposed by potash, which precipitates hydrated oxide. The small quantity of carbonate of potash which the solution of caustic potash may contain, is incapable of dissolving oxide of bismuth, as was determined by a direct experiment. The carbonate of lead, on the contrary, being completely soluble in the caustic alkalies, they offer a ready mode of separating the two oxides.

Both metals are to be dissolved in nitric acid; potash or soda is to be added in excess, and to be boiled for some time. The oxide of bismuth precipitated in the state of hydrate, loses, like the hydrate of copper, its water during ebullition, and becomes yellow. After washing, it is necessary only to dry it, for it would lose no more weight by calcination. The oxide of lead may then be determined by supersaturating the alkaline solution with acetic acid, and precipitating, according to Rose, with oxalate of ammonia. It is absolutely requisite that neither the nitric acid nor the potash should contain any muriatic acid, for in that case a subchloride would be precipitated, which the alkalies do not decompose, whilst they completely decompose the nitrate and the sulphate.—*Ann. de Chim. et de Phys.*, tom. li. p. 272.

## COMPOSITION OF OIL OF BITTER ALMONDS.

MM. Wöhler and Liebig have examined this oil, in which they found in its crude state a considerable quantity of hydrocyanic acid, as was proved by potash, a salt of iron and an acid. As the experiments were instituted to account for the production of benzoic acid from this oil, it was carefully mixed with hydrate of potash and a solution of muriate of iron, strongly agitated, and then distilled. All the oil came over with the water, but entirely freed from hydrocyanic acid, and it was rectified over recently slacked lime. The oil thus deprived of its hydrocyanic and benzoic acid is perfectly colourless and limpid: it refracts light strongly. Its smell is but little altered: its taste is burning and aromatic. Its density is 1·043. Its boiling heat is above 266° Fahr., and the author's thermometers did not go higher than this. It readily inflames, and burns with a sooty flame.

It is not decomposed by passing through a red-hot glass tube. When exposed to the air, or in dry or moist oxygen, it is completely converted into crystallized benzoic acid. Solar light greatly accelerates this tranformation, which begins in a few seconds. In the air, and when water and potash are present, benzoate of potash is formed. If these experiments are made in a glass tube over mercury, the ascent of the mercury indicates absorption of oxygen. A third body is produced during the change of oil into benzoic acid. The method in which this oil is purified shows that it is not altered by the anhydrous alkalies; but the action of their hydrates is altogether different: when heated, out of the contact of air, with hydrate of potash, benzoate of potash is formed and pure hydrogen is disengaged.

If the oil be mixed with a solution of potash or ammonia in alcohol, out of the contact of the air, a benzoate is produced, which precipitates in large brilliant crystals as soon as potash is added. When water is added, the salt is dissolved, and an oleaginous body is separated, different from oil of almonds.

The oil of bitter almonds dissolves, unchanged, in the concentrated nitric and sulphuric acids: when the latter solution is heated it becomes purplish red, then blackens, and carbon is disengaged. Chlorine and bromine form new compounds with this oil. Analysed by means of peroxide of copper, the oil is stated to be composed of, foreign atomic weights being adopted,

| | | |
|---|---|---|
| 14 atoms of carbon ...... | 1070·118 .... | 79·56 |
| 12 atoms of hydrogen .... | 74·877 .... | 5·56 |
| 2 atoms of oxygen...... | 200·000 .... | 14·88 |
| | 1344·995 | 100·00 |

According to the composition of this oil, the formation of benzoic acid cannot be explained [but?] by the mere absorption of oxygen, for during this change, no other product is found. As according to Berzelius, benzoic acid contains 15 atoms of carbon, 12 atoms of hydrogen, and 3 atoms of oxygen, MM. Wöhler and Liebig resolved to repeat the analysis of benzoic acid, both crystallized and combined with a base.

The acid was obtained from the resin which furnishes it, and also from oil of almonds; the acid was fused and then burnt with oxide of copper. It was found to consist of

| | | |
|---|---|---|
| 14 atoms of carbon ...... | 107·0118 .... | 69·25 |
| 12 atoms of hydrogen .... | 7·4877 .... | 4·86 |
| 4 atoms of oxygen ...... | 40·0000 .... | 25·89 |
| | 154·4995 | 100·00 |

As the results differ from those of Berzelius, benzoate of silver was analysed. It was prepared by precipitating neutral nitrate of silver by an alkaline benzoate. The precipitate is soluble in a large quantity of boiling water, and separates on cooling in brilliant plates, which lose neither weight nor splendour under the receiver of the air-pump.

By heating in a porcelain crucible, 100 parts of benzoate of silver gave 47·03 of metallic silver: the composition of the salt is therefore,

| | |
|---|---|
| Benzoic acid | 49·46 |
| Oxide of silver | 50·54 |
| | 100·00 |

The atom of the acid is thence 142·039. By analysis with oxide of copper, 0·600 gr. of benzoate of silver gave 0·797 of carbonic acid and 0·122 of water; giving, as the composition of 100 parts of the acid combined with a base,

| | |
|---|---|
| Carbon | 74·378 |
| Hydrogen | 4·567 |
| Oxygen | 21·035 |

Calculating according to the atomic weight, we have

| | | |
|---|---|---|
| 14 atoms of carbon | 107·0118 | 74·43 |
| 10 atoms of hydrogen | 6·2397 | 4·34 |
| 3 atoms of oxygen | 30·0000 | 21·23 |
| | 143·2515 | 100·00 |

On comparing the crystallized acid with that contained in the salt of silver, it will be seen that their difference consists in the first containing an atom of water.

Berzelius's results were obtained by analysing benzoate of lead, and in this the acid retains the water, which it does not when combined with oxide of silver, and this circumstance accounts for the difference observed.

MM. Wöhler and Liebig state, that the analysis of Dumas, in which the oxygen and hydrogen are said to be in the proportions which form water, is incorrect.

It is concluded by MM. Wöhler and Liebig, that when the oil of almonds becomes benzoic acid, by exposure either to the air or oxygen gas, it is by mere oxidation, the oil taking two atoms of oxygen gas.

When benzoate of potash is formed by heating oil of almonds with hydrate of potash, excluded from the air, the water of the hydrate supplies the oxygen, and its hydrogen is evolved.

MM. Wöhler and Liebig have called the radical of benzoic acid, *benzoyle*, composed of $C^{14} H^{10} O^{2}$, and consequently the pure oil of bitter almonds is a *hydruret of benzoyle*, and benzoic acid will become *benzoylic acid.* The authors, however, retain its ancient name.

Benzoyle combines with several elementary bodies besides oxygen to form benzoic acid, and with hydrogen to form oil of almonds.

*Chloride of Benzoyle.*—If dry chlorine gas be passed through hydruret of benzoyle (oil of almonds), heat is generated, chlorine is absorbed, and muriatic acid gas evolved, but no other compound indicating any other decomposition is formed. As soon as the formation of muriatic acid diminishes, the liquor becomes yellow, on account of the chlorine which it holds in solution: this, however, is expelled by boiling. If the liquor be made to boil while the current of gas is still passing through it, and if no disengagement of muriatic acid is observed to occur, the new compound is then pure,—it is the *chloride of benzoyle*. This chloride is as limpid as water. Its density is 1·196. Its odour is peculiar, extremely penetrating, affecting the eyes strongly, like horseradish. Its boiling point is very high. It is inflammable, and burns with a sooty flame of a greenish colour.

It sinks in water without dissolving; after long boiling in it it decomposes entirely, and gives crystallized benzoic acid and muriatic acid. By exposure to moist air it suffers similar decomposition. When chlorine gas is passed into a mixture of hydruret of benzoyle and water, the oil disappears, and crystallized benzoic acid is formed.

Chloride of benzoyle may be distilled over barytes or lime without undergoing any alteration: when heated with an alkali and water, this chloride immediately gives a metallic chloride and benzoate of potash.

In all these decompositions, benzoic and muriatic acids are the only substances formed. Hydruret of benzoyle is composed of $(14\,C+10\,H+2\,O)+2\,H$; by the action of chlorine the 2 atoms of hydrogen combine with 2 atoms of chlorine, and give muriatic acid, which is lost. But this hydrogen is replaced by 2 atoms of chlorine, according to the following formula $(14\,C+10\,H+2\,O)+2\,Cl$. This composition was proved by analysis.

Chloride of benzoyle when heated dissolves phosphorus and sulphur, which separate in crystals on cooling: it mixes in all proportions with sulphuret of carbon, and appears neither to occasion nor to suffer decomposition. When put into contact with solid chloride of phosphorus it becomes very hot, and there are produced liquid chloride of phosphorus, and an oily substance of a penetrating odour, which was not particularly examined.

[To be continued.]

## ON THE THERMO-MAGNETISM OF SINGLE PIECES OF METAL, AND ON THE ELECTRO-DECOMPOSITION OF METALLIC SOLUTIONS. BY. MR. STURGEON.

In the detail of my experiments on the thermo-magnetism of simple metals, published in the Philosophical Magazine and Annals of Philosophy, vol. x., I observed, that I had some reason for supposing that as the heat in a crystalline group meets with more obstruction in passing in one direction than in the other, this difference in its progress was probably the sole cause of the electric currents constantly observing an uniform direction with regard to the point of heat. The experiments which led to this supposition, I remarked, could not be detailed with propriety in that place. The reason was, that as those metals, (antimony and bismuth I was then speaking of,) when pure, invariably exhibit *local* currents, which return into themselves in the same piece by various windings; and as those currents always affect the *general* current in the circle, it was necessary to explain the operation of those *local* currents in the first place, and to guard against their influence when contemplating the operation of *general* currents, supposed to arise from other causes than that of crystalline groups of metallic films.

For this purpose I cast rectangular frames, of the same fashion as those I had before employed, of an alloy of tin and bismuth, in which no local or other current could be detected, to whatever point heat was applied; owing, no doubt, to the crystallization of the bismuth being nearly neutralized by the admixture of tin.

When one end of a frame was cut open by a fine saw, and one side of the opening warmed in the flame of a spirit-lamp, the whole frame became magnetic whenever the warm and cool sides were brought into contact, as if an electric current set through the saw-cut, *from* the heated to the cool extremity. I employed no multiplying galvanometer; simply sprung the sides of the opening together, and operated as with the whole frames of antimony, bismuth, &c.

I had placed a good deal of importance in this discovery, until I found that the phænomena were not uniform in all the metals; for although the current passes through the opening from the heated to the cool extremity in some metals, as in copper, brass, &c., it as constantly flows in the opposite direction in zinc, iron, &c.; just as I have shown to be the case with brass, and steel partially hardened, and perhaps for the same reason.

The facts, however, are certainly interesting: in a theoretical point of view, none, perhaps, are more so.

### *Suggestions on the Electro-Decomposition of Metallic Solutions.*

In the electro-decomposition of metallic solutions, and perhaps in that of all others, it appears to be an invariable law, that the constituent carried to the *negative pole* is the better electric conductor. This being an established fact, it is probable that the same law would be observed when more than one metal is held in the solution operated on. The best conductor in such solutions ought to be carried to the negative pole in preference to any of the rest; or at least in an earlier part of the process. For instance: a solution of copper and zinc in nitrous acid. The copper, being a better conductor than the zinc, ought, according to this law, to be revived at the negative pole in the earliest part of the process, and the zinc not until a later period. Upon the same principle, gold ought to be recovered before zinc from a solution holding them both. And for the same reason, any metal suspected to be a compound ought to have its constituents separated by a similar process. The same law, if universal, ought to be observed in all metallic solutions whatever. If, therefore, those metals which are apparently the most pure and simple should still happen to be compounds, it is highly probable that, by attending to, and operating upon, this principle, their decomposition would be very much facilitated, if not entirely accomplished.

I some time ago made a few experiments on this point; but I have not yet had time to prosecute them far enough to obtain a sufficient number of accurate results to form just notions as to the probable extent to which this mode of analysis may be carried.

With regard to copper and zinc, the law appears to hold good when the battery is not too powerful. I have employed 100 pairs of one-inch plates, and also 100 of two-inch plates, and have obtained the same results. The metals were held in solution by sulphuric acid and water. Whilst the battery was active, both copper and zinc were deposited on the negative platina wire; but when the power was less active, the copper alone was revived.

I throw out these hints in order that others, better circumstanced than I am, may, if they please, take advantage of them The field, I believe, is quite new, and appears to me to be worthy of investigation.

Artillery Place, Woolwich, Sept. 23, 1833.

## RETURN OF THE EXPEDITION UNDER CAPTAIN ROSS.

[Feeling desirous of recording in our pages, in an authentic form, the happy return of Captain Ross and his brave associates, from their perilous undertaking, we insert his official letter on the subject to the Secretary of the Admiralty. An obliging communication with which we have been favoured by Captain Ross, induces us to hope that we may be able to make public some additional particulars in our next.—Edit.]

### *Letter from Captain Ross to the Hon. Captain Elliot.*

"On board the Isabella, of Hull, Baffin's Bay, Sept. 1833.

"Sir,—Knowing how deeply my Lords Commissioners of the Admiralty are interested in the advancement of nautical knowledge, and particularly in the improvement of geography, I have to acquaint you, for the information of their Lordships, that the expedition, the main object of which is to solve, if possible, the question of a north-west passage from the Atlantic to the Pacific Ocean, particularly by Prince Regent's Inlet, and which sailed from England in May 1829, notwithstanding the loss of the foremast and other untoward circumstances, which obliged the vessel to refit in Greenland, reached the beach on which His Majesty's late ship Fury's stores were landed, on the 13th of August.

"We found the boats, provisions, &c., in excellent condition, but no vestige of the wreck. After completing in fuel and other necessaries, we sailed on the 14th, and on the following morning rounded Cape Garry, where our new discoveries commenced, and, keeping the western shore close on board, ran down the coast in a S.W. and W. course, in from ten to twenty fathoms, until we had passed the latitude of 72° north in longitude 94° west: here we found a considerable inlet leading to the westward, the examination of which occupied two days; at this place we were first seriously obstructed by ice, which was now seen to extend from the south cape of the inlet, in a solid mass, round by S. and E. to E.N.E.: owing to this circumstance, the shallowness of the water, the rapidity of the tides, the tempestuous weather, the irregularity of the coast, and the numerous inlets and rocks for which it is remarkable, our progress was no less dangerous than tedious, yet we succeeded in penetrating below the latitude of 70° north in longitude 92° west, where the land, after having carried us as far east as 90°, took a decided westerly direction, while land at the distance of forty miles to southward was seen extending east and west. At this extreme point our progress was arrested on the 1st of October by an impenetrable barrier of ice. We, however, found an excellent wintering port, which we named Felix Harbour.

"Early in January 1830, we had the good fortune to establish a friendly intercourse with a most interesting consociation of natives, who, being insulated by nature, had never before communicated with strangers; from them we gradually obtained the important information that we had already seen the continent of America, that about forty miles to the S.W. there were two great seas, one to the west, which was divided from that to the east by a narrow strait or neck of land. The verification of this intelligence either way, on which our future operations so materially depended, devolved on Commander Ross, who volunteered this service early in April, and, accompanied by one of the mates, and guided by two of the natives, proceeded to the spot, and found that the north land was connected to the south by two ridges of high land, fifteen miles in breadth, but, taking into account a chain of fresh-water lakes, which occupied the valleys between, the dry land which actually separates the two oceans is only five miles. This extraordinary isthmus was subsequently visited by myself, when Commander Ross proceeded minutely to survey the sea coast to the southward of the isthmus leading to the westward, which he succeeded in tracing to the 99th degree, or to 150 miles of Cape Turnagain of Franklin, to which point the land, after leading him into the 70th degree of north latitude, trended directly: during the same journey he also surveyed thirty miles of the adjacent coast, or that to the north of the isthmus, which, by also taking a westerly direction, formed the termination of the western sea into a gulf. The rest of this season was employed in tracing the sea-coast south of the isthmus leading to the eastward, which was done so as to leave no doubt that it joined, as the natives had previously informed us, to Ockullee, and the land forming Repulse Bay. It was also determined that there was no passage to the westward for thirty miles to the northward of our position.

"This summer, like that of 1818, was beautifully fine, but extremely unfavourable for navigation, and our object being now to try a more northern latitude, we waited with anxiety for the disruption of the ice, but in vain, and our utmost endeavours did not succeed in retracing our steps more than four miles, and it was not until the middle of November that we succeeded in cutting the vessel into a place of security, which we named Sheriff's Harbour. I may here mention that we named the newly-discovered continent, to the southward, Boothia, as also the isthmus, the peninsula to the north, and the eastern sea, after my worthy friend Felix Booth, Esq., the truly patriotic citizen of London, who, in the most disinterested manner, enabled me to equip this expedition in a superior style.

"The last winter was in temperature nearly equal to the means of what had been experienced on the four preceding voyages, but the winters of 1830 and 1831 set in with a degree of violence hitherto beyond record; the thermometer sunk to 92° below the freezing point, and the average of the year was 10° below the preceding; but, notwithstanding the severity of the summer, we travelled across the country to the west sea by a chain of lakes, thirty miles north of the isthmus, when Commander Ross succeeded in surveying fifty miles more of the coast leading to the N.W., and, by tracing the shore to the northward of our position, it was also fully proved that there could be no passage below the 71st degree.

"This autumn we succeeded in getting the vessel only fourteen miles to the northward, and as we had not doubled the Eastern Cape, all hope of saving the ship was at an end, and put quite beyond possibility by another very severe winter; and having only provisions to last us to the 1st of June 1833, dispositions were accordingly made to leave the ship in her present port, which (after her) was named Victory Harbour. Provisions and fuel being carried forward in the spring, we left the ship on the 29th of May 1832, for Fury Beach, being the only chance left of saving our lives: owing to the very rugged nature of the ice, we were obliged to keep either upon or close to the land, making the circuit of every bay, thus increasing our distance of 200 miles by nearly one half; and it was not until the 1st of July that we reached the beach, completely exhausted by hunger and fatigue.

"A hut was speedily constructed, and the boats, three of which had been washed off the beach, but providentially driven on shore again, were repaired during this month; but the unusual heavy appearance of the ice afforded us no cheering prospect until the 1st of August, when in three boats we reached the ill-fated spot where the Fury was first driven on shore, and it was not until the 1st of September we reached Leopold South Island, now established to be the N.E. point of America, in latitude 73° 56′, and longitude 90° west. From the summit of the lofty mountain on the promontory we could see Prince Regent's Inlet, Barrow's Strait, and Lancaster Sound, which presented one impenetrable mass of ice, just as I had seen it in 1818. Here we remained in a state of anxiety and suspense which may be easier imagined than described. All our attempts to push through were vain: at length, being forced by want of provisions and the approach of a very severe winter to return to Fury Beach, where alone there remained wherewith to sustain life, there we arrived on the 7th of October, after a most fatiguing and laborious march, having been obliged to leave our boats at Batty Bay. Our habitation, which consisted of a frame of spars, thirty-two feet by sixteen feet, covered with canvas, was during the month of November inclosed, and the roof covered with snow, from four feet to seven feet thick, which being saturated with water when the temperature was 15° below zero, immediately took the consistency of ice, and thus we actually became the inhabitants of an iceberg during one of the most severe winters hitherto recorded. Our sufferings, aggravated by want of bedding, clothing and animal food, need not be dwelt upon. Mr. C. Thomas, the carpenter, was the only man who perished at this beach; but three others, besides one who had lost his foot, were reduced to the last stage of debility, and only thirteen of our number were able to carry provisions, in seven journeys of sixty-two miles each, to Batty Bay.

"We left Fury Beach on the 8th of July, carrying with us three sick men, who were unable to walk, and in six days we reached the boats, where the sick daily recovered. Although the spring was mild, it was not until the 15th of August that we had any cheering prospect. A gale from the westward having suddenly opened a lane of water along shore, in two days we reached our former position, and from the mountain we had the satisfaction of seeing clear water almost directly across Prince Regent's Inlet, which we crossed on the 17th, and took shelter from a storm twelve miles to the eastward of Cape York. The next day, when the gale abated, we crossed Admiralty Inlet, and were detained six days on the coast by a strong north-east wind. On the 25th we crossed Navy Board Inlet, and on the following morning, to our inexpressible joy, we descried a ship in the offing, becalmed, which proved to be the Isabella, of Hull, the same ship which I commanded in 1818. At noon we reached her, when her enterprising commander, who had in vain searched for us in Prince Regent's Inlet, after giving us three cheers, received us with every demonstration of kindness and hospitality which humanity could dictate. I ought to mention also that Mr. Humphreys, by landing me at Possession Bay, and subsequently on the west coast of Baffin's Bay, afforded me an excellent opportunity of concluding my survey, and of verifying my former chart of that coast.

"I now have the pleasing duty of calling the attention of their Lordships to the merits of Commander Ross, who was second in the direction of this expedition. The labours of this officer, who had the departments of astronomy, natural history and surveying, will speak for themselves in language beyond the ability of my pen; but they will be duly appretiated by their Lordships, and the learned bodies of which he is a member, and who are already well acquainted with his acquirements.

"My steady and faithful friend Mr. William Thom, of the Royal Navy, who was formerly with me in the Isabella, besides his duty as third in command, took charge of the meteorological journal, the distribution and œconomy of provisions; and to his judicious plans and suggestions must be attributed the uncommon degree of health which our crew enjoyed; and as two out of the three who died the four years and a half were cut off early in the voyage, by diseases not peculiar to the climate, only one man can be said to have perished. Mr. M'Diarmid, the surgeon, who had been several voyages to these regions, did justice to the high recommendation I received of him; he was successful in every amputation and operation which he performed, and wonderfully so in his treatment of the sick; and I have no hesitation in adding, that he would be an ornament to His Majesty's service.

"Commander Ross, Mr. Thom, and myself, have, indeed, been serving without pay; but, in common with the crew, have lost our all, which I regret the more, because it puts it totally out of my power adequately to remunerate my fellow-sufferers, whose case I cannot but recommend for their Lordships' consideration. We have, however, the consolation, that the results of this expedition have been conclusive, and to science highly important, and may be briefly comprehended in the following words:—The discovery of the Gulf of Boothia, the continent and isthmus of Boothia Felix, and a vast number of islands, rivers and lakes; the undeniable establishment that the north-east point of America extends to the 74th degree of north latitude; valuable observations of every kind, but particularly on the magnet; and, to crown all, have had the honour of placing the illustrious name of our Most Gracious Sovereign William IV. on the true position of the magnetic pole.

"I cannot conclude this letter, Sir, without acknowledging the important advantages we obtained from the valuable publications of Sir Edward Parry and Sir John Franklin, and the communications kindly made to us by those distinguished officers before our departure from England. But the glory of this enterprise is entirely due to Him whose divine favour has been most especially manifested towards us, who guided and directed all our steps; who mercifully provided, in what we had deemed a calamity, His effectual means of our preservation; and who, even after the devices and inventions of man had utterly failed, crowned our humble endeavours with complete success.

"I have, &c.,
"JOHN ROSS, Captain R.N."

"*To Captain the Hon. George Elliot, &c.,*
*Secretary, Admiralty.*"

## CORRECTIONS IN MR. PRIDEAUX'S PAPER ON THE VOLTAIC THEORY.

There is a misprint in my paper on the Voltaic Theory, which destroys the meaning of the passage. *Vide* Number for April, page 253, paragraph 30.

"By passing connecting wires along 13, 23, 33, 43, &c.", "but connecting them 13, 2*c*; 23, 3*c*; 33, 4*c*, &c."

The printer has mistaken *z*, the initial of zinc, for the figure 3: the reading should be—

"By passing connecting wires along 1*z*, 2*z*, 3*z*, 4*z*, &c.; and, 1*c*, 2*c*, 3*c*, 4*c*, &c.; the whole six sets become a single pair; but connecting them 1*z*, 2*c*; 2*z*, 3*c*; 3*z*, 4*c*, &c., they become as many pairs as there are sets."

A less important error occurs at paragraph 28; *for* "dilute nitric acid (1·60)," *read* "dilute nitric acid (1 : 60), *i.e.* 1 acid to 60 water."

On the Editorial note at p. 211 of your Number for September, I would observe,—

That my reference was to the common definition of radiation, as the rapid transmission of heat through bodies, without affecting their temperature, and subject to reflection, &c., as light; whilst M. Becquerel operated on wires soldered together, and thus, *quoad* the communication of heat, in at least virtual contact.

Nor does § 217 of Sir J.F.W. Herschel's able discourse explain away, to my comprehension, the apparent essential distinctions between radiation and conduction, exemplified in the different order relating to them assumed by different substances among the metals themselves, and even amongst those the most similar in density and other qualities; as is recognised in M. Becquerel's paper, in the tendency of a variety of circumstances (as tarnishing a metallic surface, or covering it with glass, &c.) to promote the one but impede the other; in the comparative tardiness of water and similar *liquids* to communicate heat from particle to particle, though no evident obstruction to radiation interferes; as well as in many other well-known facts: radiation seeming dependent only on the emitting substance and its contained heat; conduction on the receiving as well as the emitting substance†.

Sept. 14, 1833. JOHN PRIDEAUX.

## LUNAR OCCULTATIONS FOR NOVEMBER.

*Occultations of fixed Stars by the Moon, visible at Greenwich in the Year* 1833. *Computed by* THOMAS MACLEAR, *Esq.; and circulated by the Astronomical Society.*

An Asterisk (*) annexed to the time of the phænomenon is intended to denote that the Star is *on*, or *near to*, the meridian, at that time.

| 1833. | Stars' Names. | Magnitude. | Ast. Soc. Cat. No. | Immersions. |  |  |  | Emersions. |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Sidereal time. | Mean time. | Angle from |  | Sidereal time. | Mean time. | Angle from |  |
|  |  |  |  |  |  | North Pole. | Vertex. |  |  | North Pole. | Vertex. |
|  |  |  |  | h m | h m | ° | ° | h m | h m | ° | ° |
| Nov. | 13 μ Gemin. | 3 | 790 | 5 20 | 14 35 | 103 | 87 | 6 30 | 15 45 | 268 | 267 |
| 19 | 56 f Aquarii | 6 | 2686 | 21 32 | 5 38 | 185 | 172 | 22 1* | 6 7 | 225 | 222 |
| 21 | 30 r Piscium | 4·5 | 2870 | 22 6 | 6 4 | 156 | 136 | 23 6 | 7 4 | 262 | 252 |
|  | 33 s Piscium | 5 | 2877 | 0 21 | 8 18 | 116 | 120 | 1 41 | 9 38 | 307 | 325 |
|  | (1) Ceti..... | 6·7 | 9 | 4 16 | 12 13 | 29 | 63 | 4 18 | 12 15 | 25 | 60 |
| 25 | (4) Ceti..... | 6·7 | 350 | 1 11 | 8 52 | 110 | 91 | 2 27 | 10 8 | 306 | 300 |
| 26 | (249) Tauri | 6 | 454 | 4 15 | 11 52 | 94 | 97 | 5 29 | 13 7 | 308 | 327 |
| 27 | 106 $l^1$ Tauri | 5·6 | 593 | 7 4 | 14 37 | 56 | 83 | 7 57 | 15 30 | 324 | 359 |
| 28 | 141 $Q^2$ Tauri | 6 | 745 | 4 44 | 12 13 | 136 | 113 | 5 45 | 13 14 | 244 | 238 |
|  | (338) Tauri | 6·7 | 759 | 7 54 | 15 23 | 45 | 72 | 8 52 | 16 21 | 311 | 347 |
|  | 7 η Gemin. | 4·5 | 775 | 11 24 | 18 52 | 129 | 171 | 12 4 | 19 33 | 229 | 270 |
| 29 | 44 $\omega^2$ Gemi. | 6·7 | 876 | 6 26 | 13 51 | 64 | 67 | 7 34 | 14 59 | 294 | 318 |
| 30 | 10 $\mu^2$ Cancri | 6·7 | 991 | 7 40 | 15 1 | 67 | 59 | 8 54 | 16 15 | 275 | 286 |

---

† This last remark of Mr. Prideaux respecting conduction is illustrated, perhaps, by the phænomena of vibrating metals: see Prof. Forbes's observations, in our last Number, p. 304.—EDIT.

*Meteorological Observations made by Mr. Thompson at the Garden of the Horticultural Society at Chiswick, near London; by Mr. Giddy at Penzance, and Mr. Veall at Boston.*

| Days of Month, 1833. | Barometer. | | | | | Thermometer. | | | | | Wind. | | | Rain. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | London. | | Penzance. | | Boston | London. | | Penzance. | | Bost. 8½ A.M. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
| | Max. | Min. | Max. | Min. | 8½ A.M. | Max. | Min. | Max. | Min. | | | | | | | |
| Sept. 1 | 29·777 | 29·546 | 29·904 | 29·760 | 28·88 | 56 | 38 | 58 | 49 | 51 | N. | NE. | N. | ... | 0·080 | 0·63 |
| 2 | 29·984 | 29·880 | 30·016 | 29·904 | 29·35 | 64 | 50 | 61 | 45 | 49 | W. | SW. | N. | 0·05 | ·120 | ·02 |
| 3 | 29·720 | 29·638 | 29·860 | 29·816 | 29·14 | 63 | 46 | 60 | 52 | 53·5 | S. | NW. | calm | ·39 | ·085 | ... |
| 4 | 30·237 | 29·937 | 30·016 | 30·010 | 29·46 | 60 | 41 | 62 | 50 | 53 | N. | NW. | NE. | ... | ... | ·11 |
| 5 | 30·377 | 30·329 | 29·960 | 29·910 | 29·75 | 63 | 42 | 63 | 48 | 52 | NE. | NW. | NW. | ... | ... | ... |
| 6 | 30·309 | 30·184 | 29·966 | 29·960 | 29·74 | 68 | 48 | 64 | 47 | 57 | NE. | NW. | calm | ... | ... | ... |
| ☾ 7 | 30·086 | 30·002 | 29·946 | 29·940 | 29·62 | 69 | 50 | 64 | 45 | 59 | NE. | NW. | E. | ... | ... | ... |
| 8 | 29·896 | 29·801 | 29·913 | 29·907 | 29·27 | 65 | 52 | 65 | 52 | 56 | NE. | W. | N. | ... | ... | ·12 |
| 9 | 30·079 | 29·995 | 29·910 | 29·907 | 29·43 | 66 | 52 | 67 | 50 | 60 | NE. | SW. | E. | ·16 | ·100 | ... |
| 10 | 30·078 | 29·948 | 29·990 | 29·907 | 29·36 | 66 | 50 | 65 | 50 | 59 | E. | SW. | calm | ·03 | ·090 | ... |
| 11 | 29·843 | 29·742 | 29·953 | 29·913 | 29·14 | 69 | 46 | 65 | 50 | 58 | NW. | NW. | calm | ... | ·060 | ·07 |
| 12 | 30·124 | 29·965 | 30·060 | 30·030 | 29·30 | 63 | 35 | 62 | 50 | 56·5 | W. | NW. | NW. | ... | ... | ·21 |
| ● 13 | 30·144 | 30·056 | 30·013 | 29·910 | 29·48 | 63 | 47 | 58 | 49 | 55 | SW. | NW. | calm | ... | ·770 | ... |
| 14 | 29·942 | 29·788 | 29·910 | 29·813 | 29·35 | 72 | 39 | 61 | 52 | 60 | S. | NW. | S. | ·03 | ... | ... |
| 15 | 29.949 | 29·864 | 29·910 | 29·810 | 29·40 | 68 | 45 | 57 | 50 | 56 | W. | W. | calm | ·02 | ·160 | ... |
| 16 | 29·695 | 29·628 | 29·763 | 29·560 | 29·07 | 67 | 50 | 60 | 52 | 57 | S. | NW. | calm | ·50 | ·520 | ... |
| 17 | 29·798 | 29·522 | 29·830 | 29·660 | 29·03 | 67 | 43 | 60 | 53 | 57 | W. | NW. | calm | ·04 | ... | ·14 |
| 18 | 29·901 | 29·772 | 29·978 | 29·833 | 29·13 | 62 | 40 | 59 | 53 | 57·5 | W. | NW. | NW. | ... | ·240 | ... |
| 19 | 30·183 | 30·026 | 30·138 | 30·010 | 29·36 | 62 | 38 | 64 | 53 | 53 | W. | NE. | NW. | ·06 | ... | ... |
| ☽ 20 | 30·264 | 30·248 | 30·150 | 30·138 | 29·64 | 62 | 43 | 61 | 48 | 52 | E. | NE. | calm | ... | ... | ... |
| 21 | 30·180 | 30·086 | 30·030 | 30·004 | 29·70 | 67 | 42 | 61 | 50 | 52 | E. | NW. | calm | ... | ... | ... |
| 22 | 30·061 | 29·962 | 29·960 | 29·860 | 29·44 | 69 | 45 | 63 | 49 | 56 | S. | SE. | calm | ... | ... | ... |
| 23 | 29·897 | 29·666 | 29·810 | 29·498 | 29·27 | 66 | 49 | 62 | 53 | 56 | S. | S. | calm | ·02 | ·575 | ... |
| 24 | 29·494 | 29·409 | 29·298 | 29·210 | 28·74 | 64 | 52 | 62 | 53 | 60 | SW. | SW. | NW. | ·09 | ·200 | ·10 |
| 25 | 29·768 | 29·688 | 29·561 | 29·510 | 29·00 | 67 | 47 | 60 | 52 | 58 | S. | SW. | NW. | ·02 | ·415 | ... |
| 26 | 29·912 | 29·785 | 29·766 | 29·666 | 29·14 | 65 | 34 | 58 | 46 | 57 | S. | NW. | calm | ·01 | ... | ... |
| 27 | 29·901 | 29·785 | 29·769 | 29·595 | 28·98 | 67 | 42 | 61 | 46 | 58·5 | S. | SW. | SE. | ... | ·500 | ... |
| ○ 28 | 29·721 | 29·594 | 29·660 | 29·566 | 29·12 | 60 | 37 | 57 | 52 | 58 | S. | NW. | calm | ·12 | ·300 | ... |
| 29 | 30·156 | 29·907 | 30·048 | 29·916 | 29·22 | 68 | 38 | 58 | 50 | 57 | W. | NW. | calm | ·01 | ·090 | ·09 |
| 30 | 30·299 | 30·248 | 30·116 | 30·110 | 29·65 | 67 | 39 | 61 | 48 | 51·5 | S. | SW. | calm | ... | ... | ... |
| | 30·377 | 29·409 | 30·150 | 29·210 | 29·30 | 72 | 34 | 67 | 45 | 55·8 | | | | 1·55 | 4·305 | 1·49 |

Remarks.

*London.*—Sept. 1. Cloudy and windy. 2. Fine: slight rain. 3. Heavy showers. 4. Windy: clear and cold. 5. Fine, but cool. 6, 7. Fine. 8. Rain. 9. Cloudy. 10, 11. Overcast. 12. Clear and fine. 13. Cloudy: fine. 14. Fine: rain at night. 15. Heavy dew: very fine. 16. Very fine: heavy rain at night, falling to the depth of half an inch. 17. Rain, cloudy, and fine: clear at night, with aurora borealis extending to an elevation of about 45°. 18, 19. Heavy dew: fine. 20. Foggy: slight haze: fine at night. 21—23. Foggy in the mornings: fine. 24. Rain. 25. Fine. 26. Fine with slight showers. 27. Foggy: very fine. 28. Overcast: rain. 29. Fine. 30. Foggy: very fine.

*Penzance.*—Sept. 1. Fair: showers. 2. Fair: rain. 3. Showers. 4—8. Fair. 9—11. Showers. 12. Fair. 13. Rain: fair. 14. Fair. 15. Fair: showers. 16. Rain. 17. Fair. 18. Fair: showers. 19. Fair. 20. Clear. 21. Fair: misty rain. 22. Fair. 23. Fair: rain. 24. Fair: showers. 25. Rain: showers. 26. Fair. 27. Fair; rain. 28. Fair; showers. 29. Clear; showers. 30. Fair.

*Boston.*—Sept. 1. Stormy: rain P.M. 2. Stormy. 3. Rain. 4. Cloudy and stormy. 5, 6. Cloudy. 7. Fine. 8. Rain. 9, 10. Cloudy. 11. Rain. 12—15. Fine. 16. Cloudy: rain A.M. 17—20. Fine. 21—23. Cloudy. 24. Stormy: rain early A.M. 25. Fine. 26, 27. Cloudy. 28. Fine: rain P.M. 29, 30. Fine.

THE
LONDON AND EDINBURGH
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[THIRD SERIES.]

DECEMBER 1833.

## LXIII. *On the Absorption of Light by Coloured Media, viewed in connexion with the Undulatory Theory.* *By Sir* John F. W. Herschel, *K.H.**

THE absorption of light by coloured media is a branch of physical optics which has only since a comparatively recent epoch been studied with that degree of attention which its importance merits. The speculations of Newton on the colours of natural bodies, however ingenious and elegant, can hardly, in the present state of our knowledge, be regarded as more than a premature generalization; and they have had the natural effect of such generalizations, when specious in themselves and supported by a weight of authority admitting for the time of no appeal, in repressing curiosity, by rendering further inquiry apparently superfluous, and turning attention into unproductive channels. I have shown, I think satisfactorily, however, in my Essay on Light, that the applicability of the analogy of the colours of thin plates to those of natural bodies is limited to a comparatively narrow range, while the phænomena of absorption, to which I consider the great majority of natural colours to be referrible, have always appeared to me to constitute a branch of photology *sui generis* to be studied in itself by the way of inductive inquiry, and by constant reference to facts as nature offers them.

The most remarkable feature in this class of facts consists in the unequal absorbability of the several prismatic rays, and the total abandonment of anything like regularity of progress

---

* Communicated by the Author. The substance of this paper was read before the Section of Physics of the British Association, at Cambridge.

in this respect as we proceed from one end of the spectrum to the other. When we contemplate the subject in this point of view, all idea of regular functional gradation is at an end. We seem to lose sight of the great law of continuity, and to find ourselves involved among desultory and seemingly capricious relations, quite unlike any which occur in other branches of optical science. It is, perhaps, as much owing to this as to anything, that the phænomena of absorption, in some recently published speculations, and in the view which Mr. Whewell has taken in his Report of the progress and actual condition of this department of natural philosophy, read to this Meeting, have been characterized as peculiarly difficult to reconcile with the undulatory theory of light. In so far as I have above described the phænomena in appropriate terms, it will be evident that a certain difficulty must attach to their reduction under the dominion of *any* theory, however competent, ultimately, to render a true account of them. Where such evidence of complication and suddenness of transition subsists on the face of any large assemblage of facts, we are not to expect that the mere mention of a few general propositions, like cabalistic words, shall all at once dissipate the complication, and render the whole plain and intelligible. If we represent the total intensity of light, in any point of a partially absorbed spectrum, by the ordinate of a curve whose abscissa indicates the place of the ray in order of refrangibility, it will be evident, from the enormous number of maxima and minima it admits, and from the sudden starts and frequent annihilations of its value through considerable amplitudes of its abscissa, that its equation, if reducible at all to analytical expression, must be of a singular and complex nature, and must at all events involve a great number of arbitrary constants dependent on the relation of the medium to light, as well as transcendents of a high and intricate order. We must not, therefore, set it down to the fault of either of the two rival theories if we do not at once perceive how such phænomena are to be reconciled to the one or to the other, but rather endeavour to satisfy ourselves whether there be, in the first instance, anything in the phænomena, generally considered, repugnant either to sound dynamical principles, or to the notions which those theories respectively involve as fundamental features.

Now, as regards only the general fact of the obstruction and ultimate extinction of light in its passage through gross media, if we compare the corpuscular and undulatory theories, we shall find that the former appeals to our ignorance, the latter to our knowledge, for its explanation of the absorptive phænomena. In attempting to explain the extinction of light, on the corpuscular doctrine, we have to account for the light so extinguished as a material body, which we must not suppose annihilated. It may, however, be transformed; and among the imponderable agents, heat, electricity, &c., it may be that we are to search for the light which has become thus comparatively stagnant. The heating power of the solar rays gives a *primâ facie* plausibility to the idea of a transformation of light into heat by absorption. But when we come to examine the matter more nearly, we find it encumbered on all sides with difficulties. How is it, for instance, that the most luminous rays are not the most calorific, but that, on the contrary, the calorific energy accompanies, in its greatest intensity, rays which possess comparatively feeble illuminating powers? These and other questions of similar nature may perhaps admit of answer in a more advanced stage of our knowledge; but at present there is none obvious. It is not without reason, therefore, that the question "What becomes of light?" which appears to have been agitated among the photologists of the last century, has been regarded as one of considerable importance as well as obscurity, by the corpuscular philosophers.

On the other hand, the answer to this question afforded by the undulatory theory of light is simple and distinct. The question "What becomes of light?" merges in the more general one, "What becomes of motion?" And the answer, on dynamical principles, is, that it continues for ever. No motion is, strictly speaking, annihilated; but it may be divided, and the divided parts made to oppose and, *in effect*, destroy each other. A body struck, however perfectly elastic, vibrates for a time, and then appears to sink into its original repose. But this apparent rest (even abstracting from the inquiry that part of the motion which may be conveyed away by the ambient air,) is nothing else than a state of subdivided and mutually destroying motion, in which every molecule continues to be agitated by an indefinite multitude of internally reflected waves, propagated through it in every possible direction, from every point in its surface on which they successively impinge. The superposition of such waves will, it is easily seen, at length operate their mutual destruction, which will be the more complete, the more irregular the figure of the body and the greater the number of internal reflections.

In the case of a body perfectly elastic and of a perfectly regular figure, the internal reflection of a wave once propagated within it in some particular direction might go on for ever without producing mutual destruction; and in sonorous bodies of a highly elastic nature we do in fact perceive it to continue for a very long time. But the least deviation from *perfect elasticity* resolves our conception of the vibrating mass into that of a multitude of inharmonious systems communicating with each other. At every transfer of an undulation from one such system into that adjacent, a partial echo is produced. The unity of the propagated wave is thus broken up, and a portion of it becomes scattered through the interior of the body in dispersed undulations from each such system, as from a centre of divergence. In consequence of the continual repetition of this process, after a greater or less number of passages to and fro of the original wave across the body, (however perfect we may suppose the reflections from its surface to be,) it becomes frittered away to an insensible amplitude, and resolved into innumerable others; crossing, recrossing, and mutually destroying each other, while each of the secondary waves so produced is in its turn undergoing the same process of disruption and degradation.

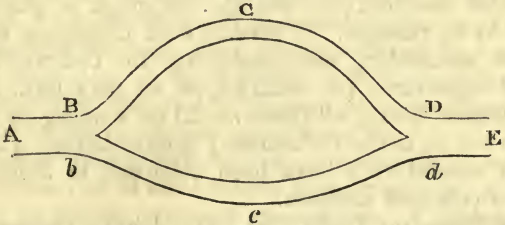
In this account of the destruction of motion, I have purposely supposed the body set in vibration to be insulated from communication with any other. In the case of a perfectly or highly elastic body struck in air, it will vibrate so long that a great part of its motion is actually carried off in sonorous tremors communicated to the air. But in the case of an inelastic or imperfectly elastic body, the internal process above described goes on with such excessive rapidity, as to allow of very few, and those rapidly degrading, impulses to be communicated from its surface to the air.

In my Essay on Sound, I have explained, on this principle of internal reflection and continual subdivision, in a medium consisting of loosely aggregated earth intermixed with much air, the hollow sounds which are often attributed to the reverberation of subterranean cavities, and in particular the celebrated instance of this kind of sound heard at the Solfaterra near Pozzuoli. The dull and ill-defined sound thus produced from a succession of partial echoes is there assimilated to the nebulous light which illuminates a milky medium when a strong beam is intromitted. If we suppose, now, such a mass of materials insulated from communication with the external air by some *sound-tight* envelope, these partial echoes, when they reach the surface in any direction, will be all sent back again as so many fresh impulses, till at length it will become impossible to assign a point within the mass which will not be agitated at one and the same moment by undulations traversing it in every possible phase and direction. Now the state of a molecule, under the influence of an infinite number of contradictory impulses thus superposed, is identical with a state of rest.

The only difficulty, then, which remains in the application of the undulatory theory to the absorptive phænomena, is to conceive how a medium (*i. e.* a combination of æthereal and gross * molecules) can be constituted so as to be transparent, or freely permeable to one ray or system of undulations, and opake, or difficultly permeable to another, differing but little in frequency. Now it is sufficient for our present purpose if, without pretending to analyse the actual structure of any optical medium, we can indicate structures and combinations in which air, in lieu of the æther, is the undulating medium, and which shall be either incapable of transmitting a musical sound of a given pitch, or shall transmit it much less readily than sounds of any other pitch, even those nearly adjacent to it. For that which experiment, or theory so well grounded as to be equally convincing with experiment, shows to be possible in the case of musical sounds, will hardly be denied to have its analogue or representative among the phænomena of colour, when referred to the vibrations of an æther.

An example of an acoustic combination, or compound vibrating system, incapable of transmitting a musical sound of a given pitch, is furnished by the pipe A E, which, after proceeding singly a certain length A B, at B branches off into two equal and symmetrically disposed pipes B C and *b c*, which reunite again at D *d*, and there again constitute a single pipe D E, whose direction shall (like A B) bisect the angle between the branches. The branches, however, are of unequal length, the one B C D being longer than the other, by a quantity equal to half the length of the undulation or pulse of the musical note in question. It is evident, then, that if that note be sounded at A, each pulse will subdivide itself at B *b*, and the divided portions will run on along the two branches with equal intensities till they reunite at D *d*. They will arrive there, how-

Fig. 1.



---

* By *gross* molecules, or gross bodies, I understand the *ponderable* constituents of the material world, whether solid, liquid, or gaseous; using the term in contradistinction to æthereal, which has reference to the luminiferous æther.

ever, in opposite phases, and will therefore destroy each other at their point of reunion, and in every point of their subsequent course along the pipe D E; so that on applying the ear at E no sound should be heard, or at best a very feeble one, arising from some slight inequality in the intensities wherewith the undulations arrive by the longer and shorter pipe,—a difference which may be made to disappear, by giving the longer a trifle larger area for its section*.

Suppose now that the pipe instead of being cylindrical were square, and that the whole surface of one side of a chamber were occupied with the orifices A of such pipes, leaving only such intervals as might be necessary to give room for their due support, and for their subdivision according to the condition above explained; and suppose, further, that the other ends (E) of all the reunited pipes opened out, in like manner, into another chamber, at some considerable distance from the first, and separated from it by masonry or some material, filling in all the intervals between the pipes, so as to be completely impervious to sound. Things being so disposed, let the whole scale be sounded, or a concert of music performed in the first chamber, then will every note, except that one to which the pipes are thus rendered impervious, be transmitted. The scale, therefore, so transmitted, will be deficient by that note, which has been, to use the language of photologists, *absorbed* in its passage. If several such chambers were disposed in succession, communicating by compound pipes, rendered impervious (or *un*tuned, as we may term it,) to so many different notes, all these would be wanting in the scale on its arrival in the last chamber; thus imitating a spectrum in which several rays have been absorbed in their passage through a coloured medium.

In my Essay on Light, Art. 505, I have suggested, as a possible origin of the fixed lines in the solar spectrum, and (*pari ratione*) of the deficient or less bright spaces in the spectra of various flames, that the same indisposition in the molecules of an absorbent body to permit the passage of a particular coloured ray *through* them, may constitute an obstacle, *in limine*, to the production of that ray *from* them. The following easy experiment will explain my meaning. Take two

---

* I ought to observe, that I have not *made* the experiment described in the text, nor am I aware that it has ever been made; but it is easy to see that it ought to succeed, and would furnish an apt enough illustration of the principle of interference. Instead of a pipe, inclosing air, a canal of water might be used, in which waves of a certain breadth, excited by some mechanical contrivance at one end, would not be propagated beyond the point of reunion, D, of the two canals into which the main channel, A B, was divided.

tuning forks of the same pitch, and heating the ends of them, fasten with sealing-wax, on one of them one, and on the other two, disks of card, (all equal in size,) on the *inner* surfaces, having the plane of the card perpendicular to that of a section of the fork through the axes of both its branches. The cards on that fork which has two, should have their surfaces about a tenth of an inch asunder, and their centres just opposite; and the other fork should be brought into unison with it by loading its undisked branch with additional wax, equal in weight to the disk and wax on the other. Now strike the forks, and a remarkable difference will be perceived in the intensity of their sounds. The fork with one disk will utter a clear and loud sound, while that of the other will be dull and stifled, and hardly audible, unless held close to the ear. The reason of this difference is that the opposite branches of the fork are always in opposite states of motion, and that in consequence the air is agitated by either the two branches vibrating freely, or by both loaded with equal disks, with nearly equal and opposite impulses; whereas in the case of a fork furnished with only one disk, a greater command of the ambient medium is given to the branch carrying it, and a much larger portion of uncounteracted motion is propagated into the air. Here then we have a case in which a vibrating system in full activity is rendered, by a peculiarity of structure, incapable of sending forth its undulations with effect into the surrounding medium; while the very same mass of matter, *vibrating with the same intensity*, but more favourably disposed as to the arrangement of its parts, labours under no such disability.

The disked tuning fork is a most instructive instrument, and I shall not quit it until I have availed myself of its properties to exemplify the easy propagation of vibrations, of a definite pitch, through a system comparatively much less disposed to transmit those of any other pitch. Take two or more forks in unison, and furnish each of them with a single disk of the size of a large wafer, looking outwards. (See fig. 17., Art. 186. of my Essay on Sound, for the mode of attaching such a disk.) Having struck one of them, let its disk be brought near to that of the other, centre opposite to centre, and it will immediately set the other in vibration, as will be evident by the sound produced by it when the first fork is stopped, as well as by its tremors, sensible to the hand which holds it. The communication of the vibration is much more powerful and complete when a small loop of fine silver wire is fixed to one of the forks, and brought lightly into contact with the other, with its looped or convex side. Imagine now a series of such forks and loops arranged as in fig. 2, and let the first, A, be maintained in vibration by any exciting cause, as, for instance, by causing to sound a musical note opposite to its disk A, in unison with its pitch. The vibrations so excited will, as is evident, run along the whole line, though with diminishing intensity, to the last fork. Here, then, we have a case analogous to the easy transmission of a ray of definite colour, accompanied with its gradual extinction, in traversing a considerable thickness of the absorbing medium. If we would avoid the actual contact of the vibrating systems, we may conceive an arrangement like that in fig. 3, where, in place of forks, straight bars, disked at both ends and supported at their nodal points, are used to form the vibrating series.

Fig. 2.

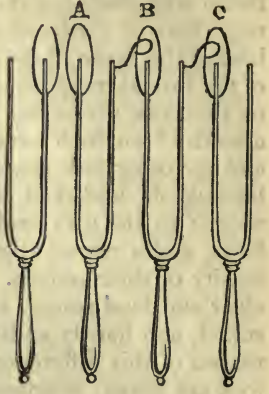
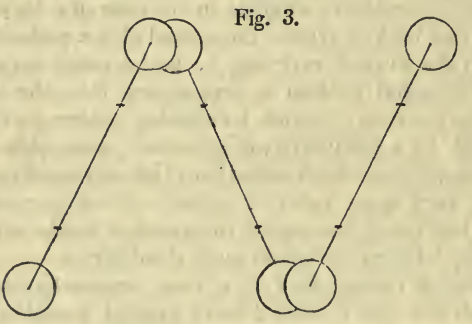


Fig. 3.



When two disked tuning forks slightly out of unison are opposed to each other, the vibrations of one are still communicated to the other, even when they differ sufficiently to produce audible and pretty rapid beats. But the communication in this case is less complete, and the sound produced feebler, than in that of perfect unison, and the degradation of intensity in the communicated sound is very rapid as the forks recede from unison. We have here a fact analogous to the appearance of a bright line in the spectrum situated between dark spaces, and as it is not difficult to imagine combinations of the nature above mentioned, in which several different notes shall be transmitted, while the intermediate one, finding no unisons, or near approaches to unison in the systems established, shall be extinguished; so by analogy we may perceive how any number of bright and dark lines may be produced in a spectrum unequally absorbed.

The case last put is entirely analogous in its principle to that of a phænomenon which is described in my Essay on Sound*, and of which, at the time of the publication of that Essay, I believed myself to have been the first and only observer, though I have recently learned to rectify that impression, and have great pleasure in referring the experiment, which is a remarkably easy and striking one, to Mr. Wheatstone, the author of so many other ingenious and instructive experiments in this department of physics. If a tuning fork be held over the open end of a pipe pitched in unison with it, the pipe will *speak* by resonance; (if the fork be disked, and the aperture of the pipe be nearly covered by the disk, the tone brought out is one of a clearness and purity quite remarkable). Now both Mr. Wheatstone and myself have observed that if *two forks*, purposely pitched out of unison with each other, so as to yield the beats of imperfect concords, be *at once* held over the orifice, the pipe will, at one and the same moment, yield both the notes, and will utter loud beats, being actually out of unison with itself. In proportion, however, as the pitch of one or other fork deviates from that to which the length of the pipe corresponds, and which the pipe alone would utter, the resonance of its tone is feeble, and beyond a certain interval becomes inaudible.

The dynamical principle on which these and similar phænomena depend is that of "forced vibrations," as it is stated in the Essay on Sound above referred to, or, more generally, in a more recent publication, (Cab. Cyclop., volume on Astronomy,) in terms as follow: "If one part of any system, connected either by material ties or by the mutual attractions of its members, be continually maintained by any cause, whether inherent in the constitution of the system or external to it, in a state of regular periodic motion, that motion will be propagated throughout the whole system, and will give rise in every member of it, and in every part of each member, to periodic movements, executed in equal periods with that to which they owe their origin, though not necessarily *synchronous* with them in their maxima and minima." The general demonstration of this as a dynamical theorem is given in the Essay on Sound already referred to, and its applicability to the transmission of light through material bodies is indicated in a note thereto appended.

The mode, then, in which we may conceive the transmission

---

* *Encyclopædia Metropolitana*, 2nd Div. vol. ii. p. 790.

of light through gross media to be performed, so as to bring the absorptive phænomena within the wording of this principle, is, to regard such media as consisting of innumerable distinct vibrating parcels of molecules, each of which parcels, with the portion of the luminiferous æther included within it, (with which it is connected, perhaps, by some ties of a more intimate nature than mere juxtaposition,) constitute a distinct compound vibrating system, in which parts differently elastic are intimately united and made to influence each other's motions. Of such systems in acoustics we have no want of examples—in membranes stretched on rigid frames, in cavities stuffed with fibrous or pulverulent substances, in mixed gases, or in systems of elastic laminæ, such as boards, sheets of glass, reeds, tuning forks, &c., each having a distinct pitch of its own, and all connected by some common bond of union. In all such systems the whole will be maintained in forced vibration so long as the exciting cause continues in action, but the several constituents, regarded separately, will assume, under that influence, widely different amplitudes of oscillation, those assuming the greatest whose pitch taken singly is nearest to coincidence with that of the exciting vibrations. Everybody is familiar with the tremor which some particular board in a floor will assume at the sound of some particular note of an organ; but when that note is not sounded, it is sufficiently apparent that the board is no less occupied in performing its dynamical office of transmitting to the soil below, or dispersing through its own substance and the contiguous bodies, the motion which the oscillation of the air above is continually imparting to it.

As we know nothing of the actual forms and intimate nature of the gross molecules of material bodies, it is open to us to assume the existence, in one and the same medium, of any variety of them which may suit the explanation of phænomena. There is no necessity to suppose the luminiferous molecules of gross bodies to be identical with their ultimate chemical atoms. I should rather incline to consider them as minute groups, each composed of innumerable such atoms; and it may be that in what are called uncrystallized media, the axes or lines of symmetry of these groups may have no particular direction, or rather all possible directions, or the groups themselves may be unsymmetrical. Such a disposition of things would correspond with a uniform law of absorption, independent of the direction of the transmitted ray, while in crystallized media a uniformity of constitution and position of these elementary groups, or rather of the cells or other combinations which they may be regarded as forming with the interfused æther, may be readily supposed to draw with it differences in their mode of vibration, and even different disposals of their nodal lines and surfaces, according to the different directions in which undulations may traverse them, and which may not impossibly be found to render an account of the change of tint of such media according to the direction of the rays in their interior, as well as of the different tints and intensities of their oppositely polarized pencils; of which latter class of phænomena, however, I shall immediately have occasion to speak further.

But as my present object is merely to throw out, as a subject for examination, a hint of a possible explanation of the phænomena of absorption, on the undulatory theory, I shall not now pursue its application into any detail, nor attempt the further development of particular laws of structure competent to apply to this or that phænomenon. I will, however, mention one or two facts in acoustics which appear to me strongly illustrative of corresponding phænomena in the propagation of light. The first of these is the impeded propagation of sound in a mixture of gases differing much in elasticity as compared with their density. The late Sir J. Leslie's experiments on the transmission of sound through mixtures of hydrogen with atmospheric air sufficiently establish this remarkable effect. It would be desirable to prosecute those experiments in larger detail, but hitherto I am not aware of anybody having ever repeated them. It would be interesting, for instance, to inquire whether the impediment offered by such a mixture of gases be the same for all *pitches* of a musical note, or not; and how far this phænomenon might be imitated by mixing actual *dust* of a uniform size of particle, such as the dust of Lycoperdon, &c., or aqueous fog, and how far such mixture would affect unequally sounds of different pitches.

The other fact in the science of acoustics which I would notice as illustrative of a corresponding phænomenon in photology, is one observed by Mr. Wheatstone, which I have his permission to mention. In attempting to propagate vibrations along wires, rods, &c., to great distances, he was led to remark a very great difference in respect of facility of propagation between vibrations longitudinal and transverse to the general direction of propagation. The former were readily conveyed with almost undiminished intensity to any distance; the latter were carried off so rapidly by the air, as to be incapable of being transmitted with any considerable intensity to even moderate distances. This strikes me as obviously analogous to the ready transmissibility of a ray polarized in one certain direction, through a tourmaline or other absorbing doubly defracting crystal, while the oppositely polarized ray (whose vibrations are rectangular to those of the first) is rapidly absorbed and stifled, *i. e.* dispersed, by the agency of the colouring matter which acts the part of the air in Mr. Wheatstone's experiment, and self-neutralized by the opposition of its subdivided portions as above explained.

Slough, October 19, 1833.

---

## LXIV. *Remarks on* Mr. Barton's *Reply, respecting the Inflection of Light. By the Rev.* B. Powell, *M.A. F.R.S. Savilian Professor of Geometry, Oxford.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

I DID not see your Number for September last, containing Mr. Barton's reply to my former paper, till very lately, and now hasten to send a few brief observations, which that reply seems to call for, and which I trust you will favour me by inserting in your Journal.

In the first place allow me to say that the courteous tenour of Mr. Barton's paper assures me that he will regard my present communication with the same candour as he has done the former; and in that spirit of candour I will proceed at once to the essential questions at issue.

The important and conclusive experiment is that in which the aperture has *straight parallel edges*. Here Fresnel's formula applies directly, and accords most exactly with the phænomena. This is evident both from what I have stated (Lond. and Edinb. Phil. Mag., vol. ii. p. 431–2), and from the exact experiments of Professor Airy, described in my postscript (*Ib.* p. 433). On this part of the question I do not perceive that Mr. Barton alleges any result of his own of an opposite kind. The only difficulty is about an experiment of Newton's. (Optics, book iii. obs. 5.) Now this experiment, as I before observed, is involved in considerable ambiguity. I am not aware whether Mr. Barton has succeeded in reproducing it *with all the concomitant circumstances* as described by Newton, viz. the "long trains of light" which he speaks of, &c. These are as essential to be explained as the appearance of a dark space in the centre. I have repeatedly tried to verify this experiment, but entirely without success; and I am much inclined to believe that there were some circumstances in the conditions of the case of which we are not fully informed. It is surely, then, most imperatively incumbent on us to ascertain carefully all the conditions, before we allege it in opposition to the united testimony of all other experiments.

But with respect not only to this, but also to the other experiments recorded by Newton in the place referred to, it is certainly most unfair and injurious to his memory to quote them without bearing in mind his strong and peculiar remark respecting them (at the end of observation 11.): "When I made the foregoing observations, I designed to repeat most of them with more care and exactness, and to make some new ones for determining the manner how the rays of light are bent in their passage by bodies for making the fringes of colours with the dark lines between them. But I was then interrupted, and cannot now think of taking these things into further consideration; and since I have not finished this part of my design, I shall conclude with proposing only some queries, in order to a further search to be made by others."

And again, in the "Advertisement" prefixed to the book: "The subject of the third book I have also left imperfect, not having tried all the experiments which I intended when I was about these matters, nor repeated some of those which I did try until I had satisfied myself about all their circumstances. To communicate what I have tried, and leave the rest to others for further inquiry, is all my design in publishing these papers."

These remarks of the illustrious author will speak for themselves; and it is evident he would be the last to urge his confessedly imperfect trials in opposition to decisive results. But even here I have, I think, sufficiently shown in my former paper, how very small his inaccuracies were; and the only case in which any real contradiction appears, is one, as I observed above, in which it is almost certain that we do not accurately know all the conditions.

Next, with regard to *curvilinear* edges, I would observe that no comparison can be fairly drawn between any experiments with straight edges and those with curved. Mr. Barton, in adopting the latter, has chosen a method which in calculation would involve extreme complexity, and it is a case to which the formula in question does not apply. In the case of the rectilinear parallel edges, an important simplification is afforded, as we have only to calculate the effects in one plane, viz. in that perpendicular to the length of the slit and to the plane of the edges. Whereas with curved edges we must combine with this the effect in the plane of the length of the aperture. To make a fair application, then, of the theory, we ought to follow out the calculation, and modify the formulæ, so as to include this case.

This, it will be readily acknowledged, by any one acquainted with the nature of the formulæ, will be a difficult investigation; nevertheless it is essential to go through it *before we* *can pronounce even the result as observed by Mr. Barton to be at variance with the theory.* And without entering into any calculation, it is obvious, on the mere consideration just referred to, (viz. the influence of the portions of light entering at the wider parts of the aperture in the direction of its *length*,) that the character of that part of the image corresponding to the narrowest part of the aperture will not be simply determined by the case of a rectilinear slit of the same width. Unfortunately I am not aware that any such investigation has been given, even in the case of inclined rectilinear edges.

Now with regard to my experiments: I have tried edges of extremely small curvature, and have never been able to find a black isolated central spot with bright fringes continuing at the sides, which is what I understand Mr. Barton to have seen. When, on the approach of the edges, the centre became dull or dark, *at the same moment* all appearance of bright bands at the sides ceased, these bands breaking off into hyperbolic branches.

On this part of my description Mr. Barton makes the remark (present vol. p. 172), that from the hyperbolic form of the curves it follows that a line at right angles to the length of the aperture must at some part cut through bright bands, having a central dark part between them. This, I must observe, really does not follow, because the hyperbolic branches extend but a very little way before they are quite lost and confounded in the shadow on either side; and the dark part in the centre of the figure stretches across, as it were, forming a junction between the shadows from each side. It is altogether very obscure, and ill-defined, and shades off so gradually into the bright central part above and below that it is quite impossible to say where it terminates. But supposing a dark centre to be really established, then I conceive the case to stand briefly thus:—Mr. Barton has brought forward a new experimental case,—and the science of theoretical optics is under great obligations to him for doing so,—a case to which neither the undulatory nor any other theory (except, I suppose, his own,) *has as yet been applied.* It remains to be seen how they may apply; and this case will form a further test of the powers of either theory WHEN FORMULÆ APPLYING TO THIS CASE SHALL HAVE BEEN INVESTIGATED.

In regard to my use of the expression "the coalescing of the shadows," I will only observe, that I did not employ it as a supplementary correction to the formula. It was suggested only in the case to which (as already observed,) the formula does not apply. It is, however, obviously included in the formula of Fresnel when the edges are parallel, as appears from the calculated numbers given in my former paper, where, with a very narrow aperture, the centre, though a point of relative brightness compared with other points in the same horizontal line, is yet a point of relative darkness compared with greater breadths of aperture. I am of course quite aware that, strictly speaking, the expression is incorrect, and though, perhaps, it may not inaptly facilitate the primary apprehension of the phænomenon, yet it undoubtedly involves a theory, and would therefore be better avoided. The idea that each edge carried with it its own fringes, which, as the two edges approached, crossed and overlapped, and thus gave rise to the bands actually observed, was the theory conceived by Biot in his analysis of the phænomenon. Fresnel's formula resolves the whole into an expression for the brightness of the light at points measured on a screen in a line at right angles to the length of the slit.

As to Mr. Barton's estimate of the comparative accuracy of the experiments of Newton, Biot and Fresnel, every reader will form his own judgement from the careful consideration of all the circumstances which ought to be taken into account. With respect to Biot's experiments, I see nothing to alter the conclusion at which I before arrived, by showing the probable amount of error which would bring the results into accordance; and I apprehend that in most cases of this nature the presumption would be in favour of the later experimenters, without any real disparagement of the earlier. With respect to Newton's results there is one circumstance to be remarked which, I believe, escaped me when writing my former paper. The particular experiment of Newton in question is that of the *inclined* knife-edges. The formula with which it is compared is that of Fresnel for *parallel* edges. This, as I have above observed, is a most essential difference; and thus, whether the error lies with me or with Mr. Barton, the whole computation, from first to last, is altogether nugatory.

The difficulty which Mr. Barton has now more fully stated respecting the origin of the rays, does not appear to me to require more than a careful reference to what is laid down in the best treatises for its elucidation. The effect of waves propagated through a narrow aperture is ably explained either in Professor Airy's tract (art. 27), or in Sir J. Herschel's treatise on Light (art. 607. 628)*. But the author's view of the subject seems to be suggested as introductory to the original theory which he proposes; and it appears to me that it would be a far better course if, instead of encumbering

---

* *Encyc. Metr.*, 2nd Div. vol. ii.

his views with extraneous considerations, he would give the scientific world a perspicuous and systematic development of them, so as fairly to contrast the explanation of the facts which his theory affords with that resulting from the other theories.

Perhaps it may not be altogether uninteresting to the reader to see at one view how the rival theories at present apply. I subjoin, therefore, a synoptic sketch, which I believe to be perfectly impartial; indeed, I have given every advantage to the corpuscular theory. It would be interesting if Mr. Barton would add a third column, giving a similar view of his own theory.

| *Phænomena.* | *Corpuscular Explanation.* | *Undulatory Explanation.* |
|---|---|---|
| Reflection | Perfect | Perfect. |
| Ditto at boundary of transparent medium | Imperfect | Perfect. |
| Refraction (light homogeneous) | Perfect | Perfect. |
| Dispersion | Imperfect | Imperfect. (? Cauchy.) |
| Absorption | Imperfect | Imperfect. |
| Colours of thin plates (in general) | Perfect (with subsidiary theory of fits) | Perfect. |
| Central spot | None | Perfect. (Imperfect according to Mr. Potter.) |
| Airy's modification | None | Perfect. |
| Thick plates | Perfect | Perfect. |
| Coloured fringes of apertures and shadows in simple cases | Imperfect (with subsidiary theory of inflection) | Perfect (Imperfect according to Mr. Barton.) |
| —— in more complex cases | None | None. |
| Stripes in mixed light | None | Perfect. |
| Shifting by interposed plate | None | Perfect. (Imperfect according to Mr. Potter.) |
| Colours of gratings | None | Perfect. |
| Double refraction | Perfect | Perfect. |
| Polarization | Imperfect (with subsidiary theory of polarity) | Perfect. (with subsidiary theory of transverse vibrations.) |
| Connexion with double refraction | None | Perfect. |
| Law of tangents | None | Perfect. |
| Interferences of polarized light | None | Perfect. |
| Polarized rings | Imperfect (with subsidiary theory of moveable polarization) | Perfect. |

| *Phænomena.* | *Corpuscular Explanation.* | *Undulatory Explanation.* |
|---|---|---|
| Circular and elliptic polarization: at internal reflection | …… None ……… | …… Imperfect. |
| at metallic surfaces | …… None ………<br>(? Sir D. Brewster) | …… None. |
| Conical refraction…. | …… None………. | …… Perfect. |

*Oxford, Nov.* 1, 1833.

## LXV. *On* Mr. Murphy's *Proof of the Existence of a real or imaginary Root for any proposed Equation.*

*To the Editors of the Philosophical Magazine and Journal.*

Gentlemen,

THE demonstration which appears in the Number of your Magazine for March 1833, by Mr. Murphy, does not seem to me to be conclusive.

For P is a function of $p$ and $q$: as also is Q: now a value being assigned to $p$, a value is found for $q$, which makes $Q = 0$: and the value of P in (1) depends upon these assigned values of $p$ and $q$.

Again: in the second substitution, for $p$ is put $p + h . \cos \frac{\pi}{n}$; the first part of this being the value above given to $p$: a value is then found for $q + h . \sin \frac{\pi}{n}$, and therefore for $q$, which makes $Q = 0$: *but this value does not necessarily appear to be the same value as before obtained for* $q$, and therefore the value of P (which is a function of $p$ and $q$) in (2) is not the same as the value in (1). J. HENRY.

Nov. 1, 1833.

## LXVI. *Observations on the Rise and Fall of Water in some Wells in Cornwall, with brief Notices of other Matters bearing on the Phænomena of Springs; in a Letter to Sir* CHARLES LEMON, *Bart. M.P. F.R.S. By* W. J. HENWOOD, *F.G.S. Lond. and Paris, Hon. M. Y.P.S.*[*]

Sir,

AT Dr. Buckland's desire, and with the assistance of gentlemen in various parts of Cornwall, I have endeavoured to follow up for one year the measurements first instituted in this country by Mr. Bland[†], and which I have now the honour to present to your notice.

---

[*] Communicated by Sir Charles Lemon.

[†] Phil. Mag. and Annals, vol. xi. p. 88.

| Wells. | 1<br>Richards. * | 2<br>Tren-gove. | 3<br>Perran Wharf. | 4<br>Opie's. | 5<br>Thomas. | 6<br>W. Ri-chards. | 7<br>Holman. | 8<br>Kempe. | 9<br>Fal-mouth. | 10<br>Fal-mouth. | 11<br>Martin. | 12<br>Bennett. | 13<br>Prater. | 14<br>Tregas-with. | 15<br>Lizard Light-house. | 16<br>Gribbel. | 17<br>Bodmin. | 18<br>Lande-wednack. | 19<br>Trebar-ber. | 20<br>Devis. | 21<br>Gatlys. | 22<br>Tubban. | 23<br>Goon-hingey. | 24<br>Chy-woon. | Preceding Month, Rain.† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strata. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Slate. | Hornbl. Slate. | Slate. | Slate. | Serpen-tine. | Gra-nite. | Gra-nite. | Gra-nite. | Gra-nite. | Gra-nite. | Gra-nite. | |
| Depth of Well. | Ft. In.<br>35 6 | Ft. In.<br>34 10 | Ft. In.<br>59 8 | Ft.<br>49 | Ft.<br>66 | Ft. In.<br>38 2 | Ft. In.<br>23 5 | Ft. In.<br>21 10 | Ft.<br>51 | Ft. In.<br>10 6 | Ft. In.<br>41 3 | Ft. In.<br>34 1 | Ft. In.<br>37 10 | Ft. In.<br>50 6 | Ft.<br>40 | Ft. In.<br>56 4 | Ft.<br>73 | Ft.<br>14 | Ft. In.<br>23 9 | Ft. In.<br>30 9 | Ft. In.<br>24 9 | Ft. In.<br>51 6 | Ft. In.<br>28 5 | Ft. In.<br>35 1 | |
| Surface above Sea. | Ft.<br>60 | Ft.<br>60 | Ft.<br>65 | Ft.<br>90 | Ft.<br>90 | Ft.<br>110 | Ft.<br>110 | Ft.<br>110 | Ft.<br>120 | Ft.<br>120 | Ft.<br>130 | Ft.<br>130 | Ft.<br>130 | Ft.<br>150 | Ft.<br>150 | Ft.<br>200 | Ft.<br>315 | Ft.<br>300 | Ft.<br>280 | Ft.<br>300 | Ft.<br>320 | Ft.<br>340 | Ft.<br>560 | Ft.<br>560 | |
| 1832. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Inches. |
| Feb. 1 | … ‡ | … | … | 21 10 | … | … | … | … | … | … | … | … | … | … | … | … | 48 0 | 13 6 | … | … | … | … | … | … | 3·2 |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | |
| March 1 | 11 0 | 9 10 | 28 0 | 25 7 | … | 5 2 | 5 6 | 7 2 | 6 5 | 4 5 | 3 2 | 13 2 | 12 1 | 24 1 | 15 0 | 17 4 | 47 0 | 10 5 | 10 2 | 6 8 | 3 5 | 10 6 | 14 1 | 8 9 | 2·31 |
| 15 | … | … | … | … | … | … | … | … | 9 10 | 5 9 | | | | | | | | | | | | | | | |
| April 1 | 12 8 | 10 9 | 29 9 | 25 10 | 16 9 | 6 1 | 6 7 | 9 0 | 7 0 | 4 7 | 9 8 | 15 11 | 15 3 | 25 10 | 15 0 | 20 8 | 45 7 | 9 7 | 11 9 | 7 7 | 3 9 | 12 2 | 15 1 | 9 7 | 4·47 |
| 15 | … | … | … | … | 13 11 | … | … | … | 4 8 | 4 1 | | | | | | | | | | | | | | | |
| May 1 | 11 3 | 9 7 | 24 2 | 20 6 | 13 6 | 4 7 | 5 0 | 6 2 | 3 10 | 3 11 | dry | 10 3 | 8 0 | 19 4 | 12 5 | 14 7 | 37 8 | 9 7 | 8 3 | 4 9 | 2 1 | 8 6 | 10 6 | 6 6 | 2·905 |
| 15 | … | … | … | … | 14 9 | … | … | … | 3 10 | 4 3 | | | | | | | | | | | | | | | |
| June 1 | 9 11 | 9 4 | 23 11 | 19 5 | 13 4 | 5 0 | 4 8 | 6 3 | 3 2 | 3 8 | dry | 10 5 | 8 7 | 17 11 | 10 8 | 13 0 | 38 6 | 9 0 | 7 4 | 5 1 | 2 10 | 9 7 | 10 7 | 7 0 | 4·225 |
| 15 | … | … | … | … | 15 0 | … | … | … | 3 6 | 4 5 | | | | | | | | | | | | | | | |
| July 1 | 8 4 | 6 9 | 19 11 | 18 5 | 11 1 | 4 4 | 4 1 | 5 2 | 2 10 | 3 4 | dry | 8 2 | 5 8 | 15 8 | 7 8 | 11 4 | 40 8 | 4 6 | … | … | … | … | … | … | 2·52 |
| 15 | … | … | … | … | 10 0 | … | … | … | 2 9 | 3 1 | | | | | | | | | | | | | | | |
| Aug. 1 | 3 4 | 2 0 | 15 1 | 9 2 | 7 6 | 3 9 | 3 1 | 4 0 | 2 6 | 2 3 | dry | 6 5 | 2 8 | 10 8 | 6 0 | 8 11 | 43 5 | 2 9 | 4 0 | 2 11 | 1 5 | 6 11 | 6 6 | 4 9 | 2·105 |
| 15 | … | … | … | … | 5 10 | … | … | … | 2 4 | 2 0 | | | | | | | | | | | | | | | |
| Sept. 1 | 8 5 | 5 8 | 14 8 | 43 9 | 11 3 | 3 4 | 2 10 | 3 8 | 3 2 | 2 10 | dry | 5 3 | 1 5 | 14 6 | 5 10 | 6 5 | 41 8 | 1 8 | 2 10 | 2 11 | 1 4 | 5 9 | 5 6 | 10 3 | 5·815 |
| 15 | … | … | … | … | 6 5 | … | … | … | 2 7 | 2 4 | | | | | | | | | | | | | | | |
| Oct. 1 | 1 9 | 2 9 | 12 8 | 4 4 | 5 10 | 2 9 | 1 11 | 3 0 | 2 3 | 1 6 | dry | 4 4 | dry | 13 4 | 4 3 | 4 11 | 42 7 | dry | 2 2 | 2 9 | 1 5 | 5 9 | 5 11 | 5 2 | 0·985 |
| 15 | … | … | … | … | 6 1 | … | … | … | 2 5 | 2 2 | | | | | | | | | | | | | | | |
| Nov. 1 | 4 1 | 1 5 | 10 5 | 4 4 | 4 11 | 2 7 | 0 10 | 2 0 | 2 2 | 1 8 | dry | 3 4 | dry | 11 8 | 1 10 | 3 4 | 28 9 | 1 0 | 3 6 | 3 6 | 1 11 | 7 4 | 7 3 | 7 8 | 3·625 |
| 15 | … | … | … | … | 21 2 | … | … | … | 5 7 | 7 4 | | | | | | | | | | | | | | | |
| Dec. 1 | 12 8 | 10 8 | 35 1 | 34 6 | 25 3 | 7 4 | 8 10 | 11 3 | 9 0 | 6 4 | 6 1 | 24 5 | 20 6 | 27 9 | 11 6 | 17 3 | 58 7 | 12 2 | 14 11 | 14 0 | 8 4 | 22 6 | 21 0 | 17 5 | 6·89 |
| 15 | … | … | … | … | 22 6 | … | … | … | 8 1 | 5 2 | | | | | | | | | | | | | | | |
| 1833. Jan. 1 | 17 11 | 14 4 | 47 7 | 34 5 | 28 2 | 9 4 | 9 10 | 12 9 | 13 2 | 10 2 | 23 3 | 26 0 | 26 7 | 33 9 | 21 10 | 30 5 | 56 8 | 12 8 | 17 9 | 15 6 | 9 4 | 25 3 | 23 0 | 16 7 | 6·095 |
| 15 | … | … | … | … | 19 10 | … | … | … | 9 2 | 5 0 | | | | | | | | | | | | | | | |
| Feb. 1 | 15 9 | 12 3 | 47 4 | 28 5 | 16 4 | 8 1 | 8 11 | 11 10 | 5 11 | 5 5 | 20 10 | 25 7 | 23 7 | 25 9 | 26 2 | 25 3 | … | full | 14 2 | 12 4 | 8 0 | 21 5 | 20 6 | 15 7 | 3·725 |
| 14 | … | … | … | … | 25 9 | … | … | … | 16 0 | running over. | | | | | | | | | | | | | | | |
| March 1 | … | … | … | .. | 27 8 | … | … | … | 16 6 | 10 3 | … | … | … | … | 27 0 | … | … | full | | | | | | | |

* For notes see next page.

On comparing the measurements of October and November, it appears that in that interval the wells *in the slate were subsiding*, whilst those in the granite were rising.

On the subject of the proportion of rain which finds its way to the rivers, Mr. Thomas has made some very pertinent remarks §. He says, "From surveys of the waters of the river Fowey, it was calculated that the quantity of water in the month of April 1825, averaged at the lowest, for every acre, about 160 cubic feet per day; and more than double that quantity when the river was swollen with heavy rains. In June 1826, which was a dry time, the quantity was reduced to about 75 cubic feet per day for each acre."

Through the kindness of John Taylor, Esq. F.R.S., and of Captain Absalom Francis, I am favoured with engine reports from the mines of the register of a rain-gauge kept at Coeddu, in Flintshire; and as they obligingly permit me to use them, I will endeavour to apply them in the same manner I have followed for the mines here ||.

As my information of the Flintshire mining-field is derived only through correspondence, these investigations are not so satisfactory to me as my former ones, in which all the materials were under my own eyes. But as I believe they will in the present state tell us more than we had before known, in the absence of what we could *wish*, we must use what we can obtain.

Captain Francis informs me, that "after the mines have reached a certain depth, the quantity of water depends much more on horizontal, than on vertical extension. The increase of water in the mines in the limestone is felt generally within a few hours after it begins to rain, notwithstanding the great quantity which is intercepted by *adits*. It is by no means unusual by the explosion of a single charge of gunpowder, to admit a stream of water sufficient to keep an 18 or 20-inch pump at work. Some of the veins are worked from the limestone into the slates; but this is not general. The cross veins are often from 50 to 100 fathoms in breadth, and the strata of limestone are much deranged by them, and by beds of shale."

---

* Wells 1 to 8, 12, 13 and 16, are within a circuit of two miles, and all those in granite within three miles of one another: 1 and 2 are within 100 yards of each other, as are also 6 and 7, and 10 and 11. For the observations on 4, I am indebted to the kindness of Mr. Wm. Opie; for 5, to R. Thomas, Esq.; for 9 and 10, to R.W. Fox, Esq.; for 14, to Mr. Richard Grigg; for 15 and 18, to the Rev. H. T. Coulson; and for 17, to L. H. Potts, Esq. M.D.; all the others were made by myself.

† From Mr. Giddy's Meteorological Observations in Phil. Mag.

‡ These numbers represent the depth of the water.

§ "History of Falmouth by R. Thomas," 8vo. Trathan, Falmouth, page 50.

|| Phil. Mag. and Annals, vol. ix. p. 170, and Lond. and Edin. Phil. Mag. vol. i. p. 287.

The following columns denote the depths†, and cubic feet of water drawn out in the respective times.

| | Mold. | | Milwr. | | Talargoch. | | Gwerny Mynydd. | | Bagillt Colliery. | | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth. | Water. | Depth. | Water. | Depth. | Water. | Depth. | Water. | Depth. | Water. | |
| 1829. | *Fms.* | *Cubic Feet.* | *Fms.* | *Cubic Ft.* | *Fms.* | *Cubic Ft.* | *Fms.* | *Cubic Ft.* | *Fms.* | *Cubic Ft.* | *In.* |
| Jan.... | 80 | 21,749,887 | 55 | 3,366,532 | 39 | * | 76 | 1,525,375 | ... | * | 1·3 |
| Feb.... | ... | 19,798,192 | ... | 2,519,166 | ... | 2,113,019 | .. | 1,301,784 | ... | * | 2·0 |
| March | ... | 21,395.095 | ... | 2,724,169 | ... | 2,536,509 | ... | 1,543,255 | ... | * | 0·33 |
| April... | ... | 22,076,786 | ... | 2,325,724 | ... | 3,909,310 | ... | 1,428,384 | ... | * | 4·03 |
| May .... | ... | 20,608,994 | ... | 2,527.631 | ... | 3,849,727 | 93 | 1,560,733 | ... | * | 0·93 |
| June.... | ... | 17,446,119 | ... | 1,893,596 | ... | 3,983,383 | ... | 1,305,851 | ... | * | 2·03 |
| July .... | ... | 18,381,345 | ... | 1,601,635 | ... | 4,091,257 | 100 | 2,751,908 | ... | * | 6·7 |
| August. | ... | 24,002,084 | ... | 2,446,515 | ... | 3,583,322 | ... | 2,336,062 | ... | * | 6·8 |
| Sept..... | ... | 24,101,999 | ... | 3,891,200 | ... | 2,773,207 | ... | 2,363,545 | ... | * | 4·7 |
| Oct...... | ... | 21,467,258 | ... | 3.745,977 | ... | 3,020,861 | ... | * | ... | * | 4·36 |
| Nov. ... | ... | 20,802,603 | ... | 3,834,975 | ... | 3,182,819 | ... | * | ... | * | 2·46 |
| Dec..... | ... | 20,271,602 | ... | 3,388,366 | ... | 3,512,845 | ... | * | ... | * | 0·53 |
| 1830. | | | | | | | | | | | |
| Jan. ... | ... | 20,753,669 | 71 | 2,705,597 | ... | 3,195,765 | ... | * | 61 | 3,287,507 | 0·33 |
| Feb. ... | ... | 18,845,958 | 79 | 4,167.659 | ... | 2,870,343 | 113 | 1,639,659 | ... | 2,726,052 | 0·93 |
| March | ... | 21,233.728 | ... | 4.681,646 | 46 | 3,286,753 | ... | 1,848,833 | ... | 2,852,149 | 0·43 |
| April ‡ | 65 | 2,197,488 | ... | 3,783,171 | 50 | 3,268,536 | ... | 1,731,038 | ... | 3,060,552 | 3·33 |
| May ... | ... | 2,241,113 | ... | 4,095,003 | ... | * | ... | 1,791,575 | ... | 3,093,396 | 4·36 |
| June ... | ... | 4,794.489 | ... | 5.573,424 | ... | * | 110 | 2,203,617 | ... | 3,257,127 | 8,53 |
| July ... | ... | 3,673,762 | ... | 6,317,095 | ... | * | ... | 2,595,005 | ... | * | 4·53 |
| August | ... | 2,172,267 | ... | 5,076,237 | ... | 3,466,367 | ... | 2,113,579 | ... | 2,801,405 | 3·16 |
| Sept. ... | ... | 2,762,864 | ... | 5,038,029 | ... | 3,193,272 | ... | 2,059,603 | ... | 2,694,146 | 4·16 |
| Oct. ... | ... | * | ... | * | ... | 5,699,507 | ... | * | ... | 3,002,129 | 2·4 |
| Nov. ... | ... | * | ... | * | ... | 3,064,251 | ... | * | ... | 2,955,960 | 5·5 |
| Dec. ... | ... | 4,111,231 | ... | 6,407,339 | ... | * | ... | * | ... | 3,054,492 | 2·56 |
| 1831. | | | | | | | | | | | |
| Jan...... | ... | 4,288,958 | ... | 6,052,003 | ... | * | ... | * | ... | 3,150,490 | 3·0 |
| Feb...... | ... | * | ... | 5,939,962 | ... | * | ... | * | . | 3,093,904 | 2·56 |
| March... | ... | * | ... | 6,638,590 | ... | * | ... | 3,736,925 | ... | 3,285,760 | 3·1 |
| April... | ... | 2,606,214 | ... | 5,987,777 | ... | * | ... | 3,755,579 | ... | 2,774,379 | 1·2 |
| May..... | ... | 2,367,829 | ... | 4,929,590 | ... | * | ... | 3,446,307 | ... | 2,888,676 | 0·66 |
| June ... | ... | 2,117,133 | ... | 3,788,074 | ... | 4,767,330 | ... | * | ... | 2,626,581 | 2·5 |
| July..... | ... | 2,271,356 | ... | 3.333,396 | ... | 6,552,767 | ... | 2,145,869 | ... | 2,618,136 | 3·73 |
| August | ... | 1,928,379 | ... | 2,639,643 | ... | 5,519,523 | ... | 1,585,184 | ... | 2,290,869 | 2·13 |
| Sept. ... | ... | 2,443,804 | ... | 2,254,286 | ... | 4,864,096 | ... | 1,400,530 | ... | 2,592,799 | 2·56 |
| Oct...... | ... | 2,809,908 | ... | 2,566,320 | ... | 4,539,608 | ... | 1,438,407 | ... | 2,382,503 | 2·5 |
| Nov..... | ... | 4,170,760 | ... | 3,078,492 | ... | 2,980,387 | ... | 1,869,267 | ... | 2,170,519 | 4·56 |
| Dec..... | ... | 3,545,611 | ... | 3,948,184 | ... | 3,066,401 | ... | 2,107,707 | ... | 2,461,047 | 2·8 |
| 1832. | | | | | | | | | | | |
| Jan...... | ... | 3,062,124 | ... | 3,463,122 | ... | 3,266,384 | ... | 1,679,121 | ... | 2,461,047 | 1·3 |
| Feb...... | ... | 2,796,307 | ... | 2,638,188 | ... | 3,916,221 | ... | 1,373,068 | ... | 2,192,055 | 1·33 |
| March.. | ... | 3,126,457 | ... | 2,566,320 | ... | 4,666,263 | ... | 1,370,890 | ... | 2,347,595 | 2·53 |
| April... | ... | 2,475.330 | ... | 3,607,990 | ... | 4,264,148 | ... | 1,764,156 | ... | 2,111,400 | 1·66 |
| May .. | ... | 2,298,726 | ... | 3,557,988 | ... | 4,472,947 | ... | 2,137,063 | ... | 2,395,594 | 2·03 |
| June ... | ... | 2,384,232 | ... | 4,057,624 | ... | 4,754,428 | ... | 2,201,644 | ... | 1,993,161 | 3·4 |
| July ... | ... | 2,138,405 | ... | 2,699,481 | ... | 5,166,220 | ... | 1,817,090 | ... | 2,103,235 | 1·23 |
| August. | ... | 2,576,020 | ... | 2,693,332 | ... | 5,466,194 | ... | 2,054,868 | ... | 2,068,327 | 8·76 |

† On the accuracy of the columns of average depths I feel less certainty than on the others.

‡ Before this month six steam-engines were worked; after, two only.

* No observations recorded.

Captain Francis also observes that the elevation of the various mines above the sea is: Mold mines,

| | | |
|---|---|---|
| South Mold | 115 | fathoms. |
| Pant y buarth | 105 | — |
| Milwr | 80 | — |
| Talargoch | 25 | — |
| Gwerny Mynydd | 125 | — |
| Bagillt (coal measures) | 2 | — |

The following Table is a ratio of comparison between the months of maxima and minima of the intensity of the springs, and of the quantity of rain. But I think much more extended observations requisite in order to put the subject beyond doubt.

| | Mold.* | | Milwr. | Talar-goch. | Gwerny Mynydd. | Bagillt Colliery. | *Rain.* |
|---|---|---|---|---|---|---|---|
| | 1. Series. | 2. Series. | | | | | |
| Jan. ... | 1·21 | 1·65 | 1·23 | 1·08 | 1·11 | 1·25 | 1· |
| Feb. ... | 1·10 | 1·25 | 1·2 | 1· | 1· | 1·13 | 1·15 |
| March.. | 1·22 | 1·4 | 1·31 | 1·17 | 1·47 | 1·19 | 1·07 |
| April ... | 1·26 | 1·09 | 1·24 | 1·28 | 1·5 | 1·12 | 1·72 |
| May ... | 1·18 | 1·03 | 1·19 | 1·4 | 1·55 | 1·18 | 1·34 |
| June ... | 1· | 1·39 | 1·21 | 1·51 | 1·3 | 1·11 | 2·77 |
| July ... | 1·05 | 1·21 | 1·1 | 1·77 | 1·65 | 1· | 2·73 |
| August | 1·38 | 1· | 1·01 | 1·51+ | 1·39 | 1·01 | 3·52 |
| Sept. ... | 1·38+ | 1·17 | 1·18 | 1·21 | 1·34 | 1·11 | 2·57 |
| Oct. ... | 1·23 | 1·26 | 1· | 1·48 | 1·0 + | 1·13 | 2·08 |
| Nov. ... | 1·19 | 1·88 | 1·09 | 1·03 | 1·29 | 1·08 | 2·81 |
| Dec. ... | 1·16 | 1·72 | 1·45 | 1·1 | 1·46 | 1·16 | 1·32 |

On another occasion, with your permission, I will endeavour to make a comparison between these results and those detailed in the papers already mentioned.

Since I last had the honour of addressing you on the same subject, I find that I was wrong in assuming that it had engaged the attention of Mr. Bland and myself only; for I find that measurements precisely similar to that gentleman's† and those of mine, were made in New South Wales by Sir Thomas M. Brisbane, and that they have been published by him‡; and although their *object* does not appear to have been exactly the same as ours, yet they lead towards the same end.

Permit me to express my most grateful thanks for your great kindness to me on every occasion: and I have the honour to remain, Sir, yours, &c.

W. J. HENWOOD.

Apartments of the Geological Society,
Penzance, July 20, 1833.

---

* I interpolate, when there is an observation wanting.

† Phil. Mag. and Annals, N.S. vol. xi. p. 88.

‡ Brewster's Journal, vol. vi. p. 226.

## LXVII. *On a brilliant Arch of an Aurora Borealis seen on the Evening of March* 21, 1833. *By* R. POTTER, *Jun. Esq.*[*]

ON this evening the sky was cloudy in the neighbourhood of Manchester: it was nevertheless noticed by Mr. John Blackwall, of Crumpsall Hall, by Mr. Hatfield, of Cornbrook, and by myself, that there was a considerable light in the N.N.W.; no one in the neighbourhood, however, was able to obtain a useful observation.

This display was, however, seen in many other places situated at considerable distances from each other, and the same general description is given of it. Professor James D. Forbes kindly sent me an account of his observation immediately after it occurred; and I am since also indebted to him for extracts from the "Proceedings" of the Royal Society, giving particulars of the observation of the Earl of Darnley, made at Athboy, in Ireland. Having made a calculation of the height from these observations, I drew up a short essay on the subject, which was the first read in the Physical Section at the late Meeting of the British Association at Cambridge[†]. Dr. Robinson of Armagh, after the reading, mentioned his having made an observation about the end of March, which, although he had not then the date, might prove to be the same display, and he politely offered me a copy of his notes.

The following are extracts from the observations above mentioned. Prof. Forbes, under the date of Edinburgh, 24th of March 1833, writes: "Going out into the open air on the evening of the 21st, at exactly 45 minutes past 8 M. T., I observed a splendid luminous arch extending tolerably nearly east and west, and considerably to the south of the zenith. It perfectly resembled all the various displays of the phænomenon which I have before seen, in its general character. But in brilliancy it was probably exceeded by none; not even, I think, by that of the 19th of March 1825. As I was on my way to witness some light-house experiments, I was unable to make any precise observations; I obtained, however, such data as will make the observation available for the determination of height. At $8^h\ 45^m$ the highest point of the arch passed through the constellation of Leo, then about an hour from the meridian. It also passed through $\alpha$ Orionis, and, I think, near Arcturus." "At its culminating point it occupied, as nearly as I recollect, the space between $\gamma$ and $\zeta$ Leonis; its breadth, therefore, was about 4°, but less towards the extremities, where, *as usual*, it was most luminous. Its greatest

---

[*] Communicated by the Author.

[†] See present vol. p. 152.—EDIT.

altitude, therefore, at 45$^m$ past 8 o'clock, was from 52° to 56° (its upper and lower edges). It faded *with great rapidity* after I first observed it; but I readily detected its southward motion, as I have done on similar occasions." "At 8$^h$ 55$^m$ it passed through $\alpha$ Leonis." "After this it was very imperfectly visible. There was a bright auroral light in the north, with occasional corruscations. I shall be very anxious to hear if you have observed this beautiful phænomenon."

Of the Earl of Darnley's observation Professor Forbes gives me the following particulars. "Seen at Athboy, Ireland, latitude 53° 47′ N., longitude 6° 54′ W." Observed about 9 P.M.: "reached from the eastern to the western horizon which it entered to the north of the constellation of Orion, passing about midway between the Great Bear and Arcturus, and *directly over the two principal stars of Gemini*:" most brilliant at the east, where 1° wide; but increased to 5° to 6° at west. "During the twenty minutes that Lord Darnley observed the phænomenon it *seemed to proceed through its whole extent from N. to S.*, its edges, when first observed, extending equally on either side of Castor and Pollux, having in that time entirely left the most northern of those stars." At 10 it had disappeared. An account of a similar phænomenon, it is stated, was *given in a Carlisle paper.* I hope you will be able to find this out." His Lordship, it appears, also notices the aurora having been seen at Castlereah, about 60 miles distant from Athboy.

The following are extracts from Dr. Robinson's letter to me, dated Armagh Observatory, July 26, 1833. "The observation I made of the aurora on March 21st last, was this: At 8$^h$ 44$^m$ 10$^s$, Armagh time (or 9$^h$ 10$^m$ 45$^s$ Greenwich), the luminous arch was bisected by Arcturus and by $\gamma$ Leonis; at the same time its upper edge was on $\alpha$ Orionis, and its lower on $\delta$ Orionis. *As to sense*, its highest point seemed on the magnetic meridian (which I found, in January 1829, to deviate 29° 7′ west)." At exactly 5 minutes later he made another observation of the arch's place, from which we learn that its upper edge was then on $\delta$ Orionis, and its lower on $\zeta$ Orionis, which indicates a considerable southward motion, the upper edge at the same time being on $\gamma$ Leonis, and the lower on $\eta$ Leonis. Dr. Robinson did not observe the aurora longer, being at the time very much indisposed.

The above observations must be allowed to demonstrate, if there were need of any further demonstration, a most important point in the theory of the aurora borealis; namely, that the symmetrical arches are rings, or portions of rings, in planes perpendicular to the magnetic axis. If we take in round numbers 73° N. latitude and 100° W. longitude as the position of the magnetic pole, which, from the observations made during Captain Parry's voyage, is probably not widely wrong, we find the magnetic polar distance, or magnetic co-latitude, of Edinburgh to be 39° 23′, that of Armagh 39° 55′, and that of Athboy 40° 21′. Now at all places situated on the same parallel of magnetic latitude, it is clear that an arch following the direction just mentioned would appear at the same altitude at its highest point, which enables us to reduce observations anywhere taken to a common magnetic meridian; and Armagh being only 32′ of a degree more magnetically southerly than Edinburgh, the arch ought to have been seen at the former place with a little greater altitude from the S.S.E. horizon than at the latter, which we find to have been the case, as the following shows:—

At Armagh, and $9^{h}\ 10^{m}\ 45^{s}$ Greenwich time, the arch was bisected by $\gamma$ Leonis, then not far from the magnetic meridian.

At Edinburgh, and $9^{h}\ 7^{m}\ 41^{s}$ Greenwich time, the arch passed over $\alpha$ Leonis, and allowing still for the southward motion of the arch during the remaining $3^{m}\ 4^{s}$ difference of time, we see that the arch had a considerably less apparent altitude at Edinburgh than at Armagh.

Though under so many disadvantageous circumstances,—of a base line of only 32 geographical miles when the places were so far distant, the quick motion of the arch, and the want of simultaneousness in the times of observing,—yet the notes taken by these accurate observers enable us to make a computation for the height of the meteor which agrees remarkably closely with former determinations, and is quite within the limits furnished by observations taken under much more favourable circumstances.

The difference of magnetic polar distance of the two places of observation is 32 geographical, or 36·84 English miles nearly; and the apparent altitude at Edinburgh for the middle of the arch, about 43° 39′; and at Armagh 52° 25′ at $9^{h}\ 10^{m}\ 45^{s}$ Greenwich time. These altitudes require still to be corrected for the inclination of the horizons of the two places, which requires 16′ to be added to the former, and subtracted from the latter of these angles. From these data we find the arch to have been 178·43 English miles from Armagh, and 142·84 miles above the surface of the earth.

The calculation which I first made by using Lord Darnley's observation, must not, I find, be insisted upon, on account that the time of it is not sufficiently indicated in the abstract in the "Proceedings" of the Royal Society to enable us to judge how nearly it might be taken as contemporaneous with that of Professor Forbes. This, it will be seen, is necessary to be attended to, for the observations at Armagh and Edinburgh agree in giving the southward motion as very nearly at the rate of 2° in 5 minutes. The calculation referred to gave 195·77 English miles for the height at $8^h\ 57^m\ 41^s$ Greenwich time. This difference of the height, in $13^m\ 4^s$ difference of time, is not otherwise than I should have expected, as I believe I have good grounds for the opinion that it will eventually be found that the arches *generally* descend nearer to the earth as they move southward.

As the locality, within certain limits, in which the aurora takes place must now be considered, by impartial persons, *well* determined, as well as the direction both of the beams and the arches, I will now state some points to which observers should pay attention, in order to extend our knowledge still further, and enable us to deduce from the phænomena of the aurora, results which will assist us in the study of the important subject of the earth's magnetism. Amongst the most important points to which an observer can attend, is that of determining, with every accuracy the subject is capable of, the azimuth in which each end of an arch cuts the horizon, and as nearly as possible at the same time its altitude. When this shall have been determined, together with observations at other places sufficient to determine the height by common trigonometry, then we should have sufficient data for deducing the position of the magnetic axis of the earth, continued to the region in which auroral phænomena occur. We may naturally expect that those anomalies in the magnetic variation, &c., which occur at the earth's surface will disappear at those great altitudes, and especially if they arise from variation in the direction of thermo-electric currents.

When observations are made with respect to the *visible* horizon of any place, they should be corrected to the *real* horizon of that place by the observer, and also the effect of refraction should be allowed for. This latter, however, will, of course, be unnecessary when the azimuthal extent of arches, or their altitudes, are determined by a comparison with stars, both being then equally affected, and the places of such stars are easily found with accuracy.

The late splendid displays on September 17th and October 12th, have been observed over a great distance of country; but the aurora has frequently a more useful character for observations than these had, when even it has a much less imposing appearance.

I may here state, that in my former papers in the Edinburgh

Journal of Science there was an error in the printing, which might cause a good deal of trouble to any persons who wished to prove upon their own observations the formulæ I have deduced for calculating the heights, &c., of arches from their azimuthal extents and altitudes. In the one paper, for $p = 1 + cg$, and in the other $p = 1 e + g$, it should have been printed $p = 1 + eg$.

The reader will, I am sure, acquit me of being a party to tolerating any notion that the meteor seen in the N.N.W. part of the heavens, over a distance of country of 200 to 300 miles, can possibly be located in the region of the clouds, or that the epithet *borealis*, acknowledged to be appropriately applied to this aurora, can be with any propriety attached to any variety of aqueous clouds seen in our lower atmosphere.

---

## LXVIII. *On the Cause of the Direction of Continents and Islands, Peninsulas, Mountain Chains, Strata, Currents, Winds, Migrations and Civilization. By* ALEXANDER WALKER, *Esq.*[*]

I SHALL first endeavour to show that all of these have one general direction.

With regard to continents and islands, which, as indicating the course of lands generally, it is proper to consider in connexion, the general direction of America is, evidently and extensively, north and south, as regards both its continent and the groups of islands to the south of the Strait of Magalhaens. The Old World, if we take into view its continent alone, has its chief direction east and west; but when we add to the further peninsula of Asia, the Indian isles, Australia and New Zealand, and observe that that world is deeply indented by the Indian Ocean, the Persian Gulf, the Red Sea, &c.,—that, in fact, Asia is thus separated to half its depth from Europe and Africa,—it is impossible not to see, even in these two divisions of that world, a prevailing tendency to the same direction, north and south. The positions of the Black Sea and the Caspian, and of the White Sea and the Gulf of Obe, tend further to the same effect.

With regard to peninsulas, it is truly remarkable how universally they have this direction. Scandinavia, Spain, Italy, Greece, Africa itself, Arabia, India, Malaya, Corea, Kamtchatka, Alaska, California, South America itself, Florida, Nova Scotia, Greenland, run from north to south; and the pen-

---

[*] Communicated by the Author.

insulas on the Arctic Sea, generally from south to north. Thus nearly all of them run north and south.

With regard to mountain chains, the primary mountains also run generally north and south, and the secondary mountains accompany them in the same direction. In America we observe an alpine chain extending from the stony mountains to the Andes and continuing to Cape Horn*. This immense chain inclines westward, in its middle and northern part; and the opposite chains of Asia incline, on the contrary, eastward; but the tendency of these, like other great mountain chains, is evidently north and south. The Jablonnoy and Stanovoy mountains, joined by those east of the Lena, and forming the first of these chains, traverse the east of Asiatic Russia from north to south. The Ural mountains, forming the second of these chains, and running similarly north and south, separate Asiatic from European Russia. These may be regarded as continued eastward, as the Stanovoy are westward, toward the Altaï mountains, whence descend the chains which traverse Mongolia, Thibet and Hindoostan to the very extremity of India. In these, the great mountain chains of Asia, there is much irregularity; but if we regard the whole as thus stretching from the Arctic to the Indian Ocean, their direction is evidently north and south; and that which is true of the whole, is of course true of the greater number of parts, in which the long courses north and south of the Jablonnoy and of the Stanovoy mountains, of those east of the Lena, of the Ural mountains, of the Belor Tagh and of the Soliman mountains, and of the Ghauts, are very remarkable†. In the remainder of the Old World there are no mountain chains so vast as these; but in Europe the Finnish and Norwegian mountains, those of Illyria, the Apennines, the Cevennes and the Vosges, and the British mountains, all run north and south; and in Africa the littoral chain of the Red Sea, and the Lupata chain, stretching apparently from Cape Guardafui to the Cape of Good Hope, have a similar direction.

Such being the prevailing direction of mountain chains, corresponding with that of continents and islands, and of peninsulas, namely, north and south, it is evident that their sides, aspects or faces are as generally turned either eastward or westward.

As, however, while this is the case, the strata which com-

---

* The Allegany and Brazilian mountains have similar directions.

† The Syrian and Arabian mountains have similar directions.

pose them are generally more or less inclined, it is also evident, that one of these faces is as generally higher than the other, and its descent is consequently more abrupt.

From a comparison of this kind as to mountains having eastern and western aspects, it appears that generally a gradual elevation takes place on the eastern side, and is continued until the strata are suddenly broken off, and terminate in precipices or abrupt descents on the west.

Thus, the eastern part of Britain is generally flat; its mountains rise towards the west; and their most rugged sides are their western or north-western ones. The Alpes of Norway are inclined toward the east, and present precipices to the west or north-west. Libanus has a gentle inclination toward the Euphrates, and is precipitous toward the Mediterranean. The Ghauts slope toward the east, and form rugged mountains toward the west.

The preceding facts as to continents and islands, peninsulas, mountain chains, and strata, have nearly all been stated by various writers, but never, perhaps, brought into connexion; and I am not aware that any one has assigned a cause for such remarkable coincidences.

On viewing these facts in connexion, it appeared to me, that the earth's rotation accounted for the last of these phænomena—the inclination of strata, and that doing this, it accounted for the whole, because any means calculated thus to raise or project these strata, is calculated to form mountain chains, peninsulas and continents, as the slightest reflection will show.

It appeared to me that a globe, rotating with velocity, would tend perpetually to displace backward, or in a direction contrary to its motion, all the masses which are somewhat loose upon its surface; and that thus the earth, rotating from west to east, would have its looser masses projected westward, precisely as are strata and mountain chains.

The tendency of the centrifugal force of a rotating globe upon any loose but imbedded mass, is to throw it outward or upward from the centre: but, in so far as the motion by which it is actuated is expended in throwing it upward, that motion is lost from the mass's tendency to pass forward with the general matter of the globe; the mass will therefore remain relatively behind,—it will also retard that which is behind it,—its posterior part will be raised,—it will continue to rise so long as it receives from other retarded matter a solid support,—it will acquire a certain degree of obliquity,—and it will remain in that degree of obliquity, when the retrocession and various accidents of other masses refuse it further support.

If an oblong and curved vessel, loaded with a soft solid and having a hard solid partially imbedded in the middle of its surface, be attached to the rim of a wheel and made to rotate with velocity, the tendency above described of the imbedded mass is such as speedily to cause a concavity in the portion of the soft solid which is before it, and a convexity in the portion which is behind it,—a retrocession and obliquity of the whole mass,—as a very simple experiment will show.

Now that which is true of a small mass of matter is true of a greater; and thus the earth's rotation, being the cause of the retrocession and obliquity of its strata, is the cause of its mountain chains, peninsulas and continents.

The same is evidently the cause of the great equatorial or tropical current of the ocean, by which, especially between the tropics, and to 30 degrees of latitude north and south, its waters are perpetually carried from east to west, in a direction contrary to that of the rotation of the globe; and it is not less the cause of the boreal and austral polar currents, which join the preceding*.

The same also is evidently the cause of the winds which blow perpetually from the east in the torrid zone, with a movement quite distinct from that of the equatorial current; and it is not less the cause of the polar winds, which join these†.

It remains for me only to apply that which now appears to be a general law, to the migrations and the civilization of mankind—to show that these, which we call moral and political acts, are fundamentally physical ones.

As to migration, the savage who launches his canoe or spreads his sail, is naturally carried with the current and the wind; and, generally speaking, this would necessarily be in the direction already described. Hence, in the very earliest ages, no portion of the globe could long remain uncolonized.

---

* Malte-Brun has a partial glimpse of this doctrine, limited, however, to these currents; but even as to [them he misleads himself by a notion of a *force of inertia* retarding the polar currents in their progress to supply *equatorial evaporation*,—instead of seeing the peculiar manner in which the centrifugal force operates upon the whole mass of the waters, equatorial as well as polar, and that, instead of polar inertia causing equatorial retardation the whole relative retardation being caused by the globe's rotation, it must be greatest at the equator and least toward the poles—the very reverse of his supposition.

† Respecting these, Malte-Brun, following others, makes precisely the same error, as described in the preceding note on the waters.

If he commit himself not to the ocean, still he either voluntarily seeks, or is driven by new colonists or invaders to the higher lands of the west.

Hence all the traditions and histories of the ancient world are of colonies and knowledge from the east—from India to Egypt, from Egypt to Greece, from Greece to Italy—from the plains of the two former to the mountains of the two latter. Hence, in all ages, the plains of Scythia have sent forth their myriads of wild and strange aspect, and of a hundred languages, to seize upon the enfeebled kingdoms of the west. Hence the New World is now fast peopling from the Old. Hence in North America, the population is slowly crossing the Allegany mountains toward the Cordilleras of its Pacific shore. Hence in South America, Mexico and Peru and Chili are more densely peopled, while Guiana and Brazil and Paraguay are [comparatively] deserts.

Nor are these migrations to western and higher lands unreasoned. The climate of mountains is almost universally more salubrious than that of plains, and (which to selfish man is, perhaps, more important,) power has naturally, in all ages, been dependent on the possession of mountain chains. These are the real reasons of the hitherto mysterious fact, that "empire constantly verges to the quarter of the setting sun."

Of this tendency an able writer says: "America certainly offers very singular facts towards the support of this *mystical doctrine*, in which, though we have no *faith*, yet there is considerable pleasure in tracing the analogy of events." Faith may be essential in religion; it is worthless in philosophy; and I trust I have rendered its exercise no longer necessary upon this subject.

As to civilization, mountaineers have more universally a manly, brave and noble character than the inhabitants of plains, who are generally more phlegmatic and indolent. And the cause of this is not obscure. It is Humboldt, if I mistake not, who observes that "those who attend to their feelings, when ascending mountains, acknowledge that they experience in elevated situations, a buoyancy of spirits, and an alertness of mind, far exceeding that which they usually possess in the plains." But this, though true, is not enough. Such regions present great variety of temperature, and cold rather predominates than heat. This excites man to all those resources and all those arts, excellence in which constitutes civilization.

In addition to these wide but rapid views, I have only to observe that the precise line which, so far as our brief annals tell, civilization has traced, is worthy of notice. Its course from India to Egypt, from Egypt to Greece, which sent it for a moment backward in the same course, from Greece to Italy, whither it was twice sent from the same quarter, and from Italy to both sides of the Rhine and to Britain,—is in that westerly or north-westerly direction which conforms to, and so far confirms the dependence of all these phænomena on, one general law—the cause I have assigned.

ALEXANDER WALKER.

---

## LXIX. *On the Theory of Resistances in Statics. By the Rev.* H. MOSELEY, *B.A., Professor of Natural Philosophy in King's College, London**.

IN a paper inserted in the Philosophical Magazine for October, I have given a demonstration of the following theorem: *If there be a system of forces in equilibrium among which there enter the resistances of any number of fixed points, then are these resistances such that their sum is a* MINIMUM; *each being considered a function of the coordinates of its point of application, taken with a positive sign, and subjected to the conditions imposed by the equilibrium of the whole.* I have also pointed out the steps by which this principle may be applied to the actual determination of the amount and direction of the *resistance* upon each point of the system in terms of the other forces which compose it.

It is my object at present to give the actual solution of that *particular* but very important case, of the more general proposition, in which the forces and resistances of the system are all parallel to one another. The solution of this case is entirely free from that elaboration of analysis which besets the more general proposition.

Let the plane of $xy$ be taken perpendicular to the given parallel directions of the forces of the system.

Let the *resistances* of the system be $P_1$, $P_2$, $P_3$, &c., and let the coordinates of the points where these directions intersect the plane of $xy$, be $x_1 y_1$, $x_2 y_2$, $x_3 y_3$, &c. Also let the sum of those forces of the system which are not resistances be M, and the sums of their moments about the axes of $y$ and $x$ respectively $N_1$ and $N_2$.

By the known conditions of equilibrium, therefore, we have

$$\left.\begin{aligned} \Sigma P + M &= 0 \\ \Sigma P x + N_1 &= 0 \\ \Sigma P y + N_2 &= 0 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

---

* Communicated by the Author.

Also, by *the principle of least pressure,*

$$\Sigma \mathrm{P} = \text{minimum}$$

$$\left.\begin{aligned} \therefore\ \Sigma\left\{\frac{d\mathrm{P}}{dx}\delta x + \frac{d\mathrm{P}}{dy}\delta y\right\} &= 0 \\ \Sigma\left\{x\frac{d\mathrm{P}}{dx}\delta x + x\frac{d\mathrm{P}}{dy}\delta y + \mathrm{P}\delta x\right\} &= 0 \\ \Sigma\left\{y\frac{d\mathrm{P}}{dx}\delta x + y\frac{d\mathrm{P}}{dy}\delta y + \mathrm{P}\delta y\right\} &= 0 \end{aligned}\right\}\cdots (2)$$

The first of these equations is satisfied by the condition $\Sigma\mathrm{P}$ = a minimum. Multiplying the two last equations by the indeterminate quantities A and B respectively, and adding them to $\delta\Sigma\mathrm{P}$, we obtain

$$\delta\Sigma\mathrm{P} = \Sigma\left\{\begin{aligned} &\left\{\frac{d\mathrm{P}}{dx}(1+\mathrm{A}x+\mathrm{B}y) + \mathrm{AP}\right\}\delta x \\ &\left\{\frac{d\mathrm{P}}{dy}(1+\mathrm{A}x+\mathrm{B}y) + \mathrm{BP}\right\}\delta y \end{aligned}\right.$$

Let the indeterminate quantities A and B be taken, subject to the condition that for *any* given values of $x_1 y_1$, $x_2 y_2$, $x_3 y_3$, &c., the values of $\mathrm{P}_1$, $\mathrm{P}_2$, &c., shall be such as will satisfy the equations (1).

$x_1 y_1$, $x_2 y_2$, &c., may then be considered *independent* variables, and $\Sigma\mathrm{P}$ a minimum function of these variables. Hence, therefore,

$$\frac{\delta\Sigma\mathrm{P}}{\delta x} = \frac{d\mathrm{P}}{dx}(1+\mathrm{A}x+\mathrm{B}y)+\mathrm{AP} = 0$$

$$\frac{\delta\Sigma\mathrm{P}}{\delta y} = \frac{d\mathrm{P}}{dy}(1+\mathrm{A}x+\mathrm{B}y)+\mathrm{BP} = 0$$

Adding the above equations, having multiplied the first by $dx$, and the second by $dy$, we obtain

$$\left(\frac{d\mathrm{P}}{dx}dx + \frac{d\mathrm{P}}{dy}dy\right)(1+\mathrm{A}x+\mathrm{B}y) + \mathrm{P}(\mathrm{A}\,dx+\mathrm{B}dy) = 0$$

$$\therefore\ d\{\mathrm{P}(1+\mathrm{A}x+\mathrm{B}y)\} = 0$$

$$\therefore\ \mathrm{P} = \frac{\mathrm{C}}{1+\mathrm{A}x+\mathrm{B}y}$$

Let there be taken a line at a perpendicular distance from the origin, equal to $\frac{1}{\sqrt{\mathrm{A}^2+\mathrm{B}^2}}$; also let it be inclined to the axis of $x$ at an angle $\alpha$, such that

$$\tan\alpha = \frac{A}{B}$$

$$\text{whence} \qquad \cos\alpha = \frac{B}{\sqrt{A^2+B^2}}$$

$$\sin\alpha = \frac{A}{\sqrt{A^2+B^2}}$$

Let the perpendicular upon this line from the point $x\,y$ be represented by $L$.

$$\therefore \quad L = \frac{1}{\sqrt{A^2+B^2}} + x\sin\alpha + y\cos\alpha$$

$$\therefore \quad (L)\sqrt{A^2+B^2} = 1 + Ax + By$$

$$\text{and} \qquad P = \frac{\left(\frac{C}{\sqrt{A^2+B^2}}\right)}{L}$$

From the above it appears that the resistance varies inversely as a perpendicular from the point in which its direction meets the plane of $x\,y$, upon a certain line or axis in that plane; and therefore, that the *moments* of all the *resistances* of the system about that axis are the same. Where the resistances are all in the same right line, this axis resolves itself into a point.

It is clear that whatever be the magnitudes of the other forces which compose the system, the resistances which enter into it will all be parallel to their resultant; provided only that *each* resisting point be capable of supplying a resistance parallel to that direction. This follows from the consideration that the *sum* of the resistances is a minimum; for it is clear that their sum will be the *least possible* when, by reason of their parallelism, they do not tend to counteract one another.

The values of A, B and C are determined by the following equations, which result from substituting the values of $P_1$, $P_2$, &c., in equations (1).

$$\Sigma\left\{\frac{C}{1+Ax+By}\right\} + M = 0$$

$$\Sigma\left\{\frac{Cx}{1+Ax+By}\right\} + N_1 = 0$$

$$\Sigma\left\{\frac{Cy}{1+Ax+By}\right\} + N_2 = 0$$

In a paper inserted in the Memoirs of the Academy of St. Petersburgh—Novi Commentarii, tom. xviii.—entitled, " *De Pressione Ponderis in Planum cui incumbit,*" Euler has investigated the conditions of the equilibrium of a heavy mass supported upon a given number of points in the same horizontal plane, and upon continuous and edged bases of given geometrical forms and dimensions. As the foundation of this investigation, he has assumed the principle, that if the surface on which the body rested were elastic, each point of support would sink to a depth proportionate to the pressure it sustains. Taking, then, the actual surface on which the mass rests for the plane of $x\,y$, and assuming

$$z = \alpha x + \beta y + \gamma$$

to be the equation to the plane in which the points of support would be found on the hypothesis of an elastic surface, $z$ is proportional to the pressure upon that point of support whose coordinates are $x\,y$. And, this admitted, the constants $\alpha, \beta, \gamma$, may be determined by the known conditions of equilibrium.

To this hypothesis, which is grounded on no experimental fact or analogy, there is an objection, apparent on the very face of it. It is this: "The forces by which the body is supported when it has at length attained its position of equilibrium on the *elastic* surface, *are not the same* with those by which it is sustained on the perfectly *hard* surface. Euler has foreseen this objection.

He thus speaks of it: " Neminem autem pannus ille pressioni cedens offendat, etsi enim illi mollitiem quandam tribuimus, eam tamen quousque libuerit diminuere licebit; ita ut tandem indolem soli illius, cui pondus revera insistit adipiscatur."

Now although it be admitted that the *actual* displacements produced by the sinking of the points of support, may be diminished to any required extent by increasing the tension of the surface, yet it is no less certain that the *relative* displacements of these points cannot be affected by that process. So that whatever error the supposition of a *perfectly yielding* surface would introduce into the *relation* of the supporting forces, the same error remains in that deduced on the hypothesis of an elastic surface of extreme tension.

There is one case of the general proposition which is in this paper solved by Euler, upon known and very elementary principles. It is that of a mass supported upon *three* points in the same plane, but not in the same right line. He has shown that if the point of intersection of the vertical through the centre of gravity with the plane of support, be joined with the points of support, thus dividing the triangle formed by joining those points into three others, which have its sides for their respective bases; then the pressure upon any one point of support is to the whole pressure as the triangle upon the side opposite to that point is to the whole triangle.

Prony, in his work entitled "Leçons de Mécanique Analytique," has applied this theorem to the determination of the pressures upon the three points of support when one of them passes into the straight line joining the other two, the triangle formed by joining them containing always the intersection spoken of above, and eventually resolving itself into a straight line. He has remarked, that under these circumstances the relations of the several pressures to the whole pressure will be expressed by fractions of the form $\frac{O}{O}$. To determine its value he has supposed the vertical through the centre of gravity of the mass first of all to intersect one of the sides of the triangle formed by the lines joining the points of support: the pressure upon the opposite point of support thus vanishing, he has supposed that point to pass into the line joining the other two points; and he has thence concluded that the pressure upon this third point, when under any circumstances occupying a position in the line joining the other two, is *evanescent.*

It is remarkable that he should not have perceived this case to come under *the first*, at the instant when the third point comes within an *insensibly small distance* of the line joining the other two points.

There is a case in which the value of this fraction $\frac{O}{O}$ may be easily determined; and it is valuable as completely overthrowing the strange position, that of a number of points of support, *situated precisely alike* with regard to a given pressure, it is possible that a certain number should sustain no portion of that pressure,—a position which is principally built upon this case of a mass supported upon three points in the same right line, and which, notwithstanding the abundance of absurd conclusions that may readily be shown to flow from it, has yet, under the sanction of respectable names, in some sort fixed itself as a principle in statics.

Let the vertical through the centre of gravity of the mass pass through the centre of gravity of the triangle formed by joining the points of support. The pressures upon these points will then all manifestly be equal, since the smaller triangles, shown by the theorem of Euler to be proportional to them, are equal. Now, this condition continuing to be satisfied, let us suppose the third point of support to move into the same line with the other two. The fractions $\frac{O}{O}$ expressing the evanescent ratio of each elementary triangle to the whole triangle, will then manifestly have the value $\frac{1}{3}$. And three points of support in the same straight line will each of them sustain the same pressure.

Prony has cited the case of a mass supported upon four points, of which he asserts one to be superfluous, the whole pressure being borne by three. Speaking of the same case, Euler has the following observation: "Verum si pondus quatuor pedibus plano insistat determinatio singularum pressionum, non solum multo magis ardua deprehenditur, sed etiam prorsus incerta et lubrica videtur; *statim enim ac illi pedes non exactissime inter se fuerint æquales, ita ut omnes plano pariter innitantur manifestum est totum pondus a ternis tantum pedibus sustentari*," &c. Thus it is manifest that Euler admitted the necessity of each point of resistance sustaining a certain definite portion of the whole pressure, *provided all were similarly situated in reference to the plane of support*. For he asserts the possibility of three out of the four points supporting the whole mass, only as contingent upon an inequality in the positions of those points in relation to the plane of support.

King's College, Oct. 14, 1833.

## LXX. *Characters of some undescribed Genera and Species of* Araneidæ. *By* JOHN BLACKWALL, *Esq. F.L.S. &c.*[*]

*Tribe*, TUBITELÆ, } Latreille.
Genus, *Clubiona*, }

### *Clubiona saxatilis.*

THIS species has the cephalothorax large, glossy, convex above, depressed and broadly truncated before; the sides, which are somewhat depressed, are marked with slight furrows, extending from the superior part to the lateral margins, and a narrow, elongated indentation occurs in the medial line of the posterior region. Eyes disposed in two transverse, parallel rows on the anterior part of the cephalothorax; the intermediate ones of the anterior row, which is the shorter of the two and situated immediately above the frontal margin, are the smallest of all, and the lateral eyes of each row are seated on tubercles united at their bases. Mandibles very powerful, vertical, triangular, exceedingly prominent at the base, provided with two rows of teeth and a dense fringe of hair on the inner side. Maxillæ robust, curved towards the lip, enlarged at the base where the palpi are inserted, and at the extremities, which are obliquely truncated on the inner side and fringed with hair. Lip longer than broad, truncated at the apex. Pectus heart-shaped, inclining to oval, glossy. Legs and palpi strong,

---

[*] Communicated by the Author.

hairy, provided with spines; the latter terminated by a pectinated claw. Last pair of legs the longest, then the first, the third pair being the shortest. The two superior tarsal claws are deeply pectinated, and the inferior one is short and inflected at its base. These parts are of a dark reddish brown colour, the legs, palpi, and nails of the mandibles being the reddest; the anterior part of the cephalothorax, the mandibles, maxillæ, and lip, which are the darkest, approaching to black. Abdomen oval and hairy, broader at its posterior than at its anterior extremity, which projects a little over the base of the cephalothorax; its colour is yellowish brown with numerous black spots above, and a black band, broad at the anterior part but gradually becoming narrower as it approaches the spinners, extending along the medial line; on each side of this band is a series of short, oblique, yellowish brown lines, which, in some individuals, unite in the posterior region of the abdomen, forming angles whose vertices are directed forwards; a few minute, blackish spots occur on the under side of the abdomen. The plates of the spiracles are of a pale yellow colour. The superior spinning mammulæ, which are longer than the rest, rather prominent, and triarticulate, have the spinning tubes disposed on the under side of the terminal joint.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{11}{20}$ths of an inch; length of the cephalothorax $\frac{1}{4}$; breadth $\frac{3}{20}$; breadth of the abdomen $\frac{1}{5}$; length of a posterior leg $\frac{3}{5}$; length of a leg of the third pair $\frac{1}{2}$.

The male is similar to the female in colour, and in the relative length of its legs, but it is smaller, and appears to be much scarcer than that sex. The third and fourth joints of the palpi are short; the former has a large, pointed apophysis on the outer side, and the latter is provided with two apophyses, one on the outer side, which is acute, and the other in front, which is obtuse and short; the fifth joint is in the form of an elongated oval pointed at the extremity; it is convex and very hairy above, concave beneath, comprising the sexual organs, which are complicated in structure, with a strong, curved spine on the inner side, and are of a red-brown colour.

I first observed this fine spider, which does not appear to belong to any of the sections into which M. Walckenaër has distributed the genus *Clubiona* in the *Faune Française*, in the spring of 1826, on Snowdon, in Caernarvonshire, under loose fragments of rock; and I have since met with it in various parts of North Wales, and in Lancashire, under stones and in the crevices of walls. It spins a compact web of small dimensions, from which a tube extends to its retreat, and it preys chiefly on *Coleoptera*. In the months of April and May it pairs, and the female deposits about a hundred and twenty spherical eggs of a yellowish white colour, (which are not agglutinated together), in a lenticular cocoon composed of white silk, of a fine, compact texture, whose greatest diameter measures half an inch; it is usually attached to the under side of stones and fragments of rock, by a small covering of web, on the exterior surface of which are frequently distributed small bits of earth and other extraneous materials.

### *Clubiona parvula.*

Anterior part of the cephalothorax very convex above, depressed and somewhat rounded in front; sides and posterior region depressed, the former having several furrows diverging from the superior part to the margins, and the latter an indentation in the medial line; colour very dark brown, five lines of white hairs, which unite at their extremities, occurring on the anterior convexity; the space below the eyes, and the base of the mandibles, are also supplied with white hairs. The four intermediate eyes form a square, the other four are disposed in pairs on the sides of the square, each pair being seated obliquely on a projection of the cephalothorax. Mandibles strong, conical, perpendicular, armed with a few minute teeth on the inner surface. Maxillæ powerful, convex underneath, enlarged at their extremities, and inclined towards the lip, which is large, oval, and rounded at the apex. Pectus heart-shaped. These parts are of a very dark brown colour, the pectus being thinly covered with whitish hairs. First pair of legs the longest, then the second, the third pair being shorter than the fourth; these organs and the palpi are robust, and their colour is brown. The two superior tarsal claws are deeply pectinated, and the inferior one is inflected near its base. The upper tarsal joint of the posterior legs is provided with a combing apparatus of fine spines precisely similar in structure and situation to that of *Clubiona atrox*; it is also employed in the same manner, and for a like purpose. Abdomen oval, convex above, projecting over the base of the cephalothorax; along the middle of the superior part a broad, dentated, dark brown band extends, which is generally bisected by an irregular, transverse, white line, between which and the spinners is a series of obscure, angular lines of a pale brown or whitish hue, whose vertices are directed forwards; a deep border of dull white, which becomes narrower as it approaches the spinners, encompasses the dark brown band; sides dark brown mottled with white; under part of the abdomen dull white, a broad, dark brown band, marked with a few white spots, occupying the medial line. Plates of the spiracles brown.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{3}{20}$ths of an inch; length of the cephalothorax $\frac{1}{14}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{11}$; length of an anterior leg $\frac{1}{5}$; length of a leg of the third pair $\frac{1}{8}$.

The male, though smaller than the female, resembles it in colour and in the relative length of its legs. The third and fourth joints of the palpi are short, the latter having a small, pointed apophysis at its superior extremity in front, and an obtuse one on the outer side of its anterior extremity; the fifth joint is oval, convex externally, concave within, comprising the sexual organs, which are highly developed, with a spiny process of a spiral form projecting upwards from the superior part, and are of a dark reddish brown colour.

I discovered this small species, which belongs to M. Walckenaër's fifth section of the genus *Clubiona*, or the *Parcæ*, in the autumn of 1832, among heath, in Frafford Park, near Manchester; and in the spring of 1833, I met with it in great abundance on gorse bushes, at Oakland, in Denbighshire. Its web, which is whitish and irregular in structure, is fabricated at the extremities of the twigs of gorse. It pairs in May, and in the same month the female constructs two or three contiguous, lenticular white cocoons of a compact texture, measuring about $\frac{1}{8}$th of an inch in diameter, which she attaches to the stems of gorse surrounded by her web, enveloping them with the refuse of her prey. In each cocoon she deposits from ten to thirty spherical eggs of a pale yellow colour, which are not agglutinated together. The combing apparatus on the superior tarsal joint of the posterior legs, from the influence it has upon their œconomy, forms a striking characteristic of the spiders constituting the section *Parcæ*.

Young females of this species were placed in glass jars, and fed with insects till they had completed their moulting and attained maturity. I then introduced to them adult males, taking care to remove the latter as soon as a connexion had been consummated in the usual manner, namely, by the application of the remarkable organs connected with the fifth or terminal joint of their palpi to the orifice situated between the plates of the spiracles in the females. I never, in a single instance, suffered the sexes to remain together any longer than I found it convenient to continue my observations; and I may remark, that their union, however prolonged and undisturbed, was invariably accomplished in the manner stated above, without the slightest deviation being perceptible on the most minute inspection. After a lapse of several weeks, the females thus impregnated fabricated their cocoons and deposited their eggs in them, all of which proved to be prolific; affording, in conjunction with the results of former experiments of a similar kind made upon spiders belonging to the genera *Agelena, Theridion, Epeira,* &c., a complete refutation of the opinion promulgated by M. Treviranus, and adopted by M. Savigny, that the palpal organs are employed for the purpose of excitation merely, preparatory to the actual union of the sexes by means of appropriate organs situated near the anterior extremity of the inferior region of the abdomen.

## Genus, *Drassus*, Walckenaër.

### *Drassus nitens.*

This handsome species has the cephalothorax of an oval form, convex above, somewhat rounded in front, and thinly covered with short, hoary hairs, which are most abundant on the anterior part; its colour is brownish black, with six faint, white lines, three on each side, diverging from the superior part to the lateral margins. Eyes disposed on the anterior part of the cephalothorax in two transverse, curved, concentric rows whose convexity is directed backwards; the interval between the intermediate eyes of the posterior row is greater than the space which separates them from the lateral eyes of the same row, and the intermediate eyes of the anterior row are the smallest of the eight. Mandibles strong, conical, perpendicular, with a curved, red nail at the extremity, and a very few exceedingly minute teeth on the inner surface. Maxillæ powerful, enlarged externally where the palpi are inserted, greatly dilated at the base, beneath, compressed near the middle, slightly enlarged, rounded at the extremities, and inclined towards the lip. Lip longer than broad, and round at the apex. Pectus of an oblong oval figure pointed at the posterior extremity. These parts are of a brown-black colour, the pectus being the darkest. Legs long, their colour brown with a faint tinge of red, the coxæ, trochanters, and thighs of the first pair, and the trochanters and thighs of the second pair excepted, which are of a dark brownish black hue; the thighs of the anterior legs are robust. Two plain, curved claws terminate each tarsus, and underneath them is a small brush; some compound, hair-like tubes, or papillæ, for the emission of a viscous secretion, similar in structure to those constituting the brushes, occur on the under side of the tarsi. Palpi filiform; the first and second joints are dark brownish black, the third, fourth, and fifth joints being of the same colour as the tibiæ and tarsi. The abdomen is in the form of an elongated oval, projecting a little over the base of the cephalothorax, and is covered with short hairs; it is deep black, but when seen in a powerful light reflects rich tints of purple, green and copper; on the upper part, in front, is a small, transverse, slightly curved, white line whose convexity is directed forwards, and behind it; but at a considerable distance is a long, transverse, white line, the middle part of which is abruptly curved in a direction opposed to that of the anterior one; nearly opposite to each extremity of the longer line is a detached white spot on the sides of the abdomen, and a short, white line extends obliquely above the outer margin of each plate of the spiracles; along the medial line of the upper part of the abdomen is a row of small white spots, the one on the coccyx, which terminates the series, being the most conspicuous. The spinning mammulæ are cylindrical and rather prominent. Some slight modifications of form and size may be perceived occasionally in the white lines and spots so remarkable on this species.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{1}{5}$th of an inch; length of the cephalothorax $\frac{1}{14}$; breadth $\frac{1}{20}$; breadth of the abdomen $\frac{1}{14}$; length of a posterior leg $\frac{1}{5}$; length of a leg of the third pair $\frac{1}{7}$.

The male though less than the female resembles it in colour, and in the relative length of its legs, but their absolute length is rather greater, a posterior one measuring $\frac{9}{40}$ths of an inch. The third and fourth joints of the palpi are short, the latter projecting a small, pointed apophysis from the outer side of its anterior extremity; the fifth joint is of an elongated oval shape pointed before; it is convex externally, concave within, comprising the sexual organs, which are highly developed, with a small, prominent, curved spine beneath, and are of a red-brown colour.

I discovered this small but brilliant spider in April 1833, among moss, in the woods about Oakland. It belongs to M. Walckenaër's third section of the genus *Drassus*, or the *Peritæ*, having a close affinity with *Drassus fulgens*. Like some other species of *Araneidæ*, it is partial to moisture, and drinks water freely. A pair which I had confined in a glass phial having become feeble and greatly shrunk, I introduced to them a few drops of water, which they drank of with avidity, and speedily resumed their strength and former plump appearance. In the month of May, females of this species, in a state of captivity, constructed cocoons of a hemispherical form, in which they deposited nine or ten globular eggs of a pale yellow colour, not agglutinated together. The cocoons were composed of delicately white silk of a very fine, compact texture, and above each was fabricated an open tube of the same material, which was usually occupied by the spider.

## *Drassus sylvestris.*

Cephalothorax oval, glossy, convex above, with slight furrows on the sides, and a narrow, longitudinal indentation in the medial line of the posterior region; it is depressed in front, where the eyes are disposed in two transverse, parallel rows, somewhat curved, having their convexity directed backwards; the posterior row is rather the longer of the two, and the intermediate eyes, which are oval, and nearer to each other than they are to the lateral eyes of the same row, form a square with the intermediate eyes of the anterior row, which are the smallest of the eight. Mandibles strong, conical, dentated on the inner surface, prominent at the base, projecting a little forwards. Maxillæ long, convex at the base, underneath, enlarged externally where the palpi are inserted, and at the extremities, depressed and contracted in the middle, and curved towards the lip, which is long, oval, convex at the base, and rounded at the apex. Pectus of an oval form pointed behind. Legs robust, moderately hairy, furnished with a few small spines; fourth pair the longest, then the first, the third pair being the shortest. Each tarsus has a brush on the under side, and two curved claws, dentated at the base, at its extremity. The palpi, which are strong, are terminated by a single claw dentated at the base. These parts are of a reddish brown colour, the mandibles, maxillæ, and lip being much the darkest. Abdomen of an oblong oval figure, thickly covered with short hairs; its colour is dull olive green tinged with brown, a band of a deeper hue, broad before and tapering to a point behind, extending from the anterior part, contiguous to the cephalothorax, nearly two thirds of its length, along the medial line, the interval comprised between it and the spinners being occupied by a series of obscure, hoary, angular lines, having their vertices directed forwards. The spinning mammulæ are prominent, cylindrical, and of a reddish brown colour. The sexual organs, which are semicircular, are of a dark reddish brown colour approaching to black. Plates of the spiracles large and yellow.

Length, from the anterior part of the cephalothorax to the extremity of the abdomen, $\frac{2}{5}$ths of an inch; length of the cephalothorax $\frac{1}{6}$; breadth $\frac{3}{20}$; breadth of the abdomen, $\frac{1}{6}$; length of a posterior leg $\frac{9}{20}$; length of a leg of the third pair $\frac{7}{20}$.

I found specimens of this spider, which does not appear to belong to any of the sections into which M. Walckenaër has subdivided the genus *Drassus*, in the woods at Oakland, in July 1833; at which season of the year the female constructs a lenticular cocoon of white silk, of a fine, compact texture, about $\frac{3}{10}$ths of an inch in diameter, which she places in a semicircular cavity formed in the ground beneath stones and lined with silk, depositing in it between one and two hundred whitish eggs of a spherical form, not agglutinated together. She is greatly attached to her cocoon and is separated from it with difficulty. Hitherto the male of this species has escaped my observation.

## *Tribe*, Territelæ, Latreille.

### Genus, *Mygale*, Walckenaër.

### *Mygale elegans.*

The male of this fine species is unknown to me. The cephalothorax of the female is large, somewhat oval, notched behind, broadly rounded before, and convex above, with an indentation in the medial line of the posterior region; its colour is very dark brown with reddish margins. The eyes, which in dead specimens have red irides, are grouped on a small, frontal eminence; three on each side, of an oval shape, form an irregular triangle whose apex is directed forwards, and the other two, which are the largest of the eight, and circular, are situated on a transverse line between the preceding groups; the intermediate eyes of the four constituting the bases of the triangles are much smaller than the rest. Mandibles very powerful, articulated horizontally, prominent, and greatly curved; they are provided with three longitudinal bands of short, fine hair or down on the upper side, the intervals, where the surface is exposed, being black and glabrous; the superior band is of a brown colour; it is interspersed with numerous long, black hairs, and is much broader than the two exterior bands, which are brown tinged with pale red. Each mandible is terminated by a large curved, acute, black nail bent underneath; a longitudinal row of teeth, and a dense fringe of long, red hair occupying its under side. Lip small and quadrate. Maxillæ strong, divergent, and densely fringed with long, red hairs on the inner margin, which is elongated into a pointed protuberance before. These organs are of a dark red-brown colour, the apex of the lip being the palest. Pectus quadrilateral, longer than broad, and of a dark brown colour approaching to black. Legs long, robust, tapering to the extremity of the tarsi, which are furnished with a dense brush on the under side, and are terminated by two claws toothed at the base; first pair the longest, then the fourth, the third pair being the shortest; their general colour is very dark brown, some narrow longitudinal spaces devoid of hair giving them a striped appearance on the upper side, when closely inspected; the anterior part of the coxæ, and the trochanters, are clad with pale red hair above; the joints are reddish beneath, and the tibiæ and tarsi are armed with black sessile spines. The palpi, which are long and pediform, are inserted at the anterior extremity of the maxillæ; their terminal joint has a plain claw at its extremity, and a dense brush underneath; they resemble the legs in colour, and are provided with sessile spines. Abdomen oval, dark brown above, intersected by six or seven curved bands of a pale red colour; several of the anterior bands have their continuity slightly interrupted in the medial line, but the posterior ones preserve theirs entire; the colour of the under side is very dark brown, with the exception of the lips of the four spiracles, which are reddish. At the posterior extremity of the abdomen are four spinning mammulæ; the two superior ones are very long and prominent, each consisting of three joints, and the two inferior ones are small; on the former, which Lyonnet, Treviranus, and other skilful zootomists have regarded as anal palpi merely, (*palpes de l'anus,*) denying that they perform the office of spinners, the papillæ or spinning tubes are arranged along the under side of the terminal joint.

Length, from the most prominent part of the mandibles to the extremity of the abdomen, not including the spinners, 1 inch and $\frac{17}{20}$ths; length, from the anterior margin of the cephalothorax to the extremity of the abdomen, $1\frac{13}{20}$; length of the cephalothorax $\frac{17}{20}$; breadth $\frac{7}{10}$; length of an anterior leg $3\frac{1}{5}$; length of a posterior leg $3\frac{1}{10}$; length of the nails at the extremity of the mandibles, following their curve, $\frac{2}{5}$; length of a superior spinning mammula $\frac{1}{2}$.

Specimens of this spider are deposited in the Museum belonging to the Society for the promotion of natural history established in Manchester; but I am not able to state in what quarter of the globe they were procured.

## Genus, *Cteniza*, Latreille.

### *Cteniza spinosa.*

The Manchester Museum contains a specimen of a female spider, belonging to the genus *Cteniza*, which does not appear to coincide with any species given by M. Latreille, under the head "*Mygale*," in the second edition of the *Nouveau Dictionnaire d'Histoire Naturelle*; I have ventured, therefore, to describe it as new to arachnologists.

Cephalothorax of an irregular oval figure, convex above, and glossy, with an indented, curved line, whose convexity is directed towards the abdomen, occupying its posterior region. The eyes are seated on a small frontal eminence, and, in dead specimens, are of a yellow hue; three on each side, of an oval shape, form an irregular triangle whose apex is directed forwards, the two anterior ones being the largest of the eight, and the other two, which are circular, are situated on a transverse line between the preceding groups. Mandibles very powerful, articulated horizontally, prominent, and curved; they have a bold projection on the upper side of their anterior extremity, just above the insertion of the nail, which is furnished with numerous short, acute, black spines; and their inferior surface is armed with two longitudinal rows of teeth, the interval between them being occupied by a strong, black nail, when in a state of repose. Maxillæ robust, divergent, densely fringed with long, red hairs on the inner margin, and provided with small, sharp, black spines underneath. The lip, which is quadrate, has some minute, black spines at its apex. Pectus nearly circular, and glabrous. Legs short, powerful, and provided with long hairs, particularly on the under side; the fourth pair is the longest, then the first, the third pair being a little shorter than the second. The thighs of the first and second pairs are compressed and slightly curved, the second or anterior joint of the tibiæ and the two tarsal joints being armed on the sides with numerous short, strong, acute, black spines curving downwards at their extremities, like small claws; the second joint of the tibiæ of the third pair of legs is greatly depressed on the upper side; its anterior extremity, and that of the epicnemis or first joint of the tibiæ, which are prominent, together with the tarsal joints, are furnished with numerous short, strong, black spines on their superior surface; the tibiæ of the posterior legs are destitute of spines, but the tarsi have some minute black ones on their exterior side, and the terminal joint has a longitudinal row of long, closely set, slender spines or bristles on the inferior part of its inner surface. Each tarsus is terminated by three black claws; the two superior ones are much curved (the one on the anterior side being the larger) and have a single large tooth near the base; the inferior claw is small and bent abruptly downwards. The palpi, which are long and pediform, are inserted at the anterior extremity of the maxillæ; the second joint is greatly compressed, and curved; the ultimate and penultimate joints are supplied with numerous short, strong, black spines on their sides, the former having a large black claw at its termination, which is provided with a solitary tooth near its base. All these parts, with the preceding exceptions, are of a deep red-brown colour, the mandibles and the depressed part of the tibiæ of the third pair of legs being the darkest. The abdomen is somewhat oval, and of a yellowish brown colour; its posterior extremity presents four spinning mammulæ; the two superior ones are robust, and prominent, each consisting of three joints, and the two inferior ones are minute. In this species the papillæ from which the silk issues occupy a circular space at the extremity of each mammula.

Length, from the most prominent part of the mandibles to the extremity of the abdomen, not including the spinners, 1 inch and $\frac{3}{20}$ths; length, from the anterior margin of the cephalothorax to the extremity of the abdomen, $1\frac{1}{20}$; length of the cephalothorax $\frac{1}{2}$; breadth $\frac{2}{5}$; length of a posterior leg $1\frac{3}{20}$; length of a leg of the third pair $\frac{9}{10}$; length of a superior spinning mammula $\frac{1}{8}$.

## LXXI. *Observations on the Use of Chemical Symbols.* By R. Phillips, *F.R.S. &c.*

CHEMICAL symbols have for several years been very generally in use on the Continent, and the employment of them is now rapidly extending in this country. At first they seem to have been chiefly intended as brief representations of accompanying detailed statements, and even this purpose they sometimes failed to answer. Now, however, symbols are given without the composition of bodies, and even without their atomic weights. The inconvenience arising from this practice I have frequently experienced, and on no occasion more sensibly than in perusing Mr. Graham's paper in the forthcoming Part of the Philosophical Transactions, entitled, *Researches on the Arseniates, Phosphates, and Modifications of Phosphoric Acid.* I intend, on a future occasion, to give a full account of the important conclusions which the author has deduced from his experiments*, when, by the assistance which I hope to receive from him, he has rendered the details of his paper intelligible, by explaining the symbols employed in it. In order to put Mr. Graham in possession of the difficulties which have occurred to me, and which must, I think, have

---

* An abstract of Mr. Graham's paper will be found in our present Number, pp. 451, 452.

been felt by others, I shall offer a few remarks on the memoir above alluded to.

In page 255, (Phil. Trans. for 1833, Part II.) Mr. Graham states, "that common phosphate of soda is a phosphate of soda and of water, and its symbol is $\dot{N}a^2\,\dot{H}\,\overset{\cdot\because\cdot}{P}$." Here we have the atomic constitution of the salt symbolically expressed; but neither its analysis, atomic weight, the atomic weight of its acid, alkali or water, is given, nor is there any reference to the author of the system of notation adopted. It became requisite, therefore, in order to understand the experiments detailed in the paper, to ascertain the nature of the salt in question by deciphering its formula. The notation used by Mr. Graham I supposed to be that of Berzelius; I therefore referred to his *Essai sur la Théorie des Proportions Chimiques*, and there found *phosphas natricus cum aquâ* represented by $\ddot{N}a\,\overset{\cdot\because\cdot}{P}+24\,Aq$. It is composed of

| | |
|---|---|
| 1 atom of soda | 781·84 |
| 1 atom of phosphoric acid | 892·30 |
| 24 atoms of water | 2698·46 |
| | 4372·60 |

Berzelius (*Traité de Chimie*, tom. v. table, p. 16,) now represents *phosphate sodique*, by $\dot{N}a^2\,\underline{\overset{\cdot\because\cdot}{P}}+24\,\underline{\dot{H}}$. It is composed of

| | |
|---|---|
| 2 atoms of soda 390·897 × 2 = | 781·794 |
| 1 atom of phosphoric acid | 892·285 |
| to which add 24 atoms of water | 2698·460 |
| | 4372·539 |

Now, although it is evident that Berzelius's views of the atomic constitution of this salt must have altered, its composition remains unchanged: let us, then, examine whether we can trace this salt (neglecting the exact proportion of water) in the symbols used by Mr. Graham. When Berzelius represents soda by $Na^2$, $\underline{\overset{\cdot\because\cdot}{P}}$ is the symbol of phosphoric acid, but Mr. Graham gives $\overset{\cdot\because\cdot}{P}$; when, on the other hand, Berzelius designates soda by $\ddot{N}a$, the phosphoric acid is $\overset{\cdot\because\cdot}{P}$, which Mr. Graham adopts with $\dot{N}a^2$. Berzelius represents water either by Aq, which was his former method, or by $\underline{\dot{H}}$ which is his present symbol; but Mr. Graham gives us $\dot{H}$, which in Berzelius's original plan had no place, and in his recent one, signifies half an atom of oxygenated water. Berzelius places the symbol of water last, with + prefixed, as will be observed in the formula quoted from him. Mr. Graham places it between the alkali and acid, without the sign +. In page 285, Mr. Graham denotes a compound of three atoms of water with one atom of phosphoric acid by $\dot{\mathrm{H}}^{3}\,\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}}$; Berzelius would formerly have denoted the compound by $\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}} + 3\,\mathrm{Aq}$, and at present he uses the formula $\underline{\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}}} + 3\,\underline{\dot{\mathrm{H}}}$.

In answer to these observations, it may perhaps be imagined that Mr. Graham has employed a totally distinct system of notation. I am not prepared to deny this, yet I much doubt it; the following statements are taken from all the systems which I have been able to collect, and it will be seen that though Mr. Graham's formula differs from them all, it is evidently, with some alterations, compounded of Berzelius's first and present systems.

| | |
|---|---|
| Berzelius | $\ddot{\mathrm{N}}\,\mathrm{a}\ \overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}} + 24\,\mathrm{Aq}.$ |
| Ditto | $\dot{\mathrm{N}}\,\mathrm{a}^{2}\ \underline{\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}}} + 24\,\underline{\dot{\mathrm{H}}}.$ |
| Graham | $\dot{\mathrm{N}}\,\mathrm{a}^{3}\ \dot{\mathrm{H}}^{24}\ \overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}}.$ |
| Rose | $\mathrm{N\,a\,O} + \mathrm{PO}^{5} + 24\,\underline{\mathrm{H}}\mathrm{O}.$ |
| Whewell | $\mathrm{N} + p' + 24\,\mathrm{q}.$ |
| Brande | $\mathrm{S} + p' + 24\,\mathrm{q}.$ |
| Turner | $\dot{\mathrm{S}}\,\mathrm{o} + \mathrm{P} + 2\tfrac{1}{2}\,\mathrm{O} + 24\,\mathrm{aq}.$ |
| Johnstone | $\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}} + \dot{\mathrm{S}}\mathrm{o} + 24\,\dot{\mathrm{H}}.$ |
| Prideaux | $N\,\overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}} + 24\,Aq.$ |
| Warrington | $\overset{\underline{00}}{\mathrm{Po}} + \mathrm{S}\overset{0}{\mathrm{o}} + 24\,\mathrm{H}^{0}.$ |

I do not exhibit this specimen of confusion in the vain hope of abolishing symbols, much as I should rejoice in the accomplishment of that object. The statement may, however, induce those who use them, to add such an account of the nature of the compound, as may render their meaning intelligible to those who have neither leisure nor inclination to examine ten systems of notation in order to discover the meaning of $\dot{\mathrm{N}}\,\mathrm{a}^{2}\ \mathrm{H}\ \overset{\cdot\,\cdot}{\overset{\cdot\,\cdot\,\cdot}{\mathrm{P}}}$; this, however, I have done, and entirely without success.

[*Note.*—The lines which we have placed *under* the letters, are in the originals placed across them,—a method not within the present means of the typographer.—See also *Annales de Chimie.*]

## LXXII. *Proceedings of Learned Societies.*

### ROYAL SOCIETY.

May 9.—A PAPER was read, entitled, "On the Anatomical and Optical Structure of the Crystalline Lenses of Animals, particularly that of the Cod." By Sir David Brewster, K.H., LL.D., F.R.S. V.P.R.S. Ed.

The author was led, by the observations he had made of some very singular phænomena in the crystalline lenses of fishes and quadrupeds when exposed to polarized light, to examine their minute anatomical structure, with the view of ascertaining if it had any relation to these optical appearances. He found that the crystalline lens of a cod has the form of a prolate spheroid, of which the axis coincides with that of vision. Its body is inclosed in an exceedingly thin and transparent capsule, within which it floats without having any apparent connexion with that capsule, and consists of a hard nucleus surrounded by softer matter. The nucleus is composed of regular transparent laminæ of equal thickness, with perfectly smooth surfaces, presenting the iridescent appearance peculiar to grooved surfaces, and exhibited by mother-of-pearl. These apparent grooves have the direction of meridian lines converging from the equator, where their breadth is greatest, to the two poles, and indicating the boundaries of the component fibres of the laminæ. The author was enabled to trace the course of these fibres to their termination very satisfactorily, when the fibres themselves could not be rendered visible by the best microscopes, by means of the reflected prismatic images of a luminous object, produced by interference. This method furnished also an accurate mode of determining the diameter of the fibres at any point of the spheroid. The uniform distribution of the light refracted through the lamina, as well as the distinctness of the reflected images, prove that these fibres are not cylindrical, but perfectly flat, and gradually tapering in breadth from the equator to the poles of the lens. The thickness of each fibre is at least five times less than its breadth, which, in the most external layer of the equator, is about the 5500th part of an inch.

The observation of another optical phænomenon apparent on looking at a bright light through a thin lamina of the lens of a cod, namely, that of two faint and broad prismatic images, situated in a line perpendicular to that which joins the common coloured images, led the author to the further discovery of the mode in which the fibres are united laterally to each other, so as to resist separation, and form a continuous spherical surface. By viewing a well-prepared lamina with a microscope of high magnifying power, he observed that the fibres are united by a series of teeth, locking into one another, exactly like those of rack-work. The breadth and depth of each tooth are about the fifth part of the breadth of the fibre itself, and all the adjacent surfaces are in perfect optical contact. This denticulated structure exists in the lenses of every fish which the author examined. In that of the cod, the number of teeth in each fibre was found to be 12,500; and since the number of fibres in the whole lens is 5,000,000, the total number of teeth amount to 62,500,000,000.

The same structure obtains universally, as far as the author has examined it, in the lenses of birds; but he has never met with it in any of the Mammalia, not even in the Cetacea. It was found in two species of lizards, and in the Ornithorhynchus*.

In the concluding part of the paper the author enters into some details as to the doubly-refracting structure of the crystalline lens of the cod and of other animals, in which several curious varieties are observable with regard to the relative positions of the strata giving positive or negative double refractions. In the prosecution of this subject he was led to the observation of a series of very curious phænomena, which he announces as the subject of a future communication to the Royal Society.

A paper was also read, entitled, "On the present Situation of the Magnetic Lines of Equal Variation, and their Changes on the Terrestrial Surface." By Peter Barlow, Esq., F.R.S.

The author has undertaken the task of collecting and arranging all the authentic information respecting magnetic variation which has been recorded in the accounts of several recent voyages and journeys of discovery. The inconvenience from the distortion and interruptions of the lines of equal variation laid down on maps or charts, induced him to trace them on a globe, where they can, of course, be exhibited in their natural situation, and in regular continuity: and he has been careful to mark only such as are deduced from actual observation. The examination of the lines thus laid down shows them to be dependent on definite and general laws, and not on local influences; their inflections and curvatures presenting systems of great regularity, and being exempt from those abrupt and angular configurations which such local disturbances might be expected to produce: neither do they appear to be consistent with the hypothesis of the action of a certain definite plurality of magnetic poles.

The author next offers some observations on the progressive changes which these lines undergo in their places and configurations, and shows their agreement with the hypothesis of a revolution of the magnetic poles for each place round the poles of the earth; each respective place having its own particular pole, the revolving motion of which is regulated by some general but hitherto unknown law.

May 16.—A paper was read, entitled, "Note on a Paper by Dr. John Davy, entitled, 'Notice on the Remains of the recent Volcano in the Mediterranean.'" By Charles Daubeny, M.D., F.R.S., Professor of Chemistry in the University of Oxford.

From the circumstance that azotic gas is frequently evolved from thermal springs, the author infers that this phænomenon is in some way connected with volcanic action; and this he considers to be the case in the instance observed by Dr. Davy, although referred by him

---

* [This fact may probably be regarded as an indication of the affinity of the Ornithorhynchus to Birds, in addition to those which have recently been established. In the Mammalia which deviate most from the normal characters of that class, in the series of affinity gradually connecting the typical species with the Ornithorhynchus, we should expect, however, that the peculiar structure of the lens detected by Sir D. Brewster would also be discovered.—E. W. B.]

to the decomposition of atmospheric air during putrefactive processes going on at the bottom of the sea. Dr. Daubeny offers objections to the theory of that gas rising to the surface in consequence of the high temperature to which it has been subjected. He conceives that the air which Dr. Davy examined cannot have been derived from sea-water, but must have originated from the atmosphere itself, with which the volcano communicated. The author is disposed to attach great importance to the accurate examination of the gases given out by warm springs, and recommends the prosecution of the inquiry.

A paper was also read, entitled, "Experimental Researches on Atomic Weights." By Edward Turner, M.D., F.R.S. Lond. and Edinb., Professor of Chemistry in the University of London.

This paper is a continuation of the Essay, by the same author, on the Composition of the Chloride of Barium, which was published in the Philosophical Transactions for 1829*. Having shown that the atomic weights current among British chemists, though in some instances correct, or tolerably approximative, have, as a whole, been adopted on insufficient evidence, he proceeds, in this paper, to give an account of the experiments he has made to ascertain the equivalent numbers for lead, chlorine, silver, barium, and nitrogen. Finding, with reference to lead, that the method adopted by Berzelius did not afford uniform results, he endeavoured to ascertain the quantity of subsulphate of lead which given weights of metallic lead and the protoxide of that metal respectively produce. He details the mode he employed for the conversion of metallic lead into the subsulphate by a mixture of nitric and sulphuric acids, diluted with an equal bulk of water, and the precautions he adopted to avoid loss. The mean of three experiments gave 146·375 grains of sulphate of lead for 100 grains of metallic lead. By the mean of four experiments, Berzelius had obtained, instead of the former number, 146·419. Dr. Turner adopts the mean of the whole, namely, 146·41. By prosecuting this inquiry, he finds the sulphate to consist of 73·575 of protoxide of lead, and 26·425 of sulphuric acid; and that the former contains 5·274 of oxygen. According to these results, the equivalent number for lead is 103·6.

By experiments with the chloride of lead, which gave very uniform results, Dr. Turner obtained an equivalent number for chlorine, closely agreeing with that calculated from the analysis of chlorate of potash in the experiments of Berzelius, namely, 35·45, but totally inconsistent with the atomic weight assigned to it by British chemists. The accuracy of this result was further confirmed by a careful comparative analysis of the binoxide and bichloride of mercury.

The author next endeavoured to determine the equivalent number for silver, by the analysis of its oxide and sulphuret, but could not arrive at any precision in his results. The equivalent number for barium may be calculated from his analysis of the chloride already published in the paper before alluded to. His investigation of the equivalent of nitrogen was attempted by means of the analysis of the nitrates of silver, of lead, and of baryta; the mean result of which

---

* See Phil. Mag. and Annals, N.S. vol. viii. p. 180; and Lond. and Edinb. Phil. Mag., vol. i. p. 109.

gives 14·15, agreeing very nearly with that assigned by Berzelius. His investigation of the atomic weight of sulphur is not yet completed; but he details several previous steps in this inquiry, which he intends to prosecute on a future occasion. He estimates the equivalent of mercury at 202; a number which he considers as a close approximation.

He concludes by various remarks on the inconsistency with experiment, which is apparent in many of the numbers adopted as chemical equivalents by British chemists; and on the inaccuracy of those numbers which have been employed as elements in calculating the equivalents of nearly all the other elementary substances. The author thinks that Dr. Prout's hypothesis, as advocated by Dr. Thomson, that all atomic weights are simple multiples of that of hydrogen, can no longer be maintained, and that it is at variance with the most exact analytical researches.

May 23.—A paper was read, entitled, "Observations of the Comet of Encke, made in June 1832." By Thomas Henderson, Esq., His Majesty's Astronomer at the Cape of Good Hope. Communicated, by Command of the Lords Commissioners of the Admiralty, by Captain Beaufort, R.N., F.R.S., Hydrographer to the Admiralty.

Most of the observations recorded in this paper were made by a circular micrometer constructed by Simms, and applied to an achromatic telescope of Dollond's, 45 inches in focal length, and 3·5 inches aperture, furnished with a portable equatorial stand, capable of being adjusted to any latitude. The magnifying power was about 30, and the radius of the ring was an arc of 1015 seconds. In other observations, a transit instrument by Dollond was used, which was 10 feet in focal length, and 4·75 inches aperture. For observing the comet, an eye-glass magnifying 86 times was employed.

A ~~paper was then read, entitled~~, "On the supposed Powers of Suction of the Common Leech." By Thomas Andrew Knight, Esq., F.R.S., President of the Horticultural Society.

From observing the feebleness of the muscular force exhibited by the leech in its progressive movements through the water, the author was led to doubt its possessing the powers of suction that are so universally ascribed to it. A fact which came under his notice above sixty years ago, of considerable loss of blood from the leg following the bite of a vigorous leech, suggested to him the idea that the animal might become filled with blood simply by the injection of its body, in consequence of the impetus with which the blood is made to flow into it from the part bitten;—an impetus which he imagines may be occasioned by the introduction of a peculiar kind of venom. He considers the irritation which often accompanies the bite of a leech as corroborating this hypothesis: he admits, however, that the inflammation excited by the sting of a bee or a wasp is attended with effects of a totally opposite kind; for, in that case, the blood, instead of having a tendency to flow, stagnates around the point where the poison has been instilled.

A paper was also read, entitled, "Experimental Researches in Electricity.—Fourth Series." By Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain.

The author, while prosecuting his researches on electro-chemical decomposition, observed some phænomena which appeared to be referable to a general law of electric conduction not hitherto recognised. He found that an electric current from a voltaic battery, which is readily conducted by water, did not pass through ice: even the thinnest film of ice, interposed in the circuit, was sufficient to intercept all electric influence of such low intensities as that produced by the voltaic apparatus, although it allows of the transmission of electricity of such high intensity as that excited by the common electrical machine. The author ascertained that a great number of other substances, which are solid at ordinary temperatures, do not conduct the electric current from the voltaic battery until they are liquefied. Among these are potassa, protoxide of lead, glass of antimony, and oxide of bismuth; various chlorides, iodides, and sulphurets; and also many of the ordinary neutral salts with alkaline bases. In almost every instance the bodies subjected to this law are decomposable by electricity; and their decomposition can be effected only when they are in a fluid state, and while they are conductors of electricity. The author inquires how far these two properties are connected together, or dependent the one upon the other; but finds that several exceptions occur to any general proposition that he attempted to establish on this subject.

The general conclusions to which he is led from the experiments detailed in this paper are the following:—First, that all bodies conduct electricity in the same manner, but in very different degrees;—Secondly, that in some the conducting power is powerfully increased by heat, in others diminished, and this without any difference that has yet been discovered, either in the general nature of the substance, or of the influence of electricity upon it;—Thirdly, that there is a numerous class of bodies which, when solid, insulate electricity, and, when fluid, conduct it freely, and are decomposed by it; yet that there are many fluid bodies which do not sensibly conduct electricity of low intensity; and some that conduct it, and are not decomposed;—and, Lastly, that fluidity is not essential to decomposition. Sulphuret of silver is the only body yet known to be capable of insulating a voltaic current when solid, and of conducting it, without decomposition, when fluid. No distinction can as yet be drawn between the conducting powers of bodies supposed to be elementary and those known to be compounds.

The Society then adjourned over Whitsun-week to the 6th of June.

June 6.—A paper was read, entitled, "An Account of a Second Series of Experiments on the Resistance of Fluids to Bodies passing through them." By James Walker, Esq., F.R.S., Civil Engineer.

The author, in a paper read to the Society in the year 1827, and printed in the Philosophical Transactions, gave an account of some experiments showing that the resistance of fluids increases in a ratio considerably higher than the square of the velocity, and that the absolute resistance is smaller than had been deduced from the experiments of the French Academy. In the present communication he states the results of his further inquiries on this subject. His experiments were made at the East India Docks, on a boat twenty-three feet long and six wide, with the stem and stern nearly vertical; one end being terminated by an angle of 42°, and the other of 72°; and the resistance to the boat's motion being measured by a dynamometer. The results are given in tables: and it appears from them, that in light vessels sharpness is more important in the bow than in the stern; but that the reverse is the case in vessels carrying heavy cargoes. From another series of experiments the author infers that the resistance to a flat surface does not exceed 1·25lb. for each square foot, at a speed of one mile per hour; increasing, for greater velocities, in a ratio considerably higher than the square of the velocity.

The author concludes with some observations on the results lately obtained in Scotland, where great velocities were given to boats moving on canals, without a proportional increase of resistance.

The reading of a paper, entitled, "Researches on the Arseniates, Phosphates, and Modifications of Phosphoric Acid," by Thomas Graham, Esq., M.A., F.R.S.E., Lecturer on Chemistry in the Andersonian Institution of Glasgow; communicated by Edward Turner, M.D., F.R.S.,—was commenced.

June 13.—Mr. Graham's paper was resumed and concluded.

The tendency of the arsenic and phosphoric acids to form subsesquisalts with the oxides of silver and lead is well known; corresponding salts with alkaline bases also exist. The author describes the method of forming the subarseniate and subphosphate of soda, and their properties; and shows that they are subsesquisalts, containing one proportion and a half of base to one of acid. They are the only known soluble salts of that constitution; and it is remarkable, that the acid of the subphosphate of soda is not convertible into pyrophosphoric acid by the action of heat, like the acid of the common phosphate of soda. This may be explained on the hypothesis, that phosphoric acid, in contradistinction to pyrophosphoric acid, contains an atom of water, which stands in a basic relation to the acid, and which may be replaced by an atom of any of the usual bases. Hence also arises the disposition of phosphoric acid to form subsesquisalts; for the common phosphate, used as a precipitant, exchanges its basic water for a fixed base; and for this reason, likewise, phosphate of soda, or any neutral phosphate, cannot be made anhydrous without becoming a pyrophosphate; but the subphosphates having an excess of base, may be anhydrous, as Stromeyer observed; and indeed they are not convertible into pyrosalts. The acid formed by the combustion of phosphorus in air or oxygen, constitutes a third modification of phosphoric acid, distinguished by peculiar properties, and which, from the difference of its saturating power, in relation to that of the phosphoric and pyrophosphoric acid, the author considers as a *polymeric* phosphoric acid;—a term lately applied by Berzelius to bodies of the same relative composition, but differing in their combining proportions.

The author devoted much time and attention to determine the quantity of water of combination in the foregoing subsalts; but the result he obtained, namely 50·22 per cent., is not easily reconciled with our best data for atomic weights. It is, however, pretty nearly compatible with 23 or 24 atoms of water, according to Berzelius's weight of the atom of arsenic; and if the latter estimate be correct, it is curious that the subarseniate differs from the neutral arseniate, merely by the substitution of an atom of soda for an atom of water; for the latter salt contains 25 atoms of water.

The author's experiments on the composition of the subarseniate of soda,—the results being reduced to the hypothesis, that it contains 23 atoms of water,—represent it as formed, (per cent.) of arsenic acid, 27·69; soda, 22·55; water, 49·75. The subphosphate of soda was found to consist (per cent.) of subsesquiphosphate, 43·97; water, 56·03; the soda in the salt amounting to 24·87.

The author attempted to determine the quantity of phosphoric acid in this salt, by direct precipitation by nitrate of silver, but could not obtain rigorously accurate results; for the subphosphate of silver carried down with it a portion of the nitrate, which washing could not entirely separate. He likewise failed in his endeavours to obtain pure subphosphate and subarseniate of potash.

The subarseniate of barytes appeared, by a single experiment, to be composed, (per cent.) of arsenic acid, 32·06; barytes, 67·94: from which the salt would seem to contain an excess of base; for by theory, the subsesquiarseniate of barytes should be composed of, acid, 33·4; base, 66·6.

When solution of muriate of lime is poured into an excess of solution of phosphate of soda, or when phosphate of lime, dissolved in muriatic acid, is precipitated by ammonia, a gelatinous mass is formed, which has been called the subphosphate of lime of bones; the composition of which is singular, consisting, on the simplest view that can be taken of it, of 3 atoms of phosphoric acid, and 4 of lime. It was noticed by Berzelius.

The author thinks the anomalous composition of this salt may in some measure be explained by considering it as consisting of 1 atom of the neutral, and 2 atoms of the subsesquiphosphate. According to Berzelius, calcined ox-bones are composed of such a phosphate of lime, with a little carbonate of lime; but a doubt arises of the accuracy of this view, from the fact, that the presence of carbonic acid in the calcined phosphate of bones is no proof of the existence of that acid in the same, previous to calcination.

The earth of bones, after calcination at a high temperature, contains phosphoric, and not pyrophosphoric, acid; the excess of base preventing the transition.

The author's analysis of subarseniate of lead, formed by the gradual addition of solution of acetate of lead to solution of subarseniate of soda, afforded a striking confirmation of the atomic weight of arsenic, deduced by Berzelius from his analysis of arsenious acid by sulphur.

~~A paper was read, entitled~~, "Some Observations on the Structure of Shells, and on the Economy of Molluscous Animals." By John Edward Gray, Esq., F.R.S.

The author distinguishes two kinds of structure in shells; the one in which the calcareous matter is crystallized, composing what Mr. Hatchett has called the *porcellaneous structure*; and the other, in which it is deposited in grains intermixed with a large proportion of animal matter, constituting the *nacreous* or *granular structure.* The former class of shells, which includes most of the turbinated univalves, may be divided into those in which the crystals are rhombic, and those in which they are prismatic. The first are composed of three distinct layers, the laminæ of which are disposed differently in the intermediate layer from what they are in the outer and inner layers. The direction of the fibres of each being nearly at right angles to that of the contiguous layer, the strength of the shell is rendered considerably greater than if the arrangement of the fibres had been uniform in each plate. The comparative thickness of the three plates varies in different shells; but the central plate is generally the thickest. The outer plate is the thinnest; and, in some shells, is easily detached, in consequence of the deposition underneath it of a white film of less coherent matter. It often happens, that when the animal arrives at its full size, it deposits layers of shell either on the lips or the columella: and in some, as the *Cypræa,* an additional coat, which is harder, more compact, and differently coloured from the rest of the shell, is formed by an extension of the mantle, and laid on the outside of the shell; the part where the two reflected portions of the mantle meet on the back being marked by what is termed the *dorsal line.*

Besides these component parts of turbinated shells, there is often deposited on the sides and interior part of their cavities, especially of the upper whorls, a transparent calcareous concretion. In shells of which the spires are elongated and acute, as in the *Turritellæ,* this deposition entirely fills up the cavity of the upper whorls; thus rendering solid the tips, which, from their small size and original thinness, would otherwise have been very liable to be broken. In other cases the animal, instead of filling up this upper cavity, suddenly withdraws its body from the upper whorls, and then forms a concave septum, by which the vital communication between the body and the apex of the shell being cut off, this part decays as a dead shell, and gradually falls to pieces.

Shells having a prismatic crystalline structure are formed of short fibres, everywhere perpendicular to the surface. The prisms are mostly hexagonal. Shells of a granular structure present a more uniform texture; the plates of animal matter they contain being very thin, and closely compacted together. They have generally a pearly or iridescent lustre, arising from this peculiar conformation. The particles of disintegrated *Placunæ* are employed by the Chinese as silver in their water-colour drawings. In many shells belonging to this class, as in the Oyster, the animal matter, being more abundant, produces a distinctly laminated texture.

It has been generally believed, and sometimes strenuously maintained, that molluscous animals have not the power of absorbing the matter of their shells when it has once been deposited. The author brings forward a large mass of evidence in proof of their frequently exercising this power. In the Cone and the Olive, all the septa between the whorls inclosed in the body are very thin and transparent, and, when compared with the corresponding portions of the outside, adjacent to the apex, are found to have lost the outer and the middle layers, the innermost alone remaining. In the *Auriculæ,* this inner layer also is removed, leaving a simple cavity in the upper half of the shell. The absorption of the substance of these internal portions of shell gives more space for the body, at the same time that it renders the shell much lighter, without any diminution of its strength; the body being sufficiently protected by the outer whorl. In the *Murices,* and other shells having ridges or spines on the front of the whorls, which, in the progress of the growth of the shell, the succeeding whorls would necessarily overlap, these appendages are generally absorbed, to make way for the succeeding whorls; their absorption being effected by the edge of the mantle as it comes in contact with them. Thus do many species of Mollusca absorb, at regular epochs of their growth, certain parts of their shells, which had, at a preceding period, been deposited about the lip in the form of ribs or teeth. Mollusca have also the power of forming excavations in the shells of other animals of this class, and sometimes of other individuals of the same species: many instances of these facts are adduced by the author; among which one of the most curious is the history of the *Spiraglyphus,* which, in the progress of its enlargement, absorbs a tubular portion of shell which it had formed at an early period of its growth. They also excavate portions of solid rock in providing for their habitation. Molluscous animals, however, do not appear to be capable of removing extraneous obstacles which oppose their progress in the formation of their shell; in proof of which, various examples are adduced of foreign bodies being inclosed in the layers of shells. The author produces evidence of the secretion of the materials of the shell by other parts than the mantle, and in particular by the upper part of the foot. The operculum is in this way formed, in a manner exactly similar to shell, by the back of the foot: and its various modifications of form, the author remarks, afford important characters for the systematic classification of this department of Natural History.

X June 20.—Professor Stromeyer, Foreign Memb. R.S., presented two specimens, one of the coarse-grained, the other of the fine-grained variety, of the remarkable mass of iron lately discovered near Magdeburg, and an account of which had been laid before the Royal Society of Göttingen on the 14th of last month. This iron was found, in several detached lumps, about four feet below the mould, by Mr. Kote, who considered himself the more authorized to pronounce it meteoric, as, in the chronicles of Magdeburg, the descent of a fiery meteor is recorded as having happened in the year 998*. Professor Stromeyer has subjected this iron to a minute analysis, the results of which are very interesting, inasmuch as, besides the alloy of nickel and cobalt, usually present in meteoric iron, he unexpectedly found a considerable portion of molybdenum,—a rare metal on our planet, occurring only in two combinations, viz. with sulphur, as glance molybdenum, and, as molybdic acid combined with oxide of lead, in the yellow lead ore of Carinthia and a few other places.

---

* The information extant on this subject would appear to be more precise than is here indicated; for Chladni has recorded the actual fall of meteorites at Magdeburg, in the above year. See Phil. Mag. vol. lxvii. p. 5.—Ed.

The following are the external characters of the six masses dug up, the largest of which was about fifty-seven pounds in weight; the others were considerably smaller. Their shape is more or less oval and flat, with surfaces rather oxidated, and here and there covered with an earthy crust. The larger lumps did not exhibit any trace of scoriæ; but in some of the smaller pieces, part of the metallic mass had passed into a porous slag-like body; of which latter a few detached pieces were likewise found. This iron possesses no degree of ductility; it is not attacked by the saw, and but slightly and with difficulty by the file. Its tenacity, however, is considerable; the masses required great strength to be broken; but small fragments did not oppose greater difficulty to be reduced to a coarse powder than white cast-iron; and glass was but slightly scratched by them. On the fresh fracture, this iron exhibits upon the whole a scaly-granular structure; its internal lustre is moderately vivid, and its colour tin-white, with a strong cast of grey. Two varieties of texture were, however, observable; in some fragments it was more distinctly scaly, of a coarser grain and a deeper grey colour, united to a greater degree of tenacity. The specific gravity of the coarse-grained variety (barom. $0^{\text{in}}{\cdot}758$, therm. $21^{\circ}{\cdot}5$ c.) $= 7{\cdot}2182$; that of the fine-grained $= 7{\cdot}3894$.

The mass contained much of a sulphuret not unlike in appearance to variegated copper ore, from which the subsequent analysis proved it not to differ in composition, except that a trace of sulphuret of silver was found in it. Also minute portions of capillary native copper were found in the interior of some pieces, together with here and there some translucid, pale yellow, olivine-like grains, but in too small quantities to admit of chemical examination.

Professor Stromeyer proceeds to give a detailed account of the chemical analysis to which this iron was subjected by him; according to which 100 parts are composed of—

| | a. *Coarse-grained variety.* | b. *Fine-grained variety.* |
|---|---|---|
| Iron . . . . . . | 76·77 | 74·60 |
| Molybdenum . . . | 9·97 | 10·10 |
| Copper . . . . | 3·40 | 4·32 |
| Cobalt . . . . . | 3·25 | 3·07 |
| Nickel . . . . . | 1·15 | 1·28 |
| Manganese . . . | 0·02 | 0·01 |
| Arsenic . . . . | 1·40 | 2·47 |
| Silicium . . . . | 0·35 | 0·39 |
| Phosphorus . . . | 1·25 | 2·27 |
| Sulphur . . . . | 2·06 | 0·92 |
| Carbon . . . . | 0·38 | 0·48 |
| | 100·00 | 100·00 |

From this it appears, that though the Magdeburg iron contains all the ingredients characteristic of meteoric iron, it is essentially distinct from all others hitherto examined, by the presence of molybdenum and arsenic; by the smaller and rather anomalous proportion of nickel and cobalt which enters into its composition; by the admixture of some capillary copper and of variegated copper ore, instead of the magnetic pyrites found in some meteoric iron; and, lastly, by the presence, though only a trace, of sulphuret of silver.

Professor Stromeyer then enters into an examination of the circumstances which appear opposed to the opinion which assigns a meteoric origin to this iron, and of the objections against its being the product of artificial fusion; among which, one of the greatest is its considerable alloy of molybdenum,—a metal which has hitherto not been observed either in ores of iron and copper, or in any slags or other products of smelting furnaces. But Dr. Stromeyer has since obtained, from the Hartz Mountains, a similar and equally problematical mass of iron, the analysis of which has furnished nearly the same results as that of the Magdeburg iron, except that it contained no variegated copper ore. Future observations will probably throw more light upon the nature of these enigmatical metallic bodies; at all events, the discovery of molybdenum in them is so far of great interest, as, in case they should ultimately prove to be artificial products, it is fair to conjecture that that scarce metal must enter into combinations still unknown to the chemical mineralogist, or occur in some ores in a masked state and such small proportions as to become (like titanium) apparent only in the products of the long-continued operations of the smelting furnace.

The following papers were read:—

1. "Observations on the Physiology of the Nerves of Sensation, illustrated by a case of Paralysis of the Fifth Pair." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

2. "On the Respiratory Organs of the Common Leech (*Hirudo officinalis*, Linn.), and their Connexions with the Circulatory System." By George Newport, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The stomach of the leech has been hitherto described as a large elongated sac, simply divided into ten compartments by perforated membranous partitions: but the author, by a more accurate examination, finds that each portion of that organ is expanded into two lateral cæca, which increase both in size and in length as they are traced along the canal towards the pylorus. The cæca belonging to the tenth cavity are the longest, extending as far as the anus, and have themselves four constrictions: the cavity itself terminates in a funnel-shaped pylorus. When the posterior end of the animal is cut off, the cæcal portions of the stomach are laid open, and the blood which it receives flows out freely, as fast as it is swallowed; and hence the leech, under these circumstances, continues to suck for an indefinite time.

The respiratory organs consist of two series of pulmonary sacs, arranged along the under side of the body, on each side of the nervous cords and ganglia. They each open upon the surface of the body by a very minute but distinctly valvular orifice. The membrane which lines them appears to be continuous with the cuticle, and is exceedingly delicate and highly vascular, receiving the blood, for the purpose of its being aerated, from the veins of the system. The blood is returned from these sacs into the lateral serpentine vessels by vessels of a peculiar construction, passing transversely, and forming loops, which are situated between the cæca of the stomach, and which are studded by an immense number of small rounded bodies closely congregated together, and bearing a great resemblance to the structure of the venæ cavæ of the cephalopodous Mollusca. The purpose answered by this structure is involved in much obscurity: the author offers a conjecture that they may be analogous in their office to the mesenteric glands of the higher animals.

With a view to determine some circumstances relating to the mode of the respiration of the leech, the author made some experiments, by confining the animal in water deprived of air by boiling. After some time the leech was observed to give out bubbles of air; and the water of the vessel, when tested by lime-water, indicated the presence of carbonic acid.—The paper is accompanied by drawings of the structures described.

3. “On the Comparative Osteological Forms in the Adult European Male and Female of the Human Species.” By Walter Adam, M.D., Fellow of the College of Physicians of Edinburgh.

With a view to the future investigation of the osteological development of the human race, the author gives, in the present paper, the results of a great number of measurements, which he has very carefully made, of the dimensions of the different bones composing the adult human skeleton. The male bones examined were those in the collection of Dr. Monro; the female bones were furnished by Dr. Hamilton. The author was anxious to fix on some one dimension in the skeleton which might be taken as the standard of all the measurements: and finding that no bone of the trunk or limbs possessed the requisite characters for that purpose, he sought for it in the cranium; and the result of an extensive series of observations led him to adopt as the standard of measure the distance between the prolongations of the zygomatic ridges, immediately over the meatus auditorius externus, as being that dimension which was less liable to variation than any other of the human cranium. This line he denominates the *auricular transverse*; and, adopting a scale of which the unit is the 14th part of this line, being generally about the third of an inch, he states at length, in multiples of this unit, the dimensions, in different directions, of almost every bone in the skeleton; noting more especially the differences that occur in those of the two sexes. Of these measurements, which are given in much detail, and in many instances arranged in a tabular form, it is impossible to give any abridgement. The conclusion he deduces from his inquiry is, that every bone in the body exhibits certain modifications, according to the sex of the individual.

4. “Some Experiments and Observations on the Combinations of Carbonic Acid and Ammonia.” By John Davy, M.D., F.R.S.

The author was led to the investigations of which he gives an account in the present paper, by finding in the note-books of his brother, the late Sir H. Davy, some memoranda of experiments which he had made on the salts of ammonia, and more especially on the carbonates. The first part of the paper relates to the direct combination of carbonic acid and ammonia, by which a salt is formed possessing singularly alkaline properties. The second is on the sesquicarbonate of ammonia; a term which Mr. Richard Phillips has applied to that salt of ammonia which is commonly called the subcarbonate, and which is obtained by the mutual decomposition of carbonate of lime and sal-ammoniac, by means of heat. This the author concludes, from his experiments, to be composed of one proportion ammonia, one and a half of carbonic acid, and one of water. He then enters into a comparative review of the analyses of this salt by other chemists, and gives an account of the results of his experiments to determine its solubility at different temperatures. He next proceeds to consider the bicarbonate of ammonia, which he finds to consist of one proportion of ammonia, two of carbonic acid, and two of water. He concludes by an inquiry into the effects of heat on the solid sesquicarbonate and the carbonate of ammonia, in which he reviews the experiments and inferences which Sir H. Davy has recorded in his manuscript notes.

5. "On the Influence of Colour on Heat and Odours." By James Stark, M.D., of Edinburgh. Communicated by Sir David Brewster, K.H., LL.D., F.R.S. V.P.R.S. Ed.

The author observes, that the only experiments on record relating to the modifying effect of different colours on the absorption of heat from solar light, are those of Franklin and of Sir H. Davy. In order to investigate this subject, the author employed pieces of wool, silk, and cotton, which were wrapped round the bulb of a thermometer placed in a glass tube: the tube was then plunged into boiling water, and the time which elapsed during the rise of the thermometer from one given point to another was accurately noted. Other experiments were also made with an air-thermometer, of which the bulb was coated with various coloured materials, and heat thrown on the ball by means of polished tin reflectors from an Argand burner. The results accord very nearly with those of Franklin and of Davy; the absorbing power with regard to different colours being nearly uniformly in the order of *black, brown, green, red, yellow*, and *white*. The author next investigates the differences which occur in the radiation of heat by differently coloured substances; a subject on which he is not aware that any experiments have ever been made previously to his own. The mode of ascertaining the amount of radiation was generally the converse of that by which the absorption of heat had been determined; namely, by exposing the coloured substances, in contact with a thermometer, to cooling instead of heating processes. The general result of all his experiments was, that the loss of caloric by radiation follows exactly the same order, with regard to the colour of the radiating surface, as its absorption.

In the second part of his paper the author gives an account of a course of experiments which he made with a view to discover the influence of colour on the absorption of odorous effluvia, and more especially in the case of the absorption of the fumes of camphor and assafœtida by woollen cloth of different colours. Black cloth was always found to be possessed of the greatest absorbing powers, and white of the least; red cloth being intermediate between them. Cottons and silks gave, on trial, precisely the same results, which were further confirmed by the different weights acquired by these substances from the deposition of camphor upon them.

6. "Researches on the Arseniates, Phosphates, and Modifications of Phosphoric Acid." By Thomas Graham, Esq., M.A, F.R.S.E., Lecturer on Chemistry in the Andersonian Institution at Glasgow. Communicated by Dr. Turner, F.R.S.

This paper, which forms the sequel to the one on the same subject which was read at the preceding meeting, continues the inquiry into the combinations of phosphoric acid with different bases, and more particularly with soda. The crystallized salt of phosphate of soda was found to contain 37·1 of the phosphate, and 62·9 of water; so that the author infers its composition to be three atoms base, namely, two of soda and one of water. The pyrophosphate of soda, on the other hand, contains only two atoms soda as base, and gives accordingly bibasic precipitates. The biphosphate of soda was found to admit of so great a number of changes in its composition and properties, as to render it an object of great interest. Of the four atoms of water which the crystals contain, they lose two atoms at the temperature of 212°, and not a particle more till the heat is raised to about 375°. There is every reason to believe that the two atoms of water retained are essential to the constitution of the biphosphate of soda; and that it contains three atoms of base, namely, one atom soda to two atoms water, united to a double atom of phosphoric acid. Other varieties of this salt are also met with; the first of which may be called a bi-pyrophosphate, containing only one atom of basic water; the second being anhydrous, though soluble in water, and neutral in its reaction on litmus, but of which the exact composition is not well determined; the third being an insoluble variety; and a fourth being a metaphosphate of soda,—the author designating, by the term Metaphosphoric acid, a peculiar hypothetical state of composition of the elements of phosphoric acid in conjunction with water. This new acid enters into combination with barytes and with lime, forming with these bases other metaphosphates. The author concludes by a general review of the several modifications of phosphoric acid which have resulted from these inquiries.

7. "On the Development of the Disturbing Function upon which depend the Inequalities of the Motions of the Planets, caused by their Mutual Attraction." By James Ivory, Esq., K.H., M.A., F.R.S.

The progress of physical astronomy has been retarded by the excessive labour requisite for the arithmetical computation of the inequalities in the motions of the planets, arising from the perturbations produced by their mutual attractions. If an inequality depended solely on the quantity of the coefficient of its argument in the expanded algebraic function, the difficulty of computation would not be great, since, from the smallness of the elements on which it depends, namely, the eccentricities and the inclinations of the orbits to the ecliptic, the resulting series decreases, in every case, with great rapidity: but as its magnitude depends also upon the length of its period, the coefficient of its argument will, when this period embraces many years, acquire, in the process of integration, a high multiplier, and comes thus to have a sensible effect on the place of the planet. Such is the origin of some of the most remarkable of the planetary inequalities, and, in particular, of the great equations in the mean motions of Jupiter and Saturn. It is necessary, therefore, that the astronomer be furnished with the means of computing any term in the expansion of the disturbing function below the sixth order; since it has been found that there are inequalities depending upon terms of the fifth order, which have a sensible effect on the motions of some of the planets. The object of the author in the present paper is to give the function such a form that the astronomer may have it in his power to select any inequality he may wish to examine, and to compute the coefficient of its argument by an arithmetical process of moderate length. The investigation comprehends every argument not passing the fifth order; but as the formulæ are regular, the method may be extended indefinitely to any order.

8. "On the Reflex Function of the Medulla Oblongata and Spinalis, or the principle of Tone in the Muscular System." By Marshall Hall, M.D., F.R.S. L. & E.

9. "Experimental Researches in Electricity.—Fifth Series." By Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain.

The object of the author in this paper is to investigate the nature of electro-chemical decomposition. From the consideration of the circumstances of difference that mark the electricities obtained from the common electrical machine, and from the voltaic battery, and of which he had already established the theory in preceding papers, he was led to expect that the employment of the former in effecting chemical decomposition would exhibit some new conditions of that action, evolve new series of the internal arrangements and changes of the substance under decomposition, and perhaps give efficient powers over matter as yet undecomposed. For the purpose of greater distinctness, he divides the inquiry into three heads. In the first, he treats of some new conditions of electro-chemical decomposition, and shows that that effect does not depend upon the simultaneous action of two metallic plates, since a single pole might be used to effect decomposition; in which case one or other of the elements liberated passes to that pole, and the other element to the other extremity of the apparatus, the air itself acting as a pole. In the second, he considers the influence of water in electro-chemical decomposition; and he combats the opinion that the presence of that fluid is essential to the process as erroneous, and shows that water is merely one of a very numerous class of bodies, by means of which the electric influence is conducted and decomposition effected. In the third, he enters at large into the investigation of the theory of electro-chemical decomposition; and after discussing at some length the various theories of different writers on this curious subject, he is led to consider the effect in question as produced by an internal corpuscular action, exerted according to the direction of the electrical current, and as being the result of a force either superadded or giving direction to the ordinary chemical affinity of the bodies present; that is, modifying the affinities in the particles through which the current is passing, so that they act with greater force in one direction than in another, and consequently cause them to travel, by a series of successive decompositions and recompositions, in opposite directions, so as to be finally disengaged at the boundaries of the decomposing body. Various experiments are detailed in corroboration of these views, which appear to explain, in a satisfactory manner, all the prominent features of electro-chemical decomposition.

10. "The Anatomy and Physiology of the Liver." By Francis Kiernan, Esq., M.R.C.S. Communicated by J. H. Green, Esq., F.R.S.

The Society then adjourned over the Long Vacation to the 21st of November.

---

## PHILOSOPHICAL SOCIETY OF CAMBRIDGE.

A Meeting of the Cambridge Philosophical Society was held on Monday, November 11, the President of Queen's College (the Vice-Chancellor) being in the chair. A communication was read by Mr. Murphy, being a "Second Memoir on the Inverse Method of Definite Integrals."

The principal object of Mr. Murphy's present memoir is to afford the means of recurring from $\phi(x)$ to $f(t)$ when the definite integral of the latter function, multiplied by $t^x$ and taken from $t=0$ to $t=1$, is expressed by the former. When $f(t)$ is any of the functions ordinarily adopted in analysis, $\phi(x)$ converges to zero as $x$ increases indefinitely. Mr. Murphy's former memoir was confined to this case. In the investigation of the properties of $f(t)$, when $\phi(x) = 0$, the author proves that the former function vanishes an indefinitely great number of times, and corresponds with such physical phænomena as are usually called latent. He next gives the theory of reciprocal functions, namely, of such functions, $L_n$, $\lambda_m$, (generally, but not necessarily, of different species,) that the integral single or double, &c., of the product may vanish between limits when $n$ and $m$ are unequal integers: Laplace's functions are a particular instance of this reciprocity.

The author, in the last section of his memoir, has applied the theory of reciprocal functions to the problem of recurring from $\phi(x)$ to $f(t)$, whatever be the form of the given function; and also to the expansion of any function $\phi(x)$ in negative powers of $x$, and other forms which vanish when $x$ is taken very great.

Professor Airy gave an account of deductions founded on the observations of the Auroræ Boreales of September 17 and October 12. They related principally to the elevation of the upper part of the luminous arch above the earth's surface. For the former he used observations made by himself at Cambridge, by Mr. Phillips at York, and by an unknown observer at Manchester; for the latter he relied on his own observations at Cambridge, those of Mr. Phillips at York, those of Messrs. Potter, Clare and Hadleigh at Manchester, those of an unknown correspondent of the *Durham*

*Advertiser* at Guisborough, those of Professor Sedgwick at Dent near Kendal, and those of Dr. Robinson at Armagh. The apparent position of the arch was defined by all the observers with considerable precision (especially in the aurora of October 12), by the manner in which it passed between different stars; and several important identifications were established by the accuracy with which the time had been noted, especially at York and at Cambridge, where the watches with which the observations were made had been immediately corrected by comparison with transit-clocks. These established beyond doubt the identity, and consequently the greatness of distance of the arch which had been observed at these distant stations; at the same time the Professor expressed his conviction that the streamers in the aurora of September 17 were connected with the clouds visible at Cambridge. The method by which the elevation of the luminous arches was obtained was entirely graphical. A map of the places of observation was made; through one of these a line was drawn in the direction of the magnetic meridian; ordinates from the different places were drawn perpendicular to this line, and the observations were then treated as if they had been made at the foot of the ordinate instead of the actual place of observation. For the determination of the distance, &c., of the arch, a projection of the places of observation and the direction of the visual rays on the vertical plane passing through the magnetic meridian, was constructed. The direction of the visual rays had been determined from the observations, by the use of a celestial globe: in the projection of the magnetic meridian, the earth's sphericity was taken into account. The general conclusion was that the two arches were nearly of the same height, (that of September 17 being probably rather the higher,) and that the height was less than sixty miles, but probably more than fifty; and that its situation was but a few miles to the north of Armagh. Different combinations gave results slightly discordant; the observations at Guisborough generally gave the altitude of the arch greater than was consistent with the others; the observations at Armagh could not easily be reconciled with those made at other places, either for the elevation or for the general appearance of the phænomena; but this did not appear surprising when it was considered that the arch there passed near the zenith, and that the part of the arch seen there had at Cambridge a very confused appearance. It seemed that the arch had approached rapidly from an unknown distance, and had afterwards remained nearly stationary. Its motion (from its apparently stationary character at Cambridge,) seemed to be not parallel to the earth's surface, but inclined downwards, perhaps 15°. The Professor remarked that the elevation must depend principally (among the observations here collected,) upon those made at Cambridge. Fort he lower edge of the arch, which was at one time extremely well defined at Cambridge, he could find no satisfactory corresponding observations. He then alluded to a beam or permanent streamer which was seen at the same time at Cambridge and at York, and remained visible at both places for about half an hour, with very small change of position. At Cambridge it was seen about a degree south of the Pleiades, directed to a point three or four degrees south of α Cygni, and therefore north of α Arietis: at York it was seen four degrees south of the Pleiades and south of α Arietis, passing between α Arietis and Jupiter. On tracing these directions on a celestial globe, it appeared that they both met the horizon at a point about twenty-six degrees north of the east; and the Professor's conclusion was that this was a horizontal arch seen according to the rules of perspective in these different positions at York and Cambridge. If so, it was probably seen as an arch in some country to the east or north-east of us. At Brussels, the only place from which any account had been received, the weather was cloudy. The principal arch was seen to become double at the same time at Cambridge and at York; and the undulations or pulsations of light commenced at the same time at both places. The Professor pointed out as a phænomenon probably of great importance in reasoning on the physical cause of these flashes, and which he had verified with care in this and in a previous instance, that the successive flashes always illuminated the same portions of the heavens, the light passing in the order of *upwards* over these portions.

This communication was followed by oral remarks from several of the members present.

## LXXIII. *Reviews, and Notices respecting New Books.*

### *The Analysis of Inorganic Bodies. By* J. J. Berzelius. *Translated from the French Edition by* G. O. Rees.

THE fame of Berzelius with respect to all that is practical in chemistry, and especially in analysis, is fixed upon too firm a basis to need any commendation. Mr. Rees, in translating this work on analysis, has performed a useful task for those who are unacquainted with the language of the original or with the French.

This treatise forms a part of Berzelius's large work on Chemistry, and is contained in the eighth volume of the French translation lately completed. In the original it appears to have been in the second volume, and not the twelfth, as Mr. Rees has by mistake translated *deuxième*, from the French editor's advertisement.

The notes which Mr. Rees has added, though not numerous, will in general be found useful, and we especially approve of his preference of Dr. Christison's method of detecting arsenic to that of Berzelius (p. 117.).

The translation, which we have in many parts compared with the French original, is in general correct, and the faults which we have noticed mostly arise from an attempt to be almost literal; thus in page 3, "*qu'on souffle soi-même*," is rendered by "*self-blown*," which does not express the intended meaning.

Again, in page 37, *note*, Mr. Rees says "In all cases the oxide must be dissolved after calcination, in order to be sure that it does not contain sulphuric acid." Now from this it might be supposed that the mere operation of solution would in some way determine the question; the French editor's words are, however, "*Et s'assurer s'il ne renferme point de l'acide sulfurique;*" that is, by a subsequent, although not named, operation. In p. 30, *note*, a gramme is stated to be equal to nineteen grains English, instead of 15·406; and in the following page, first line, one grain is stated instead of one gramme.

These, however, are not very important mistakes. When a second edition is called for, Mr. Rees will of course refer to the French translation of Berzelius, in which he will find that new matter has been added to the section on analysis; and he would greatly enhance the value of his translation by giving a list of atomic weights, so that the pupil might estimate the products of his analysis without the necessity of referring to other works.

## LXXIV. *Intelligence and Miscellaneous Articles.*

### THE SCIAGRAPHICON.

SEVERAL applications of scientific knowledge to the united purposes of the amusement and instruction of young persons, or to that of domestic use, which have been produced by Mr. Alfred Essex, have already been noticed in our pages. He has now requested our opinion of a kind of instrument, which, by taking advantage of certain principles in perspective, and known means of deceiving the sense of sight when the other senses are not employed to correct its impressions, is intended as much to amuse the youthful mind by the perfection with which it deceives, as it is calculated to inform it by demonstrating the fallacy of mere visual perception. The Sciagraphicon is an *Anamorphosis*, representing a Castle, distorted by the elongation and gradual expansion consequent on the ordinary form of that mode of projection, but which, on being viewed from the proper point of sight, determined by a well-constructed eyepiece, appears erect "in all its fair proportions," and that with a semblance of solidity, which no exertion of the sight alone could possibly detect to be unreal. This instrument is in all respects well designed and well executed, and in a manner not unworthy of the existing state of science and of the arts of drawing and lithography: a brief explanation, however, of the principles of perspective according to which the figure is described, and also of the laws of vision which are concerned in the deception, would in our judgement greatly augment the value of the Sciagraphicon, by furnishing the means of rendering permanently profitable the interest in the sciences of perspective and optics which it is so well adapted to excite.

### SOLANIA, ATROPIA, DATURIA, &c.

The family of the *Solana* particularly merits the attention of chemists, on account of the still uncertain nature of the principles to which it is reasonable to conclude that their marked action upon the animal œconomy is owing.

Solania, discovered by M. Desfosses, is one of the best known of the alkaline substances occurring in the *Solana*. It is a white pearly powder, insoluble in cold, scarcely soluble in boiling water, and fusible at 212° Fahr. When decomposed by heat, it yields products which contain no azote: it restores the blue colour of litmus which has been reddened by an acid, and forms with acids perfectly neutral but uncrystallizable salts.

Solania was discovered by M. Desfosses in the ripe berries of the *Solanum nigrum*, and also in the leaves and stocks of the *S. Dulcamara*. M. Morin met with it in the fruit of the *Solanum mammosum*, and MM. Payen and Chevallier, in that of the *Solanum verbascifolium*.

Atropia was extracted from the Belladonna by Brandes, but several chemists in France have been unable to procure it; and thus Berzelius, in his *Traité de Chimie* (tome vi. p. 271,) states, that its existence is still questionable. The same may be said of Daturia and Hyoscyama. Nicotia, the latest announced alkali of the *Solana*, is an almost colourless liquid, very manifestly alkaline, miscible with water in all proportions, and soluble in alcohol and æther: it is very acrid and volatile. This principle is obtained by the distillation of a decoction of tobacco, previously mixed with sulphuric acid, and then, on the addition of an alkali, the nicotia is set at liberty. This process is similar to that employed by Vauquelin to obtain the acrid principle of the bark of the *Garou*. It will be remembered also that he supposed Daphnia to be probably a mixture or compound of ammonia with an acrid but not alkaline principle.—*Journal de Chimie Médicale*, Feb. 1833.

### IMPREGNATIONS OF THE ATMOSPHERE NEAR THE SEA.

M. Roubaudi observes, that M. Vogel of Munich is the only chemist, as far as he knows, who has made any experiments on the atmosphere of the ocean. His experiments made on the Baltic prove,

1st, That the atmosphere of this sea contains less carbonic acid than that of the land, and that it is probable the carbonic acid diminishes proportionally to the distance from the continent.

2nd, That the atmosphere of the Baltic contains muriates in variable proportions.—*Journal de Pharmacie*, Septième année, p. 461.

M. Fodéré (*Voyage aux Alpes Maritimes*, tome ii. p. 256.) has observed, that the air of the Mediterranean disagrees with persons affected with pulmonary diseases, on account, as he supposes, of the presence of muriatic salts, or even muriatic acid, or one of its elements, developed by electro-chemical agency.

M. Roubaudi made several experiments in order to determine whether the atmosphere of the coasts contained either free or combined muriatic acid, and whether either of them existed in the atmosphere at some distance from the coast. In order to determine the first question, he suspended, some feet in the air and at a few paces distant from the sea, during calm weather, a large glass balloon filled with a freezing mixture of snow and sulphuric acid. The atmospheric vapour which condensed on the outside of the balloon, produced a colourless inodorous liquid, which suffered no change by keeping six months. Neither the nitrate of silver, protonitrate of mercury, muriate of barytes, nor oxalate of ammonia, caused any change in it. It appeared to be perfectly similar to distilled water. Lime and barytes water were the only reagents with which this liquor became slightly cloudy, and after standing some hours they occasioned a slight deposit, soluble in nitric acid. The same apparatus, placed at the same distance from the sea when it was rough, condensed a liquor, which produced, with the following reagents, the annexed effects :

1. Nitrate of silver. An opalescent tint, which, on standing some hours, formed a light precipitate, possessing the characters of chloride of silver.

2. Protonitrate of mercury. White flocks which precipitated to the bottom of the vessel.

3. Barytes and lime-water. Turbidness, and eventually a precipitate soluble in nitric acid.

4. Litmus-paper. No change of tint.

5. Muriate and nitrate of barytes, ammonia, solution of potash, subacetate of lead, oxalic acid, and oxalate of ammonia, produced no appreciable effect.

During a calm season, but when the sea was rough, the fluid obtained by means of the same balloon, at the distance of about 50 feet, gave no precipitates with the fore-mentioned reagents; but when the wind blew from the sea towards the balloon, the liquid gave more or less of precipitates with them.

The same experiment was repeated on the sea, during a calm period. The balloon was suspended four feet from the surface, in a vessel at one hundred paces from the shore. The condensed liquor evaporated to one third of its bulk, produced no effect upon the above-mentioned reagents.

M. Roubaudi then, with some variation in the mode of making the experiment, attempted to determine the extent to which the saline particles of the sea are carried from the shore ; and from various experiments he concluded:

1st. That the air on the sea-shore, and over the sea, contains neither muriatic acid nor muriates.

2nd. That when the sea is rough, and especially when the wind is violent, particles of sea-water, in a state of great tenuity, float in the air, especially on the shore where the waves break ; and that these particles are carried to greater or less distances according to the violence of the wind and the degree to which the sea is agitated.

3rd. That without attempting to determine the distance with great precision, it may be admitted, that at Nice, where the south wind is seldom violent, the saline particles are rarely carried more than 100 paces inland.—*Journal de Pharmacie*, Nov. 1833.

## HYDROGRAPHIC PAPER.

M. Chevallier has examined a paper lately introduced, which may be written on with a pen dipt in water. He found that it was prepared by soaking the sheets of paper in a solution of sulphate of iron, drying, and then covering them with finely powdered galls. M. Chevallier states that similar papers may be prepared by using other solutions and powders ;—thus blue is probably prepared by powdering the paper soaked in sulphate of iron with ferrocyanate of potash.—*Journal de Chimie Médicale.*

### CRYSTALLIZED PERNITRATE OF IRON.

M. Houton Labillardière procured the above salt, but neither the process by which it was obtained, its composition, nor its crystalline form is mentioned. M. Robiquet obtained crystallized chloride of iron by dissolving iron in muriatic acid: the crystals were octohedrons.—*Ibid.*

### DEATH OF EDWARD COLLINS GIDDY, ESQ.

We record with much regret the decease of our much valued correspondent Mr. Giddy, which took place, somewhat suddenly, although he had been for some time unwell, at his residence, Chapel-Street, Penzance, on the 5th of November. Mr. Giddy was by the father's side cousin of Davies Gilbert, Esq., D.C.L., late President of the Royal Society; and in addition to an extensive medical practice, had for many years been Curator of the Cornwall Geological Society's Museum, and had just retired from the office of Secretary to the same Society. He was until the last known to our readers as a valuable and constant contributor to our meteorological columns, and his "Observations on the Climate of Penzance *," had been continued for nearly 30 years. We in common with an extensive circle of friends and acquaintance, shall experience a loss which we fear we shall be ill able to supply.

### LUNAR OCCULTATIONS FOR DECEMBER.

*Occultations of Fixed Stars by the Moon, visible at Greenwich in the Year* 1833. *Computed by* Thomas Maclear, *Esq.; and circulated by the Astronomical Society.*

*** The *angles* are reckoned *from* the northernmost point, and also *from* the vertex, *towards* the right hand, round the circumference of the Moon's image, as exhibited in an inverting telescope.

An Asterisk (*) annexed to the time of the phænomenon is intended to denote that the Star is *on*, or *near to*, the meridian, at that time.

| 1833. | Stars' Names. | Magnitude. | Ast. Soc. Cat. No. | Immersions. | | | | Emersions. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Angle from | | | | Angle from | |
| | | | | Sidereal time. | Mean time. | North Pole. | Vertex. | Sidereal time. | Mean time. | North Pole. | Vertex. |
| | | | | h m | h m | ° | ° | h m | h m | ° | ° |
| Dec.13 | (159) Sagit. | 7 | 2282 | 20 9 | 2 41 | 83 | 89 | 21 26 | 3 57 | 291 | 306 |
| 14 | (146) *f* Cap. | 6 | 2406 | 20 34 | 3 2 | 82 | 93 | 21 46 | 4 14 | 308 | 328 |
| 21 | (225) Ceti. | 7 | 214 | 23 54 | 5 53 | 65 | 49 | 0 38 | 6 37 | 357 | 353 |
| 24 | 68 δ³ Tauri | 5 | 499 | 22 0 | 3 48 | 68 | 29 | 22 42 | 4 30 | 330 | 289 |
| 26 | 13 μ Gemin. | 3 | 790 | 23 17 | 4 57 | 156 | 118 | 23 44 | 5 24 | 228 | 188 |
| 27 | (179) Gemi. | 7 | 945 | 7*31 | 13 6 | 108 | 115 | 8 38 | 14 13 | 238 | 261 |
| 28 | 33 η Cancri | 6 | 1037 | 2 4 | 7 36 | 25 | 344 | 2 31 | 8 3 | 327 | 285 |
| 31 | 3 ν Virginis | 4·5 | 1371 | 12 27 | 17 46 | 103 | 117 | 13 19 | 18 38 | 197 | 220 |

---

* Phil. Mag. and Annals, N.S. vol. iii. p. 173.

## *Meteorological Observations made by Mr.* THOMPSON *at the Garden of the Horticultural Society at Chiswick, near London; by Mr.* R. HOCKING *at Penzance, and Mr.* VEALL *at Boston.*

| Days of Month, 1833. | Barometer. | | | | | Thermometer. | | | | | Wind. | | | Rain. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | London. | | Penzance. | | Boston | London. | | Penzance. | | Bost. | Lond. | Penz. | Bost. | Lond. | Penz. | Bost. |
| | Max. | Min. | Max. | Min. | $8\frac{1}{2}$ A.M. | Max. | Min. | Max. | Min. | $8\frac{1}{2}$ A.M. | | | | | | |
| Oct. 1 | 30·287 | 30·273 | 30·190 | 30·116 | 29·70 | 62 | 40 | 60 | 48 | 49 | S. | SE. | calm | ... | ... | ... |
| 2 | 30·232 | 30·160 | 30·196 | 30·060 | 29·67 | 63 | 40 | 61 | 46 | 49 | NE. | SE. | calm | ... | ... | ... |
| 3 | 30·092 | 30·053 | 30·016 | 30·010 | 29·42 | 60 | 39 | 59 | 48 | 56 | SW. | SE. | calm | ... | ... | ... |
| 4 | 30·146 | 30·130 | 30·016 | 30·010 | 29·54 | 62 | 38 | 63 | 50 | 56·5 | NE. | SE. | calm | ... | ... | ... |
| 5 | 30·138 | 30·114 | 30·116 | 30·110 | 29·56 | 61 | 39 | 57 | 47 | 58 | NE. | NE. | E. | ... | ... | ... |
| ☾ 6 | 30·150 | 30·119 | 30·119 | 30·116 | 29·56 | 64 | 40 | 59 | 47 | 57 | E. | N. | calm | ... | ... | ... |
| 7 | 30·156 | 30·104 | 30·119 | 30·116 | 29·47 | 60 | 40 | 60 | 46 | 48·5 | NE. | SE. | calm | ... | ... | ... |
| 8 | 30·056 | 29·993 | 30·019 | 30·016 | 29·55 | 64 | 41 | 58 | 46 | 49 | E. | N. | calm | ... | ... | ... |
| 9 | 30·257 | 30·140 | 30·119 | 30·116 | 29·24 | 60 | 43 | 57 | 49 | 45 | NE. | NE. | calm | ... | ... | ... |
| 10 | 30·239 | 30·111 | 30·119 | 30·016 | 29·49 | 64 | 33 | 60 | 47 | 46 | E. | E. | calm | ... | ... | ... |
| 11 | 30·017 | 29·962 | 29·966 | 29·966 | 29·34 | 65 | 40 | 57 | 48 | 50·5 | SW. | W. | W. | 0·01 | ... | ... |
| 12 | 30·002 | 29·901 | 29·996 | 29·969 | 29·50 | 61 | 33 | 60 | 47 | 45 | W. | SW. | calm | ·20 | ... | ... |
| ● 13 | 30·130 | 29·860 | 30·019 | 29·916 | 29·55 | 60 | 48 | 60 | 47 | 43 | S. | W. | calm | ·10 | 0·390 | 0·10 |
| 14 | 29·539 | 29·402 | 29·619 | 29·519 | 28·91 | 60 | 45 | 58 | 52 | 59 | SW. | SW. | W. | ·50 | ·280 | ·16 |
| 15 | 29·236 | 29·058 | 29·222 | 29·204 | 28·60 | 57 | 39 | 52 | 45 | 49 | SW. | NW. | W. | ·06 | ·240 | ... |
| 16 | 29·413 | 29·205 | 29·654 | 29·419 | 28·74 | 52 | 41 | 56 | 46 | 40 | NW. | NW. | calm | ·10 | ·050 | ·18 |
| 17 | 29·764 | 29·571 | 29·904 | 29·869 | 29·01 | 54 | 37 | 53 | 46 | 49 | NW. | N. | N. | ... | ... | ·04 |
| 18 | 29·613 | 29·436 | 29·719 | 29·704 | 29·20 | 52 | 37 | 56 | 47 | 46·5 | W. | NW. | calm | ·13 | ·160 | ·37 |
| 19 | 29·463 | 29·410 | 29·619 | 29·504 | 28·91 | 56 | 29 | 53 | 45 | 46 | W. | NW. | calm | .. | ·090 | ... |
| ☽ 20 | 29·817 | 29·576 | 29·716 | 29·710 | 29·10 | 57 | 38 | 54 | 45 | 41 | NW. | W. | calm | ·03 | ·480 | ·07 |
| 21 | 29·706 | 29·588 | 29·666 | 29·560 | 29·06 | 61 | 53 | 58 | 48 | 55·5 | S. | SW. | W. | ·33 | ·190 | ·01 |
| 22 | 29·683 | 29·646 | 29·607 | 29·607 | 28·90 | 65 | 51 | 57 | 50 | 55 | SW. | SW. | W. | ·66 | ·130 | ·32 |
| 23 | 29·753 | 29·436 | 29·604 | 29·416 | 28·85 | 59 | 40 | 58 | 50 | 52 | S. | SW. | calm | ... | ·200 | ·40 |
| 24 | 29·697 | 29·528 | 29·416 | 29·304 | 29·16 | 68 | 46 | 60 | 45 | 45 | S. | SW. | E. | ... | ·150 | ·40 |
| 25 | 29·474 | 29·343 | 29·166 | 29·154 | 28·94 | 67 | 49 | 59 | 48 | 54 | SE. | SW. | calm | ... | ·200 | ... |
| 26 | 29·623 | 29·513 | 29·404 | 29·310 | 29·03 | 66 | 39 | 56 | 50 | 55 | S. | SE. | S. | ·01 | ·135 | ... |
| 27 | 29·940 | 29·813 | 29·516 | 29·504 | 29·36 | 61 | 49 | 58 | 48 | 52·5 | E. | SE. | calm | ·17 | ·070 | ... |
| ○ 28 | 29·769 | 29·743 | 29·510 | 29·504 | 29·28 | 62 | 47 | 60 | 51 | 55 | E. | SE. | E. | ·01 | ... | ·10 |
| 29 | 29·876 | 29·719 | 29·530 | 29·524 | 29·24 | 67 | 38 | 60 | 52 | 55 | S. | SE. | calm | ... | ... | ... |
| 30 | 30·048 | 30·000 | 29·984 | 29·910 | 29·45 | 67 | 42 | 61 | 52 | 50 | N. | NE. | calm | ... | ... | ·08 |
| 31 | 30·066 | 30·026 | 29·990 | 29·964 | 29·45 | 62 | 40 | 61 | 50 | 51 | SW. | N. | calm | ·06 | ... | ... |
| | 30·287 | 29·058 | 29·818 | 29·749 | 29·25 | 68 | 29 | 57 | 49 | 50·4 | | | | 2·37 | 3·765 | 2·23 |

Remarks.

*London.*—October 1, 2. Dense fog: fine. 3. Foggy: light haze. 4. Foggy: very fine. 5. Fine: cloudy. 6, 7. Fine. 8. Dense fog. 9. Overcast: cloudy: clear at night. 10. Fine. 11, 12. Dense fog: overcast: fine. 13. Clear: overcast 14. Rain and strong wind. 15. Fine: heavy rain at night. 16. Cold rain: fine: showery. 17. Cloudy. 18. Overcast: rain. 19. Very damp: clear. 20. Frosty: fine. 21. Windy, with showers: stormy and wet at night. 22. Cold and raw: rain at night. 23. Stormy, with rain: strong gale: overcast and fine. 24, 25. Fine. 26. Very fine. 27. Fine: slight showers. 28. Hazy. 29. Foggy: fine. 30. Dense fog: very fine. 31. Foggy.

*Penzance.*—October 1. Clear. 2. Clear: fair. 3. Clear. 4. Fair. 5. Clear. 6. Fair 7—9. Clear. 10. Fair. 11. Rain: fair. 12. Rain: misty: fair. 13, 14. Fair: rain at night. 15. Showers: hail and rain. 16. Fair: showers. 17. Fair. 18. Showers: fair. 19. Showers: fair: hail and rain. 20. Fair: rain. 21. Rain throughout. 22. Fair: evening, rain. 23, 24. Rain: fair. 25. Fair: rain. 26, 27. Fair: showers. 28, 29. Misty. 30, 31. Fair.

*Boston.*— October 1. Cloudy. 2, 3. Fine. 4—6. Cloudy. 7. Foggy. 8. Fine. 9—11. Cloudy. 12. Fine: rain P.M. 13. Fine. 14. Cloudy: rain early A.M. 15. Fine: rain P.M. 16. Cloudy. 17. Stormy: rain early A.M.: rain P.M. 18. Cloudy. 19. Fine: rain P.M. 20. Fine. 21, 22. Cloudy: rain early A.M. 23. Rain. 24. Cloudy. 25—27. Fine. 28. Cloudy: rain early A.M. 29. Fine: rain P.M. 30, 31. Foggy.

# INDEX TO VOL. III.

END OF THE THIRD VOLUME.

PRINTED BY RICHARD TAYLOR, RED LION COURT, FLEET STREET.
1833.