PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY,

FOR THE YEAR 1841-2.

PART VI.

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PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1840. No. 25.

November 9.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The President read a letter from the Secretary of State for the Home Department, informing him that her Majesty had been pleased to receive very graciously the address of the President, Council, and Members of the Royal Irish Academy, congratulating her Majesty on the recent providential deliverance of herself and her illustrious Consort.

The decease of the Very Rev. the Dean of St. Patrick's, V.P., having been announced to the Academy, it was resolved—

That we have heard with deep regret of the death of our valued Vice-President, the Dean of St. Patrick's; and that while we sympathize with all classes of our fellow-citizens, in lamenting the removal of one so universally beloved and esteemed, we would desire to record our sense of the peculiar loss sustained by the Academy, in being deprived of the assistance of one who could estimate the value of our Institution, and give to it his most cordial cooperation; one who found leisure from the multifarious duties of his station, to cultivate successfully the researches connected with the antiquities of Ireland, and had earned for himself a high place among those who labour to illustrate her ancient records, or to save from destruction the perishing relics of her former civilization.

Samuel Ferguson, Esq., was elected to the vacant place in the Council; and the Rev. J. H. Todd, D.D., was appointed by the President, under his hand and seal, to succeed the Dean of St. Patrick's in the office of Vice-President.

The Rev. T. R. Robinson, D.D., M.R.I.A., gave the Academy an account of a large reflecting telescope, lately constructed by Lord Oxmantown, and of the processes employed in forming its specula.

After explaining the relative importance of magnifying and illuminating power, Dr. R. proceeded to give a brief sketch of the history of the reflecting telescope, which seemed to have been forgotten for many years after its invention, till it was revived by Hadley. The labours of Short soon gave it celebrity; yet even this artist limited himself in almost every instance to sizes which were not more powerful than the achromatics of his day, and his large instruments appear to have been failures.* It was not till a full century after the publication of Newton's paper, that Sir William Herschel gave this telescope the gigantic development which has crowned him with imperishable fame; and by the construction of telescopes of nineteen

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* A Newtonian of six feet focus, and 9·4 inches aperture, is said by Maskelyne to have shewn the first satellite of Jupiter 13″ longer than a *triple* achromatic of 3·6 inches aperture. The telescope of twelve feet focus, and eighteen inches aperture, now at Oxford, shewed multiple rings of Saturn.

and forty-eight inches aperture, placed regions almost beyond the scope of measurement within the reach of human intellect. But as Short, in a spirit unworthy of his talents, took care that his knowledge should die with himself, and Herschel published nothing of the means to which his success was owing, the construction of a large reflector is still as much as ever a perilous adventure, in which each individual must grope his way. Accordingly, the London opticians themselves do not like to attempt a mirror even of nine inches diameter, and demand a price for it which shews the uncertainty and difficulty of its execution. In Ireland we are more fortunate, for a member of our Academy, Mr. Grubb, finds no difficulty in making them of admirable quality up to this size, or even fifteen inches; but with all his distinguished mechanical talent, he is believed to be doubtful of the possibility of more than doubling this last magnitude in perfect speculum metal.

Under these circumstances, too much praise cannot be given to Lord Oxmantown, who, in the midst of other pursuits, has found leisure for such researches; and by a rare combination of optical science, chemical knowlege, and practical mechanics, has given us the power of overcoming the difficulties which arrested our predecessors, and of carrying to an extent which even Herschel himself did not venture to contemplate, the illuminating power of this telescope, along with a sharpness of definition scarcely inferior to that of the achromatic.

The chief difficulties which are to be overcome in the construction of reflectors, arise from the excessive brittleness of the composition of which specula are made, and from the necessity of giving them figures which shall be free from aberration. The great mirror in the Newtonian form is (if the eyepiece and plane mirror be correct) the conical paraboloid.

It is necessary that speculum metal should possess, in the highest attainable degree, the qualities of whiteness, brilliancy, and resistance to tarnish. Lord Oxmantown has found that these conditions are best satisfied in the *definite* combinations of four equivalents of copper to one of tin; or by weight, 32 and 14·7 nearly. Metals differing from this by a slight excess of either component, are, when first polished, scarcely less brilliant, but are dimmed so rapidly that the lapse of a few days produces a sensible difference. On the other hand, some large specula of the atomic compound have been lying uncovered for years, without material injury to their polish.

But this compound is brittle almost beyond belief; a slight blow, or even the application of partial warmth, will shiver a large mass of it; though harder than steel, its surface is broken up with the utmost facility, and it has a most energetic tendency to crystallize. The common process of the founder fails with it, except for masses of very limited magnitude, as the cast cracks in the mould, and the subsequent difficulties of the annealing are such, that it has been a very general practice to use an alloy lower (containing more copper) than the atomic standard. Even Sir William Herschel was obliged to yield to this necessity. It appears from a letter of Smeaton, (Rees' Cyclopædia, Art. Telescope,) that for his 20 feet mirror of 19 inches aperture, the composition was 32 copper to 12·4 tin; and that for the 40 feet it was even lower. Yet two out of three attempts to cast this huge speculum failed.

Lord Oxmantown at first endeavoured to evade the difficulty, by constructing a speculum in pieces, soldering plates of fine metal to a back of a peculiar brass, ascertained to have the same expansion; and has completed one of thirty-six inches aperture and twenty-seven feet focal length, which performs very well on stars below the fifth magnitude, but above that exhibits a cross formed by the diffraction at the joints; and in unsteady states of the air exhibits the sixteen divisions of the great mirror on the star's disk. By diminishing the number and size of the joints it is found, that these inconveniences can be diminished, so as to be scarcely perceptible; and in all probability this is the process by which the remotest limits of telescopic vision will ultimately be attained. It is, however, not necessary for instruments of even greater dimensions than this, since Lord Oxmantown has succeeded, by a contrivance as simple as ingenious, in casting at the first attempt a *solid* mirror of the same size; and there is no reason to suppose that it will be less effective on a much larger scale.

But however difficult it may be to obtain the rough speculum of large dimensions, it is still more so to give it a proper figure, combined with that brilliant polish which is technically called black, because it reflects no light out of the plane of incidence. In such mirrors as can be wrought by hand, they are worked by short cross strokes on the polisher, and at the same time have a slow rotation relative to it. This might be expected to produce merely a spherical figure; but by varying the length of the stroke, by circular movement, elliptic figure of the polisher, or removing portions of its pitch covering, a parabolic figure is obtained. For sizes above nine inches diameter, the work must be performed by machinery; but in all which Dr. R. has seen, (the most remarkable of which are those of Sir William Herschel* and Mr. Grubb,) the cross stroke is given by a lever moved by hand; and it is supposed that perfect results cannot be obtained but by the *feeling* of the polisher's action. Sir John Herschel is believed to have made important

* Dr. R. had the good fortune to see this at Slough, in 1830, while at work on a twenty-feet mirror.

additions to his father's apparatus; and it is to be hoped he will soon redeem his promise (Mem. R. Ast. Soc. vol. vi.) of publishing his improvements.

Lord Oxmantown has in many respects deviated from the usual process. His polisher, of the mirror's diameter, intersected by transverse and circular grooves, into portions not exceeding half an inch of surface, is coated, first, with a thin layer of the common optical pitch, and then with a much harder compound. It is worked *on* the mirror, and counterpoised so that but little of its weight bears; but the want of pressure is compensated by a long and rapid stroke. The mirror revolves slowly in a cistern of water, maintained at a uniform temperature, to prevent the extrication of heat by friction. The polisher moves slowly in the same direction, while it is also impelled with two rectangular movements. The machine is driven by steam, and requires no superintendence, except to supply occasionally a little water to the polisher, and to watch when the polish is complete. By an induction from experiments on mirrors from six to thirty-six inches aperture it was found, that if the magnitudes of the transverse movements be $\frac{1}{3}$ and $\frac{9}{100}$ of the aperture, and their times be to its period of rotation as 1 and 1·8 to 37, the figure will be parabolic: but to combine with this the highest degree of lustre, it is found necessary to apply, towards the close, a solution of soap in liquid ammonia, which seems to exert a specific action.

The certainty of the process is such, that the solid mirror of thirty-six inches aperture, after being scratched all all over its surface with coarse putty, was, in Dr. R.'s presence, perfectly polished in about six hours, and was placed in its tube for examination, without any previous trial as to quality.

Lord Oxmantown has preferred the Newtonian to the Herschelian form, and, in Dr. R.'s opinion, with good reason. In the latter, the inclination of the great mirror to the incident rays must deform the image,* and it is now known, that even with faint objects sharp definition is of high importance. It should, in fact, be a segment of a paraboloid, exterior to the axis; and though a theorem of Sir William Hamilton (Trans. R. Irish Acad., vol. xv. p. 97,) might seem to indicate mechanical means of approximating to the figure, yet Dr. R. fears there would be greater difficulty in applying them than in enlarging the aperture of the Newtonian, so as to make up for the loss of light. Another serious objection is, that in the Herschelian the observer's position at the mouth of the tube, must cause currents of heated air, which will materially interfere with sharpness of definition.

As to the loss of light by the second reflexion, Dr. R. thinks it has been much overrated, and expresses a wish that a careful set of experiments were made on reflexion by plane specula at various incidences, on prisms of total reflexion, and the achromatic prism, proposed as a substitute by Sir David Brewster.

As to the rest of the instrument, it may suffice to say, that it bears a general resemblance to that of Ramage, but that the tube, gallery, and vertical axis of the stand are counterpoised, so that one man can easily work it, notwithstanding its enormous bulk. The specula, when not in use, are preserved from moisture or acid vapours, by connecting their boxes with chambers containing quicklime, which is occasionally renewed. This arrangement, (which also occurred to Dr. R., and has been for several years applied by

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* Any one who has a Newtonian telescope can verify this, by inclining a little the great mirror, so however as not to pass the edge of the plane mirror by the pencil. In Lord O.'s instrument, an inclination of 11′ sensibly injures it; were it Herschelian, the inclination must be 3° 11′.

him to the Armagh reflector,) appears to be very effective in preserving the polish.

In trying the performance of the telescope, Dr. R. had the advantage of the assistance of one of the most celebrated of British astronomers, Sir James South; but they were unfortunate in respect to weather, as the air was unsteady in almost every instance; the moonlight was also powerful on most of the nights when they were using it. After midnight, too, (when large reflectors act best,) the sky, in general, became overcast. The time was from October 29th to November 8th.

Both specula, the divided and the solid, seem exactly parabolic, there being no sensible difference in the focal adjustment of the eyepiece with the whole aperture of thirty-six inches, or one of twelve; in the former case there is more flutter, but apparently no difference in definition, and the eyepiece comes to its place of adjustment very sharply.

The solid speculum showed α Lyræ round and well defined, with powers up to 1000 inclusive, and at moments even with 1600; but the air was not fit for so high a power on any telescope. Rigel, two hours from the meridian, with 600, was round, the field quite dark, the companion separated by more than a diameter of the star from its light, and so brilliant that it would certainly be visible long before sunset.

ζ Orionis, well defined, with all the powers from 200 to 1000, with the latter a wide black separation between the stars; 32 Orionis and 31 Canis minoris were also well separated.

It is scarcely possible to preserve the necessary sobriety of language, in speaking of the moon's appearance with this instrument, which discovers a multitude of new objects at every point of its surface. Among these may be named a mountainous tract near Ptolemy, every ridge of which is dotted with extremely minute craters, and two black parallel stripes in the bottom of Aristarchus.

The Georgian was the only planet visible; its disc did not show any trace of a ring. As to its satellites, it is difficult to pronounce whether the luminous points seen near it are satellites or stars, without micrometer measures. On October 29, three such points were seen within a few seconds of the planet, which were not visible on November 5; but then two others were to be traced, one of which could not have been overlooked in the first instance, had it been in the same position. If these were satellites, as is not improbable, there would be no *great* difficulty in taking good measurement both of their distance and position.

There could be little doubt of the high illuminating power of such a telescope, yet an example or two may be desirable. Between ε^1 and ε^2 Lyræ, there are two faint stars, which Sir J. Herschel (Phil. Trans. 1824) calls "debilissima," and which seem to have been, at that time, the only set visible in the twenty-feet reflector. These, at the altitude of 18° were visible *without an eye-glass*, and also when the aperture was contracted to twelve inches. With an aperture of eighteen inches, power 600, they and two other stars (seen in Mr. Cooper's achromatic of 13·2 aperture, and the Armagh reflector of 15) are easily seen. With the whole aperture, a fifth is visible, which Dr. R. had not before noticed. Nov. 5th, strong moonlight.

In the nebula of Orion, the fifth star of the trapezium is easily seen with either speculum, even when the aperture is contracted to eighteen inches. The divided speculum will not shew the sixth with the whole aperture, on account of that sort of disintegration of large stars already noticed, but does, in favourable moments, when contracted to eighteen inches. With the solid mirror and whole aperture, it stands out conspicuously under all the powers up to 1000, and even with eighteen inches is not likely to be overlooked.

Comparatively little attention was paid to nebulæ and clusters, from the moonlight, and the superior importance of ascertaining the telescope's defining power. Of the few examined were 13 Messier, in which the central mass of stars was more distinctly separated, and the stars themselves larger than had been anticipated; the great nebula of Orion and that of Andromeda shewed no appearance of resolution, but the small nebula near the latter is clearly resolvable. This is also the case with the ring nebula of Lyra; indeed, Dr. R. thought it was resolved at its minor axis; the fainter nebulous matter which fills it is irregularly distributed, having several stripes or wisps in it, and there are four stars near it, besides the one figured by Sir John Herschel, in his catalogue of nebulæ. It is also worthy of notice, that this nebula, instead of that regular outline which he has there given it, is fringed with appendages, branching out into the surrounding space, like those of 13 Messier, and in particular, having prolongations brighter than the others in the direction of the major axis, longer than the ring's breadth. A still greater difference is found in 1 Messier, described by Sir John Herschel, as "a barely resolvable cluster," and drawn, fig. 81, with a fair elliptic boundary. This telescope, however, shews the stars, as in his figure 89, and some more plainly, while the general outline, besides being irregular and fringed with appendages, has a deep bifurcation to the south.

From these and some other discrepancies, Dr. R. thinks it of great importance that the globular nebulæ and clusters should be all carefully reviewed, as it is chiefly from their supposed regularity that the hypothesis of the condensation of nebulous matter into suns and planets has arisen, an hypothesis which he thinks has, in some instances, been carried to an unwarrantable extent.

On the whole, he is of opinion that this is the most powerful telescope that has ever been constructed. So little has been published respecting the performance of Sir W. Herschel's forty-foot telescope, that it is not easy to institute a comparison with *that,* the only one that can fairly be made to compete with it. But there are two facts on record which lead to the inference that it was deficient in defining power; one, the low power used, which Dr. R. thinks was not above 370; the other, the circumstance that neither the fifth nor sixth stars of the trapezium of the nebula of Orion were shewn by it. As to light, there is no reason to believe that the composition of the forty-foot mirror was as reflective as that of the twenty-foot; and if Dr. R. be correct in the opinion, that the latter* did not shew the fifth star easily, or the sixth at all, and that it only exhibited the "debilissima" and one star near the ring-nebula, then *it* has decidedly less illuminating power than eighteen, perhaps not more than fourteen inches aperture of Lord Oxmantown's mirror, notwithstanding the loss of light in that by the reflexion at the second speculum.

However, any question about this optical pre-eminence is likely soon to be decided, for Lord Oxmantown is about to construct a telescope of unequalled dimensions. He intends it to be six feet aperture, and fifty feet focus, mounted in the meridian, but with a range of about half an hour on each side of it. If he succeeds in giving it the same degree of perfection as that which he has attained in the present instance, which is exceedingly probable, it will be, indeed, a proud achievement; his character is an assurance that it will be devoted, in the most unreserved manner, to the service of astronomy, while the energy that could accomplish

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* In its original state, not as improved by the more perfect means latterly employed by Sir John Herschel.

such a triumph, and the liberality that has placed his discoveries in this difficult art within reach of all, may justly be reckoned among the highest distinctions of Ireland.

DONATIONS.

Eleven Quern Stones of different Kinds.

Eight Methers of different Sizes and Patterns.

A round wooden Goblet.

An ancient Horn Vessel. Presented by Captain Portlock, M.R.I.A.

An ancient Spur found in the Grave-yard at Ferns. Presented by Stephen Radcliffe, Esq., per Haliday Bruce, Esq., M.R.I.A.

A Papal Bulla, found near the Foundation of the Cathedral of Cloyne, (*Clemens PP. IIII.*) Presented by R. J. Graves, M.D.

Fisica di Corpi ponderabili. 2 vols. 8vo. By the Chevalier Amadeo Avogadro. Presented by the Author.

Third Annual Report of the Proceedings of the Botanical Society of Edinburgh. Presented by the Society.

Sixth Report of the Poor Law Commissioners in Ireland. Presented by George Nicholls, Esq.

Ancient Laws and Institutes of England. Presented by the Commissioners of the Public Records of the Kingdom.

A Geological Map of England and Wales. By G. B. Greenough, Esq. Presented by the Geological Society.

Transactions of the Geological Society of London. Vol. V. (1840.) Presented by the Society.

Quarterly Journal of the Statistical Society of London. July, 1840. Presented by the Society.

Address of the General Secretaries of the British Association. Presented by the Authors.

Journal of the Franklin Institute. Vol. XXV. (1840.) Presented by the Institute.

Transactions of the Royal Society of Gottingen, from 1828 *to* 1831. Vol. VII. Presented by the Society.

Proceedings of the American Philosophical Society, to July, 1840. (No. 12.) Presented by the Society.

Directions for using Philosophical Apparatus. By E. M. Clarke, Esq. Presented by the Author.

Manuscript Notices relating to the Cathedral of St. Patrick, Armagh. By John Davidson, Esq., M.R.I.A. Presented by the Author.

Ordnance Survey of the King's County. In 49 Sheets, including Title and Index. Also,

Ordnance Survey of Carlow. In 28 Sheets, including Title and Index. Presented by His Excellency the Lord Lieutenant.

November 30, (Stated Meeting.)

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Dr. Kane read a Paper "On the Production of Audible Sounds," of which the following is an abstract.

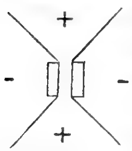
The sensation of sound is produced upon the ear by the tympanum being thrown into vibratory motion, isochronous with the vibrations transmitted from the sounding body.

Any body which vibrates as a single mass gives origin at the same moment to two waves, whose motions are in opposite directions, and of which one is rarefied and the other condensed.

If these two arrive at the tympanum at the same moment and with equal power, perfect neutralization should result, and no sound be heard: hence, where a vibratory body produces upon the ear the sensation of sound, it arises from one wave of the two being either totally intercepted or, at least, diminished in force, and the loudness of the sound is proportional to the difference of the intensity of the two waves when they affect the ear.

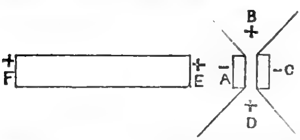
All instruments for increasing sound, and producing resonance, act upon this principle.

The following facts will illustrate these principles in detail.

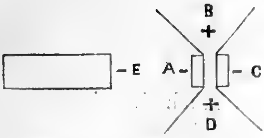


A tuning fork is a centre of four waves, two + and two —, but unless it be very close to the ear, no sound is heard from it; because the centre of all the four waves being very close, all act on the ear with equal force, and the difference is 0, (approximatively.)

Now, if an open tube, of the same length as a one-phase wave from the fork, be approached to one centre, as A, in the adjoining figure, the air in it commences to vibrate in unison with the fork, from being set in motion by the first wave which passes into it: the vibration of the tube is, however, a phase behind that of the fork, and hence, when a — wave passes from the centre A, it meets a + wave from the end of the tube E, and both are destroyed. The — centre, C, destroys also a + centre, as D, and there remain only the centres of + waves, B from the fork, and F from the tube, and these acting in concert on the tympanum produce the sound that we hear.

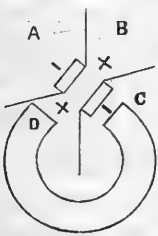


If the tube be closed, and of only one-half the length, the + wave, which emanates from the centre A, passes in, and being reflected from the bottom, issues again at the moment when the next — wave from A is about to enter; E and A then destroy each other, and C and D also interfering, there results only the + wave B, which acts unimpeded on

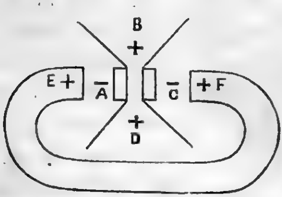


the ear. The sound of an open tube is, therefore, *ceteris paribus*, much stronger than that of a closed tube, as there are two waves in place of one.

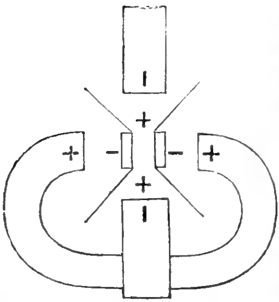
That the office of closed tubes, when resonant, is to destroy a portion of the sound of the original vibrating body, and of the open tubes to afford, in addition to that, a new centre of a wave of the same phase as that which remains, may be exhibited in many ways. Thus, Mr. Adams shewed long since, that when two closed tubes are placed at right angles to each other, they interfere when made to speak to a tuning fork, and for this effect no explanation has hitherto been given. But it is evident that the tubes being at right angles to each other, the waves destroyed are in opposite phases, and those which remain are in opposite phases also, so that the effect is the same as if no tubes were present at all.



The same effect may be produced by a single tube, bent so that its apertures may be at right angles to each other; the — and + waves, D and C, meeting in the tube, produce neutralization, and the waves A and B, also + and —, which remain, interfere also, and hence no sound results. In an open tube bent into a circle, as in the figure, the two waves destroyed (A C) are of the same phase, and also those which remain, (B D,) and hence, such a tube sounds with nearly double the power of an ordinary open tube.

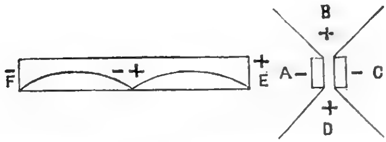


That it is the sound of the waves which do not go into the tube, and not that of the waves in the tube, we hear, may be shewn by applying two closed tubes, as in the next figure. When the two — waves are absorbed



by the circular open tube, each closed tube absorbes a + wave, and hence, notwithstanding that there is so much vibrating material, no sound is heard. But if the tubes A and B were open, then the vibrating centres should have been simply transferred to their farther extremities, and the tubes would emit sound as the fork had done without them in the preceding figure.

If the open tube be double the length of a phase, then



the neutralization occurs as in the figure, the residual waves being B and F, in opposite phases; but as their centres are separated so far, they interfere only in hyperboloidal planes, which are not detected unless when carefully sought for, but have been noticed to exist by Savart, although he did not suspect their cause.

All these principles have received very full verification from an instrument constructed for the purpose, and termed a *Chorizophone*. It consists of a square glass plate, which is placed above a set of closed tubes of such size, that when the plate vibrates in four pieces, with diagonal nodal lines, the length of each tube is half the length of the phase of the wave produced, and their form is triangular, of the magnitude of one of the four vibrating portions of the plate; when one of these tubes is presented to the plate, and this brought to vibrate by a violin bow applied to the centre of one of the sides, the tube resounds, and more loudly in proportion as the plate is brought nearer to its orifice. Now here the entire wave from the plate is caught by the tube, and the more perfectly its escape into the air is prevented, the louder is the sound produced, the sound must arise therefore from the waves which do not pass into the tube. Any one or more waves may thus be absorbed by the closed tubes, and a range of loudness of sound produced from the same plate with one or more of the four tubes, according as they are disposed as follows:

The vibrating plate gives eight waves, four above and four below, 4 being + and 4 minus.

With one tube, one wave is absorbed, and 3 + and 3 − destroying each other, a wave remains opposite in phase to that which is absorbed, and produces an audible sound.

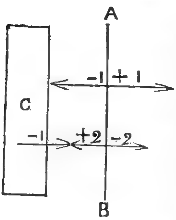
With two tubes, the waves absorbed may be either of opposite or of the same phases. If opposite, then, the remaining waves are 3 + and 3 −, and no sound is produced; but if the waves absorbed be of the same phase as +, then there remains 4 − and 2 +, and hence the ear is doubly affected by 2 −. The two tubes may be either both above or both below, or one above and one below the plate.

With three tubes, the absorbed waves may be either all of the same phase, or two of one and one of the other. In the first instance, 3 + being absorbed, there remains 4 − and 1 −, and the ear receives the impulse of 3 −. In the other case 2 + and 1 − being absorbed, there remains 2 + and 3 − and the impulse on the ear is only 1 −. The position of the tubes may vary in this as in the former case.

With four tubes, the absorption may be either all of the same phase, or 2 + and 2 −. In the former case, the remaining waves will be either 4 + or 4 −, in which case the greatest sound the plate can produce is heard, or else there remain 2 + and 2 −, in which case the plate gives no sound. These results prove fully that it is the residual sound that is heard, and not that which passes into the tube.

A vibrating plate gives some sound always, even without the tubes, for since there are at least eight waves, some one will always be more favourably disposed for acting on the ear than another, this difference will increase with the number of waves; and hence, the independent sound of a plate increases in proportion as the vibrating portions into which it divides, become more numerous.

A string vibrating in free space, produces little or no sound; but if it be strung over, or in connexion with, an elastic board or box, a great resonance is produced. This arises from two sources; first, the string when by itself is the centre of two waves excessively close, and the action of which is therefore interfering. But if the string AB, vibrate near a plane surface C, the wave -1, which passes towards it is reflected back, and meeting the wave $+2$, which follows, it neutralizes it partly, and enables the wave -2, to reach the ear without diminution. It is probable, however, that the great portion of the sound arises from the board or plate itself vibrating in parts, or as a whole. If



in parts, these parts are variously situated, as regards the ear, and hence produce an effect upon it. Or if, as a whole, the plate C is so broad, or bounded, if a box, that one wave is lost by internal reflexion, and only the wave emanating from the outer surface can arrive at the ear.

When a tuning fork is placed on a table, one wave is lost by internal transmission and reflexions, whilst that directed from the outer surface reaches to the ear.

In the case of reed instruments, the reed produces two waves, which, if it vibrated freely, should neutralize each other on the ear; but in practice whilst an open passage is allowed to one by the mouth-piece, the other wave is lost within the cavities of the lips and mouth. In mouth-piece instruments, as bugles and trumpets, the cavity of the mouth serves also for the absorption of the one wave, leaving the other free to act.

The following note, "On the Course of the diurnal Fluctuations of the Barometer," by James P. Espy. A.M., of Philadelphia, was communicated by Dr. Apjohn.

"It is a law of inertia, that if a body is forced upwards, it will react and press on its support, more than its natural gravity; and if it is permitted to descend, it will press on its support less than its natural gravity, and the increase and diminution of pressure will be proportional to its velocity.

"Moreover, if a body is permitted to descend with a certain velocity, and then retarded, it will, when retarded, press more on its support than its natural gravity, and that in proportion to the rapidity of its retardation.

"This principle will explain the four fluctuations of the barometer which occur every day.

"Just before sunrise, when the atmosphere is neither becoming hotter nor colder, the barometer will indicate the natural weight of the air, which we may call a mean; as the sun rises the air will begin to expand by heat, and the whole atmosphere will be lifted up by this expansion, and by its reaction will cause the barometer to rise; and this will be the greatest, at the time when the air is receiving the most rapid accessions of heat, which must take place before the hottest time of the day, when the air is becoming neither hotter nor colder. On this principle, then, the maximum day fluctuation will take place between daylight in the morning and the hottest time of the day, and this corresponds with the fact; for this maximum, which amounts to more than the tenth of an inch, takes place about nine or ten o'clock, A. M.

"At the hottest part of the day, when the air is neither expanding nor contracting, it is manifest that the barometer will stand again at a mean. Soon after this, however, the air will begin to contract from diminishing temperature, and at the moment of the most rapid acceleration of contraction, the barometer will stand at its day minimum, which will probably be late in the afternoon; and it is found in fact to be from four to five o'clock. From this time the rapidity of the downward motion of the air from contraction begins to diminish, and the barometer of course begins to rise; and at the moment when it is most rapidly retarded in its contraction, the barometer will be at its maximum night fluctuation, and will again be above the mean, but not so much as the day max.

"This max. is found to occur about ten or eleven o'clock, P. M. The air will now go on contracting more and more slowly, until about daylight, when it will be at rest, and the barometer will again be at a mean.

"This theory was given by me to the Journal of the Franklin Institute, and published ten or twelve years ago.

"I ventured in that paper to predict, notwithstanding some alleged observations at St. Bernard's Hospital to the contrary, that it would be found by more careful observations that the morning max. fluctuation would be greater in lofty situations on the sides of mountains, provided they were not very lofty, than on the plain below.

"For it is manifest, that there will be not only a reaction at these lofty situations, (a little less, it is true, than below,) but some of the air will be lifted up, by the expansion of the air below, above the upper place of observation; which would in all probability more than compensate the diminished reaction at moderate elevations.

"This prediction has been entirely verified by Lieutenant-Colonel Sykes's observations in India, and this verification may be considered as a strong proof of the correctness of the theory. It is quite probable, that max. day fluctuation occurs later at considerable elevations than on the plain below.

"The theory would lead us also to suppose, that at very *great elevations,* where the reaction is very minute, only two fluctuations would be found in the day: the maximum at about two o'clock, P. M., when most air would be above the barometer; and the minimum at daylight in the morning, when least air would be above it; but I know of no observations to confirm or refute these deductions."

Mr. Ball brought under the notice of the Academy the fact, that the ordinary sturgeon of the Dublin markets is an undescribed species. He stated that Mr. Thompson of Belfast, and Professor Agassiz, concurred with him in this opinion, and he proposed to call it *Accipenser Thompsoni,* purposing, if permitted, to give figures and full descriptions in a future number of the Proceedings.

A notice of an unpublished Irish coin of Edward IV. was read by A. Smith, M.D., M.R.I.A.

" Within the last month some workmen were employed in cleaning one of the city drains in the Cross Poddle, and a few coins were found. Among them was one of no intrinsic value, and apparently of no interest whatever. It is made of brass, and was originally plated with silver, traces of which still remain. On one side it has a crown within a circle of pellets, outside which, in place of a legend, are crosses and roses alternately; on the other side it has the common type—a cross, with three pellets in each quarter; the legend is defaced. It weighs nearly five grains, and is now in the cabinet of Lieutenant-Colonel Weld Hartstonge.

"This little coin bears no evidence in itself which would enable us to say to what king's reign it should be appropriated, or even to what country. But on referring to an Act passed in the second year of Edward IV., at a parliament held in Dublin, we find it enacted, ' that a coyne of copper mixed with silver, be made within the Castle of Dublin, having on one side the print of a cross, and on the other part a crown, of which four shall be taken for a penny; and that the said coyne shall have graven within the circumference of the said cross, the name of the place where it was made; and on the other part *suns and roses in the circumference of the said crowne.*'*

"It is to be regretted, that this little coin, the only one of the kind which has been found, is not in better preservation; but such as it is, it corresponds in every particular with the description in the Act; and, therefore, we do not hesitate to assert that it is one of the farthings of mixed metal ordered to be made in 1462.

"It may be objected, that this coin has crosses instead of suns round the crown, and it would be difficult indeed to give a more accurate symbol of the sun, in so many places, within so limited a space; but we should recollect, that similar crosses occur on some of the silver groats of Edward IV., coined in Dublin, in the beginning of his reign. On these groats, immediately over the crown, on the obverse, are placed three small crosses, which have usually been considered as privy marks.†

"Now taking for granted, that these crosses on the groats were intended to represent suns, as they evidently were on the farthing, we suspect we can account for them, not only as privy marks, indicating that the coins on which they are found belong to Edward IV., but also assign a probable reason why *three* only should appear.

"The sun was first introduced by Edward IV. upon the coins, 'in commemoration of an extraordinary appearance in the heavens, immediately before the battle of Mortimer's Cross, in Herefordshire, (in 1461,) where *three suns* were seen which shone for a time, and then were suddenly conjoined in one.'‡

"It matters little whether the extraordinary phenomenon

* Simon's Essay on Irish Coins, Appendix, No. VII.

† Simon, pl. 4, fig. 71.

‡ Ruding's Annals of the Coinage, vol. ii. p. 359, 2nd Edition, 8vo.

just alluded to be explained or not; it is sufficient for our purpose to know, that it gave rise to the introduction of the sun as a privy mark on the coins of Edward; and we may be permitted to hazard the conjecture, that the three crosses on his Irish groats, coined shortly after the battle of Mortimer's Cross, were intended to represent the *three suns.*

"We could refer to many instances in which dates and other matters were determined with certainty, by studying with attention minute particulars in the type of coins, concerning which the records were unsatisfactory, or altogether wanting; and there are still in existence authentic records of more than one Irish coinage, specimens of which have not yet been discovered; and within the last few years numerous coins, whose existence had not been suspected, have come to light, for the preservation of many of which we are indebted to the indefatigable zeal and research of a highly esteemed and deeply lamented individual, whose memory will long be regarded with respect and admiration, and the recollection of whose labours in preserving the proud memorials of our country, will, we trust, be perpetuated by depositing within these walls his collection of Irish antiquities, in accordance with his well known intention, and thus constituting a monument worthy of the late Dean of St. Patrick's."

The Archbishop of Dublin made some observations on a remarkable meteor, lately seen in different parts of Britain.

Resolved—That the Committee of Antiquities be requested to take immediate steps towards opening a subscription for the purchase of the collection of Irish antiquities which belonged to the late Dean of St. Patrick's.

DONATIONS.

Memoires de l'Academie Imperiale des Sciences de St. Petersbourg. Tome I.—XI.

Sciences Mathematiques, &c. Tome IV. 3rd and 4th Livraisons, and Tome IV. *Sciences Politiques, Histoire, &c.* 4th and 5th Livraisons.

Novi Commentarii Academiæ Scientiarum Imperialis Petropolitanæ. Tom. I.—XX.

Nova Acta Academiæ Scientiarum Imperialis Petropolitanæ. Tom. VI. VII. VIII. and XV.

Recueil des Actes de l'Académie Impériale des Sciences de St. Petersbourg. An. 1838 and 1839. Nos. 13 and 14. Presented by the Academy.

The Polytechnic Journal. Vol, III. Part 5. Presented by W. Farran, Esq.

Quarterly Journal of Statistical Society. Vol. III. Part 3. Oct. 1840. Presented by the Society.

An Inquiry into the Causes of popular Discontents in Ireland. By an Irish Gentleman. 1804. Presented by Joseph Hone, Esq.

Descriptive Catalogue of the Museum of the Royal College of Surgeons in Ireland. Vol. II. By John Houston, M.D., M. R. I. A., &c. Presented by the College of Surgeons.

On the Diminution of Temperature with Height of the Atmosphere.

Researches on Heat. Fourth Series.

Additional Experiments on terrestrial Magnetism in 1837. By James D. Forbes, Esq. Presented by the Author.

Memorie della Reale Academia delle Scienze di Torino. Second Series. Vol. II. Presented by the Academy.

Transactions of the American Philosophical Society. New Series. Vol. VII. Part 1. Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1840. No. 26.

December 14, 1840.

REV. J. H. TODD, D.D., Vice-President, in the Chair.

Dr. Apjohn read the following notice, by George J. Knox, Esq., of "some Improvements in the Voltaic Pile."

"The chief imperfection in the voltaic pile, its want of a constant uniform power of long duration, by which it is rendered almost useless as an instrument of research, having been overcome by the ability of Professor Daniell, the only thing that remained to render it efficient seemed to be, to increase its power; a desideratum accomplished by Mr. Grove, by substituting for copper and sulphate of copper, platinum and nitric acid. To give to Grove's battery a constancy of action equal to that of Professor Daniell's, would require an increase in the quantity of acids, (particularly the sulphuric,) into which the metals are immersed; but inasmuch as in galvanic batteries of the ordinary construction an increase of acid solution would require an increased distance of the metals from each other, producing a diminution of intensity, I endeavoured to obviate these disadvantages by the following contrivance. Porous vessels are fixed half an inch apart in lateral wooden supports, in which grooves are cut, to retain the zinc plates from touching; the porous vessels are filled with nitric acid, from a long glass tube, sealed at one end, and bent at the other at right angles. Along the side of the tube also holes are bored at distances corresponding to the distances of the porous vessels from each other; so that, upon pouring nitric acid into the tube, the vessels are all filled at the same moment; when filled, the entire apparatus is placed in a vessel containing sulphuric acid. The advantages of this arrangement were, that I had only two solutions to pour in, whatever number of alternations were employed; a sufficient supply of acid solutions to keep up a constant action for a length of time; and a distance between the plates scarcely exceeding the thickness of the porous vessel employed.

"The following experiments were undertaken with the intention of estimating the relative values of the different constructions of Grove's battery, recommended by Mr. Knight of Foster Lane, as far as respects the arrangement of the zinc and platina plates, when, to my surprise, I found the *same* quantity of electricity to be evolved when the zinc is bent so as to expose an opposing surface to *each* surface of a platinum plate, as when a platinum plate, of the size of the former zinc, is similarly placed with respect to a plate of zinc of the same size as the former platinum, affording an economical method of arranging a Wollaston's battery, the zincs being bent round the coppers, in place of the coppers round the zincs.

"*Experiments with Grove's Battery.*

"The acid solutions were those recommended by Mr. Grove, i. e. pure nitric acid, in contact with the platina; sulphuric acid + 4·5 water by measure, in contact with the zinc. The surfaces of zincs immersed were 3 by 2·5 inches; those of the platina, bent round the porous vessel holding the zincs, were 6 by 2·5 inches. The glasses containing the acid, &c., were 3·2 inches long, 1·5 broad, 3·5 deep. The length of the porous vessel of pipeclay was 2·5 inches, the breadth 0·3, the depth 3·5. The number of alternations was five.

		Cubic Inches.
Time, 2 minutes,	. . . .	8·0
The battery being at rest for 10 minutes,	. . . . .	8·0
,, ,, 25 ,,	. . . . .	3·0
,, ,, 1 hour,	. . . . .	1·0
,, ,, 19 hours,	. . . . .	none

"The porous vessel was found filled with sulphate of zinc, which stopped the action of the battery.

"*Second Experiment.*

"The zinc plates being of the same size as the former platina, and the platina of the same size as the former zincs, the zincs bent round the platina, all other things being as before.

		Cubic Inches.
Time, 2 minutes,	. . . .	8·
After 10 minutes,	. . . .	8·
,, 25 ,,	. . . .	8·

"*Third Experiment.*

"Another battery, the diameter of the cells of which was 2½ inches, gave a diminution of only *one-half* of the quantity of gas after the lapse of *forty-eight hours*, shewing the advantage of having a large supply of sulphuric acid.*

"*Experiments with Smee's Battery of Platinized Silver.*

"The acid solution was of the same strength as before, and the sizes of the zincs and platinized silver the same as

* "The porous vessels were of pipeclay. The same experiments repeated with unglazed porcelain gave 10 cubic inches in two minutes; with very porous pipeclay, they gave as much as 15 cubic inches in two minutes, shewing the importance of attending to the nature of the porous vessel employed."

of the zincs and platina formerly employed. The zincs were bent round the platina.*

	Cubic Inches.
Time, 2 minutes, ...	3·
After 5 minutes, ...	2·6

"*Second Experiment.*

"The zincs being raised out of the acid, cut in two, and re-immersed.

	Cubic Inches.
Time, 2 minutes, ...	1·6
After 5 minutes, ...	1·6

"*Third Experiment.*

"The zincs and platinized silver being removed, the acid remaining untouched; the platinized silver plates were bent round the zincs.

	Cubic Inches.
Time, 2 minutes, ...	2·6
After 5 minutes, ...	2·4

"*Fourth Experiment.*

"The platinized silver cut in two.

	Cubic Inches.
Time, 2 minutes, ...	1·4
After 5 minutes, ...	1·4

"Supposing from these experiments the same quantity of electricity to be developed, whichever of the opposed surfaces of the two metals be the greater, I placed in separate glasses five zinc cylinders, one-inch diameter, immerged

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* "The most advantageous method of arranging a Smee's battery is, packing the zincs and platinized silvers in the manner recommended by Dr. Faraday in his 10th series, (also by Mr. Young, Phil. Mag. vol. x. p. 241,) placing the package on supports so as to allow the sulphate of zinc to fall to the bottom of the vessel, while the fresh acid rises to the surface."

eight-tenths of an inch in the acid; platina foil, connected by binding screws with the zincs, was rolled into cylinders two-tenths of an inch in diameter, and then immersed in pipeclay tubes one inch deep.

	Cubic Inches.
Time, 2 minutes,	1·0
After 10 minutes,	1·0

"*Second Experiment.*

"Platina foil of the same size as the zincs, and zinc rods of the same diameter as the platina cylinders being employed, the effects were precisely the same.

	Cubic Inches.
Time, 2 minutes,	1·0
After 10 minutes,	1·0

"*Third Experiment.*

"The zinc cylinders being made twice the diameter of the former; the quantity of gas generated in two minutes was the same as before; the increased number of lines of electrical force compensating the increased resistance offered by the acid solution.

"*Fourth Experiment.*

"With cylinders twice the diameter of these, a very feeble current passed, the obstacle being too great to be overcome; by increasing the diameter of the porous vessels, and thereby of the nitric acid solution, which is a good conductor, the impediment is diminished, as shewn in experiment fifth. Thus Mr. Binks (Phil. Mag. vol. xi. p. 68) finds, that in dilute sulphuric acid, the size of the copper compared to a given surface of zinc, to produce a maximum effect, should be 16, that of the zinc to a given surface of copper being 7; while in a galvanic arrangement, in which the zinc is immersed in dilute sulphuric acid, inclosed in a membranous bag, and the copper in a surrounding solution of sulphate of copper, the proportion of zinc to copper was as one to eight, the impediment to the passage of the current being double in the latter case what it was in the former.

" *Fifth Experiment.*

" Five cylinders of zinc, 10 inches high, ½ diameter, were placed in glass vessels, containing sulphuric acid, as before. Into these were placed cylindrical earthenware vessels, 1½ inches diameter, containing pure nitric acid; slips of platina foil were rolled into cylinders as before.

	Cubic Inches.
Time, 2 minutes, ...	2·0
After 10 „	2·5
„ 30 „	3·0*

" From these data may be calculated the heights of the zinc pipes, and the weight of platina foil required to obtain any given decomposition, to be employed, as shewn by Jacobi, either as a motive power, or applied to light-houses, to the polariscope, or to the fusion of refractory substances. For the latter purposes, I had fixed to a strong, shallow woolf bottle, two tubes with glass cocks, and to them tubes containing chloride of calcium, applied to a Daniell's jet, playing upon a cylinder of lime, rotated by clock work. A third tube was inserted in the bottle, intended as a regulation of the pressure, or a safety valve, in case of explosion."

Dr. Apjohn then made a brief verbal communication on the subject of the Composition of Pyrope. This mineral, long

* "The dilute acid in the voltameter began to boil; the cause of the increase of decomposition, compared to what took place in the small cylinder, was the small stratum of sulphuric acid between the porous vessel and the zinc. For a continuous action the zinc pipes, sealed at one end and amalgamated, should be connected by pipes at top and bottom, with an earthenware vessel, containing the sulphuric acid."

confounded with garnet, is known to be distinguished from it by containing chrome, and by exhibiting, not the dodecahedral, but the hexahedral form. The best analyses of it, however, which are by Kobel and Wachtmiester, are obviously imperfect, of which no better proof can be given than that Gustavus Rose, in his Crystallography, does not attempt to give the formula of the mineral, but contents himself with enumerating the different oxides of which it is composed. Under these circumstances, Dr. Apjohn conceived that a re-examination of the constitution of pyrope would not be without interest. He, therefore, undertook its analysis; and the result has been that he has detected in it yttria, one of the rarest of the earths; one, in fact, which had previously been known to exist only in a few minerals of exceeding scarcity. The yttria was insulated in the following manner.

The mineral being fused with carbonate of potash, and the silex separated in the usual way, the peroxide of iron, alumina, and yttria were precipitated together by a mixed solution of ammonia and sal-ammoniac. The alumina was taken up by caustic potash; and to the iron and yttria, dissolved in a minimum of muriatic acid, such a quantity of tartaric acid was added, that upon subsequently pouring in ammonia in excess there was no precipitate produced. The iron was now removed by sulphuretted hydrogen; and the solution evaporated to dryness, and ignited in a large platinum crucible, so as to volatilize the ammoniacal salts, and burn away the carbon of the tartaric acid, left the *yttria* slightly coloured by oxide of chrome. From this latter substance it is separated, but not perfectly, by the action of a dilute acid, and by the addition of ammonia, or caustic potash, to the solution the yttria is again recovered. That the substance thus obtained is yttria seems proved by the following considerations.

It is separated, though not completely, from acids by ammonia largely diluted with sal-ammoniac, and hence cannot be one of the alkaline earths.

It is insoluble in potash, and is, therefore, not alumina or glucina. After ignition it dissolves readily in dilute acids, and is hence not zirconia or thorina. From zirconia it is further distinguished by its saline solutions, being precipitated by ferrocyanide of potassium.

It is not oxide of cerium, for it does not redden in the exterior flame of the blow-pipe, and because its salts are not precipitated by the sulphate of potash. The quantity of the yttria amounts to at least 3 per cent.

Dr. A. is still engaged in investigating the composition of pyrope; and expressed his intention of bringing his results on a future occasion in a more detailed form under the notice of the Academy, when he hoped also to be able to assign the true formula of the mineral.

Mr. J. Huband Smith exhibited to the Academy an ancient monastic seal, from an impression of which the annexed wood engraving is taken.

This seal has been for some time supposed to have been that of the Dean and Chapter of Lismore, and it was recently found among the effects of the late Rev. Sir George Bisshopp, formerly Dean of Lismore; but the legend around the seal shews this supposition to be totally groundless.

It reads thus: "SIGILLVM : CAPITVLI : PRIORIS : ET : CONVENTVS : DE : BVLLYNGIONA." It surrounds the figures of the Virgin and Child. She appears seated, and wearing a highly ornamented crown; her robe, which falls in gracefully arranged folds, displays no inconsiderable degree of skill and tastefulness of design. In her right hand is a star of five rays, intended possibly to represent the star of Bethlehem, to which the infant Saviour points. It is observable that his head displays the ecclesiastical tonsure. The seal is of a pointed oval form, and measures two inches and seven-eighths in length, and one inch and three-quarters in its greatest breadth.

It has been surmised, with considerable appearance of probability, that this seal (which, if an inference were drawn solely from the style of the characters, might be pretty confidently referred to the close of the fourteenth, or the beginning of the fifteenth century) belonged to a monastic establishment dedicated to the Virgin, as Archdall states, [*Monast. Hibern.* 626,] at Ballindown, on Lough Garagh, in the county of Sligo, of which but inconsiderable remains now exist. It is said to have been founded by M'Donogh, lord of Corran and Tirreril, A.D. 1427, for nuns of the order of Saint Dominick, about the very period to which the characters of the legend may be attributed.

Like other names of places in Ireland, that of Ballindown is variously written. In a tract entitled, "Valor beneficiorum ecclesiasticorum in Hiberniâ," we find "V. de Ballendowne in the "Diœcesis Tuamensis," of which the "Extenta et taxatio facta fuit, 28mo. Eliz." So that it seems highly probable that "Bullyngiona" may have been but an arbitrary Latinization of the same name by the artificer by whom the seal was made, possibly a monk of the religious house to which it belonged.

Mr. Clibborn made the following communication on the subject of the Leyden Jar.

"In Brand's Manual of Chemistry, vol. i., 3rd Edition, p. 76, I find it stated, that, 'if one Leyden jar be insulated, with its internal surface connected with the positive conductor, another jar may be charged from its exterior coating; and if this second jar be insulated, a third may be charged from its exterior coating, and so on for any number of jars, provided always that the exterior coating of the last jar be connected with the ground.'

"As my electrifying machine was but small, it occurred to me that I might economise both time and labour by constructing a battery of jars so arranged that I should be able to take advantage of this principle, and make one jar charge another, instead of my being obliged to charge the whole series; for, though they are all connected together, and charged by the same operation in the common electric battery, yet the time and labour consumed in charging the battery is exactly the same as if each jar were charged separately and then added to the series. A great saving of labour and time would have been effected had the arrangement of jars answered, for it was exactly the same as that described by Brand, so far as the charging part of the apparatus was concerned; but when the jars were loaded, or rather *should have been loaded,* they were made to turn through a quadrant, and form a new arrangement, by which all their outside coatings were connected together by a common conductor. A similar arrangement connected all their inside coatings, which made all the conditions necessary to the perfection of the common battery; and I found it capable of being charged by the electrifying machine in this form, but it could not be charged to any extent in the other. It appeared, that but few sparks would pass from the conductor to the first jar. If the last one was removed, and its chain fastened to the next, the first jar would take a few more sparks, and so on; for it was found that whenever the last jar in the series at any time was removed, the same results followed; and this was the case when the last but one was removed, clearly proving, that the capacity or aptitude of the first jar to take a charge was influenced and diminished by the second, more so by the third, fourth, &c. Its aptitude was greatest when it was by itself, and not connected, as described, with the others.

"This result disappointed my expectations, so far as my intended improvement on the electric battery was concerned; and it also appeared to point out the existence of a principle influencing the charge of the electric jar, which was not recognized in the popular treatises on electricity. I procured a number of glass plates with fixed and moveable coatings. These plates were insulated and arranged with and without coatings in every way that Brand's rule required, but the general result was the same as that given above.

"From numerous experiments made with these plates, I came to the following general conclusions:

"1. That the actual quantity of the positive and negative electricities which we can accumulate in the *opposite surfaces* of an electric or non-conductor, as a plate of glass or dry ice, depends upon the *distance* of these surfaces.

"2. Every case of charge of *one* jar or plate may be assimilated to that of any number of jars or plates in a series, such as Brand's, by supposing the one jar or plate to be divided into the greater number, its thickness being the *sum of the thicknesses of all the segments or plates.* The inside of the first jar or surface of first plate, in contact with conductor, and outside of last jar or plate in contact with the ground, being considered as the proper *opposite surfaces* of the proper plate, and those on which the electricities evolved by the friction of the cylinder and rubber of the electrifying machine are accumulated or heaped.

"If we make a pile of the plates coated or not, and charge the outside surfaces by coating them, and connecting one with the cylinder and the other with the rubber of the machine, we find all the conditions of the experiment complied with. There is no necessity for any connexion with the ground, which in Brand's can act merely as the conductor to convey the negative charge of the rubber to the extreme surface.

"Let us now unpack the pile, and we find that the charge of the intermediate plates diminishes, as we approximate towards the centre of the pile, being greatest near the extremes. At equal distances the charges are equal; for the charges of the first plate but one, and the last but one, will as perfectly neutralize each other as the charges of the surfaces of the first and last. The same is found to be the case with the surfaces of the third plates from each extreme, and so on of the others; but it is not the case with a second and a third, a first and a fourth plate, and so on, *no two unequals as to place* exactly neutralizing each other. Hence we may conclude, that the charge of the intermediate jars in a series, such as described by Brand, though it really depends on inductive agency, is altogether different from that kind he alludes to, which may be inferred from his erroneous representation of the actual fact; and the charge of the extreme surfaces is immediately the result of that action only, which several electricians have called conduction, arising from the connexion of these surfaces with the sources of the free electric forces.

"The fact here described appears capable of throwing much light on the corpuscular arrangement of the atoms of bodies, which retain an electric charge on their surfaces, or which, by a change of form from mechanical pressure or difference of temperature, exhibit differences of electric state. In speaking of a charged electric, we may consider it a pile of an infinite number of plates, each of which, except the extreme surfaces, is composed of a surface of atoms, which are acted on by two sets of induced electric forces, whose differences, arising from their distances from the extremes, we discover when we split the plate, or if it be a pile, when we separate the plates from each other."

January 11, 1841.

His Grace the ARCHBISHOP OF DUBLIN, V. P., in the Chair.

Rev. Henry Barry Knox, Rev. John West, Thomas Fortescue, Esq., M. P., Chichester Bolton, Esq., and Henry Coulson Beauchamp, M. D., were elected Members of the Academy.

The Rev. Thomas H. Porter, D.D., read a paper "On the Deposits of Gravel in the Neighbourhood of Dublin."

After detailing the facts commonly known as to the stratified beds and ridges of limestone gravel, lying over the great central limestone region of Ireland, and the continuance of deposits containing a large proportion of rounded pebbles and stones of the same material, over the granite and other primitive rocks to the eastward of the limestone country; it was argued that there were clear indications of a great diluvial action from west to east, by which the surface of the limestone was reduced to its present level, and the remains of its upper portions spread over the limestone region itself, and carried eastward to the sea. The occurrence of similar calcareous deposits in the seaward glens and valleys of the Dublin and Wicklow mountains for some miles south, and on their sides to a considerable height, was ascribed to the current of the same deluge, sweeping the transported substances over the lower parts of the mountain range, and then turning southwards along the sea coast, after passing the north flank of the mountains. Similar facts, but in an inverted order, from south to north, have been observed towards the southern flank, in the County Wexford.

It was urged, that the subsiding waters of this inundation, rushing down the valleys, and meeting below with the main current on the plains, would throw up those ridges along the sides of the hills, and on the flats beneath; of which a remarkable example is presented in the glen of Ballynascorney, (through which the Dodder descends from the Dublin mountains,) and in the gravel hills in front of that, from Tallaght to Crumlin.

The direction assumed in this paper for the diluvial current agrees remarkably with that assigned by Professor Phillips, as the cause of the distribution of the Shapfell boulders over the north-east of England. A conjecture was proposed as to the possible occasion of such a movement of water over the country. The limestone tract was evidently formed under the sea. Its elevation may have been connected with the last great convulsion, which determined nearly the present form of the surface. Great disturbances are seen at Killiney, the Scalp, &c., to have attended the appearance of the granite, and even to have followed that period, affecting the granite itself. Many parts of the Irish coasts present such abrupt terminations towards the sea, as to indicate either a violent raising of the island from a continuous tract at the bottom, or a sudden sinking of an extent of dry land around the present surface.

Either of these events would create immense commotions in the waters.

Reference was made, in the course of this argument, to the theory of Professor Agassiz, respecting the supposed evidence, that glaciers once existed in the mountains of this island, and produced, as *moraines*, some of the accumulations of mountain debris commonly attributed to the agency of water. This theory having been pushed so far by some eminent British geologists as to have almost every ridge of gravel and stones unhesitatingly called a *moraine*, it was urged, that their principle could not be applied here at least, since the limestone abounding in the deposits of the glens could never have been brought down by ice from mountains in which no limestone rocks exist. It is but justice to Professor Agassiz to state, that *he* did not ascribe the limestone gravel ridges at Ballynascorney to a glacier; but professed to find the traces of one higher up the course of the stream.

Against the glacier theory, in general, it was maintained, that evidences of a glacier having existed in any locality must be derived from the existing form of the ground; and that, therefore, no considerable change of the surface could be admitted, since the time when the moraines were imagined to have been thrown up. More especially, no *deluge* could have taken place since their formation; for in that case, the moraines must have been swept away. Hence they must be supposed to have existed between Noah's flood and the commencement of the historical periods. This interval, it was contended, would not allow time for their formation and disappearance.

A gradual change of the temperature of the whole northern hemisphere would be at variance with the fact established by geologists, that the heat of the earth's surface had been formerly much greater than now.

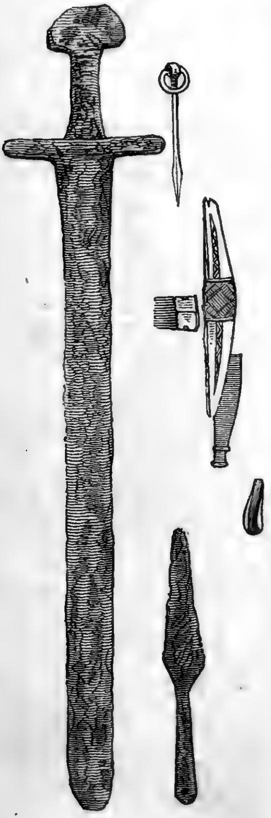
Had the degree of cold necessary for the formation of glaciers, been owing to a greater elevation of this entire country, its sinking to its present level must have been attended with convulsions and floods, which could scarcely have failed to obliterate all vestiges of moraines.

An objection, brought from the known change of temperature in Greenland within modern times, was met by observing, that Greenland in its best days was always a land of glaciers; in the extent of which it is easy to suppose an occasional increase or diminution.

Mr. J. Huband Smith gave an account of the discovery, in the month of November last, of a human skeleton, accompanied with weapons, ornaments, &c., interred on the sea shore, in the vicinity of Larne, in the county of Antrim.

He suggested, that a timely effort to preserve a record of such interesting discoveries, can hardly fail to rescue from destruction some valuable "scattered leaves belonging to the lost books of history."

The locality in which these remains were found is one of considerable historical interest; it was within less than a mile of Olderflete Castle, where it will be remembered that Edward Bruce landed with a considerable force for the invasion of this country, in the beginning of the fourteenth century. A very cursory inspection, however, suffices to shew that these weapons and ornaments could not have belonged to one of his followers, but must be referred to a period considerably more remote. They consist of a sword of very characteristic form, double edged, and rounded at the point; measuring two feet eight inches and nearly a quarter in its extreme length; a small portion, said to have been about six inches in length, was broken off and lost at the time of its discovery; the blade varies from two inches to two inches and a quarter in breadth;—the head of a lance (both this and the sword are of iron or steel, much corroded);—a small and very elegantly formed bronze pin, which measures five inches and a half in length, thickly encrusted with verd antique, and of the shape usually supposed to have been used in fastening the cloak or mantle;—and lastly, four fragments of bone; three of them being portions of a comb, the back of which (attached to the serrated part by rivets) is slightly but not untastefully carved on both sides; and the fourth is so minute and indistinct, as to render its original use and form uncertain.



The manner in which the skeleton was discovered was thus: some lime quarries having been lately opened along the shore, at a distance from the jetty, or wooden pier, at which small coasting vessels, trading between Larne and the opposite ports of Scotland, usually take in their cargoes, it became necessary, for the greater convenience of transporting limestone from the newly opened quarries, to construct a rail or tramway. In leveling the line marked out for the purposes of such construction, in the afternoon of the 7th of last November, the workmen discovered these remains at a spot three quarters of a mile distant from the town of Larne, about seventy yards from the sea shore, and about five feet above the level of high water mark. The skeleton, when uncovered, lay obliquely, the head pointing towards the N. W. The soil about it, consisting of sand, without almost any admixture of clay, may have, in the lapse of time, shifted its depth; but there scarcely appeared to have been more than from eighteen inches to two feet of sand or soil above these remains.

There was no appearance of stone kist, or hollow space formed by flags set edgeways, which appear to belong exclusively to the more ancient interments preceded by cremation; fragments of the skeleton alone being found in such, with indications of the action of fire, and usually accompanied by one or more cinerary urns. Yet although there was in the present instance no trace of coffin, either of stone or wood, there appeared no reason to doubt that the interment was effected in a regular and orderly manner. Across the breast was found the sword, its handle disposed towards the right hand. On the same side, but beneath the sword, was the lance head. The position of the remaining articles was not noticed at the time by the workmen, and therefore cannot now be ascertained.

Mr. Smith placed beside these weapons a sword and lance from his collection, selected from some found in the remarkable heap of bones in the townland of Lagore, near Dunshaughlin, in the County of Meath; a paper descriptive of which was read before the Academy by Doctor Wilde, on the 27th of April last. The straight shape and uniform breadth of the blade of this last mentioned sword, and the form of the lance head, appeared remarkably similar, though on a reduced scale, to those of the weapons found near Larne. The comb and bronze pin are nearly identical with several of those discovered at Dunshaughlin, where, it is observable, no brazen weapon of any description occurred.

From a consideration of all these circumstances, Mr. Smith ventured to express an opinion that the remains found at Larne, as well as those at Dunshaughlin, are to be referred to that remote period when the use of brass or bronze was superseded by iron and steel in the manufacture of offensive weapons, while it was yet retained in the lighter works of ornament. From the invariable shortness of the Dunshaughlin swords, he was disposed to infer, that the remains there discovered were of a period not far removed from the age of the bronze swords of similar length, still not unfrequently found in Ireland; while he suggested, that the articles to which the present paper referred might be considered as furnishing a closely following, though later link in the chain.

The sword bears no slight resemblance to one which has been engraved in Walker's Essay on the Costume and Arms of the Ancient Irish, and which, attributing it to the Knights Templars, he states to have been found about forty years before, near the site of the old priory of Kilmainham. It was accordingly objected, that the weapons found at Larne belonged to some one of that Order, and were therefore of a much later date than that assigned to them as above mentioned. In reply to this, Mr. Smith urged the remarkable circumstance of the bronze pin, of unquestionable antiquity, having been found in connexion with the sword, a fact of which he was able to give the most decisive assurance, upon the testimony of the overseer of the works, a person of strictest integrity, and who, not having any antiquarian predilections, could not be aware of the force or nature of the evidence he was furnishing. It was also to be recollected, that long antecedent to the establishment of the priory of Knights Templars by Richard Earl Strongbow, in 1174, a monastic institution had been founded there by St. Magnen, from whom Kilmainham (which in many ancient documents is written *Kilmaynan*) took its name so early as the sixth or seventh century of our era; and that the adjoining burial ground was used by the Irish, we learn from the Munster book of battles, attributed to Mac Liag, a poet who died in the year 1015, where it is recorded, that several of the chiefs who fell at the battle of Clontarf were interred at Kilmainham.

In the hall of the Commander of the Forces is suspended a sword of the same shape and character found in the old burial ground, vulgarly known by the name of "Bully's Acre," about forty years ago. In some adjacent fields, between the immediate grounds of the Royal Hospital and the brink of the river Liffey, about four years ago, some labourers, employed in raising gravel, discovered a skeleton, around which were disposed a variety of weapons and ornaments; they are now in the possession of the Commander of the Forces, and Mr. Smith had the advantage of inspecting them. They consist of a sword, lance head, and brass or bronze pin, all of precisely the same form and character as that now exhibited to the Academy. The total length of the sword is 3 feet 2 inches, the blade being 2 feet 8, and the handle 6 inches in length; the pin measures about 6 inches. There was also found along with these a hatchet head, and some fragments of iron, so much shattered and corroded as to occasion some difficulty in coming to the conclusion, which however may be just, that they once formed an iron skull cap. Common rumour asserts, that the labourer, by whom these remains were discovered, had also the good fortune to find with them some ornaments of gold of considerable value; which fact, for prudential reasons, he kept profoundly secret; but its effects became speedily apparent, in a well-stocked shop, which he soon afterwards opened in a village not ten miles distant from Dublin.

In the Memoirs of the French National Institute,* a memoir is given, furnished by M. Mongez, concerning a Gaulish sword, as he denominates one found in the bed of the river

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* Literature et Beaux Arts, tom. V.

Somme, near Abbeville. A comparison of his description, as well as of the engraving appended, shews this sword to have been nearly identical in form and size with those found in Ireland. This description, which applies in a remarkable manner to the sword exhibited to the Academy, is as follows:

"Sa lame et sa poignée ne font qu'un tout solidement affermi; elle a deux tranchans, et, loin d'être terminée en pointe, elle est obtuse et arrondie a son extremité. . . . . Il n'y manque que l'osier tressé, ou la corde, ou le bois, ou enfin la substance qui entouroit la soie pour former une poignée solide. . . . . La lame prolongée forme la soie sur laquelle est fixée la traverse de la poignée par le moyen de deux clous rivés; et la masse imparfaitement arrondie qui la ter mine est traversée et maintenue par cette même soie. . . . . Longueur totale, 33 pouces 10 lignes; lame seule, 28 pouces 10 lignes; poignée, 5 pouces; largeur de la lame a la poignée, 2 pouces 3 lignes."

If it be kept in recollection, that the French inch is somewhat greater than the English, these measurements will be seen to correspond surprisingly with those of the sword found at Larne. M. Mongez's paper exhibits great research and learning. He quotes passages at length, from Polybius, Plutarch's Life of Camillus, Dion Cassius, and Strabo, which describe with considerable minuteness the swords which the Gauls used in their engagements with the Romans; and he rests his argument not only on the identity he alleges of these descriptions with that of the sword found near Abbeville, but also on the fact of bronze and brazen ornaments having been found with skeletons having similar iron or steel weapons about them, discovered in 1788 at Velu, near Bapaume, in Artois. He adds, "Je puis donc assurer que l'épée qui est sous les yeux de la classe est l'épée gauloise décrite par les auteurs anciens. J'ajouterai que c'est la seule à ma connaissance qui soit conservée. On jugera d'apres cela combien elle est précieuse pour l'etude des costumes anciens."

Mr. Smith, in conclusion, drew the attention of the Academy to the circumstance that those and many other venerable and most interesting remains of remote antiquity, which are but rarely, and at distant intervals of time, discovered in Great Britain, and on the Continent, literally abound in Ireland; and hence inferred, the incalculable advantage which will be attained, in the study of the ancient history not only of this country but of the world, by the formation of a great National Museum of Irish Antiquities, such as is at present projected to be formed under the auspices of the Academy.

"Without claiming any undue importance for the pursuit of antiquarian research, it nevertheless has its office, and that by no means an ignoble one, as the handmaid of history—'Principatum non habet; ancillari debet.' It furnishes the critical student not only with curious information and the most valuable commentary on minute points, but summons up for him a host of most important witnesses, whom, though silent, he can subject to the most scrutinizing examination again and again; on whose testimony, carefully weighed as to its true value, history ever rests as on its securest basis."

The reading of a paper by the Rev. T. R. Robinson, D. D., "On the Constant of Refraction, determined by Observations with the Mural Circle of the Armagh Observatory," was commenced.

A paper by Dr. Andrews of Belfast, "on the Heat developed during the Combination of Acids and Bases," was read.

The general conclusions at which the author arrives are contained in the two following Laws.

Law 1. "The heat developed during the union of acids and bases is determined by the base, and not by the acid; the same base producing, when combined with an equivalent of different acids, nearly the same quantity of heat, but different bases a different quantity."

Law 2. " When a neutral is converted into an acid salt, no change of temperature occurs."

In the commencement of the paper a preliminary experiment is described, the object of which is, to determine the exact quantity of heat evolved during the combination of nitric acid and potash. The solutions, both acid and alkaline, were taken so weak in this and all the other experiments detailed in the communication, that subsequent dilution with water did not produce any change of temperature. On neutralizing the solution of caustic potash, containing 0·353 grammes of pure alcali, with nitric acid, the temperature of the resulting solution of nitrate of potash, whose weight amounted to 30 gr., was found (after all corrections had been made) to rise 6·75°,F.

To illustrate law first, the author adduces tables which shew, at a glance, the heat produced when an eqnivalent of each base is neutralized by different acids. Thus, when the same proportion of pure potash is combined under similar circumstances with the arsenic, phosphoric, nitric, boracic, hydrochloric, hydriodic, and oxalic acids, the elevations of temperature, indicated by the thermometer, vary only from 6·8° to 6·6°. Sulphuric acid produces rather a higher temperature than any other acid (7·3°), and the acetic, formic, tartaric, citric, and succinic acids, give rather less heat than those before mentioned (from 6·4° to 6·1°) In like manner, ammonia produces an increase of temperature varying from 5·7° to 5·5°, when neutralized by the nitric, hydrochloric, hydriodic, arsenic, oxalic, and acetic acids ; the greatest divergence from these numbers occurring, on the one hand, with the sulphuric acid (6·3°), and on the other, with the citric, tartaric, and succinic acids (5·1°). Analogous results are described as having been obtained with other bases, such as soda, barytes, magnesia, lime, and the oxides of zinc and lead. On the contrary, the heat developed by each base is peculiar to itself; and, consequently, the same acid gives different elevations of temperature, with equivalents of different bases. To take, as an example, the nitric acid, which also produces very nearly the mean quantity of heat given by all the acids, the following numbers express the increments of temperature obtained on combining the same quantity of it with each base: magnesia, 8·1°; lime, 7·2°; barytes, 6·9°; potash, 6·8°; soda, 6·5°; ammonia, 5·6°; oxide of zinc, 4·8°; oxide of lead, 4·2°; oxide of silver, 3·2°. The numbers for barytes, potash, soda, and ammonia, are strictly comparable with one another (except a slight correction for differences in the specific heats of the solutions;) but in the case of the other bases, an absorption of heat, unknown in amount, takes place in consequence of their conversion from the solid to the fluid state. Hence the numbers for these bases are all below the truth.

Two singular anomalies are described as occurring in the combinations of the peroxide of mercury with the hydracids, and in those of the hydrocyanic acid with the bases.

In confirmation of the second law the author adduces a series of experiments, which prove, that during the conversion of a neutral into a supersalt no heat is produced. Thus while the normal development of heat occurs when a solution of caustic potash is neutralized by oxalic acid, the subsequent additions, first of one, and afterwards of two more atoms of the same acid, so as to convert the neutral oxalate into the binoxalate, and the latter again into the quadroxalate of potash, is not accompanied by any change of temperature in the solutions. In testing the accuracy of this law, it is necessary to select examples where all the compounds are soluble in water, otherwise the heat arising from the formation of precipitates would interfere with and complicate the result.

The second law does not extend to the case of the conversion of neutral into basic compounds,—a part of the subject which the author has carefully investigated.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 27.

January 25, 1841.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The Rev. Dr. Todd, V.P., made some remarks on two large medallion busts, with Greek inscriptions, which are preserved in the Manuscript Room of the Library of Trinity College. These busts have been in the possession of the College for upwards of a century, but there is no record in the archives of the University stating how or from whom they were obtained. In the Appendix to the Preface of Gudius's *Inscriptiones Antiquæ*,* the editors of that work have given a list of inscriptions, which they state to have been furnished by Herman Van der Hoorst, Chaplain to the Dutch in Smyrna; and, in this list, the very busts now in Dublin are thus described, (No. XIII.):

"No. XIII. Smyrnæ in domo cujusdam Græci Zachariæ

* The full title of this work is as follows:—"Antiquæ Inscriptiones olim a Marquardo Gudio collectæ, nuper a Ioanne Koolio digestæ, hortatu consilioque Joannis Georgii Grœvii; nunc a Francisco Hesselio editæ, cum annotationibus eorum." Leovard. 1731. Fol.

nomine, duæ muliebres imagines sculptæ adfabre, et incorruptæ; altera cum hac inscriptione,

ΚΛΑΣ. ΛΥΣΙΜΑΧΗΝ ΤΗΝ ΦΙΛΑΝΔΡΟΝ
Ο ΘΡΕΨΑΣ ΘΗΛΥΜΙΤΡΗΣ

altera cum hac inscriptione

———— ΤΗΝ ΝΕΑΝ ΜΥΗΣΙΩΝ ΠΟΛΙΝ
———— ΤΙΑΣ ΑΤΤΙΚΟΣ."

Dr. Todd stated that he had met with a letter in the Bodleian Library, in which these busts are mentioned, and the interpretation of the inscriptions discussed. It is preserved in the valuable correspondence of Dr. Thomas Smith, who was Fellow of Magdalen College at the Revolution, and whose lot it was to have been twice deprived of his Fellowship by the opposite parties of that period; first, by King James II., when the attempt was made by that monarch to alter the constitution of the College; and secondly, by King William III., when Dr. Smith resigned his preferment rather than take the oath to the new dynasty. The letter is addressed by Dr. Smith to Dr. Narcissus Marsh, then Lord Primate of Ireland, who had been Principal of St. Alban Hall, Oxford, and subsequently Provost of Trinity College, Dublin. The portion of the letter which relates to the busts is as follows:—

"The two busts sent to Dublin from Legorne, I suppose came from Smyrna, or the country thereabout, where old monuments are continually discovered.

"The first erected to the honour (for so I will favourably interpret it) of Clodia Lysimache (who is styled there φίλανδρος, i. e. *viri sive mariti amans;* tho' oftentimes φίλανδρος γυνὴ is taken in an ill sense for a lascivious and incontinent woman) by one who bred her up and maintained her, viz., *Thelymitres,* if that be his proper name, which is not unlikely, tho' the appellative Θηλύμιτρος is used of an effeminate man abandoned to the excessive love of the other sex, and therefore explained by Suidas by the word πόρνος. But bee that as it will, hee was desirous to preserve the memory of his Θρεπτὴ or *Alumna* by this representation, as some of the Θρεπτῆρες or οἱ Θρέψαντες used to do frequently enough, as is evident from undoubted inscriptions.

"'Tis pity, that the other inscription is imperfect and erased. Stephanus Byzantinus, in his booke περὶ πόλεων, mentions Μῦης a city of Ionia, its ἐθνικὸν or *Gentilitium nomen* Μυήσιος, w^ch^ is the name in the inscription; but whether Myes bee here meant by νέα πόλις then newly erected into a city, or some other city built by the inhabitants of the former, forced to remove to a more convenient and healthier place, the defect in the beginning, owing to the injury of time after so many ages, will not suffer us to know now who it was that did honour to this *new city* by setting up this monument, who I suppose was a Greeke of Attica, and the word preceding it may be the name of the tribe or δῆμος to which hee belonged. If it be the same with Myûs, Μυοῦς, as is very likely, then it is certaine that it was a maritime city of Ionia, not farre from the river Mæander, w^ch^ I passed over in my travells to take a view of the once famous churches of Asia, on a rotten wooden bridge going thence, leaving Caria on the other side into Ionia, of w^c^ wee have several accounts given by Strabo, Pausanias, and Pliny, not to mention other authors both Greek and Latine. Pliny now lying upon my table I think fit to transcribe his words, *Nat. Histor. lib. v. cap.* 29—*Myûs, quod primo condidisse Iones narrantur, Athenis profecti.* But I do not pretend to write a commentary on these marbles, but leave that to be done by those learned men, who are in possession of them."

In a P. S. he adds:

"Reviewing those hasty notes upon the two Greek inscriptions, I began soone to doubt of my conjecture about Atticus, as if it had beene a patronymic, and the name of the tribe or δῆμος of Attica prefixed: but now I am prone to believe that this *Atticus* reckoned among the most famous orators of Greece, who flourished in the times of Hadrian and Antoninus Pius, and who had been sent upon several embassyes πρεσβεῖαι to Smyrna, and other free cityes of the lesser Asia, where hee presided with great honour, as appears from Philostratus in the life of Scopelianus, and was the father of *Herodes Atticus,* as hee is commonly called by the Roman writers, as if it were the name of the familye : whereas it should bee more properly *Herodes Attici,* viz., *filius,* as in the inscription on his monument at Athens preserved by Philostratus in his life.

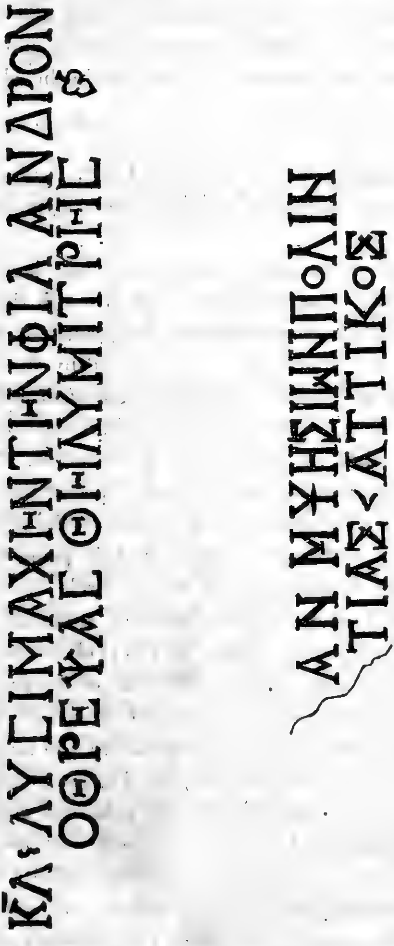
Ἀττικοῦ Ἡρώδης, Μαραθώνιος, οὗ τάδε πάντα
Κεῖται τῷδε τάφῳ, πάντοθεν εὐδόκιμος.

This Herodes succeeded his father in the same honours at home, and in the like governments abroad, and was magnificent in his buildings and public works, in Greece and Italy, having been preceptor to Marcus Aurelius in the studyes of oratory (of which he was universally esteemed a most celebrated Master) as Julius Capitolinus has observed in the life of that Emperour, and Consul A.U.C. 896. A. Ch. 143. But I thinke to the father, rather than the son, the Atticus in the inscription is to bee ascribed, and if so, how hee comes to bee called *Hippitias* or *Hippotias* if that bee his prenomen, and the right reading, or whether Hippatias, or whatever it should bee, bee the proper name of the person, who put up the monument, and Atticus of his country, I have not time nor leisure to enquire ; and in the whole am no way fond of my conjecture, w[ch] I look upon as altogether uncertaine."

"4 *Nov.* 1707."*

* Collect. Smith, vol. 58, p. 257.

The following are exact representations of the inscriptions reduced to one-fifth of the original size:



Dr. Todd stated that one of the busts appears to have suffered some injury since they were described by the editors of Gudius, and by Dr. Smith. The second inscription has lost some letters; instead of THN NEAN, the words with which its first line then commenced, the last two letters of these words only are now discernible. He also exhibited to the Academy fac-similes of the inscriptions, and made some remarks on the differences observable in the characters in which they are written.

The Rev. Charles Graves, F.T.C.D., read a paper On certain general Properties of the Cones of the Second Degree.

Let a sphere be described whose centre is at the vertex of a cone of the second degree, and through the vertex let two planes be drawn parallel to the planes of the circular sections of the cone; the curve formed by the intersection of the cone and sphere is called a *spherical conic*, and the two planes meet the surface of the sphere in two great circles which are called the cyclic arcs of the conic. These arcs, as M. Chasles has observed, possess properties relative to the conic exactly analogous to those of the asymptotes of a hyperbola. Moreover, many of their properties depend on the most elementary ones of the circle; but, as all the properties of cones, and therefore of spherical conics, are double, each theorem relative to the cyclic arcs furnishes a corresponding one relative to the foci of the supplementary conic, formed by the intersection of the sphere with a cone whose generatrices are perpendicular to the tangent planes of the cone on which the proposed conic is traced. And further, the theorems relating to spherical conics become applicable in general to the plane conic sections, by supposing the radius of the sphere to become infinite.

These considerations, for which we are indebted to M. Chasles, are calculated to direct the attention of geometers to the cyclic arcs of the spherical conics. In following this track, Mr. Graves has been led to many new and general properties of the cones of the second degree, amongst which the following deserve to be noticed:

1. If two fixed tangent arcs be drawn to a spherical conic, and any third tangent arc be drawn meeting them in two points, the arcs passing through these two points and through the pole of a cyclic arc will intercept on that cyclic arc a portion of a constant length.

2. If from two fixed points in a spherical conic, arcs be drawn to any third point on the curve, and produced to meet one of the director arcs, they will intercept between them on that director arc a portion which will subtend a constant angle at the corresponding focus.

3. A spherical conic and one of its cyclic arcs being given, if, round the pole of this cyclic arc, as vertex, a spherical angle of variable magnitude be made to turn, whose sides intercept between them on the cyclic arc a portion of a constant length, the arc joining the points in which the sides of the moveable angle meet the given conic will envelope a second spherical conic: the given cyclic arc will be a cyclic arc of the new conic, and this arc will have the same pole with relation to the two curves.

4. A spherical conic and one of its foci being given, if round that focus, as vertex, a constant spherical angle be made to turn, and from the points in which its sides meet the director arc corresponding to the given focus, two arcs be drawn touching the given conic, their point of concourse will generate a second spherical conic: the given focus will be a focus of the new conic, and the corresponding director arc will be the same in the two curves.

5. If a variable spherical angle turn round a fixed point on the surface of a sphere so as to intercept between its sides a constant segment on a fixed arc, the arc joining the points in which its sides meet two other fixed arcs will envelope a spherical conic touching these two fixed arcs.

6. If a constant spherical angle turn round a fixed point

on the surface of a sphere, the arcs joining the points in which its sides meet a fixed arc with two other fixed points will intersect in a point, the locus of which will be a spherical conic passing through these two last mentioned fixed points.

If two tangents to a parabola intersect at a constant angle, the radii vectores drawn from the focus to the two points of contact will also contain between them a constant angle. But, as is well known, in any conic section, the point of concourse of the tangents at the extremities of two focal radii vectores, which contain between them a constant angle, will generate a conic section. Hence we deduce the following very general properties of spherical conics.

7. If two tangent arcs to a spherical conic intercept between them a segment of a constant length on a fixed tangent arc to the curve, their point of concourse will generate a second spherical conic.

8. If a constant spherical angle turn round a fixed point on a spherical conic, the arc joining the points, in which its sides meet the curve, will envelope a second spherical conic.

9. In theorem 7, if the segment intercepted on the fixed tangent arc be a quadrant, the point of concourse of the tangent arcs will move along an arc of a great circle.

10. In theorem 8, if the constant angle be right, the arc which it subtends in the spherical conic will pass through a fixed point.

The two following theorems may be obtained by the aid of the equation of a spherical conic, expressed in spherical coordinates:

11. From two fixed points on the surface of a sphere, the distance between which is 90°, let arcs p, p', be drawn perpendicular to a moveable arc, and let α, β, be arcs of a given length; if $\frac{\sin^2 p}{\cos^2 \alpha}+\frac{\sin^2 p'}{\cos^2 \beta}=1$, the moveable arc will

envelope a spherical conic whose principal diametral arcs are $2a$, and 2β; they will pass through the fixed points, and the centre of the conic will be the pole of the great circle passing through the two fixed points.

12. The base of a spherical triangle being a quadrant, if its base angles a, b, be such that $\frac{\cot^2 a}{\tan^2 a} + \frac{\cot^2 \beta}{\tan^2 b} = 1$, where a and β are given arcs, the locus of the vertex will be a spherical conic, whose principal diametral arcs are $2a$, and 2β; they will pass through the extremities of the given quadrant, and the centre of the conic will be the pole of the quadrant.

Some of the preceding theorems lead to new and very general properties of the conic sections: and one (No. 6) gives rise to a new and remarkably simple organic description of them. It should be observed that the arcs here spoken of are all arcs of great circles.

His Grace the Archbishop of Dublin having taken the Chair, the President continued the reading of Dr. Robinson's Paper "On the Determination of the Constant of Refraction by Observations with the Mural Circle of the Armagh Observatory."

The author remarks, that the problem of astronomical refraction is embarrassed by two causes of error. The differential of the refraction is obtained by supposing the atmosphere to consist of spherical shells concentric with the earth; and the integral of this, by assuming some mathematical relation between the height above the earth and the corresponding density of the air. He shews that the first of these cannot be rigorously true; and that the relation between density and height, besides being unknown in general, may be expected to vary with the latitude. He therefore considers all existing refraction tables as approximations which require correction for each individual observatory.

For about 74° from the zenith, the refraction is independent of the law of density, and requires only an exact knowledge of the air's refractive power; this, however, has not been yet obtained with sufficient accuracy by direct experiment, and, therefore, must be deduced from astronomical observations. At greater zenith distances some constitution of the atmosphere must be assumed, and if its expression contain a sufficient number of arbitrary constants, the resulting refraction can always be made to represent with sufficient exactness what is actually observed. As, however, neither the formula of Bessel, nor that of Ivory, very readily admits such modifications, Dr. R. used the method given by the late Bishop of Cloyne, in the twelfth volume of the Royal Irish Academy's Transactions, which, however, he has extended to 85° zenith distance.

If the atmosphere be supposed of uniform temperature the refraction has been computed by Kramp; it is found greater than the truth. If the density be supposed to decrease uniformly as the height above the surface increases, the refraction is given by Simson; it is nearly as much in defect as the other in excess, and it is found that their mean is very near the truth. If then the differential equation of refraction be developed in terms of the tangent of the apparent zenith distance, it is found, on integrating, that the first term belongs to an atmosphere bounded by parallel planes; the second depends on the equilibrium of the strata, and the others alone are affected by the assumed hypotheses. Their geometrical means are found to satisfy the Armagh observations as far as 85° zenith distance, below which the series ceases to converge, and the mean changes its relation to the true refraction according to the temperature and pressure. The expression thus obtained for refraction admits of being tabulated with the corrections for the thermometer and barometer in a couple of pages; and he thinks this form of tables more convenient than any other with which he is acquainted.

To compute them are required the expansion of air by heat; the ratio of the height of the homogeneous atmosphere to the radius of curvature of the meridian at the place of observation, and the refractive power of air at a given temperature and pressure. For the first he has used the value given by Rudberg, namely, that 1 of air at 32° becomes 1·365 at 212°. This differs from Gay Lussac, but is identical with that deduced by Bessel from astronomical observations. The second is derived from the researches of Arago and Biot, corrected for the change of gravity from Paris to Armagh.

Of the refractive power of air there are different values of high authority. Denoting by the symbol μ the quantity $\frac{\sin \text{I} - \sin \text{R}}{\sin \text{R} \times \sin 1''}$, for 50° Fahrenheit and 29·60 inches pressure, the experiments of Arago and Biot give it 57·82. The observations of Delambre with a repeating circle give 57·72, which is also adopted by Brinkley. But the barometer used by this great astronomer is shewn by Dr. R. to require the correction $+$ 0·078, which would change the constant to 57·567; and as he also used the internal thermometer, perhaps a further diminution might be necessary. That of Bessel is 57·524, and that deduced by Dr. R. from his own observations is 57·546; but they cannot be exactly compared without a knowledge of the length of the pendulum at each station, as the measure of density given by the barometer depends on local gravity.

It was determined as follows by circumpolar stars. The refraction is obtained by subtracting from the subpolar distance 270° plus the declination observed above the pole. If the constant of refraction require a correction, it affects this declination both at the star and at the polar point, and the latter also affects the subpolar observation; hence, calling the tabular refraction μV, and the difference between it and the observed dR, we have for each observation the equation of condition

$$d\text{R} = d\mu\ \{\text{V} - \text{V}' - 2\text{P}\} = d\mu \times \text{K};$$

combining which by minimum squares, the value of $d\mu$ for that star is obtained. If the values of it at different zenith distances are equal, or differ only by what may reasonably be considered error of observation, then it may be also inferred, that the formula correctly assigns the refraction through the range of zenith distance included by the observations.

Dr. R. then gives details respecting the mural circle which he used, the permanence of its microscopes as to *run*, and the mode of obtaining its index correction, and the correction of its divisions. When the stars are spectra, he bisects the yellow near the green, and remarks that the fluctuations of irregular refraction are often of considerable duration. The hygrometric state of the air does not seem to produce any effect, and he shews that the external thermometer is to be used at his observatory. The details of observation are then given for seventeen stars, from 77° 10′ to 84° 56′ zen. dist., of which there are 317 subpolar observations.

If a southern star be determined at a place when it passes near the zenith, so that its place may be assumed as free from error of refraction, the value of $d\mu$ is multiplied by a much larger factor. This advantage, however, is more than balanced by the uncertainty caused by the difference of instruments and local circumstances at the two observatories; but Dr. R. has given the result of such a trial. He used the declinations of Mr. Johnson, (St. Helena Catalogue,) and, in many instances, those of Mr. Henderson at the Cape, and by 241 observations from 77° 53′ to 84° 40′ he found for μ 57·586; but conceives the result obtained from the northern stars decidedly preferable, and has used it alone in computing the tables which are given at the end of the paper.

DONATIONS.

Proceedings of the Royal Academy of Berlin. July, 1838—*January,* 1840, *with Index from* 1836-39. Presented by the Academy.

Observations of the Magnetic Intensity in Europe. By A. D. Bache, LL.D., &c. Presented by the Author.

The Seventh Annual Report of the Royal Cornwall Polytechnic Society for 1839. Presented by the Society.

Natural History as a Branch of General Education. Presented by the Natural History Society of Belfast.

Proceedings of the Numismatic Society of London. 1838, 1839. Presented by the Society.

Proceedings of the American Philosophical Society. No. 13. Presented by the Society.

Flora Batava. By Jan Kops. Nos. 120 and 121. Presented by the Author.

Memoirs of the Royal Astronomical Society. Vol. XI. Presented by the Society.

Edinburgh Astronomical Observations. Vol. III. 1837. Presented by the Royal Astronomical Society.

On Paralytic, Neuralgic, and other Nervous Diseases of the Eye. By Arthur Jacob, M.D. Presented by the Author.

Quarterly Journal of the Statistical Society of London. Vol. III. Part 4. Presented by the Society.

An ancient Silver Ring found near Drogheda. Presented by Lieut. W. Persse Newenham, R.N.

Model of Thumb Screws lately found in the Priory of St. James, Drogheda. Presented by the same.

A large Collection of Miscellaneous Antiquities, consisting of Stone, Flint, Bronze, and Iron Instruments, Coins, &c. &c. Presented by Captain Portlock, M.R.I.A.

The special thanks of the Academy were voted to Captain Portlock for his large donation of Irish Antiquities.

February 8, 1841.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Mr. J. Huband Smith submitted to the inspection of the Academy the sword and other iron weapons, brass mantle-pin, &c., with which he had been favoured by the Commander of the Forces, and which were discovered, with a human skeleton, at Kilmainham some years since. He further produced a still more perfect iron sword, which was also most obligingly lent to him by Captain Hort of the Royal Hospital. This, too, had been found about eight years ago in the same vicinity, and under similar circumstances with the weapons above mentioned.

The remarkable similarity of these, and all the incidents of the interments which they appear to have accompanied, with the remains found in the county of Antrim, described in the paper which Mr. Smith read before the Academy, on the 25th of January, as well as with the engraving and description of the Gaulish (Celtic) weapons, the account of which by M. Mongez, Keeper of the Museum of St. Genevieve at Paris, he had also on that occasion alluded to, together with the invariable discovery of bronze, or brass ornaments, unquestionably Celtic, in connexion with them, induced Mr. Smith to adhere to his opinion, that all these various remains were to be referred to people of Celtic race.

If this conclusion be just, the inference would seem to follow, that in the skeletons accompanying these weapons, &c., an opportunity is offered to the student of ethnography and the natural history of the human family, of investigating the characteristics of the pure Celtic type of a considerable branch of the Caucasian variety of man.

His Grace the Archbishop of Dublin communicated some observations "On the Leafing of Plants."

It is well known that there is a diversity in the times of leafing and shedding in individual trees of the same species; e. g. hawthorn, sycamore, horse-chesnut, beech, &c., sometimes as much as a fortnight; and the earliest in leaf are also the earliest shed, the same individuals keeping their time every year. Hence the question, whether this diversity arises from the "separable accidents" of soil, situation, &c., or whether from "inseparable accidents" which constitute what physiologists call *varieties?*

An experiment was tried by grafting an early hawthorn on a late, and *vice versa.* The scions kept their times (about a fortnight's difference) as if on their own stocks; thus proving that it was a case of "*seedling variety.*"

Many other such varieties are known, not only of apples, peaches, &c., but of wild trees also, differing in shape of leaf, form of growth, colour and size of fruit, &c., and also *time of ripening.* It was, therefore, to be expected that there should be the like, in respect of times of leafing.

This may throw some light on the question respecting "*acclimating.*" It may be, that species may be brought to bear climates originally ill-suited,—not by any especial virtue in the seeds *ripened in any particular climate,* but—by multiplying seedlings, a few of which, out of multitudes, may have qualities suited to this or that country, e. g. some to cold, some to drought, some to wet, &c.

In some cases, a plant's beginning to vegetate later may secure it from spring frosts, which would destroy a precocious variety; in others, earlier flowering may enable a tree to ripen fruit in a climate in which a later would be useless, &c.

Further, the experiment shews that the common opinion respecting the commencement of spring vegetation,—the rise of the sap from the roots, through the trunk and branches to the twigs,—is groundless; since a scion of an early variety, on a late stock, will be in leaf while the stock is torpid.

Resolved,—(on the recommendation of Council,) "that the sum of £200 be placed at the disposal of the Committee of Antiquities, to employ such portion of it as they may deem necessary in increasing the present collection of Irish Antiquities in the possession of the Academy."

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 28.

February 22, 1841.

Rev. H. LLOYD, D. D., Vice-President, in the Chair.

Mr. Charles T. Webber presented to the Academy an ancient stone, on which is carved a rude bass-relief, supposed to be the representation of a dog killing a wolf. Mr. Webber accompanied the present with a communication to the effect, that the stone was taken from the Castle of Ardnaglass, in the barony of Tireragh and county of Sligo, and was said to commemorate the destruction of the last wolf in Ireland. The current tradition in the place from whence it came was, that some years after it was supposed that the race of wolves was extinct, the flocks in the county of Leitrim were attacked by a wild animal which turned out to be a wolf; that thereupon the chieftains of Leitrim applied to O'Dowd, the chieftain of Tireragh, (who possessed a celebrated dog of the breed of the ancient Irish wolf dog), to come and hunt the wolf; which application being complied with by O'Dowd, there ensued a chase, which forms the subject of an ancient Irish legend, detailing the various districts through which it was pursued, until at length the wolf was overtaken and killed in a small wood of pine trees, at the foot of one of the mountains in Tireragh. The quarter of land on which the wolf was killed, is to this day called *Carrow na Madhoo*, which means *the dogs' quarter.* In commemoration of the event, O'Dowd had the annexed representation of it carved on the stone, and placed in the wall of his baronial residence.

The Secretary read the following "Collection of Notes on the early History of Science in Ireland." By James Orchard Halliwell, Esq., F. R. S., F. S. A., F. R. A. S., &c.

"The following scraps on a subject which has never yet been treated of by any writer with whose works I am acquainted, although unfolding no views of any great importance, will, it is believed, form a subject of discussion interesting to all natives of Ireland, who would think favourably of the intellectual character and resources of their countrymen.

"The earliest remnant of Irish science that I have met with, is contained in MS. Arundel, 333, in the British Museum, which contains several medical and astrological tracts in the Irish language of the thirteenth century, together with similar tracts of the fourteenth and fifteenth centuries. These tracts are of a similar nature with contemporary manuscripts written in England and on the continent.

For instance, at fol. 27, is an extract translated from the treatise of the venerable Bede, "De Divisionibus Temporis;" at fol. 35, is a short tract on the months of the year and their several durations; at fol. 76, is a scrap on the four seasons of the year, and on the planets which govern them.

"The whole volume contains astrology, mixed with the sciences of medicine and astronomy. Medical manuscripts in Irish of this early period are more numerous than others; and the Egerton collection in the British Museum contains several; one dated in the year 1303, and written on the continent.*

"Some writers say, that Johannes de Sacro Bosco, the contemporary of Roger Bacon, and who shines so conspicuously in the history of the mathematical sciences of the thirteenth century, was a native of Ireland; but, whatever obscurity may hang over the actual place of his birth, it is certain that he resided nearly the whole of his life in England and France, and there is nothing to show that his writings were ever circulated in that country.

"Be this as it may, yet it appears from MS. Egerton, No. 90, that the Arabic numerals usually, though erroneously,† ascribed to Roger Bacon, were well known and understood in Ireland at the commencement of the fourteenth century. The document contained in this volume is very valuable evidence, in the absence of any other as early. The MS. referred to contains an astronomical and ecclesiastical calendar, together with a table of ecclesiastical computation, all in the Irish character, and the numerals are written in identically the same form as they appear in foreign documents of the same period:—

"The introduction of the zero is a proof, that the Arabic

* MS. Egerton, No. 89.

† See my Rara Mathematica, p. 114.

notation was fully understood by the writer of the manuscript. It may be added, that there follows, immediately after the documents just mentioned, a table of the twelve signs of the zodiac, with their different astrological influences, viz.: Aries = good; Taurus = evil; Gemini = evil; Leo = evil; Virgo = evil; Libra = good; Sagittarius = good; Capricornus = evil; Aquarius = good. The others are said to neutralize their influences.

"In the Philosophical Transactions of the Royal Society of London,* Dr. Ward has given an account of a date in Arabic numerals found on a stone in Ireland, which he considered to belong to the twelfth century. Professor Peacock, however, in his History of Arithmetic, has ably confuted this conjecture.

"The Liber Niger of Christ Church, Dublin, is said to contain 'a curious treatise on arithmetic, exhibiting the state of that science before the introduction of Arabic numerals.'† I much question the accuracy of this statement, and should be rather inclined to think, that it is merely an account of the numbers of algorism, so common in manuscripts of this class. The same volume also contains, a transcript of the French poetical treatise entitled 'Imago Mundi,' one of the most curious unpublished scientific tracts of the middle ages. This latter treatise is now in the progress of publication, by the Historical Society of Science.

"But by far the most curious document that I have met with relating to the early science of Ireland, is a manuscript in the possession of C. Wright, Esq., of Cambridge, who has kindly allowed me to make use of it, and has also furnished me with a translation of the greater part, which has been of great assistance to me. This MS. consists of six folio leaves on vellum, slightly injured by damp, apparently

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* For the year 1745, p. 283.

† Report on the Public Records of Ireland, p. 307.

belonging to the early part of the fifteenth century, and containing the following articles:

"1. A brief treatise on arithmetic.

"This unfortunately commences imperfectly in the account of the rule of duplation; 'In duplation only one order of figures is necessary: in the three preceding kinds, we commenced from the right and from a smaller figure; but in this this, and the following kinds, we commence from the left and from a larger figure. For if you wish to double from the first figure, it happens that you must double it twice. And if you can in any other manner commence from the right hand, the operation and construction will be much more difficult. If, therefore, you wish to double any number, that number must be written by its differences, and the last number must be doubled. From that duplation, therefore, either results a digit, an article, or a composite. If a digit, it must be written in the place of the other blotted out. If an article, a 0 must be written in the place of the other blotted out, and the article must be removed towards the left hand. If a composite number, the digit which is a part of that composite must be written in the place of the other blotted out, and the article be removed to the left hand. This being done, the last figure must be doubled, and whatever thence arises must be dealt with as before; but if a cipher turns up, it must be left untouched. We prove duplation by means of mediation.'

"This extract will be sufficient to give an idea of the whole tract. After this rule, follow those of multiplication, division, and progression in their proper order. For the comprehension of the uninitiated in the old arithmetic, it may be necessary to state, that a digit is any number below ten, an article is ten, or any multiple of ten, and that all other numbers are composites, or composed of an article and some digit. My friend Mr. Wright, gives it as his opinion, that this tract is a translation from the Latin or French.

"2. 'Tractatus de Geometria.'

"This is an Irish tract with a Latin title, and consists of only one page, containing the simplest rules of geometrical measurement, applied to one example of finding the height of a tower. No mention occurs of any of the old geometers.

"3. A treatise on the signs of the zodiac.

"An astrological tract with very curious drawings of the various signs. Messabalah, the famous Arabic astronomer, is mentioned at the commencement, and this tract is very probably translated from one of that author's works.

"4. A treatise on the length of the days, in the year.

"5. A fragment (one half page).

"This terminates the contents of this manuscript, and is written in Latin. It appears to relate to abacal arithmetic, but as I confess myself unable to understand its meaning, I give it here entire, in the hopes that some other may be more fortunate in attempting to decipher its meaning.

"Intervalla autem in quibus distribuuntur. dicimus sedes horum numerorum. qui in abaci regula secundum geometricam habitudinem sic proportionaliter ordinati continentur. ut juxta numerum novem caracterum nonis termis alternati distinctis terminis. secundum propor. * * *'

"I have pointed this exactly as in the original manuscript, but the fragment appears to be altogether unconnected.

"In addition to the above, I may mention, that in the library of Trinity College, Cambridge, under the press mark R. xiv. 48, is preserved a short poem in the Irish language on astronomy, of the early part of the thirteenth century.* And in the the Bodleian Library, MS. Rawlinson, B. 490, is a translation of the 'Secreta Secretorum,' of Aristotle, by James Yonge, on vellum, of the early part of the fifteenth

* This I learn from Mr. Wright. In the printed catalogue, it is said to be in Saxon characters.

century. This work of Young is not mentioned by Sir James Ware, nor does it appear to be at all known to Irish writers. It is almost unnecessary to observe, that this latter work has no relation with science, but its rarity is a sufficient excuse for mentioning it here.

"It will now be necessary to pass over nearly two centuries before we meet with any traces of scientific progress. Some time about the year 1600, William Farmer, 'Chirurgian and Practitioner in the Mathematicall Artes,' dwelt at Dublin; and among the manuscripts of Archbishop Tenison, at Lambeth Palace, No. 816, is an autograph MS. by him, entitled, 'A Prognosticall Almanack for this Bissextile yere, 1612, composed with a three fould Kallender generally calculated for this Kingdom of Ireland, and will also serve very well for alle the Northe and Northweste partes of England.' William Bourne also, who flourished at the same time, and greatly distinguished himself by his mechanical inventions, was a native of Ireland. To these two we may add, Nathaniel Carpenter, an Englishman by birth, but who resided in Dublin early in the seventeenth century, and left behind him treatises on geography and optics. A copy of this latter work is still preserved in MS. in the Library of University College, Oxford.*

"With Molyneux, in more recent times, the science of Ireland rose to a level with that of surrounding nations, and the names Ponce, Boyle, Petty, and Ashe,† serve to fill the complement of the seventeenth century. In January, 1684, Molyneux succeeded in forming a Philosophical Society at Dublin, on the plan of the Royal Society of London. The first meeting of the Society took place on the 28th of January, 1684, when Sir William Petty was chosen President,

* Under the press mark L. 14. See Bernard's Catalogue, 1697, p. 5.

† Archbishop Ussher was the author of some treatises on sciences and their history, more especially astronomy.

Dr. Charles Willoughby, Director, and Molyneux undertook the combined offices of Secretary and Treasurer. November 1st, All Saints' day, was chosen for the anniversary of the Society. On the 1st of November, 1684, Sir William Petty was re-elected President, Molyneux as Secretary, and William Pleydell, Esq., Treasurer. On the 2nd of November, 1685, Lord Viscount Mountjoy was elected President, George Tollet, Esq., Treasurer, and St. George Ashe Secretary. In this year, Molyneux retired from actual office, but retained his place on the council of the Society. On the 1st of November, 1686, Lord Viscount Mountjoy was re-elected President, George Tollet Esq., Treasurer, and Edward Smyth, Secretary.

"The preceding particulars are taken from the original Minute-book of the Society preserved in the British Museum, MS. Addit. 4811.* The last entry in this book is, the account of the General Meeting of 1686, and this would lead us to suppose that the Society was dissolved at this period, although Dr. Hutton assures us, that it was not broken up till 1688.†

"From MS. Addit. 4812, it appears that in the year 1707, an attempt was made to reestablish the Society, but its success was not of any long duration, and this MS. contains a register of the philosophical papers read before the Society, from August 15th, 1707, to March 11th, 1708. The Earl of Pembroke, then Lord Lieutenant of Ireland, presided over the Society at this revival.

"In 1686, Molyneux printed at Dublin, his 'Sciothericum Telescopium,' containing a description of the structure and use of a telescopic dial invented by him. In the British Museum is preserved the author's own copy of this volume,

* The same volume likewise contains copies of numerous letters and papers on scientific subjects, addressed for the most part to Molyneux.

† Mathematical Dictionary, vol. ii. p. 117.

enriched with numerous MS. notes, and observations, and what is particularly worthy of being noticed, an analysis of its history."

March 16, (Stated Meeting).

SIR WM. R. HAMILTON, LL.D. President, in the Chair.

On the recommendation of Council, the following gentlemen were elected Honorary Members of the Academy:

Professor Adrian, *Giessen.*
Jean B. Dumas, *Paris.*
A. Quetelet, *Brussells.*
J. O. Halliwell, Esq., *Cambridge.*

The Secretary of Council read the following Report:

In conformity with the precedent lately established, the Council, at the expiration of their year of office, beg to offer the Academy a general account of its history and progress during that interval.

The Council have to report, in the first place, that the publications of the Academy have proceeded with considerable vigour. The first Part of Vol. XIX. of the Transactions has been lately issued, and the second Part, for which many papers are in readiness, is now beginning to be printed. The first Volume also of the Proceedings, containing, along with other ordinary business, an account of the communications made to the Academy during the last four sessions, has just been published. As the quantity remaining on hands of the *fourth* Number of the Proceedings was remarkably small, the Council, on the recommendation of the Committee of Publication, have ordered 250 copies of that Number to be reprinted, by which means a large stock of complete copies of the first Volume has been made up for the supply of future demands, and for sale to Members and others at a fixed price.

The Council are gratified to observe the increasing interest which is every day felt in the publication of the Proceedings. Not being confined to the mere analysis of elaborate memoirs intended for the Transactions, but giving free admission, and occasionally complete insertion, to smaller papers of various kinds, the Proceedings serve as a repository for scattered facts, and important notices, which would otherwise be lost. Speedy publication is an additional inducement to authors to communicate such notices; and by the adoption of woodcuts for antiquarian and scientific objects, of which the mere verbal description would be vague and unsatisfactory, the value of the communications is very much enhanced.

The expenses of printing and engraving continue, as might be expected, to press very heavily on the funds of the Academy. With the view, therefore, of practising every possible economy, the Council have entered into an arrangement with Mr. Petrie, by which that gentleman has bound himself to print, at his own risk, his Essay on the Round Towers of Ireland, as the twentieth Volume of the Transactions, engaging to supply the Academy with 450 copies of the work at a settled price, the sum which they have already expended for engraving to be deducted therefrom. The Academy will thus be furnished with as many copies as they want, and will be saved the additional outlay which would be requisite if they were themselves to defray the charge of the whole edition. After the great and unusual delays which have attended the publication of this Essay, the Council are gratified in being able to state that it has been actually put to press, and that the author confidently expects it will make its appearance soon after the second part of the nineteenth Volume of the Transactions.

Notwithstanding the limited extent of the resources of the Academy, the Council are of opinion that the formation of a National Museum of Antiquities is an object which the Academy should continue steadily to pursue, as far as these resources will reasonably permit; and since many articles of great value to the antiquarian are disposed of from time to time by public and by private sale, and may never again be met with, if such opportunities of procuring them are lost, they have thought it advisable to recommend to the Academy that a sum of money should be entrusted to the Committee of Antiquities to enable them to profit by such chances. The Academy have accordingly, by a recent vote, placed at the disposal of the Committee the sum of £200, which will probably serve the purpose for a considerable period. In the meantime, from the liberality of members and other gentlemen, the Museum is receiving constant accessions, which are regularly recorded in the Proceedings, and among which the large donation lately made by Captain Portlock is deserving of especial mention.

In touching on this subject, the Council are reminded of the severe loss which the Academy have sustained by the decease of their late respected Vice-President, the Very Rev. Henry Richard Dawson, Dean of St. Patrick's, a gentleman universally lamented by those who had the pleasure of knowing him in private life, but whom the lovers of Irish antiquities have peculiar reasons to regret; for he was a zealous preserver and collector of the old memorials of his country, and the treasures of this kind which he had accumulated in a period of many years, would have been bequeathed to the Museum now begun withinth ese walls, had not his well-known intentions been frustrated by the suddenness of the stroke which removed him from amongst us. The Dean having died intestate, his collections will of course be sold; but as they will fetch a price far above what the Academy could afford, a subscription, which it is to be hoped may be successful, has been set on foot, under the management of the Committee of Antiquities, for the purpose of depositing these valuable remains in the place for which they were intended by their generous collector.

The past year has also deprived us of some other distinguished Members, among whom was Thomas Drummond, Esq., Captain in the Corps of Royal Engineers, and Under-Secretary of State for Ireland. In his professional character, Mr. Drummond was remarkable for combined energy and talent, and for the singular power which he possessed of making the truths of science available for important purposes in practice. Though this was not the country of his birth, yet it was here that he spent the most active period of his life. Engaged in the Ordnance Survey, at its commencement in this kingdom, he enriched the practice of geodetical operations with some of its most useful instruments, which have now become indispensable in the observation of distant stations; and it deserves to be remembered, that it was from the summit of Slieve Snaght, in Donegal, to a party stationed on the hill of Divis, near Belfast, that he first exhibited, across the haze of Lough Neagh, the celebrated Light which bears his name, and which will serve, better than any monument, to perpetuate his memory.

In the person of Nicholas Aylward Vigors, Esq., late Member of Parliament for the county of Carlow, the Academy and the scientific world have lost one of the best zoologists of his day. His papers, in the department of ornithology more especially, are highly esteemed by naturalists; and the zeal which he felt for the advancement of his favourite science was manifested in the active part which he took, along with some other eminent men, in the foundation of the Zoological Society of London.

But a very few days have elapsed since the hand of death has blotted from our roll the honoured name of Laurence Earl of Rosse, one of the original Members of this Academy, and one of the ablest vindicators of the ancient literature of Ireland. Of the illustrious noblemen and gentlemen who founded our Society, who watched over its infancy, and powerfully promoted its early progress, his Lordship was the last survivor. Hitherto, for more than half a century of our corporate existence, our meetings have been cheered by the presence of some—though a constantly decreasing number—of those who witnessed their beginning, and who felt, as it were, a paternal interest in our welfare. But now they have all disappeared from amongst us. Let us endeavour to show that we are worthy to succeed them; for so we shall best do honour to their memory.

The other Members whom the Academy has lost by death within the year are:

The Earl of Ranfurly.
Right Honourable Lord Garvagh.
Rev. Sir Francis Lynch Blosse, Bart.
Arthur Hamilton, Esq., L.L.D.
Rev. Hosea Guinness.
John Crampton, Esq., M.D.

And the new Members added to the body since the 16th of March, 1840, are:

J. Davidson, Esq.	Rev. Henry Barry Knox.
Abraham Abell, Esq.	Rev. J. West.
J. H. Blake, Esq., Q. C.	Thomas Fortescue, Esq., M.P.
G. Wilkinson, Esq.	Chichester Bolton, Esq.
George Willoughby Hemans, Esq.	Henry Coulson Beauchamp, M.D.

In accordance with the suggestion of the Council of last year, the Council have ordered the compositions received in lieu of annual subscriptions to be henceforth invested in the Government Funds.

The following have been added to the list of Societies with whom the Academy interchange Transactions:

The Bavarian Academy of Sciences.
The Institute of Sciences of Milan.
The Rotterdam Society of Sciences.

In connexion with the subject of Mr. Webber's remarks at the last meeting, Sir W. Betham communicated the following document, giving an account of an order made by King James I. for the destruction of wolves in Ireland.

Patent Roll, 12 Jac. I. d. R. 17. "The King being given to understand the great loss and hindrance which arose in Ireland by the multitude of wolves, in all parts of the kingdom, did by letters from Newmarket, 26th November, 1614, direct a grant to be made by patent to Henrie Tuttesham, who by petition had made offer to repair into Ireland, and there use his best skill and endeavour to destroy the said wolves, providing at his own charge men, dogs, traps, and engines, and requiring no other allowance, save only four nobles sterling, for the head of every wolf, young or old, out of every county, and to be authorized to keep four men and twelve couple of hounds in every county, for seven years next after the date of these letters." 12 Jac. s. L. R. 27.

The Rev. C. Otway read a letter from Mr. Blacker, on the origin of the emblem of the shamrock.

Mr. J. M. Ferrall drew the attention of the Academy to several drawings, and a preparation, exhibiting a new and beautiful mechanism belonging to the human eye, and discovered by him in April last, while engaged in researches on certain diseases of the orbit, which the received anatomy of those parts did not appear to him to explain.

The new structures consisted of a distinct fibrous tunic, investing the globe of the eye, facilitating its movements, and separating it from all the surrounding tissues.

The anatomy of the schools, and of the best authors, from the earliest time to the present, teaches that the ball of the eye is in contact with its muscles, and, between them, with a quantity of adipose substance on which it was supposed to be cushioned. It was difficult to conceive, however, why the eye did not manifest any of the symptoms incidental to pressure suddenly endured, whenever those muscles were brought into action, since there appeared to be no provision for its protection. That pressure, suddenly made on the globe of the eye, produces the sensation of a spark or flash of light, is familiarly known as the consequence of a slight blow on the eye.

The act of sneezing is frequently followed by a similar phenomenon, and Sir Charles Bell has shown, in a paper published in the Philosophical Transactions, that it is occasioned by the sudden pressure on the ball of the eye, by the orbicularis palpebrarum or principal muscle of the eyelids, which is suddenly brought into action by the respiratory nerves. The four recti muscles, which move the eye in different directions, being favourably placed, (according to the received anatomy), for exercising such a pressure, it might have been expected that a similar phenomenon would have resulted; but no such coruscations have ever been observed to follow their most rapid actions.

The discovery of this tunic, which Mr. Ferrall has ventured to term the TUNICA VAGINALIS OCULI, at once explains the absence of those phenomena, by showing that a protective provision has always existed to prevent them.

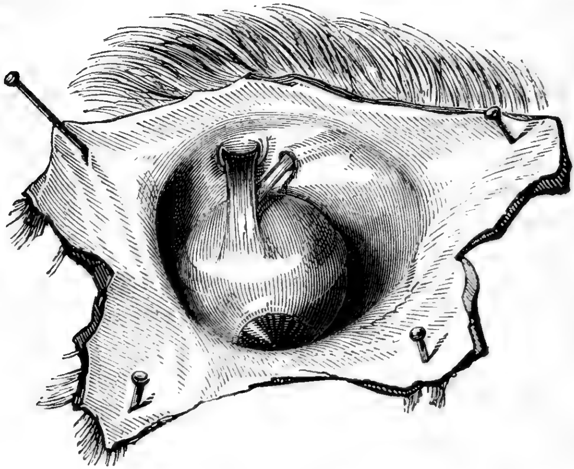
Mr. Ferrall went on to state, that the most beautiful portion of this mechanism remained to be described. It was one of those exquisite manifestations of design which abound in the animal frame.

In the anterior portion of this tunic were to be found six different well defined openings, through which the tendons of the muscles pass to their insertion in the sclerotic coat of the eye, and over which they play as over pulleys in their progress.

The annexed engravings, executed from original drawings made in April, 1840, for Mr. Ferrall's clinical lectures in St. Vincent's Hospital, display this conformation faithfully.

Fig. 1, shows the tendon of the internal rectus, emerging from behind the tunic, and passing through its pulley to be inserted in the eyeball.

Fig. 2, represents the eyeball drawn downwards, in order to expose the exit of the tendons of the superior rectus and superior oblique muscles; the superior rectus plays over its pulley, and the superior oblique passes beneath the former to reach its insertion in the sclerotic coat.



The presence of some such contrivance as is here exhibited might have been inferred from its necessity, and yet it has never been suspected to exist. The four recti muscles running from the bottom or apex of the orbit, forward to grasp the eye, must, without it, have had the power of retracting the ball of the eye, and yet no such retraction has ever been observed in the human eye. Retraction is certainly performed in some of the lower classes of animals; but *they* are provided with a strong retractor muscle, independent of the four recti muscles. Again, the rotatory movements of the human eye, which enlarge the sphere of vision, and contribute to expression, are not easily accounted for by the received anatomy of the orbit, because the course of the muscles from the bottom of the orbit forwards, manifestly gives them a power of retracting rather than of rotating the eye upon its centre. Thus, then, there appeared to be no provision for the rotatory movements of the ball of the eye, which are of *constant occurrence,* and nothing to prevent retraction, which we knew *did not take place.* A knowledge of the existence of this new and beautiful mechanism reconciles and explains these anatomical and physiological contradictions.

Mr. Ferrall said, he had found these structures in several of the lower animals, in whom they appear to enable the recti to antagonize the proper retractor muscles.

Several phenomena in diseases of those parts, formerly obscure, are now easily understood; but Mr. Ferrall refrained, on this occasion, from discussing questions of a practical nature.

The Auditors appointed by Council to examine the Treasurer's Account, for the year ending December 31, 1840, reported as follows:

"We have examined the above account,* with the vouchers produced, and have found it to be correct; and we find that there is a balance in Bank of £100 7*s.* and in the Treasurer's hands, of £110 9*s.* 4*d.* making a total balance of 210 16*s.* 4*d.*

"(Signed,)

"FRANC SADLEIR.

"SAMUEL LITTON.

"*March,* 13*th* 1841."

"The Treasurer reports that there is £1390 17*s.* 4*d.* in three per cent. consols, and £1526 6*s.* 1*d.* in three and a-half per cent. Government Stock, to the credit of the Academy, in the Bank of Ireland; the latter being the Cunningham Fund.

"(Signed,)

"THOMAS HERBERT ORPEN.

"*March* 18*th,* 1841."

The ballot for the annual election having closed, the scrutineers reported that the following gentlemen were duly elected Officers and Council for the ensuing year:

* Entered in the Treasurer's book.

President.

Sir Wm. Rowan Hamilton, LL.D.

Committee of Science.

Rev. Franc Sadleir, D.D., Provost; Rev. Humphrey Lloyd, D.D.; James Apjohn, M.D.; James Mac Cullagh, Esq., LL.D.; Rev. William D. Sadleir, A.M.; Robert Ball, Esq.; Robert Kane, M.D.

Committee of Polite Literature.

His Grace the Archbishop of Dublin; Rev. Joseph H. Singer, D.D.; Samuel Litton, M.D.; Rev. William H. Drummond, D.D.; Rev. Charles R. Elrington, D.D.; Rev. Charles W. Wall, D.D.; Rev. Thomas H. Porter, D.D.

Committee of Antiquities.

Thomas H. Orpen, M.D.; George Petrie, Esq., R.H.A.; Rev. Cæsar Otway; Rev. James H. Todd, D.D.; Henry J. Monk Mason, Esq., LL.D.; Aquilla Smith, M.D.; Samuel Ferguson, Esq.

Officers.

Treasurer.—Thomas H. Orpen, M.D.

Secretary to the Academy.—Rev. Joseph H. Singer, D.D.

Secretary to the Council.—J. Mac Cullagh, Esq., LL.D.

Secretary of Foreign Correspondence.—Rev. Humphrey Lloyd, D.D.

Librarian.—Rev. William H. Drummond, D.D.

Clerk and Assistant Librarian.—Edward Clibborn.

The President appointed under his hand and seal the following Vice-Presidents:

His Grace the Archbishop of Dublin; the Provost of

Trinity College; the Rev. Humphrey Lloyd, D. D.; the Rev. J. H. Todd, D. D.

DONATIONS.

Résumé des Observations Météorologiques faites en 1839, *a l'Observatoire Royal de Bruxelles,* par A. Quetelet.

Second Mémoire sur le Magnétisme Terrestre en Italie, par A. Quetelet.

Deuxiéme Mémoire sur les Variations Annuelles de la Température de la Terre a différentes profondeurs, par A. Quetelet.

Extraits du Tom. VII. No. 2, des Bulletins de l'A. R. de Bruxelles. No. 2. Température de la Terre. No. 3. Magnetisme Terrestre. No. 4. Magnetisme Terrestre. Par A. Quetelet. Presented by the Author.

Bulletin de l'Academie Royale de Bruxelles. Nos. 1—8 An. 1840. Presented by the Academy.

American Almanack for 1841. Presented by the American Philosophical Society.

Nautical Observations on the Port of Cardiff. By Captain W. H. Smith, R. N., &c. Presented by the Author.

Ninth Report of the British Association. Presented by the Association.

A Catalogue of the Miscellaneous Manuscripts in the Library of the Royal Society. By J. O. Halliwell, Esq., F.R.S., &c. Presented by the Royal Society.

A Collection of Letters illustrative of the Progress of Science in England. Edited by J. O. Halliwell, Esq., F.R.S., &c. Presented by the Editor.

Proceedings of the Royal Society of Lordon, 1839—40. Nos. 41—44. *List of Members of the Royal Society of London,* (30th November, 1840).

Philosophical Transactions of the Royal Society of London for 1840. Parts I. and II. *Catalogue of the Miscellaneous*

Manuscripts in the Possession of the Royal Society. Presented by the Society.

Remarks on the Classification of Human Knowledge. An Elementary Treatise on the Tides. On the Theory of the Moon. On Currency. By J. W. Lubbock, Esq. Presented by the Author.

An Examination of the ancient Orthography of the Jews. Vol. III. By Rev. C. W. Wall, D.D. Presented by the Author.

The Negroland of the Arabs. By W. Desborough Cooley, Esq. Presented by the Author.

Constitution and By-Laws of the National Institution for the Promotion of Science at Washington.

Discourse on the Objects and Importance of the National Institution for the Promotion of Science. By Joel R. Poinsett, Esq. &c. Presented by order of the Directors.

Memoires de la Société Géologique de France. Tome 4me. 1re partie. Pesented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 29.

April 12.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The following gentlemen were elected Members of the Academy:

William Monsell, Esq., Robert Tighe, Esq., W. E. Hudson, Esq., G. Fitzgibbon, Esq., William Phibbs, Esq., Rev. James Reid, William Lee, Esq., F.T.C.D., Robert Jones, Esq., Thomas Wilson, Esq., Beriah Botfield, Esq., M.P., W. T. Mulvany, Esq.

Mr. Ferguson made a communication on the Classification of ancient Military Weapons found in Ireland.

DONATIONS.

Transactions of the Cambridge Philosophical Society. Vol. II. Part 2; Vol. III. Parts 1, 2, 3; Vol. IV. Part 1; Vol. V. Part 3. Presented by the Society.

On the Geological Structure of the Northern and Central Regions of Russia in Europe. By R. J. Murchison, F.R.S., &c. Presented by the Author.

Proceedings of the Geological Society of London. Nos. 74 and 75. Presented by the Society.

Journal of the Franklin Institute. Vol. XXVI. (1840). Presented by the Institute.

The Numismatic Chronicle. No. 12. Presented by the Numismatic Society of London.

Abstract of the Account of the Royal Irish Academy,

FOR THE YEAR ENDING MARCH 31, 1841.

THE CHARGE.

	£	s.	d.	£	s.	d.
Balance in favour of the Academy				74	3	9
Parliamentary Grant	300	0	0			
Treasury warrants for Rent, Taxes, &c.	146	17	8			
				446	17	8
Transactions sold	2	14	6			
				2	14	6
One half year's interest on £1500, 3½ Government Stock	26	5	0			
One half do. do. £1367 5*s.* 8*d.*, 3 per cent. Consols	20	10	2			
One half do. do. £1526 6*s.* 1*d.*, 3½ Stock,	26	14	2			
One half do. do. £1390 17*s.* 4*d.*, 3 per cent. Consols	20	17	3			
				94	6	7
One year's rent of stable	21	0	0			
Allowance of Poor Rate	1	1	8			
				22	1	8
Life Subscriptions	165	18	0			
Entrance do.	84	0	0			
Annual do.	224	14	0			
				474	12	0
The total charge				£1114	16	2

THE DISCHARGE.

	£	s.	d.	£	s.	d.
Coals, Candles, &c.	47	6	1			
Repairs of House, Furniture, &c.	56	8	2			
Rent, Taxes, and Insurance,	149	19	3			
Books, Printing, and Stationery	397	2	5			
Salaries, Servants' Wages, &c.	250	7	9			
Contingencies	154	11	2			
The Total Discharge				1055	14	10
Balance in favour of the Academy				59	1	4
The Charge as before				£1114	16	2

STATE OF THE BALANCE.

	£	s.	d.	£	s.	d.
In Bank of Ireland	£40	0	0			
In Treasurer's hands	19	1	4			
Balance as above				£59	1	4

Signed,

THOMAS HERBERT ORPEN, *Treasurer.*

April 26.

Rev. H. LLOYD, D. D., V.P., in the Chair.

Mr. George Downes read a paper "On the Norse Geography of Ancient Ireland." The earlier part consisted of remarks on an "Essay on the earliest Expeditions from the North to Ireland," and on a small Map of Ireland accompanying it, as published in the Annals and Memoirs of the Royal Society of Northern Antiquaries.

The author began by adverting to the two provincial names on the map—*Úlaztir* (Ulster), and *Kunnáktir* (Connaught),—and to two names of districts in Leinster—*Dyflinarskíri*, or Dublinshire, and *Kunnjáttaborg* (a part of Meath). He argued that the local name in Johnstone's edition of Lodbroc's Death-Song, translated "Leinster's," more probably belongs to Lambay, the Λιμνιος of Ptolemy, supporting his argument also by a geographical consideration.—He next proceeded to the estuaries—*Jölldulilaup*, supposed to be Lough Swilly; and *Úlfreksfjörðr*, or *Úlfkelsfjörðr*, supposed to be either Lough Foyle or Carlingford Bay, but perhaps an English locality, and, if so, that arm of Morecambe Bay which runs up to Ulverstone.—The town *Dýflin* he stated to be evidently a Norse adaptation of the Irish name of *Dublin; Veðrafjörðr*, or Waterford, to be undoubtedly Norse, adducing its various derivations, and giving the preference to *veðr* "weather," and *fjörðr* "bay;" and *Hlimrék*, or Limerick, to be probably a Norse adaptation of the Irish name *Luimneach*,—notwithstanding its consisting of two Norse words, meaning "branch" and "district," and the resemblance between the Lower Shannon and the *Limfiord*, or "branching bay," in Denmark. *Kunnjáttaborg*, or *Kantaraborg*, given in the *Antiquitates Celto-Scandicæ* as *Kunnaktirborg*, and (in the genitive form) *Kantaraborgar*—the place of Brian Boru's nuptials with Kormlöda, or Gormliath—he concluded to be *Cancora;* and then adverted to the minor localities of *Iniskillen* (perhaps *Inisclothran,* in Lough Ree), *Themar* (Tara), and *Glendelaga* (Glendalogh).

The name *Smerwick,* laid down as *Smjörvik* on the map, but left unexplained in the essay, was traced by the author to two sources. The first derivation—from *smjör* "butter," and *vik* "bay," or "town"—was supported by the frequency of the former word as an element of Norse local nomenclature, and the probability that some trade in butter was carried on between the Northmen and the south-western Irish. A curious tradition, connected with the fortunes of Leif, the son of Hrodmar, was adduced, in which the name *mynnthak* occurs—that is, meal and butter blended together—a word apparently identical with the Irish móınṫeaċ "boggy," and somehow connected with the discovery of butter, or an adipocere resembling it, in the Irish bogs. The second derivation was founded on a tradition current in Munster, that *Smerwick* is a contraction of *St. Mary's Wick;* and a tradition from Olave Tryggvason's Saga was adduced, showing the probability that, if it be so, the name is due to him.

Kaupmannaey, laid down on the map at the entrance of Belfast Lough, and also left unexplained in the essay, was shown to be Copeland Island.

Mr. Downes prefaced the latter part of his subject by briefly adverting to the principal countries, in which the Northmen have left topographical traces of their invasions—namely, Normandy, Eastland (extending from Mecklenburgh to the White Sea), and the British Islands—alluding to various classes of Norse names occurring in Normandy, a few solitary instances in Eastland, and dwelling at some length on those found in Ireland. A minute analysis of the Irish localities, ending in *ford,* was closed by the inference, that as *Odin's Ford,* in the county of Carlow, is certainly a Norse locality, so *Urlingford, Freshford,* and *Erke,* in the adjacent county of Kilkenny, are Norse likewise. A less minute analysis was undertaken with several similar names; after which the author proceeded to a rapid scrutiny of names of baronies, townlands, and towns—noticing in particular, as wholly or partly of Norse derivation, *Rathgorman*, *Slaghtmanus*, and *Ballyvedra, alias Weatherstown*, near Waterford.—The last class of Irish names analysed was that of islands. Several instances were adduced of insular localities derivable from some one of the three Norse words for island—*ey*, *holm*, and *kalfr*—the distinctive meanings of which were explained. The name of a locality, in particular, off the south coast of Iceland, called "Irishman's Islands," was explained from the sequel of the tradition of Leif, before cited.

The author closed his paper by recommending to the antiquary some attention to the neglected literature of the North, as a means not only of accumulating information, but of correcting error; and concluded by adducing the following examples of error, corrected by a comparison of specimens found in different countries:—" 'The short sword, or dagger,' with which King, in his account of Richborough, has equipped a Roman bagpiper, would still maintain its belligerent masquerade, had not the discovery of a more perfect specimen in Scandinavia proved it to be the more appropriate appendage of a pipe; and certain figures, published by Pennant, which were deified in Sweden, might have long enjoyed their sanctity, had not the subsequent discovery of more perfect specimens in Denmark desecrated them into—knife-handles."

Dr. Anster, on the part of Dr. Luby, F.T.C.D., read a letter of the late Rev. Charles Wolfe, author of the lines on the burial of Sir John Moore. The letter, or rather fragment of a letter, had been found by Dr. Luby among the papers of a deceased brother, who was a college friend of Wolfe and of Mr. Taylor, to whom the letter was addressed.

The part found had the appearance of having been torn off from the rest of the letter. It contains the address; a complete copy of the ode; a sentence mentioning to Mr. Taylor that his praise of the stanzas first written led him to complete the poem; a few words of a private nature at the end of the letter; and the signature. There is no date on the part preserved; but the post-mark of September 6, 1816, fixes the time at which it was sent. Dr. Anster read passages from Captain Medwin's "Conversations of Lord Byron" and Archdeacon Russell's "Remains of Wolfe," in which mention is made of the various guesses as to the author, when the poem first appeared, without the author's name, in the newspapers and magazines. It was attributed to Moore, to Campbell, to Wilson, to Byron, and now and then to a writer in many respects equal to the highest of these names, whose poems have been published under the name of Barry Cornwall. Shelley thought the poem likely to be Campbell's; and Medwin believed Byron to be the author. When Medwin's book appeared in which this was stated, several friends of Wolfe's, among others Mr. Taylor, to whom was addressed the letter, of which an important part has been fortunately found, stated their knowledge of Wolfe's having written the ode. One gratifying result of the controversy was the publication, by Archdeacon Russell, of the Remains of Charles Wolfe, with a memoir written with great beauty, and, what constitutes the rare charm of the work, describing with entire fidelity the character, and habits, and feelings of one of the most pureminded, generous, and affectionate natures that ever existed.

The question as to the authorship of the ode was for ever set at rest to any one who had seen either the letters of Mr. Wolfe's friends, at the time of Captain Medwin's publication, or Archdeacon Russell's book. Were there any doubt on the subject of authorship, the document now produced would completely remove it; but for this purpose it would really not be worth while to trouble the Academy with the communication, as it would be treating the insane pretensions, now and then put forward in the newspapers for this person or the other, with too much respect to discuss them seriously, or at all; but another and a very important purpose would be answered by the publication of this *authentic* copy of the poem, from Wolfe's *autograph*, in their Proceedings. The poem has been more frequently reprinted than almost any other in the language; and, an almost necessary consequence of such frequent reprints, it is now seldom printed as it was originally written. Every person who has had occasion to compare the common editions of Milton, or Cowper, or any of our poets, with those printed in the life-time of the authors, is aware that no dependence whatever can be placed on the text of the books in common use. Every successive reprint from a volume, carelessly edited, adds its own stock of blunders to the general mass. Wolfe's ode has been, in this way, quite spoiled in many of its best passages. The Academy had now the opportunity of correcting these mistakes by publishing an authentic copy of the poem. Dr. Anster stated the fitness of this being done by the Academy, not only from its being the natural and proper guardian of every thing relating to the literature of Ireland,—which alone would seem to him a sufficient reason,—but even yet more, from the circumstance, that the Academy's Proceedings must command a circulation over the Continent, which it would be in vain to expect for any private publication. The poem has been often translated; and the strange blunders which have got into our copies are faithfully preserved in the translations. In a German translation of the ode, three stanzas of a poem, consisting of but eight, are spoiled by the translator's manifestly having read an imperfect copy of the original. In one it is quite plain that the stanza, which closes with the lines—

> "And we heard the distant and random gun
> That the foe was sullenly firing,"

and in which the word "suddenly" is often substituted for "sullenly," was printed falsely in the copy before the German translator. In the second stanza, "The *struggling* moonbeam's misty light," is lost probably from some similar reason. The general effect of Wolfe's poem is exceedingly well preserved in the translation; but there are several mistakes in detail, most of which, perhaps all, arise from the translator's having used an incorrect copy of the original. The translation is printed in the *octavo* edition of "Hayward's Faust," p. 304.

The Rev. Dr. Todd, V.P., having taken the Chair, Professor Lloyd read a supplement to his paper, "On the Mutual Action of Permanent Magnets in an Observatory," printed in the Transactions, Vol. XIX. p. 159.

This supplement was immediately printed in the same volume of the Transactions.

May 10.

Sir Wm. R. HAMILTON, LL.D., President, in the Chair.

Oliver Sproule, Esq., and James Thompson, Esq., were elected Members of the Academy.

A note on some new Properties of Surfaces of the second Order, by John H. Jellett, Esq., F.T.C.D., was read.

I. Let the points on the focal conic, at which the tangent is parallel to the trace of the tangent plane, be considered analogous to foci.

II. Let the axis of the surface, perpendicular to the plane of the conic, be considered analogous to the conjugate axis; then, since the square of the distance from focus to centre, in a conic, is equal to the difference between the squares of the transverse and conjugate semi-axis, we may consider, as analogous to the transverse semi-axis, the line drawn to the extremity of the perpendicular axis from the point analogous to the focus.

III. Since the square of the semiconjugate diameter is equal to the sum of squares of semiaxes minus the square of central radius vector, let the same be supposed true of the line analogous; i. e. if A be the line analogous to the transverse, and B to the conjugate semi-axis, let

$$B' = \sqrt{A^2 + B^2 - A'^2}.$$

Assuming these definitions, we shall have the following theorems analogous to those *in plano*.

1. The sum or difference (according as the focal conic is perpendicular to a real or imaginary axis) of the distances from the points analogous to the foci, to the corresponding point on the surface, is equal to $2A$.

2. The rectangle under them $= B'^2$.

3. The sine of the angle, made by either with the tangent plane, is $\frac{B}{B'}$.

4. The rectangle under the perpendiculars from these points on tangent plane $= B^2$.

5. The sine of the angle between the central radius vector and tangent plane $= \frac{AB}{A'B'}$, (A' being the central radius vector).

6. The portion of the normal intercepted between the surface and the plane of the focal conic is $\frac{B}{A} . B'$.

7. If a plane be drawn perpendicular to the line joining points analogous to the foci, and at a distance from the centre equal to $\frac{A^2}{C}$ (C being the distance of one of the focal points from the centre), the distance of a point in the surface from the corresponding focus will be to its distance from this plane $:: C : A$.

8. Hence, given a focal conic and the perpendicular axis,

we can find points and tangent planes *ad libitum*, by the following construction :—Take in the focal conic two diametrically opposite points ; with one as centre, and twice the distance from it to the extremity of the perpendicular axis as radius, describe a sphere. Through the other point draw a plane, normal to the focal conic ; it will cut the sphere in a certain circle. Connect any point in this circle with the two points on the focal conic, and at the middle point of the line connecting it with the second point draw to it a perpendicular plane. This is a tangent plane to the surface, and the point where it cuts the first connecting line is a point on the surface.

Another mode of generating the surface is easily derivable from (7).

Mr. Petrie gave an account of some ancient Irish inscriptions of the sixth century, found in the island of Arran.

Dr. Kane made some remarks on the Theory of Types.

DONATIONS.

Transactions of the Literary and Historical Society of Quebec. Vols. I. and II. ; and Parts 1—4 of Vol. III. Presented by the Society.

Report of the Directors of the Chamber of Commerce at Manchester on Import Duties. 11th March, 1841.

Report of the Select Committee of the House of Commons on the Import Duties.

Proceedings of a Meeting of Members of the House of Commons, held at the Thatched House Tavern, St. James's-street, on the 20th February, 1841. Presented by Joseph Hume, Esq., M.P.

May 24.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Mr. Robert Mallet read a paper "On the Physical Properties and Electro-Chemical and other Relations of the Alloys of Copper with Tin and Zinc."

These experiments are collateral to the researches on the action of air and water on iron, upon which the author has been engaged at the desire of the British Association. In the progress of these inquiries, it became necessary to determine the action of solvents on iron in presence of various definite alloys of copper and tin and of copper and zinc. Hence it was requisite to form many such alloys in rigidly assigned proportions as to their constituents, a matter known to experimenters to be one of difficulty, especially in the case of so oxidable and volatile a metal as zinc. The difficulties were overcome by a peculiar arrangement of apparatus, permitting the metals to be fused and combined in close vessels. The results were verified by assay. Having these alloys which belong to the classes of brass or gun metal, of which most of our instruments of precision are made, and their constitution being atomic and certain, it seemed useful to determine some of their properties for practical purposes. The results are given in the two annexed tables.

The author has also determined the numerical conditions governing the rate of solution, or amount of loss sustained in a given time by equal surfaces of iron in solvent menstrua, when in presence of all these alloys, and of the alloys themselves. Tables of these were presented: the results do not seem to coincide with the law of volta equivalents, which is explained by showing galvanometrically that the $\varepsilon -$ and $\varepsilon +$ metals of the alloy are often not acted on equally by a solvent; thus, that an alloy of $Zn_y + Cu_x$ may assume a copper surface after a certain time of reaction. This circumstance, the author has shown, suggests a method of determining the molecular arrangement of an alloy; and, in general, whether any alloy be a chemical compound or a mixture.

The author also enters into several details as to peculiar, and, in some cases, singular reaction of these and other alloys upon solutions of the salts of their own metals: thus, certain alloys of lead and zinc decompose solutions of lead as rapidly as pure zinc; while others, containing much zinc, act as lead towards the salts of lead.

In the case of three metals, A, B, C, whereof A is $\varepsilon +$, and C is $\varepsilon -$ to B, the author investigates the question as to what will be the electro-chemical relation of the atomic alloys of $A_x + C_y$ towards B, in solvent menstrua; and in the class of alloys of copper and zinc, has determined *the alloy of no action*, with reference to iron; and has also found alloys which protect iron in solvents electro-chemically as fully as pure zinc, and yet are not themselves acted on by the solvent.

He enters into the subject of the specific gravities of the alloys of Zn + Cu and Sn + Cu minutely, and shows reason to doubt the accuracy of the published specific gravities of most alloys of these and some other classes.

Professor Mac Cullagh read a supplement to his paper "On the dynamical Theory of Crystalline Reflexion and Refraction."

In his former paper on that subject (see Proceedings, 9th December, 1839) the author had given the general principles for solving all questions relative to the propagation of light in a given medium, or its reflexion and refraction at the separating surface of two media; but he had applied them only to the common case of waves, which suffer no diminution of intensity in their progress, and in which the vibration may be represented by the sine or cosine of an arc multiplied by a constant quantity. Some months after that paper was read, it occurred to him that he might obtain new and important results by substituting in his differential equations of motion a more general expression for the integral, that is, (as usual in such problems), by making the displacements proportional to the sine or cosine of an arc, multiplied by a negative exponential, of which the exponent should be a linear function of the coordinates. Such vibrations would become very rapidly insensible, and would, therefore, be fitted to represent the disturbance which, in the case of *total reflexion*, takes place immediately behind the reflecting surface; and the laws of this disturbance being thus discovered, the laws of polarization in the totally reflected light would also become known, by means of the general formulæ which the author had established for all cases of reflexion at the common surface of two media.

The present supplement is the fruit of these considerations. It contains the complete theory of the new kind of vibrations, not only in ordinary media, but in doubly refracting crystals; and also the complete discussion of the laws of total reflexion at the first or second surface of a crystal, including, as a particular case, the well known empirical formulæ of Fresnel for total reflexion at the surface of an ordinary medium.

The existence of vibrations represented by an expression containing a negative exponential as a factor, had been recognized by other writers, and was indeed sufficiently indicated by the phenomenon of total reflexion; but it was impossible to obtain the laws of such vibrations, so long as the general equations for the propagation of light were unknown.

The method of deducing these equations was given in the abstract of the author's former paper, (see Proceedings, as above); but as they were not there stated, it may be well to transcribe them here. If then we put

$$\mathrm{X} = \frac{d\eta}{dz} - \frac{d\zeta}{dy}, \quad \mathrm{Y} = \frac{d\zeta}{dx} - \frac{d\xi}{dz}, \quad \mathrm{Z} = \frac{d\xi}{dy} - \frac{d\eta}{dx}, \qquad (1)$$

and suppose the axes of coordinates to be the principal axes of the crystal, the equations, in question may be thus written:

$$\left.\begin{aligned}\frac{d^2\xi}{dt^2} &= c^2\frac{d\mathrm{Z}}{dy} - b^2\frac{d\mathrm{Y}}{dz},\\ \frac{d^2\eta}{dt^2} &= a^2\frac{d\mathrm{X}}{dz} - c^2\frac{d\mathrm{Z}}{dx},\\ \frac{d^2\zeta}{dt^2} &= b^2\frac{d\mathrm{Y}}{dx} - a^2\frac{d\mathrm{X}}{dy};\end{aligned}\right\} \quad (2)$$

and if we further put

$$\xi = \frac{d\eta_1}{dz} - \frac{d\zeta_1}{dy}, \quad \eta = \frac{d\zeta_1}{dx} - \frac{d\xi_1}{dz}, \quad \zeta = \frac{d\xi_1}{dy} - \frac{d\eta_1}{dx}, \qquad (3)$$

they will take the following simple form:

$$\frac{d^2\xi_1}{dt^2} = -a^2\mathrm{X}, \quad \frac{d^2\eta_1}{dt^2} = -b^2\mathrm{Y}, \quad \frac{d^2\zeta_1}{dt^2} = -c^2\mathrm{Z}, \qquad (4)$$

in which it is remarkable that the auxiliary quantities ξ_1, η_1, ζ_1, are exactly, for an ordinary medium, the components of the displacement in the theory of Fresnel. In a doubly defracting crystal, the resultant of ξ_1, η_1, ζ_1 is perpendicular to the *ray*, and comprised in a plane passing through the ray and the wave normal. Its amplitude, or greatest magnitude, is proportional to the amplitude of the vibration itself, multiplied by the velocity of the ray.

The conditions to be fulfilled at the separating surface of two media were given in the abstract already referred to. From these it follows, that the resultant of the quantities ξ_1, η_1, ζ_1, projected on that surface, is the same in both media; but the part perpendicular to the surface is not the same; whereas the quantities ξ, η, ζ, are identical in both. These assertions, analytically expressed, would give five equations, though four are sufficient; but it can be shown that any one of the equations is implied in the other four, not only in the case of common, but of total reflexion; which is a very remarkable circumstance, and a very strong confirmation of the theory.

The laws of double refraction, discovered by Fresnel, but not legitimately deduced from a consistent hypothesis, either by himself or any intermediate writer, may be very easily obtained, as the author has already shown, from equations (2), by assuming

$$\xi = p \cos a \sin \phi, \quad \eta = p \cos \beta \sin \phi, \quad \zeta = p \cos \gamma \sin \phi, \qquad (5)$$

where

$$\phi = \frac{2\pi}{\lambda}(lx + my + nz - st);$$

but the new laws, which are the object of the present supplement, are to be obtained from the same equations by making

$$\left.\begin{aligned} \xi &= \varepsilon(p \cos a \sin \phi + q \cos a' \cos \phi), \\ \eta &= \varepsilon(p \cos \beta \sin \phi + q \cos \beta' \cos \phi), \\ \zeta &= \varepsilon(p \cos \gamma \sin \phi + q \cos \gamma' \cos \phi), \end{aligned}\right\} \qquad (6)$$

where ϕ has the same signification as before, and

$$\varepsilon = e^{-\frac{2\pi r}{\lambda}(fx + gy + hz)};$$

the vibrations being now elliptical, whereas in the former case they were rectilinear. In these elliptic vibrations the motion depends not only on the distance of the vibrating particle from the plane whose equation is

$$lx + my + nz = 0, \qquad (7)$$

but also on its distance from the plane expressed by the equation

$$fx + gy + hz = 0; \qquad (8)$$

and if the constants in the equation of each plane denote the cosines of the angles which it makes with the coordinate planes, we shall have λ for the length of the wave, and s for the velocity of propagation; while the rapidity with which the motion is extinguished, in receding from the second plane, will depend upon the constant r. The constants p and q may be any two conjugate semidiameters of the ellipse in which the vibration is performed; the former making, with the axes of coordinates, the angles α, β, γ, the latter the angles α', β', γ'.

As vibrations of this kind cannot exist in any medium, unless they are maintained by total reflexion at its surface, we shall suppose, in order to contemplate their laws in their utmost generality, that a crystal is in contact with a fluid of greater refractive power than itself, and that a ray is incident at their common surface, at such an angle as to produce total reflexion. The question then is, the angle of incidence being given, to determine the laws of the disturbance within the crystal.

The author finds that the refraction is still *double*, and that two distinct and separable systems of vibration are transmitted into the crystal. He shows that the surface of the crystal itself (the origin of coordinates being upon it at the point of incidence) must coincide with the plane expressed by equation (8), a circumstance which determines the three constants f, g, h. The plane expressed by (7) is parallel to the plane of the refracted wave; and a normal, drawn to it through the origin, lies in the plane of incidence, making with a perpendicular to the face of the crystal an angle ω which may be called the angle of refraction, so that, if i be the angle of incidence, we have

$$\sin \omega = s \sin i,$$

the velocity of propagation in the fluid being regarded as unity.

To each refracted wave, or system of vibration, corresponds a particular system of values for r, s, ω. These the author shows how to determine by means of the *index-surface* (the reciprocal of Fresnel's wave surface) which he has employed on other occasions, (Transactions of the Academy, vol. xvii. and xviii.), and the rule which he gives for this purpose affords a remarkable example of the use of the imaginary roots of equations, without the theory of which, indeed, it would have been difficult to prove, in the present instance, that there are two, and only two, refracted waves. Taking a new system of coordinates x', y', z', of which z' is perpendicular to the surface of the crystal, and y' to the plane of incidence, while x' lies in the intersection of these two planes, put $y'=0$ in the equation of the index-surface referred to those coordinates, the origin being at its centre; we shall then have an equation of the fourth degree between x' and z', which will be the equation of the section made in the index surface by the plane of incidence. In this equation put $x'=\sin i$, and then solve it for z'. When i exceeds a certain angle i', the four values of z' will be imaginary, and if they be denoted by

$$u \pm v\sqrt{-1}, \qquad u' \pm v'\sqrt{-1},$$

each pair will correspond to a refracted system, and we shall have, for the first,

$$\tan\omega = \frac{\sin i}{u}, \qquad s = \frac{\sin\omega}{\sin i}, \qquad r = sv; \qquad (9)$$

and for the second,

$$\tan\omega' = \frac{\sin i}{u'}, \qquad s' = \frac{\sin\omega'}{\sin i}, \qquad r' = s'v'. \qquad (10)$$

When i lies between i' and a certain smaller angle i'', two of the roots will be real, and two imaginary. The real roots correspond to waves which follow the law of Fresnel; the imaginary roots give a single wave, following the other laws just mentioned.

Lastly, when i is less than i'', all the roots are real, the refraction is entirely regulated by Fresnel's law, and the reflexion by the laws already discovered and published by the author.

If the crystal be uniaxal, and all the values of z' imaginary, the ordinary wave normal will coincide with the axis of x'; whilst the extraordinary wave normal and the axis of z' will be conjugate diameters of the ellipse in which the index surface is cut by the plane of incidence.

When $a = b = c$, the crystal becomes an ordinary medium; there is then only single refraction, and the refracted wave is always perpendicular to the axis of x'.

With regard to the ellipse in which the vibrations are performed, it may be worth while to observe, that if it be projected perpendicularly on the plane of incidence, the projected diameters which are parallel to the surface of the crystal and to the wave plane will, in all cases, be conjugate to each other, and their respective lengths will be in the proportion of r to unity. The vibrations, it is obvious, are not performed in the plane of the wave, though they take place without changing the density of the ether.

The new laws here announced are, properly speaking, laws of double refraction, and are necessary to complete our knowledge of that subject. Between them and the laws of Fresnel a curious analogy exists, founded on the change of real into imaginary constants.

The laws of the total reflexion, which accompanies the new kind of refraction, need not be dwelt upon in this abstract, as nothing is now more easy than to form the equations which contain them. In fact, the difficulties which formerly surrounded the problem of reflexion, even in the simplest cases, have completely disappeared, since the author made known the conditions which must be fulfilled at the separating surface of two media.

In what precedes, it has been supposed that the reflexion and refraction take place at the *first* surface of the crystal, because this is the more difficult and complicated of the two cases into which the question resolves itself. But it will usually happen in practice that a ray which has entered the crystal will suffer total reflexion at the *second* surface, while the new kind of vibration is propagated into the air without. The refracted wave will then be always perpendicular to the axis of x'; the two reflected rays, within the crystal, will be plane-polarized, according to the common law, but they will each undergo a change of phase; and the *vis viva* of the two rays together will be equal to that of the incident ray, the *vis viva* being measured by the square of the amplitude multiplied by the proportional mass.

In conclusion, the author states a mathematical hypothesis by which both the laws of dispersion, and those of the elliptic polarization of rock crystal, may be connected with the laws already developed.

The Rev. Dr. Todd communicated the following particulars concerning an ancient inkstand, contained in a letter from Joseph H. Monck Mason, Esq., dated Rome, May 4th, 1841:

"This relic (described by Mrs. Hamilton Gray, in her Tour in Etruria, p. 334) is of coarse *terra-cotta*, black and ill-formed; it is a truncated cone, about eight inches long, about four or five inches *round* the mouth, and about twelve (not more, I think) round the base; there are about twelve lines of letters written round the upper three-fourths, and one round the very base; they are written from left to right. I repeat it, that, being cramped by the rules and restrictions, I was not entirely particular; and the upper part was dirty, and not very legible without close inspection. I could see of the last line (I do not mean that round the base, which has some Greek capitals,) about three-fifths; this contained fourteen letters. I saw no *omicron* or *omega*. This line might have had twenty-four letters; and allowing about twelve, or say fifteen lines in all, gradually diminishing as on the outside of a cone, there was scarcely room for *ba, be,* in a second language. I believe them all to be Greek. About three or four lines up, I remember, there was P (*ro,*) and a little higher, *mu*, with vowels in order. So much for this wonder, if it be the right one; and it was shown to me as such by one who knew it to be so."

The following Note "On the Force of aqueous Vapour within the Range of atmospheric Temperature," was read by James Apjohn, M.D., M.R.I.A., Professor of Chemistry in the Royal College of Surgeons.

Having had it in contemplation some time since to investigate by means of an indirect, but I believe a very accurate process, the caloric of elasticity of the vapours of several liquids, I found myself stopped on the threshold of the inquiry by a want of knowledge of the tension of such vapours at different temperatures; for, with the exception of the vapours of water, alcohol, ether, and oil of turpentine, the tension of no others had been made the subject of experiment; and even in the case of the fluids just named, the results recorded in the books appeared to me very far from being of such a nature as to preclude the necessity of further research.

The method which I intended to employ, in order to arrive at the latent heats of vapours, not requiring a knowledge of their tensions beyond the range of atmospheric temperature, it occurred to me, that the necessary data for the solution of the preliminary problem might be obtained with facility, and, at the same time, with much precision, in the following manner:

Let a known volume of dry air be charged with moisture at any given temperature, and let the expansion produced by the moisture be accurately noted. The pressure being also measured by an accurate barometer, we have the means of calculating the force of the vapour which has produced the expansion. For if v be the volume of the dry air, and v' that of same air when charged with moisture, f the force of the vapour, and p the existing atmospheric pressure, we shall have

$$v' = v \times \frac{p}{p-f},$$

from which we deduce

$$f = \left(\frac{v'-v}{v'}\right) \times p.$$

It was not my original intention to make any experiments upon the force of *aqueous* vapour, believing the table which I have hitherto employed, and which was calculated by the author of the article "Hygrometry," in Brewster's Encyclopædia, from the experiments of Dalton, to have been sufficiently exact. But the correctness of this table having been indirectly called in question by so high an authority as Mr. Kupffer, who has come to the conclusion, that the table of the force of aqueous vapour, given by a German meteorologist, of the name of Kämtz, is alone to be relied upon, I resolved to commence with the vapour of water, in the hope that I might be able, by the results of direct experiment, to corroborate a conclusion previously drawn by Professor Lloyd, from a discussion of some hygrometrical observations of mine, viz., that for temperatures within the atmospheric range, the table of Kämtz is less accurate than that of Dalton, the values given in the former being all too low.

The apparatus I have employed in my experiments is composed of a glass ball prolonged on the one side into a short tube, furnished with a cap and stopcock, and, on the other, into a long tube of somewhat smaller diameter, divided into 100 equal parts, each being .042 of a cubic inch, or the .001 of the total capacity of ball and tubes down as far as the division marked 1000.

The first step consisted in filling this vessel with dry air, which was done in the following manner: into the extremity of the graduated tubular portion, a cork pierced by a small tube, open at both ends, was inserted, and this tube was then connected with the orifice of a table air-pump usually occupied by a syphon gauge. The stop-cock was now connected with one end of a long tube, packed with fragments of fused caustic potash, while the other end of this tube was attached by means of a slip of caoutchouc to a second tube passing through an air-tight cork fixed in one of the mouths of the bottle, at present used for the inhalation of chlorine. This bottle being charged with oil of vitriol, and the orifice of the plate of the pump being closed, the pump was worked, and a current of air was thus drawn through the glass vessel for about fifteen minutes, which in passing through the oil of vitriol, and over the fused potash, was deprived of all hygrometric moisture. The included air being now absolutely dry, the stopcock was closed, and the small tube connecting the air vessel with the pump having been drawn out in the middle, and sealed hermetically by means of a spirit lamp, the air apparatus was separated from the potash tube, and transferred to a tall jar containing mercury, after which the sealed end of the small glass tube was broken beneath the surface of the quicksilver. The apparatus, however, being now completely filled, it became necessary to remove some of the air, and this was done by opening the stopcock very gradually, care being taken that during this manipulation the external mercury should be higher than its level within the tubular portion. The entire was then placed in a small room, the temperature of which was found not to vary more than one degree Fahrenheit during the twenty-four hours, the stopcock having been first attached to one extremity of a string, which was carried over a fixed pulley placed in the ceiling, and whose other end carried a counterpoise by which the air vessel was kept in a vertical position, and the observer was enabled readily to bring the mercury within and without to the same level, before he registered the volume of the included air.

On the next day, after the apparatus was mounted, and the four following ones, the volume of the dry air, its temperature, and the existing pressure were accurately noted. This pressure, which was measured by a portable barometer of Newman's, having undergone a variety of corrections, for the capacity of the cistern compared to that of the tube, for the excess of the temperature of the quicksilver over 32°, for capillarity, and for a constant error by which I found my barometer affected, when compared with the standard instrument in the Observatory of Trinity College, I reduced by calculation in each instance the observed volume of air to what it would be at 32°, and under a pressure of 30, using for the expansion of air the corrected coefficient $\frac{1}{493}$, which has resulted from the experiments of Rudberg, and thus obtained the following numbers, which, it will be observed, differ very little from each other.

1	911·11
2	911·85
3	910·21
4	913·30
5	911·72

911·64, therefore, the mean of the five observations, may be assumed as the true volume of the included dry air, at 32°, and under a pressure of 30.

The volume of the dry air being determined, the next step was to charge it with moisture. In order to accomplish this, the air vessel was lifted by means of the string, so as that the mercury within should be about an inch higher than the external mercury, and distilled water was then poured into the upper cavity of the stopcock, so as completely to fill it. The stopcock was now cautiously turned, so as to admit the entrance of the moisture *guttatim*;

and more water being occasionally poured on, this manipulation was repeated until the mercury within came to be covered by a film of water of about one-tenth of an inch in thickness. The stopcock was now closed, and the apparatus being lowered, the whole was left to itself until the following day, when the first of a series of observations, continued for twenty successive days, was made, each comprehending the volume of the moist air, the pressure, and the temperature both of the air and of the mercury in the barometer. To deduce from these by the formula $f = \frac{v' - v}{v'} \times p$, the force of vapour, it was necessary, in the first instance, to apply to p all the corrections already explained, and in addition to raise 911·64, the volume of the dry air, to what it would be at the temperature and pressure of the moist air, as noted in each observation. But, as this involved tedious arithmetical computations, and as the thermometer during the performance of the twenty experiments varied only about 15°, I came to the resolution, being at the time upon the eve of leaving town for a couple of months, to postpone the calculations until I should be possessed of *data* applicable to the solution of the problem I had undertaken, throughout a more extended range of temperature.

Accordingly, in November last, I resumed the subject with the very same apparatus, which had been left *statu quo* in the interval, and succeeded in completing a series of forty-five additional observations, extending nearly as low as 32°, and which I had every reason to expect would lead to satisfactory results. Upon, however, submitting the whole to calculation, I have been led to the mortifying conviction, that in consequence either of the absorption of the oxygen by the mercury and brass-work, or some accident which befel the apparatus during my absence from town, the entire of the latter series of observations is of no value, as they lead to results for the force of aqueous vapour, which are certainly greatly below the truth. Upon the present occasion, therefore, I can direct attention only to the observations made in July and August last. These are contained in the following table, and, as has been already stated, they amount to twenty in number, the highest temperature having been 65°, and the lowest 49°·6. The numbers in the last column represent the bulks which the 911·64 volumes of dry air would have, if reduced to the temperature *t*, and the corrected pressure *p*.

TABLE I.

v'	t	p observed	Temperature of Barometer.	p corrected.	911·64 reduced to t and p corrected.
1001	60·4	29·450	59·9	29·430	982·82
1001·5	59·8	29·364	60·1	29·338	984·77
997	60	29·548	60	29·524	978·94
984	59·1	29·822	59·5	29·807	967·97
977	58·4	29·980	58·6	29·971	961·38
984	58·4	29·780	58·9	29·767	967·97
991	59	29·624	59·4	29·607	974·33
983·5	59·4	29·862	59·8	29·847	967·23
979·5	60·2	30·100	60·6	30·086	962·69
977·5	61·2	30·132	61·3	30·165	960·35
983	61·6	30·05	62·2	30 037	965·18
973·3	62·2	30·230	62·4	30·212	960·69
978·4	61·6	30·214	62·2	30·197	960·06
983·5	63·1	30·156	63·6	30·131	964·93
987·5	64·3	30·130	64·7	30·104	968·01
991	64·1	30·032	64·6	30·005	970·83
994·5	64·8	29·989	65	29·961	973·55
994·5	65	29·972	66	29·940	974·61
989	65·2	30·152	66·5	30·120	969·12
1000	64·8	29·834	65	29·306	978·62

From the first, last, and second last columns of the preceding table, the force of aqueous vapour has been calculated in the manner already explained. The values thus obtained are exhibited in the second column of Table II.

Column 1 contains the temperatures; column 3 the tensions, as deduced from Dalton's experiments; and column 4 the same as given by Kämtz.

TABLE II.

1	2	3 Dalton.	4 Kämtz.
60°·4	·5345	·5302	·5125
59 ·2	·4908	·5197	·5023
60 ·	·5348	·5232	·5061
59 ·1	.4855	·5077	·4893
58 ·4	·4917	·4960	·4768
58 ·4	·4849	·4960	·4768
59 ·	·4980	·5060	·4875
59 ·4	·4937	·5128	·4949
60 ·2	·5169	·5265	·5093
61 ·2	·5292	·5444	·5261
61 ·6	·5445	·5517	·5343
62 ·2	·5412	·5628	·5458
61 ·6	·5660	·5517	·5343
63 ·1	·5689	·5798	·5615
64 ·3	·5941	·6033	·5860
64 ·1	·6107	·5993	·5824
64 ·8	·6311	·6133	·5949
65 ·	·5988	·6173	·5985
65 ·2	·6054	·6214	·6029
64 ·8	·6372	·6133	·5949

When the corresponding numbers in the three columns are compared, it will be at once observed, that the values of f, investigated by the method just explained, are somewhat less than those extracted from the table I have been hitherto in the habit of using; but that they are considerably greater than the values of Kämtz, the differences being generally better than twice as great in the latter instance as in the former. This will be more manifest by taking a mean of the different results in column 2, and comparing it with the force of vapour corresponding to the same temperature as given in the two other tables. Now, the mean of the temperatures is 61°·63, the quotient got by dividing their sum by twenty. But the corresponding mean value of *f*, in column 2, must be differently calculated, seeing that the temperature and the corresponding tensions of the vapour augment at a very different rate. For temperatures, in fact, in arithmetic progression, the corresponding tensions are in geometric progression; and, although this is well known to be but an approximate law, it may be considered as rigorously true for the limited range of temperature within which my experiments have been made. To calculate, therefore, the mean force of vapour, as deducible from the numbers in column 2, and which must correspond to the temperature 61°·63, it is only necessary to add together the logarithms of the numbers in this column, and divide their sum by twenty, and the quotient will be the logarithm of the mean. When this process is gone through, the mean logarithm is found to be ·73699, and the corresponding number ·54575. The following, therefore, are the tensions of aqueous vapour at 61°·63, as deduced from my experiments, and as extracted from the tables of Dalton and Kämtz.

	My Experiments.	Dalton.	Kämtz.
61°·63, . .	·5457	·5523 . . .	·5349

Difference between Dalton's number and mine, = + .0066.

Difference between Dalton's number and that of Kämtz, = + .0174.

It thus appears, that the result at which I have arrived is somewhat less than the Daltonian number, but considerably greater than that given by Kämtz; and that, therefore, my experiments, as far as they have been discussed, give at least a *prima facie* countenance to the opinion, that the values of the elastic force of aqueous vapour, as given by the latter philosopher, are, at and about 61°·63, below the truth.

Before, however, this conclusion can be considered as fully established, and before we can judge correctly of the amount of the errors by which his table is affected, it will be necessary to inquire whether the thermometer I have employed be a true one. This essential inquiry I have been enabled to institute by my friend, Professor Lloyd, who has put into my possession, for the purpose, a thermometer given him by Professor John Phillips, together with a table of differences between it and the standard thermometer belonging to the Royal Society. Upon a comparison of the two instruments, I find, that at and about 60°, the thermometer I have employed stands ·6 of a degree higher than that lent me by Professor Lloyd, while the latter stands ·3 of a degree higher than the standard in possession of the Royal Society; so that the indications of my instrument are at 60° 9-10ths of a degree higher than the truth. If such be the case, ·5457, instead of being the force of vapour at 61°.63, is the force at $61{\cdot}63 - 0{\cdot}9 = 60°{\cdot}73$; and to compare the result of my experiments with the tables of Dalton and Kämtz, it is only necessary to extract from these the values of the force of vapour corresponding to the temperature 60°·73.

	My Experiments.	Dalton.	Kämtz.
60°·73	·5457	·5361.	·5157

Difference between Dalton's number and mine — ·0096.

Difference between Dalton's number and that of Kämtz + ·0184.

The consideration, therefore, of the error of my thermometer, and the allowance made for it, only strengthens the conclusion already arrived at; and I do not now feel any difficulty in giving it as my deliberate opinion, that the table of the force of vapour given by Kämtz is, within the atmospheric range of temperature, erroneous, his values being all too low.

Dr. Anster, on the part of the Rev. Dr. Luby, F.T.C.D., presented to the Academy the original letter of the Rev. C. Wolfe, which he had read at a former Meeting, and of which a *fac-simile* is published in the present Number of the Proceedings. (See p. 90.)

The special thanks of the Academy were voted to Doctor Luby for the donation of this very interesting document.

Professor Mac Cullagh presented to the Academy three additional ornamented plates belonging to the cross of Cong. When the cross came into his possession, these plates were missing; but they were lately recovered for him by the exertions of a friend. The front of the cross is now complete, and only one plate is left wanting at the back.

DONATIONS.

Astronomical Observations made at the Honourable the East India Company's Observatory at Madras, for the Years 1831—39. Vols. I.—V. Presented by the Court of Directors.

Journal of the Statistical Society. Vol. IV. Part 1. Presented by the Society.

Contributions towards the History of Swansea. By Lewis W. Dillwyn, F.R.S., &c. Presented by the Author.

Mémoires préséntes par divers savants a l'Académie Royale des Sciences de l'Institut de France; Science Mathématiques et Physiques. Tome V.

Mémoires de l'Institut Royal de France, Académie des Inscriptions et Belles Lettres. Tomes XI., XII., XIII., and XIV.; Part 2.

Mémoires de l'Institut de France, Académie Royale des Sciences. Tome XIV.—XVII.

Séance Publique Annuelle de l'Académie Royale des Inscriptions et Belles Lettres, du Vendredi 25th Septembre, 1840.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Premiere Semestre, 1840. Nos. 20—26; Deuxieme Semestre, 1840. Nos. 1—26; Premiere Semestre, 1841, Nos. 1—10. Presented by the Academy.

Catalogue des Manuscrits de la Bibliotheque de Chartres. Presented by J. O. Halliwell, Esq., M. R. I. A.

Greenwich Astronomical Observations for the Year 1839. Presented by the Royal Astronomical Society.

Report of the Tenth Meeting of the British Association for the Advancement of Science. 1840. Presented by the Association.

Transactions of the American Philosophical Society. Vol. VII. New series. Part 2.

Proceedings of the American Philosophical Society. Nos. 14—16. (1841). Presented by the Society.

On the Composition of Chalk Rocks and Chalk Marl by invisible organic Bodies; with an Appendix. By Thomas Weaver, Esq., M.R.I.A. Presented by the Author.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 30.

June 14.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

James Patten, M.D., was elected a member of the Academy.

Dr. Aquilla Smith read a paper "On the Irish Coins of Henry VII."

In the preliminary remarks, the author entered at some length into the history of the Irish coinage during the reigns of Henry V. and Henry VI., with the view of facilitating his inquiries in the subsequent part of his essay. And from the evidence of several Acts of Parliament, which were not known to previous writers on the coinage of Ireland, he inferred that no legal money was coined in this country by Henry V., and that very few coins are known which can be appropriated to his immediate successor.

The coins of Henry VII., which are very numerous, were divided into three sections, each distinguished by the form of the cross on the reverse; and in the last section the author supported Mr. Lindsay's appropriation to Henry VII. of the untressured groats which Simon had given to Henry V.

Rev. H. Lloyd, V. P. read a "Note on the Mode of observing the vibrating Magnet, so as to eliminate the Effect of the Vibration."

The following modification of one of the methods proposed by Gauss, for the attainment of this end, appears to combine the greatest number of advantages; namely, *to take three readings, at the times*

$$t - \text{T}, \quad t, \quad t + \text{T};$$

t being the epoch for which the position of the magnet is desired, and T *its time of vibration.** In order to show that this method is adequate, it is necessary to deduce the equation of motion of a vibrating magnet in a retarding medium.

Let X denote the horizontal part of the earth's magnetic force; q the quantity of free magnetism in the unit of volume of the suspended magnet, at the distance r from the centre of rotation; and θ the deviation of the magnet from its mean position. The moment of the force exerted by the earth on the element of the mass, dm, is

$$\text{X}qrdm \sin\theta;$$

and the sum of the moments of the forces exerted upon the entire magnet is

$$\text{X}\mu \sin\theta;$$

where μ denotes the value of the integral $\int qrdm$, taken between the limits $r = \pm l$, $2l$ being the length of the magnet.

Again, the velocity being small, the resistance may be assumed to be proportional to the velocity. Accordingly, if ω denote the angular velocity, the retarding force due to resistance, upon any element of the surface, ds, at the distance r from the centre of motion, is

$$-\text{K}ds\, r\omega;$$

and the entire moment of this force upon the whole magnet is

* In practice, it is sufficient to take the nearest whole number of seconds, for the value of T.

$$-\text{K}\omega \int r^2 ds = -\text{K}\omega \int \frac{r^2 dm}{\text{H}};$$

where $\text{H} = \frac{dm}{ds}$. The ratio, H, is constant for all bodies of prismatic form; and for these, therefore, the moment of resistance is

$$-\frac{\text{MK}}{\text{H}}\omega;$$

M denoting the moment of inertia $\int r^2 dm$.

The differential equation of motion is, therefore,

$$\frac{d\omega}{dt} = \frac{\text{X}\mu}{\text{M}} \sin\theta - \frac{\text{K}}{\text{H}}\omega.$$

But $\omega = -\frac{d\theta}{dt}$; and, θ being small, we may substitute θ for $\sin\theta$. The equation thus becomes

$$\frac{d^2\theta}{dt^2} + \frac{\text{K}}{\text{H}}\frac{d\theta}{dt} + \frac{\text{X}\mu}{\text{M}}\theta = 0.$$

Making, for abridgment, $\frac{\text{K}}{\text{H}} = 2\text{A}$, $\frac{\text{X}\mu}{\text{M}} = \text{B}^2$, the integral is

$$\theta = (c\cos\sqrt{\text{B}^2 - \text{A}^2}\,.\,t + c'\sin\sqrt{\text{B}^2 - \text{A}^2}\,.\,t)\,e^{-\text{A}t}.$$

But, A being small, we have approximately

$$e^{-\text{A}t} = 1 - \text{A}t;$$

and, if T denote the time of vibration,

$$\sqrt{\text{B}^2 - \text{A}^2}\,.\,\text{T} = \pi.$$

Hence the preceding equation may be put under the form

$$\theta = (1 - \text{A}t)\left(c\cos\pi\frac{t}{\text{T}} + c'\sin\pi\frac{t}{\text{T}}\right).$$

Now, let $\theta_{\prime}$ and θ' denote the values of θ, when t becomes

$t - \tau$ and $t + \tau$. It will be seen at once, on substitution, that

$$\theta_{,} + 2\theta + \theta' = 0.$$

Hence by combining the three readings according to the preceding formula, the deviation of the magnet from its mean position, arising from the vibratory movement, is completely eliminated; and it will readily appear that the same result may be attained by any greater number of readings, taken and combined according to the same law.

Now, let the value of θ contain an *additional* term, $+pt$, proportional to the time: or, in other words, let us suppose that there is a *progressive* change of the declination, which may be regarded as *uniform* during the whole interval of observation. It is then manifest that $\theta_{,} + 2\theta + \theta' = 4pt$; and accordingly that the quantity

$$\tfrac{1}{4}(\theta_{,} + 2\theta + \theta')$$

will give the mean place of the magnet corresponding to the epoch t.

The supposition of a uniform change can, however, be regarded as an approximation to the truth, only when the interval of time between the first and last reading is very small, in comparison with the interval between the successive maxima and minima, in the fluctuations of the irregular movement. Hence, we may conclude, that it is important, in the first place, to employ three readings in preference to any greater number; and, secondly, that it is desirable that the time of vibration of the magnet itself should be as small as possible, consistently with the accuracy of its indications in other respects.

Professor Lloyd read the following extract of a letter from the Rev. George S. Smith, containing some facts relative to the storm of May 26th and 27th.

" It appears that the thunder storm commenced on Wednesday night in Tipperary, Clare, Limerick, and Waterford, reaching its greatest violence on Thursday morning at about six. It was on Thursday evening that it was most severe in Carlow and Queen's County, from nine till twelve P.M., having, however, been felt in the morning of the same day. On Thursday evening it began in Dublin; but the thunder was loudest at half-past three A.M. on Friday morning. On Friday morning, at ten o'clock, A.M., it raged in the county Mayo.

" In Windsor forest and the neighbouring country it was a more furious tempest, and took place on the evening of Thursday the 27th, as in the county Carlow.

" It was reported to me, that there were some remarkable phenomena of the tide in Dublin Bay during the storm; and I accordingly inquired from a variety of persons on the quays and elsewhere, and they concurred in stating, that about half-past three the tide, which was then flowing and approaching to high water, suddenly retired in half an hour to low water mark, and that it rapidly returned and rose two feet higher than high water mark, and so quickly that boats were knocked violently against each other. The coal-porters, and dockyard keepers, and various sailors both in the river and Kingstown, agreed in this statement.

" Further, in the River Foyle, in the North of Ireland, there is an embankment in the course of being formed by Thomas Hutton, Esq., and he states that the tide on Thursday night, or Friday morning, retired so suddenly, that considerable damage was done to his embankment.

" The concurrence of these phenomena with the storm is a point of some interest; and I write these few lines to invite inquiry, and to ascertain, if possible, whether this extraordinary tide-wave was generally observed, and on what day and hour, and whether it coincided or not with the storm.

"The newspapers report the occurrence of the storm, as mentioned above; but say nothing of the tide.

"The course of the storm seems to have been from south to north; but I think a north-east wind was blowing."

A communication by Francis Crawford, Esq., A.B., "On the Utility of the Irish Language in Classical Studies," was read.

The object of the writer was to show, that, notwithstanding the contempt and ridicule into which the subject had fallen in consequence of the rash and unphilosophic views of injudicious advocates, still there existed reasonable grounds for believing that a careful and sober analysis of Heathen mythological names would resolve them into *Celtic* elements through the medium of *Irish;* accordingly he proceeded to give numerous instances of such analysis, at the same time declaring, that unless supported by such analogies, or other external evidence, as he offered, investigations of this sort were by no means to be relied upon.

After interpreting, in this manner, the names of some of the Syrian deities mentioned by Selden, in his learned work "De Dis Syris," the writer went on to set the whole subject in a more interesting point of view, by attempting to show, that even the Bible might receive illustration and confirmation from such inquiries; to effect this, he undertook to identify the *Melchizedek* of Scripture with the famous *Tyrian Hercules;* he shewed at some length, that they were contemporaries in history, that they agreed in character, that tithes were paid to both, and finally that the name of *Malcarth,* by which the *Tyrian Hercules* was best known, when resolved into its Celtic components Mal-ceart, literally signified "Righteous King," or "*King of Righteousness.*"

The writer, after some further proofs of their identity, concluded by giving a description of the rites and ceremonies used in the worship of Hercules at Gades, intimating that they denoted a purer mode of religious culture than generally obtained in the heathen world.

DONATIONS.

Notes on the United States of North America in 1838, 1839, 1840. 3 Vols. By George Combe, Esq., Hon. M.R.I.A., &c. Presented by the Author.

The Silurian System. By William H. Fitton, Esq. Presented by the Author.

Dublin Metropolitan Police Returns of Persons taken into Custody in 1840. Presented by the Commissioners.

Ordnance Survey of the County of Galway, in 139 sheets, Presented by his Excellency the Lord Lieutenant.

Verhandelingen van het Bataafsch Genootschap der Proefondervindelyke Wysbegeerte te Rotterdam. Vols. I.—XII., and New Series, Vols. I.—VIII. Part I.

A Collection of Temperance Medals. Engraved by J. C. Parkes. Presented by the Artist.

June 28.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Mr. Mallet read a paper "On a new Method of raising Ships of War out of Water for the Purpose of Repair."

Although the author conceived that the objects of the Royal Irish Academy were rather to investigate principles than to apply them in detail, still as any application of these, which proposes to add to our naval power, is of importance, and as on a like subject the Royal Society conferred on Sir R. Seppings their highest reward for his application of diagonal framing to ships, he did not deem it altogether out of place to bring his method of raising ships out of water before the Academy, with models and drawings to illustrate it. The inventor first gave a rapid description of the several methods of taking ships out of water for repair, which have been in use from the earliest times to the present day, viz., by—

1. Stranding on bilge ways.
2. Careening.
3. The machine called the Camel, invented about 1680.
4. The graving dock.
5. Morton's patent slip.
6. The screw dock.
7. The hydraulic dock.

(6 and 7: Both comparatively recent American inventions, and only used there.)

8. The floating dock of the River Tyne, used at Newcastle.

He then pointed out the several disadvantages to which each of these is severally liable.

These are briefly, in the first case, costliness, tediousness, straining of the ship, and imperfect access to the hull. In the second, great danger and imperfect access to the hull. The Royal George was sunk by careening her. In the third case, want of access to the ship—impossibility of exposing the whole hull—straining of the framing, and danger. In the fourth or graving dock, great original outlay; great labour and loss of time in pumping out water where rise of tide is small; loss of two or three hours of daylight every day by the sunken position of the ship, and awkwardness in handling long spars or timber; difficulty of inspection, and unhealthiness of situation to workmen; and, lastly, rotting of timbers, from the constant damp atmosphere of a sunk or graving dock.

Morton's slip overcomes most of these evils, but has some peculiar to itself. Ships can only come on and go off the slip at high and low water; hence, in large vessels, the loss of one tide is often the loss of a fortnight;

it cannot be used in foul weather, or with the tail of the slip in a tideway; the average length of the inclined plane being about five hundred feet, and the rate of elevation of a ship from three to five feet per minute, the time of taking a ship out of water, including the removal of the cradle, occupies from four to six hours; and hence, though nominally cheap, this is by loss of time really a dear mode of repair to the ship-owner—the ship lies on an inclined plane, which is inconvenient in hoisting or lowering heavy parts, particularly in steam-ships. The hull is always strained, and new coppering is often found wrinkled, by the ship running off the slip, and receiving unequal support from the water meeting her at an angle to her plane of stable floatation. The vibration of the numerous rollers is also injurious in the same way.

The American screw and hydraulic docks have the advantage, in point of speed, when in use; but are unsafe for large ships, and awkward in the posture of the ship's hull.

The Newcastle-on-Tyne floating dock possesses all the disadvantages (except original costliness) of the graving dock, and is without the safety of the latter.

The author then explained the nature of his own method, and exhibited it in action by means of a large working model; without plates it is difficult to describe this combination. The vessel to be raised, floats in over a timber platform of a suitable size laying at the bottom, and by means of two very powerful cabstern cranes, actuated by a small steam engine, and acting on two large flat linked chains, the platform is raised above the surface of the water, bringing up the vessel along with it, and placing her upon a suitable level for the convenience of workmen to get under and round the hull, for which the platform is specially adapted. The two chains spoken of lay horizontally at either side of the platform, and above it, and are armed with rollers at equal intervals, resting on a hollow iron railway; and from these points of the chains a number of suspending rods proceed to the platform; at each side below the latter, are an equal number of jointed struts or supports; and the nature of the motion is such, that, when the platform is at the bottom, these struts are nearly horizontal, and the suspending rods vertical, and *vice versa* when the platform is at its greatest elevation; hence, the latter is at all times fully and firmly supported.

The combination is such, that power is to the utmost economized, the ratio of the power to the weight increasing as the hull of the vessel leaves the water, and advantage being taken of her own floatage power as long as possible.

The inventor stated, that a fifty gun frigate, with her standing rigging up, could be taken out of water, and laid dry and ready for workmen, ins ixteen minutes from the time she came over the platform, by his arrangement, which is equally applicable where there is no tide, (as at Malta, &c.,) as where the rise and fall are considerable. The objects also held in view, and he conceives attained, by his method, are equal strain, and wear and tear (by principle) on all the parts—and hence freedom from risk of accident—durability and facility of repair in the machine itself.

A paper by the Rev. Dr. Hincks, "On the Egyptian *Stèle*, or Tablet," was read.

Among the Egyptian monuments in museums, there is none more likely to afford information than the stèles, or funeral tablets, which resemble in form the head-stones in our grave-yards, and which appear to have been set up in similar positions. The object of this paper is to describe the parts of which the inscriptions that these tablets contain usually consist, with such observations as may enable a person, who should meet with one of them, to form a judgment as to its age, and as to the importance of its contents.

It commences with some details respecting two tablets each of which records the dates of the birth and death of the deceased person, and also the length of his life. A diligent search should be made for similar tablets, which would evidently be of the greatest value in settling the chronology of the Egyptian sovereigns. One of these, which is at Florence, records that a person named Psammetich was born in the third year of Necho, the tenth month and first day; that he died in the thirty-fifth year of Amasis, the second month and sixth day; and that he lived seventy-one years, four months, and six days. From this it appears, that the interval between the first year of Necho and the first of Amasis was forty years; and it follows that the reigns of these kings must have commenced in 611 and 571 before our era. The other tablet, which belongs to Mr. Harris of Alexandria, is that of a priest named Psherinphthah, who died, aged forty-nine years, in the eleventh year of Cleopatra, the eleventh month and twentieth day. The chronology of this period being well known from other sources, the dates of the tablet would be of no value, did not that of the birth contain a royal cartouche, which does not occur elsewhere, and an unknown numeral character. The cartouche is shown to be that of Ptolemy Alexander, though it does not contain his usual surname; and the unknown character, a bird's head, is proved to stand for *twenty*. The tablet of Te-imothph, the wife of this priest, who was also his half-sister, is in the British Museum; and several circumstances in their family history, taken from the two tablets, are collected together. The birth of their son Imothph, in the sixth year of Cleopatra, and when the father was turned of forty-three, is recorded on both of them.

The most usual form of the inscription on a stèle is tranlated as follows:—"An act of homage to A; he has (or as the case may be) given B unto C; who says D." The blank at A is filled up with the names and titles of deities; that at B with an enumeration of gifts; that at C with the name and descriptiou of the deceased person; and at D is the speech attributed to him, in which he sometimes records the leading events of his life. Sometimes the tablet is without a speech, the inscription closing at the end of C; and sometimes it begins with C, containing only the name and description of the deceased person and his speech. In a few tablets the prefatory matter is somewhat different from the above; but the form given above is much the most usual.

No record of facts is to be expected in a tablet till we come to C; the preceding part of the inscription is only valuable, as it may aid us in the study of the language, and as it may lead us to know the age of the tablet, supposing it to be without a regular date. For this last purpose, a number of criteria of antiquity are proposed, the result of a careful examination of a great many tablets of known ages. The most remarkable of these is, that in the most ancient tablets the sculptured figures are exclusively those of the deceased person and his relatives; never these of deities, as in the tablets of the eighteenth dynasty and subsequent ages.

At the close of the paper some remarks are made on the chronology of the early Egyptian kings, who are mentioned in the course of it. It is demonstrated that the predecessor of Amenemhe II., the first king in the series of Abydos, was Osortasen I.; the latter being the successor of Amenemhe I., and not his predecessor, as he has been stated to be by Major Felix and others, on the supposed authority of an inscription at Beni-Hassan. This completely overturns the hypothesis of Mr. Cullimore, respecting the connexion of a pretended royal series at Karnac with the series of Abydos.

The phonetic hieroglyphics are represented in this paper by Hebrew characters, in preference to Roman. This has been done on account of the author's peculiar views respecting *the extended arm*, *the crux ansata*, and some other characters, which he considers to be equivalent to the Hebrew Ayin, and by no means "vague vowels," as Champollion supposed. He regards these characters as essentially distinct from *the feather, the eagle,* and others, with which they have been hitherto confounded, and which he represents by the Hebrew Aleph.

The Rev. Charles Graves, F.T.C.D., read a paper "On the Application of Analysis to spherical Geometry."

The object of this paper is to investigate and apply to the geometry of the sphere, a method strictly analogous to that of rectilinear coordinates employed in plane geometry.

Through a point O on the surface of the sphere, which is called *the origin*, let two fixed quadrantal arcs of great circles OX, OY, be drawn; then if arcs be drawn from Y and X through any point P on the sphere, and respectively meeting OX and OY in M and N, the trigonometric tangents of the arcs OM, ON, are to be considered as the *coordinates* of the point P, and denoted by x and y. The fixed arcs may be called *arcs of reference*. An equation of the first degree between x and y represents a great circle; an equation of the second degree, a spherical conic; and, in general, an equation of the n^{th} degree, between the spherical coordinates x and y, represents a curve formed by the intersection of the sphere with a cone of the n^{th} degree, having its vertex at the centre of the sphere.

Though it is not easy to establish the general formulæ for the transformation of spherical coordinates, they are found to be simple.

Let x and y be the coordinates of a point referred to two given arcs, and let x', y', be the coordinates of the same point referred to two new arcs, whose equations as referred to the given arcs are

$$y - y'' = m\,(x - x''),$$
$$y - y'' = m'\,(x - x''),$$

x'', y'', being the coordinates of the new origin; then the values of x and y to be used in the transformation of coordinates would be

$$x = \frac{x''(ax' + by' - 1)}{px' + qy' - 1},$$

$$y = \frac{y''(cx' + dy' - 1)}{px' + qy' - 1}.$$

In which a, b, c, d, p, and q, are functions of m, m', x'', and y''. It is evident that the degree of the transformed equation in x', y', will be the same as that of the original one in x and y.

The great circle represented by the equation

$$\alpha x + \beta y = 1,$$

meets the arcs of reference in two points, the cotangents of whose distances from the origin are α and β; and, if the arcs of reference meet at right angles, the coordinates of the pole of this great circle are $-\alpha$, and $-\beta$. It appears from this, that if α and β, instead of being fixed, are connected by an equation of the first degree, the great circle will turn round a fixed point. And, in general, if α and β be connected by an equation of the n^{th} degree, the great circle will envelope a spherical curve to which n tangent arcs may be drawn from the same point. Thus, the fundamental principles of the theory of polar reciprocals present themselves to us in the most obvious manner as we enter upon the analytic geometry of the sphere.

A spherical curve being represented by an equation between rectangular coordinates, the equation of the great circle touching it at the point x', y', is

$$(y - y')\,dx' - (x - x')\,dy' = 0\,;$$

the equation of the normal arc at the same point is

$$\begin{gathered}(y - y')\,[dy' + x'\,(x'dy' - y'dx')] \\ + (x - x')\,[dx' + y'\,(y'dx' - x'dy')] = 0.\end{gathered}$$

Now, if we differentiate this last equation with respect to

x' and y', supposing x and y to be constant, we should find another equation, which, taken along with that of the normal arc, would furnish the values of x and y, the coordinates of the point in which two consecutive normal arcs intersect: and thus, as in plane geometry, we find the evolute of a spherical curve.

Let 2γ be the diametral arc of the circle of the sphere which osculates a spherical curve at the point x', y', Mr. Graves finds that

$$\tan\gamma = \pm \frac{[dx'^2 + dy'^2 + (x'dy' - y'dx')^2]^{\frac{3}{2}}}{(1 + x'^2 + y'^2)^{\frac{3}{2}}(dx'd^2y' - dy'd^2x')}.$$

For the rectification and quadrature of a spherical curve given by an equation between rectangular coordinates, the following formulæ are to be employed:—

$$ds = \frac{\sqrt{dx'^2 + dy'^2 + (x'dy' - y'dx')^2}}{1 + x'^2 + y'^2},$$

and

$$d\,(\text{area}) = \frac{ydx}{(1 + x^2)\sqrt{1 + x^2 + y^2}}.$$

In the preceding equations the radius of the sphere has been supposed $= 1$.

The method of coordinates here employed by Mr. Graves is entirely distinct from that which is developed by Mr. Davies in a paper in the 12th Vol. of the Transactions of the Royal Society of Edinburgh. Mr. Graves apprehends, however, that he has been anticipated in the choice of these coordinates by M. Gudermann of Cleves, who is the author of an "Outline of Analytic Spherics," which Mr. Graves has been unable to procure.

The President communicated a new demonstration of Fourier's theorem.

A letter was read from Professor Holmboe, accompanying his memoir, "*De Priscâ re Monetariâ Norvegiæ*," &c., and requesting to know from the Academy whether any of the coins described in that work are found in Ireland.*

July 12.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Part I. of a "Memoir on the Dialytic Method of Elimination," by J. J. Sylvester, Esq. A. M., of Trinity College, Dublin, and Professor of Natural Philosophy in University College, London, was read.

The Author confines himself in this part to the treatment of two equations, the final and other derivees of which form the subject of investigation.

The Author was led to reconsider his former labours in this department of the general theory by finding certain results announced by M. Cauchy in *L'Institut*, March Number, of the present year, which flow as obvious and immediate consequences from Mr. Sylvester's own previously published principles and method.

Let there be two equations in x,

$$U = ax^n + bx^{n-1} + cx^{n-2} + ex^{n-3} + \&c. = 0,$$
$$V = \alpha x^m + \beta x^{n-1} + \lambda x^{n-2} + \&c. \qquad = 0,$$

and let $n = m + \iota$, where ι is zero or any positive value (as may be).

Let any such quantities as $x^r U$, $x^e V$, be termed augmentatives of U or V.

To obtain the derivee of a degree s units lower than V, we must join s augmentatives of U with $s + \iota$ of V. Then out of $2s + \iota$ equations

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* The Committee of Antiquities, having been consulted on this point, reported in the negative.

$$x^0 . U = 0, \quad x^1 . U = 0, \quad x^2 . U = 0, \ldots . x^{s-1} . U = 0,$$
$$x^0 . V = 0, \quad x^1 . V = 0, \quad x^2 . V = 0, \ldots . x^{\iota+s-1} . V = 0,$$

we may eliminate linearly $2s + \iota - 1$ quantities.

Now these equations contain no power of x higher than $m + \iota + s - 1$; accordingly, all powers of x, superior to $m - s$, may be eliminated, and the derivee of the degree $(m - s)$ obtained in its prime form.

Thus to obtain the final derivee (which is the derivee of the degree zero), we take m augmentatives of U with n of V, and eliminate $(m + n - 1)$ quantities, namely,

$$x, x^2, x^3, \ldots \ldots \text{ up to } x^{m+n-1}.$$

This process, founded upon the dialytic principle, admits of a very simple modification. Let us begin with the case where $\iota = 0$, or $m = n$. Let the augmentatives of U, be termed U_0, U_1, U_2, U_3, ... and of V, V_0, V_1, V_2, V_3, ... the equations themselves being written

$$U = ax^n + bx^{n-1} + cx^{n-2} + \&c.$$
$$V = a'x^n + b'x^{n-1} + c'x^{n-2} + \&c.$$

It will readily be seen that

$$a' . U_0 - a . V_0,$$
$$(b' U_0 - b V_0) + (a' U_1 - a V_1),$$
$$(c' . U_0 - c . V_0) + (b' U_1 - b V_1) + (a' U_2 - a V_2),$$
$$\&c.$$

will be each linearly independent functions of x, x^2, ... x^{m-1}, no *higher* power of x remaining. Whence it follows, that to obtain a derivee of the degree $(m - s)$ in its prime form, we have only to employ the s of those which occur first in order, and amongst them eliminate x^{m-1}, x^{m-2}, ... x^{m-s+1}. Thus, to obtain the *final* derivee, we must make use of n, that is, the entire number of them.

Now, let us suppose that ι is not zero, but $m = n - \iota$.

The equation V may be conceived to be of n instead of m dimensions, if we write it under the form

$$0.x^n + 0.x^{n-1} + 0.x^{n-2} + \ldots\ldots + 0.x^{m+1} + \\ ax^m + \beta x^{m-1} + \&c. = 0.$$

and we are able to apply the same method as above; but as the first ι of the coefficients in the equation above written are zero, the first i of the quantities

$$(a'U_0 - aV_0),\ (b'U_0 - bV_0) + (a'U_1 - aV_1),\ \&c.$$

may be read simply

$$-a.V_0,\ -b.V_0 - aV_1,\ -cV_0 - bV_1 - aV_2,\ \&c.$$

and evidently their office can be supplied by the simple augmentatives themselves

$$V_0 = 0,\ V_1 = 0,\ V_2 = 0\ \ldots\ldots\ V_{\iota-1} = 0;$$

and thus ι letters, which otherwise would be *irrelevant*, fall out of the several derivees.

The Author then proceeds with remarks upon the general theory of simple equations, and shows how by virtue of that theory his method contains a solution of the identity

$$X_r . U + Y_r . V = D_r;$$

where D_r is a derivee of the r^{th} degree of U and V, and, accordingly, X_r of the form

$$\lambda + \mu x + \nu x^2 + \ldots\ldots + \theta x^{m-r-1},$$

and Y_r of the form

$$l + mx + \ldots\ldots + tx^{n-r-1},$$

and accounts *a priori* for the fact of not more than $(n-r)$ simple equations being required for the determination of the $(m+n-2r)$ quantities λ, μ, ν, &c. l, m, n, &c., by exhibiting these latter as *known* linear functions of no more than $(n-r)$ unknown quantities left to be determined.

Upon this remarkable relation may be constructed a method well adapted for the expeditious computation of numerical values of the different derivees.

He next, as a point of curiosity, exhibits the values of the secondary functions

$$a'.U_0 - aV_0,$$
$$b'.U_0 - bV_0 + a'.U_1 - aV_1,$$
$$c'.U_0 - c.V_0 + b'.U_1 - bV_1 + a'.U_2 - aV_2,$$
&c.

under the form of symmetric functions of the roots of the equations $U = 0$, $V = 0$, by aid of the theorems developed in the "London and Edinburgh Philosophical Magazine," December, 1839, and afterwards proceeds to a more close examination of the final derivee resulting from two equations each of the same (any given) degree.

He conceives a number of cubic blocks each of which has two numbers, termed its *characteristics*, inscribed upon one of its faces, upon which the value of such a block (itself called an *element*) depends.

For instance, the value of the *element*, whose *characteristics* are r, s, is the difference between two products: the one of the coefficient r^{th} in order occurring in the polynomial U, by that which comes s^{th} in order in V; the other product is that of the coefficient s^{th} in order of the polynomial V, by that r^{th} in order of U; so that if the degree of each equation be n, there will be altogether $\frac{(n+1)}{2}$ such elements.

The blocks are formed into squares or flats (*plafonds*) of which the number is $\frac{n}{2}$ or $\frac{n+1}{2}$ according as n is even or odd. The first of these contains n blanks in a side, the next $(n-2)$, the next $(n-4)$, till finally we reach a square of four blocks or of one, according as n is even or odd. These flats are laid upon one another so as to form a regularly ascending pyramid, of which the two diagonal planes are termed the plânes of separation and symmetry respectively. The former divides the pyramid into two halves, such that no element on the one side of it is the same as that of any block in the other. The plane of symmetry, as the name denotes, divides the pyramid into two exactly *similar* parts; it being a rule, that *all elements lying in any given line of a square (plafond) parallel to the plane of separation are identical;* moreover, the sum of the characteristics is the same, for *all* elements lying *any where* in a *plane* parallel to that of separation.

All the terms in the final derivee are made up by multiplying n elements of the pile together, under the sole restriction, that no two or more terms of the said product shall lie in any one plane out of the two *sets* of planes perpendicular to the sides of the squares. The *sign* of any such product is determined by the places of either set of planes parallel to a side of the squares and to one another, in which the elements composing it may be conceived to lie.

The Author then enters into a disquisition relating to the *number* of terms which will appear in the final derivee, and concludes this first part with the statement of two general canons, each of which affords as many tests for determining whether a prepared combination of coefficients can enter into the final derivee of any number of equations as there are units in that number, but so connected as together only to afford double that number, *less* one of independent conditions.

The first of these canons refers simply to the number of letters drawn out of *each of the given equations,* (supposed homogeneous); the second to what he proposes to call the *weight* of every term in the derivee in respect to *each of the variables* which are to be eliminated.

The Author subjoins, for the purpose of conveying a more accurate conception of his Pyramid of derivation, examples of the mode in which it is constructed.

When $n = 1$ there is one flat, viz.

1, 2

When $n = 2$ there is one flat, viz.

2, 3	2, 4
2, 4	3, 4

Let $n = 3$, there will be two flats:

2, 3

1, 2	1, 3	1, 4
1, 3	1, 4	2, 4
1, 4	2, 4	3, 4

Let $n = 4$, there will still be two flats only:

2, 3	2, 4
2, 4	3, 4

1, 2	1, 3	1, 4	1, 5
1, 3	1, 4	1, 5	2, 5
1, 4	1, 5	2, 5	3, 5
1, 5	2, 5	3, 5	4, 5

Let $n = 5$, there will be three flats :

3, 4

2, 3	2, 4	2, 5
2, 4	2, 5	3, 5
2, 5	3, 5	4, 5

1, 2	1, 3	1, 4	1, 5	1, 6
1, 3	1, 4	1, 5	1, 6	2, 6
1, 4	1, 5	1, 6	2, 6	3, 6
1, 5	1, 6	2, 6	3, 6	4, 6
1, 6	2, 6	3, 6	4, 6	5, 6

Let $n = 6$, there will be three flats:

3, 4	3, 5
3, 5	4, 5

2, 3	2, 4	2, 5	2, 6
2, 4	2, 5	2, 6	3, 6
2, 5	2, 6	3, 6	4, 6
2, 6	3, 6	4, 6	5, 6

1, 2	1, 3	1, 4	1, 5	1, 6	1, 7
1, 3	1, 4	1, 5	1, 6	1, 7	2, 7
1, 4	1, 5	1, 6	1, 7	2, 7	3, 7
1, 5	1, 6	1, 7	2, 7	3, 7	4, 7
1, 6	1, 7	2, 7	3, 7	4, 7	5, 7
1, 7	2, 7	3, 7	4, 7	5, 7	6, 7

Thus the work of computation reduces itself merely to calculating $n.\frac{n+1}{2}$ elements, or the $n\ (n+1)$ cross-products out of which they are constituted, and combining them factorially after that law of the pyramid, to which allusion has been already made.

DONATIONS.

First Principles of Medicine. 4th Edition. By Archibald Billing, M.D., &c. Presented by the Author.

Bulletin de la Société Geologique de France. Tome XI. (1839 à 1840.) Presented by the Society.

O'Halloran on the Air; a Manuscript, presented by Major-General Sir Joseph O'Halloran, M.R.I.A., &c.

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome IX., 1ere Partie. Presented by the Society.

Calcul de la Densité de la Terre, suivi d'un Memoire sur un cas special du Mouvement d'un Pendule. Par L. F. Menabrea. Presented by the Author.

Proceedings of the Royal Society of Edinburgh. Nos. 16—18.

Transactions of the Royal Society of Edinburgh. Vol. XIV. Part 2; Vol. XV. Part 1. Presented by the Society.

Transactions of the American Philosophical Society. Vol. VII. Part 3. (New Series.) Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 31.

November 8.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

John H. Jellett, Esq., F. T. C. D., was elected a member of the Academy.

A letter was read from Dr. Orpen, stating that increasing ill health would not allow him to continue to discharge his duties to the Academy, and tendering the resignation of his office of Treasurer, and of his place as a member of Council.

RESOLVED,—That the Academy have heard Dr. Orpen's communication with much regret, and that they deeply lament the cause which deprives them of his valuable services.

Professor Mac Cullagh read the following notes on some points in the Theory of Light.

I.

On a Mechanical Theory which has been proposed for the Explanation of the Phenomena of Circular Polarization in Liquids, and of Circular and Elliptic Polarization in Quartz or Rock-crystal; with Remarks on the corresponding Theory of Rectilinear Polarization.

The theory of elliptic polarization, which I feel myself called upon to notice, was first stated by M. Cauchy, and has been made the subject of elaborate investigation by other writers. That celebrated analyst, conceiving (though without sufficient reason, as will presently appear) that he had fully explained the known laws of the propagation of *rectilinear* vibrations by the hypothesis that the luminiferous ether, in media transmitting such vibrations, consists of separate molecules *symmetrically* arranged with respect to each of three rectangular planes, and acting on each other by forces which are some function of the distance, was led very naturally to imagine that he would find the laws of *circular* and *elliptic* vibrations, in other media, to be included in the more general hypothesis of an *unsymmetrical* arrangement. Accordingly, in a letter read to the French Academy on the 22nd of February, 1836, a letter to which he attached so much importance that he desired it might not only be published in the Proceedings, but also "deposited in the Archives" of that body (see the *Comptes rendus des Séances de l'Académie des Sciences*, tom. ii. p. 182), he gave a precise statement of his more extended views, informing the Academy that he had submitted his new theory to calculation, and that, among other remarkable results, he had obtained (with a slight variation or correction) the laws of circular polarization, discovered by Arago, Biot, and Fresnel. Referring to his Memoir on Dispersion, published at Prague, under the title of *Nouveaux Exercices de Mathématiques*, he observes, that the results therein contained may be generalised, by "ceasing to neglect" in the equations of motion [the equations marked (24) in § 2 of that memoir], certain terms which vanish in the case of a symmetrical distribution of the ether. He then goes on to say—

"Nos formules ainsi généralisées représentent les phénomènes de l'absorption de la lumière ou de certains rayons, produite par les verres colorés, la tourmaline, &c., le phenomène de la polarisation circulaire produite par le cristal de roche, l'huile de térébenthine, &c. (*Voir* les expériences de MM. Arago, Biot, Fresnel). Elles servent même à déterminer les conditions et les lois de ces phénomènes ; elles montrent que généralement, dans un rayon de lumière polariseé, une molecule d'éther décrit une ellipse. Mais dans certains cas particuliers, cette ellipse se change en une droite, et alors on obtient la polarisation rectiligne." "Enfin le calcul prouve que, dans le cristal de roche, l'huile de térébenthine, &c., la polarisation des rayons transmis parallèlement à l'axe (s'il s'agit du cristal de roche) n'est pas rigoureusement circulaire, mais qu'alors l'ellipse diffère très peu du cercle."

Thus, to say nothing for the present of the questions of dispersion and absorption, it appears that M. Cauchy conceived he had completely accounted for the facts of circular and elliptic polarization, and that he had deduced the formulas "which serve to determine the conditions and laws of these phenomena." But neither in this letter, nor in any subsequent version* of his theory, has he given the formulas themselves. Nor has he told us the nature of the calculations by which he was enabled to correct the received opinion, and to prove that the vibrations in a ray transmitted along the axis of quartz, or through oil of turpentine, are not rigorously circular, as Fresnel and others have supposed, but slightly elliptical. Now—to take the case of quartz—if we consider that the vibrations of a ray passing along the axis are in a plane perpendicular to it, and if we admit, as M. Cauchy always does in the case of other uniaxal crystals, that there is a perfect optical symmetry all round the axis, we shall find it hard to conceive on what grounds he could have

* From some statements that have been made within the last few days by Professor Powell (Phil. Mag. vol. xix. p. 374), at the request of M. Cauchy himself, it appears that the latter republished his views about circular and elliptic polarization, in a lithographed memoir of the date of August, 1836. But I do not find that he published, either then or since, the detailed calculations which he seems to have made.

come to the conclusion that the vibrations of such a ray are performed in an ellipse. For if all planes passing through the axis of the crystal be alike in their optical properties, there will be absolutely nothing to determine the position and ratio of the axes of the ellipse; there will be no reason why its major axis, for example, should lie in one of these planes, rather than in any other. But, whatever may be thought of this case independently of observation, it is manifestly absurd to suppose that the vibrations are elliptical in the case of a ray passing through oil of turpentine, or any other *liquid* possessing the property of rotatory polarization; for, in a liquid, all planes drawn through the ray itself are circumstanced alike. From these simple considerations it is evident that the theory of M. Cauchy is unsound; but a closer examination will show that it is entirely without foundation, and that it is directly opposed to the very phenomena which it professes to explain. To make this appear, however, in the easiest way that the abstruseness of the subject will allow, it will be necessary to advert to some former researches of my own, which have a direct bearing on the question.

The same day on which M. Cauchy's letter was read to the French Academy, I had the honour of reading to the Royal Irish Academy, a paper "On the Laws of Double Refraction in Quartz" (see Transactions R. I. A., vol. xvii. p. 461), wherein I showed that every thing which we know respecting the action of that crystal upon light is comprised mathematically in the following equations:

$$\frac{d^2\xi}{dt^2} = \text{A}\frac{d^2\xi}{dz^2} + \text{C}\frac{d^3\eta}{dz^3},$$
$$\frac{d^2\eta}{dt^2} = \text{B}\frac{d^2\eta}{dz^2} - \text{C}\frac{d^3\xi}{dz^3}, \qquad (1)$$

which differ from the common equations of vibratory motion by the two additional terms containing third differential coefficients multiplied by the same constant C, this constant having *opposite* signs in the two equations. The quantities ξ and η are, at any time t, the displacements parallel to the axes of x and y, which are supposed to be the principal directions in the plane of the wave, one of them being therefore perpendicular to the axis of the crystal. The constants A and B are given by the expressions

$$\text{A} = a^2, \quad \text{B} = a^2 - (a^2 - b^2)\sin^2\psi,$$

where a and b are the principal velocities of propagation, ordinary and extraordinary, and ψ is the angle made by the wave-normal (or the direction of z) with the axis of the crystal. The only new constant introduced is C, which, though the peculiar phenomena of quartz depend entirely on its existence, is almost inconceivably small; its value is determined in the paper just referred to. The equations are there proved to afford a strict geometrical representation of the facts; not only connecting together all the laws discovered by the distinguished observers to whom M. Cauchy refers, and including the subsequent additions for which we are indebted to Mr. Airy, but leading to new results, one of which establishes a relation between two different classes of phenomena, and is verified by the experiments of M. Biot and Mr. Airy. Having, therefore, such conclusive proofs of the truth of these equations, we are entitled to assume them as a standard whereby to judge of any theory; so that any mechanical hypothesis which leads to results inconsistent with them may be at once rejected.

Now I assert that the mechanical hypothesis of M. Cauchy contradicts these equations, and therefore contradicts all the phenomena and experiments which he supposed it to represent. But before we proceed to the proof of this assertion, it may perhaps be proper to remark, that previously to the date of M. Cauchy's communication, and of my own paper, I had actually tried and rejected this identical hypothesis, and had even gone so far as to reject along with it the whole of M. Cauchy's views about the mechanism of light. For though, in my paper, I have said nothing of any mechanical investigations, yet, as a matter of course, before it was read to the Academy, I made every effort to connect my equations in some way with mechanical principles; and it was because I had failed in doing so to my own satisfaction, that I chose to publish the equations without comment,* as bare geometrical assumptions, and contented myself with stating orally to the Academy, as I did some months after to the Physical Section of the British Association in Bristol (see Transactions of the Sections, p. 18), that a mechanical account of the phenomena still remained a *desideratum* which no attempts of mine had been able to supply. I am not sure that on the first occasion I stated the precise nature of these attempts, though I incline to think I did; but I have a distinct recollection of having done so on the second occasion, in reply to questions that were asked me by some Members of the Association.† Now, my first attempt to explain those equations, which was made almost as soon as I discovered them, actually turned upon the very idea which about the same time found entrance into the mind of M. Cauchy—I mean the idea of an unsymmetrical arrangement of the ether. For as it was generally believed, at that period,

* The circumstances here related will account for what Mr. Whewell (*History of the Inductive Sciences*, vol. ii. p. 449) calls the "obscure and oracular form" in which those equations were published. Having, at that time, no good explanation of them to give, I thought it better to attempt none. But in the general view which I have since taken (see p. 103 of this volume), they do not offer any peculiar difficulty.

† At the period of this meeting, M. Cauchy's letter on Elliptic Polarization had been published for some months; but I was not then aware of its existence. Indeed the letter appears not to have attracted any general notice; for the theory which it contains was afterwards advanced in England as a new one, and M. Cauchy has been lately obliged to assert his prior claim to it, through the medium of Professor Powell.—See notes, pp. 144, 149.

that the hypothesis of ethereal molecules symmetrically distributed had led, in the hands of M. Cauchy, to a complete theory of rectilinear polarization in crystals (see his *Exercices de Mathématiques, Cinquième Année*, Paris, 1830, and the *Mémoires de l'Institut*, tom x. p. 293), the notion of endeavouring to account for the phenomena of elliptic polarization, by freeing the hypothesis from any restriction as to the distribution of the ether, would naturally occur to any one who was thinking on the subject, no less than to M. Cauchy himself. And though, for my own part, I never was satisfied with that theory, which seemed to me to possess no other merit than that of following out in detail the extremely curious, but (as I thought) very imperfect, analogy which had been perceived to exist between the vibrations of the luminiferous medium and those of a common elastic* solid (for it is usual to regard such a solid as a rigid

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* The analogy was suggested by the hypothesis of transversal vibrations, which, when viewed in its physical bearing, was considered by Dr. Young to be "perfectly *appalling* in its consequences," as it was only to *solids* that a "lateral resistance" tending to produce such vibrations had ever been attributed. (*Supplement to the Encyclopædia Britannica*, vol. vi. p. 862: Edinburgh, 1824). He, admits, however, that the question whether fluids may not "transmit impressions by lateral adhesion, remains completely open for discussion, notwithstanding the apparent difficulties attending it." As far as I am aware, Fresnel always regarded the ether as a *fluid*. M. Poisson affirms that it *must* be so regarded, and attributes its apparent peculiarities to the immense rapidity of its vibrations, which does not allow the law of equal pressure to hold good in the state of motion (*Annales de Chimie*, tom. xliv. p. 432). M. Cauchy calls the ether a fluid, though he treats it as a solid. My own impression is, that the ether is a medium of a peculiar kind, differing from all ponderable bodies, whether solid or fluid, in this respect, that it absolutely refuses, in any case, to change its density, and therefore propagates to a distance transversal vibrations *only*; while ordinary elastic fluids transmit only normal vibrations, and ordinary solids admit vibrations of both kinds. This hypothesis also includes the supposition that the density of the ether is unchanged by the presence of ponderable matter. As to M. Cauchy's *third ray*, with vibrations nearly normal to the wave, there is no reason to believe that it has even the *faintest* existence; but it is necessarily introduced by his identification of the vibrations of light with those of an indefinitely extended elastic solid.

system of attracting or repelling molecules, and M. Cauchy has really done nothing more than transfer to the luminiferous ether both the constitution of the solid and differential formulas of its vibration), still I should have been glad, in the absence of anything better, to find my equations supported by a similar theory, and their form at least countenanced by the like mechanical analogy. Besides, I recollected that Fresnel himself, in his Memoir on Double Refraction, had indicated a "helicoidal arrangement," or something of that sort, as a probable cause of circular polarization (*Mémoires de l'Institut*, tom. vii. p. 73); and as this was an hypothesis of the same kind as the other, only not so general, I was prepared to find that the supposition of an arbitrary arrangement, whatever might be thought of its physical reality, would lead to equations *of the same form* as those which I had assumed. Upon trial, however, the very contrary proved to be the case, for though it was possible to obtain additional terms, containing differential coefficients of the third order, multiplied by the same constant C, yet this constant always came out with the *same* sign in both equations, whereas a *difference* of sign was *essential* for the expression of the phenomena. I had no sooner arrived at this result, than I perceived it to be fatal to the theory of M. Cauchy, and to afford a demonstration of its insufficiency, not only in the particular application which I had made of it, but in all its applications. For the hypothesis which I used was, in fact, identical with that theory, in the most general form of which it is susceptible, when unrestricted by any particular supposition as to the arrangement of the ethereal molecules; and therefore the fundamental conception of the theory could not be true, as it not merely failed to explain a large and most remarkable class of phenomena—those of circular and elliptical polarization—but absolutely excluded them, and left no room for their existence. It followed from this, that the mechanical explanation, which the same theory was supposed to have given, of the phenomena of rectilinear polarization and double refraction in crystals, could not be well founded; indeed, as I have said, I had always distrusted it, and that for various reasons, of which one has been already mentioned, and another was suggested by the forced relations which M. Cauchy had found it necessary to establish among the constants of his theory, and by which he had *compelled*, as it were, his complicated formulas to assume the appearance of an agreement (though, after all, a very imperfect one) with the simple laws of Fresnel.

Such were the conclusions at which I arrived, and the reflections which they forced upon me, nearly six years ago. They have been frequently mentioned in conversation to those who took an interest in such matters, and their general tenor may be gathered from what I have elsewhere written (Transactions of the Academy, vol. xviii. p. 68); but I did not think it worth while to publish them in detail, because it seemed probable that juster notions would prevail in the course of a few years, and that the ingenious speculations to which I have alluded would gradually come to be estimated at their proper value. But from whatever cause it has arisen—whether from the real difficulties of the subject, or the extreme vagueness of the ideas that most persons are content to form of it, or from deference to the authority of a distinguished mathematician—certain it is that the doctrines in question have not only been received without any expression of dissent, but have been eagerly adopted, both in this country and abroad, by a host of followers; and even the extraordinary error, which it is my more immediate object to expose, has been continually gaining ground up to the very moment at which I write, and has at last begun to be ranked among the elementary truths of the undulatory theory of light. Notwithstanding my unwillingness, therefore, to be at all concerned in such discussions, I do not think myself at liberty to remain silent any longer.

There are occasions on which every consideration of this kind must give way to a regard for the interests of science.

To show that the principles of M. Cauchy contradict, instead of explaining, the phenomenon of elliptic polarization, let us take the axes of coordinates as before; and let us suppose, for the sake of simplicity, and to avoid his *third ray*, that the normal displacements vanish. Then his fundamental equations take the form

$$\begin{aligned} \frac{d^2\xi}{dt^2} &= \Sigma f \Delta\xi + \Sigma h \Delta\eta, \\ \frac{d^2\eta}{dt^2} &= \Sigma g \Delta\eta + \Sigma h \Delta\xi, \end{aligned} \qquad (2)$$

where f, g, h are quantities depending on the law of force and the mutual distances of the molecules.* If, therefore,

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* I have not thought it necessary to transcribe the original equations of M. Cauchy, which are rather long. He has presented them in different forms; but the system marked (16) at the end of § 1 of his Memoir on Dispersion, already quoted, is the most convenient, and it is the one which I have here used. The directions of the coordinates being arbitrary, I have supposed the axis of z to be perpendicular to the wave-plane. Then, on putting $\zeta = 0$, $\Delta\,\zeta = 0$, in order to get rid of the normal vibration, the last equation of the system becomes useless, and the other two are reduced to the equations (2), given above; the letters f, g, h, being written in place of certain functions depending on the mutual actions of the molecules. It will be proved, further on, that this simplification does not at all affect the argument. As the directions of x and y still remain arbitrary, I have made them parallel to the axes of the supposed elliptic vibration.

It may be right to observe, for the sake of clearness, that, when the medium is arranged symmetrically, it is always possible to take the directions of x and y such that the two sums depending on the quantity h may disappear from the equations (2), and then the vibrations are rectilinear. But when the arrangement is unsymmetrical, this is no longer possible.

The equations (2) are precisely the same as those which have been employed by Mr. Tovey and by Professor Powell, the latter of whom, in his lately published work, entitled, "*A General and Elementary View of the Undulatory Theory, as applied to the Dispersion of Light, and other Subjects,*" has dwelt at great length on the theory of elliptic polarization, which they have been supposed to afford, and which he regards as a most important accession to the Science of Light. Professor Powell has also made some communications on the subject to the British Assowe assume that each molecule describes an ellipse, the axes of which are parallel to those of x and y; that is to say, if we make

$$\begin{aligned} \xi = p \cos \phi, \quad \eta = q \sin \phi, \\ \phi = \frac{2\pi}{\lambda}(st - z), \end{aligned} \tag{3}$$

and consequently

$$\begin{aligned} \Delta\xi &= p(\sin 2\theta \sin \phi - 2 \sin^2\theta \cos \phi), \\ \Delta\eta &= - q(\sin 2\theta \cos \phi + 2 \sin^2\theta \sin \phi), \end{aligned}$$

where $\theta = \frac{\pi \Delta z}{\lambda}$, we shall find, by substituting these values in the equations (2), which must hold good independently of ϕ,

$$s^2 = A' + C'k, \qquad s^2 = B' - \frac{C'}{k}, \tag{4}$$

$$\Sigma f \sin 2\theta - 2k\Sigma h \sin^2\theta = 0,$$

$$\Sigma g \sin 2\theta + \frac{2}{k}\Sigma h \sin^2\theta = 0,$$

wherein $k = \frac{q}{p}$ expresses the ratio of the semiaxes of the elliptic vibration, and

$$A' = \frac{\lambda^2}{2\pi^2}\Sigma f \sin^2\theta, \qquad B' = \frac{\lambda^2}{2\pi^2}\Sigma g \sin^2\theta,$$

$$C' = \frac{\lambda^2}{4\pi^2}\Sigma h \sin 2\theta.$$

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ciation, and has written two papers about it in the Philosophical Transactions (1838, p. 253; and 1840, p. 157), besides several others in the Philosophical Magazine. He, however, always attributed this theory of elliptic polarization to Mr. Tovey, until his attention was directed, by a letter from M. Cauchy, to some investigations of the latter which he had not previously seen (Phil. Mag. vol. xix. p. 374). Mr. Tovey set out with the principles of M. Cauchy, and therefore naturally struck into the same track, in pursuit of the same object, apparently quite unconscious that any one had preceded him. It was, indeed, an obvious reflection, that these principles, when generalised to the utmost, ought to include, not only the laws of elliptic polarization, but (as really has been thought by M. Cauchy and his followers) of dispersion and absorption, and, in short, of all the phenomena of optics.

Equating the two values of s^2, we get, for the determination of k, the following quadratic:

$$k^2 + \frac{A' - B'}{C'} k + 1 = 0. \tag{5}$$

Now making the substitutions (3) in equations (1), page 142, we have

$$s^2 = A - \frac{2\pi}{\lambda} Ck, \qquad s^2 = B - \frac{2\pi}{\lambda} \frac{C}{k}, \tag{6}$$

and thence

$$k^2 - \frac{\lambda}{2\pi C} (A - B)\, k - 1 = 0, \tag{7}$$

a result which is perfectly inconsistent with the former, since the two roots of (5) have the *same sign*, if they are not imaginary, while those of (7) have *opposite signs*, and cannot be imaginary. If, therefore, one equation agrees with the phenomena, the other must contradict them. The last equation indicates that, in the double refraction of quartz, the two elliptic vibrations are always *possible*, and performed in *opposite* directions, which is in accordance with the facts; whereas the equation (5), deduced from M. Cauchy's theory, would inform us that the vibrations of the two rays are either *impossible* or in the *same* direction.*

To apply the results to a particular instance, let us conceive a circularly polarized ray passing along the axis of quartz, or through one of the rotatory liquids, such as oil of turpentine; the position of the coordinates x and y, in the plane of the wave, being now, of course, arbitrary. In each of these cases we have $k = \pm 1$, and $A = B = a^2$, so that the value of s^2 in equation (6) is expressed by the constant a^2, *plus* or *minus* a term which is inversely proportional to the

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* This conclusion, which shows that M. Cauchy's Theory is in direct opposition to the phenomena, might have been obtained without any reference to the equations (1). But these equations are necessary in what follows.

wave-length λ; the sign of this term depending on the direction of the circular vibration. Now it will not be possible to obtain a similar value of s^2 from the formulas (4), unless we suppose $\text{A}' = \text{B}' = a^2$, since it is only in the expansion of C' that a term inversely proportional to λ can be found; but on this supposition the formulas are inconsistent with each other, nor can they be reconciled by any value of k. Indeed, when $\text{A}' = \text{B}'$, the equation (5) gives $k = \pm\sqrt{-1}$. Thus it appears that circular vibrations, such as are known to be propagated along the axis of quartz, and through certain fluids, cannot possibly exist on the hypothesis of M. Cauchy. It was probably some partial perception of this fact that caused M. Cauchy to assert that the vibrations, in these cases, are not exactly circular, but in some degree elliptical; a supposition which, if it were at all conceivable, which we have seen it is not (p. 142), would be at once set aside by what has just been proved; for no assumed value of k, whether small or great, will in any way help to remove the difficulty.

But this is not all. Rectilinear vibrations are excluded as well as circular; for we cannot suppose $k = 0$ in the equations (4), so long as the quantity C', resulting from the hypothesis of unsymmetrical arrangement, has any existence. Thus the inconsistency of that hypothesis is complete, and the equations to which it leads are utterly devoid of meaning.

The foregoing investigation does not differ materially from that which I had recourse to in the beginning of the year 1836. To render the proof more easily intelligible, and to get rid of M. Cauchy's "third ray," which has no existence n the nature of things, I have suppressed the normal vibrations; a procedure which is not, in general, allowable on the principles of M. Cauchy. It will readily appear, however, that this simplification still leaves the demonstration perfectly rigorous in the case of circular vibrations, and does not affect its force when the vibrations are elliptical. For in the rotatory fluids it is obvious that the normal vibrations, supposing such to exist, must, by reason of the symmetry which the fluid constitution requires, be independent of the transversal vibrations, and separable from them, so that the one kind of vibrations may be supposed to vanish when we wish merely to determine the laws of the other. The equations (2) are, therefore, quite exact in this case; and they are also exact in the case of a ray passing along the axis of quartz, since such a ray is not experimentally distinguishable from one transmitted by a rotatory fluid, and its vibrations must consequently be subject to the same kind of symmetry. In these two cases, therefore, it is *rigorously* proved that the values of k, which ought to be equal to *plus* and *minus* unity, are imaginary, and equal to $\pm \sqrt{-1}$. And if we now take the most general case with regard to quartz, and suppose that the ray, which was at first coincident with the axis of the crystal, becomes gradually inclined to it, the values of k must evidently continue to be imaginary, until such an inclination has been attained that the two roots of equation (5) become possible and equal, in consequence of the increased magnitude of the co-efficient of the second term. Supposing the last term of that equation to remain unchanged, this would take place when the co-efficient of k (without regarding its sign) became equal to the number 2, and the values of k each equal to unity, both values being positive or both negative. The vibrations which before were impossible, would, at this inclination, suddenly become possible; they would be *circular*, which is the exclusive property of vibrations transmitted along the axis; and they would have the same direction in both rays, which is not a property of any vibrations that are known to exist. At greater inclinations the vibrations would be elliptical, but they would still have the same direction in the two rays. These results would not be sensibly altered by regarding the equation (5) as only approximate in the case of rays inclined to the axis; for the last term of that equation, if it does not remain the same, can never differ much from unity; since it must become exactly equal to unity, *whatever* be the direction of the ray, when the crystalline structure is supposed to disappear, and the medium to become a rotatory fluid.

That a theory involving so many inconsistencies should have been advanced by a person of M. Cauchy's reputation, would, perhaps, appear very extraordinary, if we did not recollect that it was unavoidably suggested by the general principles which he had previously adopted, and which were supposed, not merely by himself, but by the scientific world generally, to have already afforded the only satisfactory explanation of the laws of double refraction in the common and well-known case where the vibrations are rectilinear. This supposed explanation was obtained, as has been said, by restricting the application of M. Cauchy's principles to the hypothesis of a vibrating medium arranged symmetrically, in which case it was shown that the vibrations were necessarily rectilinear; and of course the removal of this restriction was the only way in which it was possible, on those principles, to account for the existence of circular and elliptical vibrations. Accordingly, when M. Cauchy perceived that, on the hypothesis of unsymmetrical arrangement, the existence of rectilinear vibrations became impossible, and that of elliptic vibrations, generally speaking, possible, he found it very easy to persuade himself that he had obtained a new proof of the correctness of his views, and a new and most important application of the fundamental equations by which his general principles were analytically expressed. To have supposed otherwise would have been to admit that his general principles were false. If the elliptical or *quasi*-circular vibrations which he was now contemplating were not capable of being identified with those which had been recognized in the phenomena presented by quartz and the rotatory fluids—if their laws were essentially or very considerably different—his theory would be inconsistent with a wide range of well known facts, and, notwithstanding its so-called explanations of other laws, should be finally abandoned. Under these circumstances, therefore, he very naturally supposed that his new results *must* be in complete harmony with the phenomena discovered by M. Arago, and analysed so successfully by MM. Biot and Fresnel; although, had he taken the precaution of acquiring such a clear notion of the phenomena as would have enabled him to translate them into analytical language, he must have perceived that they were entirely opposed to his results, and that this opposition furnished an argument which swept away the very foundations of his theory. For, if the constitution of the luminiferous medium were such as M. Cauchy supposes, the well-known phenomena of circular and elliptic polarization would, as we have seen, be absolutely impossible.

Thus the argument which overturns the particular theory of elliptical polarization destroys at the same time all the other optical theories of M. Cauchy, because they are all built on the principles which we have now *demonstrated* to be false. But though the principles of M. Cauchy are now, for the first time, formally refuted, they were objected to, on general grounds, so long ago as the year 1830, by a person whose opinion, on a question of mechanics, ought to have had considerable weight. This was M. Poisson, who, having deduced from the equations of motion of an elastic solid the consequence that such a body admitted vibrations perpendicular to the direction of their propagation, thought it right to remark that this conclusion could not be supposed to account for transversal vibrations in the theory of light, because (as he expressed himself) "the same equations of motion could not possibly apply to two systems [of molecules] so essentially different from each other" as the ethereal fluid and an elastic solid.*—(See the *Annales de Chimie*, tom. xliv. p. 432). The remark, however, did not meet with much attention from mathematicians, who were, perhaps, not disposed to scrutinize too closely any hypothesis which gave transversal vibrations as a result. Besides, the hypothesis appeared to go much further, as it offered *primâ facie* explanations of a great variety of phenomena; it was one to which calculation could be readily applied, and therefore it naturally found favour with the calculator; and as to M. Poisson's objection, it was easily removed by a change of terms, for when the elastic *solid* was called an "elastic *system*," there was no longer anything startling in the announcement that the motions of the ether are those of such a system. The hypothesis was therefore embraced by a great number of writers in every part of Europe, who reproduced, each in his own way, the results of M. Cauchy, though sometimes with considerable modifications. Every day saw some new investigation purely analytical—some new mathematical research uncontrolled by a single physical conception—put forward as a "mechanical theory" of double refraction, of circular polarization, of dispersion, of absorption; until at length the Journals of Science and Transactions of Societies were filled with a great mass of unmeaning formulas. This state of things was partly occasioned by the great number of "disposable" constants entering into the differential equations of M. Cauchy and their integrals; for it was easy to introduce, among the constants, such relations as would lead to any desired conclusion; and this method was frequently adopted by M. Cauchy himself. Thus, in his theory of double (or rather triple) refraction, given in the works already cited (p. 145), he supposes three out of his nine constants to vanish, and assumes,

* As the theory of M. Cauchy (*Mem. de l'Institut*, tom. x.) had been communicated to the Academy of Sciences some months before the period (October, 1830) at which M. Poisson wrote, there can be no doubt that M. Poisson's remark was directed against that theory, though he did not expressly mention it.

among the other six, three very strange and improbable relations, by means of which each of the principal sections of his wave-surface (considering only two out of its three sheets) is reduced to the circle and ellipse of Fresnel's law; and the three principal sections being thus *forced* to coincide, it would not be very surprising if the two sheets were found to coincide in every part with the wave-surface of Fresnel. The coincidence, however, is only approximate; but M. Cauchy is so far from being embarrassed by this circumstance, that he does not hesitate to regard his own theory as rigorously true, and that of Fresnel as bearing to it, in point of accuracy, the same relation which the elliptical theory of the planets, in the system of the world, bears to that of gravitation (*Mémoires de l'Institut*, tom. x. p. 313). Nor is he at all embarrassed by the supernumerary ray belonging to the third sheet of his wave-surface; he assumes at once that such a ray exists, though it was never seen, and promises, for the satisfaction of philosophers, to make known the means of ascertaining its existence (*Ibid.* p. 305). But he afterwards contented himself with observing that as its vibrations are in the direction of propagation they probably make no impression on the eye, and he then gave it the name of the "invisible ray." (*Nouveaux Exercices*, p. 40).

In these investigations, the suppositions which M. Cauchy had made respecting the constants led to the result that the vibrations of a polarized ray are *parallel* to its plane of polarization; but in the year 1836 he changed his opinion on this point, and then, by reinstating the constants that he had before supposed to vanish, and establishing proper relations amongst them and the rest, he arrived at the conclusion that the vibrations are *perpendicular* to the plane of polarization (*Comptes Rendus*, Tom. ii. p. 342). All his other results, of course, underwent some corresponding change; and it is this new theory which must now be regarded as rigorous, while that of Fresnel is to be looked on as approximate. But it is needless to say, that if the accuracy of Fresnel's law of double refraction is to be disputed, it must be on much better grounds than these; and the results of M. Cauchy are certainly too far removed from that law to have any chance of being consonant with truth. Although, for example, his new views respecting the direction of the vibrations agree, in a general way, with those of Fresnel, there is yet, in one particular, an important difference between them; for according to Fresnel, the vibrations are always exactly in the surface of the wave, while, according to M. Cauchy (in his old theory as well as the new), they are only so in ordinary media. In a biaxal crystal he finds—and this is one of the ways in which the "invisible ray" manifests its influence—that the direction of vibration, in each of the two rays that are visible, is inclined at a certain angle to the wave-plane; but this angle, though small, is by no means inconsiderable, as M. Cauchy seems to intimate, overlooking the fact, which appears from his own equations, that it is of the same order of magnitude as the quantities on which the double refraction depends. It is true, the deviation measured by this angle cannot, if it exists, be directly observed in the refracted light; but its indirect effects on *reflected* light ought to be very great, since the action of the crystal on a ray reflected at its surface differs from that of an ordinary medium by a quantity of the same order merely as the aforesaid angle; and as the problem of crystalline reflexion has been already solved (Trans. R. I. A. vol. xviii., p. 31) on the supposition (which is an essential one in the solution) that the vibrations are *exactly* in the plane of the wave, it is highly improbable, considering the complex nature of the question, that it will be solved, in any satisfactory way, on a supposition so different as that which is required by the theory of M. Cauchy. However, as the laws of such reflexion are now well known, by means of the solution alluded to, it is possible that M. Cauchy may, as in the case of double refraction, succeed in deducing the same laws, or, if not the same, what may seem to be more exact laws, from certain principles* of his own, helped out, if need be, by proper relations among his constants; especially if, to allow greater scope for such relations, the number of constants be increased by the hypothesis of two coexist-

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* In applying these principles to the question of reflexion and refraction at the surface of an *ordinary* medium (*Comptes Rendus*, Tom. ii. p. 348), M. Cauchy has arrived at the singular conclusion, that light may be greatly increased by refraction through a prism, at the same time that it is almost totally reflected within it. Supposing the refracting angle of the prism to be very little less than the angle of total reflexion for the substance of which it is composed, a ray incident perpendicularly on one of the faces will emerge making a very small angle with the other face; and as the reflexion at the latter face is nearly total, it is self-evident that the intensity of the emergent light, as compared with that of the incident, must be very small. M. Cauchy, however, finds, by an elaborate analysis, that a prodigious multiplication of light ["*une prodigieuse multiplication de la lumière*"] takes place, the emergent ray being nearly six times more intense than the incident when the prism is made of glass, and nearly nine times when the prism is of diamond. This result was, in a general way, actually verified experimentally by himself and another person; so easy it is, in some cases, to see anything that we expect to see. Had the result been true, it would have been a very brilliant discovery indeed; for then we should have been able, by a simple series of refractions, to convert the feeblest light into one of any intensity we pleased; but the very absurdity of such a supposition should have taught M. Cauchy to distrust both his theory and his experiment. Far from doing so, however, he considers the fact to be perfectly established, and to afford a new argument against the system of emission. "Ici," says he, "un rayon, réfléchi en totalité, est de plus transmis avec accroissement de lumière; ce qui est un nouvel argument contre le système d'émission." The system of emission has at least this advantage, that by no possible error could such a conclusion be deduced from it. For if all the particles of light be reflected, certainly none of them can be refracted.

The truth is, that M. Cauchy mistook the measure of intensity in the hypothesis of undulations, supposing it to be proportional simply to the square of the amplitude of vibration; whereas it is really measured by the *vis viva*, or by that square multiplied by the quantity of ether put in motion, a quantity which in the present case is evanescent, since the corresponding volumes of ether, moved by the ray within in the prism and by the emergent ray, are to each other as the sine of twice the angle of the prism to the sine of twice the very small angle which the emergent ray makes with the second face of the prism. The intensity of the emergent light is therefore very small, as it ought to be, though the amplitude of its vibrations is considerable.

ing systems of molecules, an hypothesis which M. Cauchy has already considered with his usual generality, but without making any precise application of it. (*Exercices d'Analyse et de Physique Mathématique*, Tom. i. p. 33.)

Perhaps one cause why M. Cauchy's views on the subject of double refraction have met with such general acceptance, may be found in the fact, that a theory setting out from the same principles, and leading, by the same relations among constants, to formulas identical in every respect with his earlier results, was advanced independently, and nearly at the same time, by M. Neumann of Königsberg (*Poggendorff's Annals*, vol. xxv. p. 418). A coincidence so remarkable would be looked upon, not unreasonably, as a strong argument in favour of the theory; though it must be allowed that, in the effort to extend the knowledge of any subject, there is a tendency in different minds to adopt the same errors respecting it, as well as the same truths; a fact of which we have seen other examples in the course of the present article.

According to M. Neumann (*ibid.* p. 454), the "third ray," not being perceived as light, must manifest its existence as radiant heat, or as a chemical power, or as some other agent ["*als strahlende Wärme, oder chemisch wirkend, oder als irgend ein anderes Agens*"], and he thinks that the nature of this ray will be more easily investigated, if the laws of *reflexion* shall be deduced from the aforesaid theory. But we have seen that the laws of reflexion are, to all appearance, at variance with the theory, and they take no account whatever of the third ray. Besides, the discoveries which have been made of late years respecting the polarization of radiant heat, and the strong analogies that have been traced between it and light, amount to a demonstration that its vibrations are transversal, and of course essentially different from those of the supposed third ray, which are normal, or nearly so. There is every reason to believe that the vibrations of the chemical rays are also transversal; and we may confidently assert, that the three species of rays—those of light and heat, and the chemical rays,—are produced not only by vibrations of the same medium, but by the same kind of vibrations, propagated with nearly the same velocities. If, therefore, the third ray of MM. Cauchy and Neumann has any existence, it must be referred to " some other agent," the nature of which it is impossible to conjecture.

Enough has now been said to show that the optical theory which we have examined, and which has passed current in the scientific world for a considerable period, is quite inadequate to explain the leading phenomena of light, and that it is based upon principles which are altogether inapplicable to the subject. M. Cauchy states, in the memoir so often quoted (*Mem. de l'Institut*, Tom. x. p. 294), that the first application which he had made of his principles was to the theory of *sound*, and that the formulas which he had deduced from them agreed remarkably well with the experiments of Savart and others on the vibrations of elastic solids. As I have already intimated, it is in the solution of such questions (which, however, have long been familiar to mathematicians) that the fundamental equations of M. Cauchy may be most advantageously employed ; and had he pursued his researches in this direction, his labours would doubtless have been attended with more success, and with greater benefit to science.

II.

On Fresnel's Formula for the Intensity of Reflected Light, with Remarks on Metallic Reflexion.

When Mr. Potter discovered, by experiment, that more light is reflected by a metal at a perpendicular incidence than at any oblique incidence (at least as far as 70°), the fact was looked upon, by himself and others, as contrary to all received theories ; and certainly the universal opinion, up to that time, was, that the intensity of reflexion always increases with the incidence. It may therefore be worth while to remark, that the formula given by Fresnel for reflexion at the surface of a transparent body, though not of course applicable, except in a very rude way, to the case of metals, would yet lead us to expect, for highly refracting bodies as the metals are supposed to be, precisely such a result as that obtained by Mr. Potter. For when the index of refraction exceeds the number $2+\sqrt{3}$, or the tangent of 75°, the expression for the intensity of reflected light will be found to have a *minimum* value at a certain angle of incidence; while for all less values of the refractive index the intensity will be least at the perpendicular incidence.

Let i and i' be the angles of incidence and refraction, and put

$$\mathrm{M}=\frac{\sin i}{\sin i'}, \quad \mu=\frac{\cos i}{\cos i'};$$

then if I be the intensity of the reflected light, when common light is incident, Fresnel's expression

$$\mathrm{I}=\tfrac{1}{2}\left\{\frac{\sin^2(i-i')}{\sin^2(i+i')}+\frac{\tan^2(i-i')}{\tan^2(i+i')}\right\},$$

in which the intensity of the incident light is taken for unity, may be put under the form

$$\mathrm{I}=\frac{\left(\frac{1}{\mu}-\mu\right)^2+\left(\frac{1}{\mathrm{M}}-\mathrm{M}\right)^2}{\left(\frac{1}{\mu}+\mu+\frac{1}{\mathrm{M}}+\mathrm{M}\right)^2},$$

which has a minimum value when

$$\mu+\frac{1}{\mu}=\mathrm{M}+\frac{1}{\mathrm{M}}-\frac{8}{\mathrm{M}+\frac{1}{\mathrm{M}}};$$

the value of I being in that case

$$\mathrm{I}=\frac{\left(\mathrm{M}-\frac{1}{\mathrm{M}}\right)^2-4}{2\left(\mathrm{M}-\frac{1}{\mathrm{M}}\right)^2}=\frac{\left(\mathrm{M}+\frac{1}{\mathrm{M}}\right)^2-8}{2\left(\mathrm{M}+\frac{1}{\mathrm{M}}\right)^2-8},$$

and the corresponding angle of incidence being given by the formula

$$\sin i = \frac{\sqrt{M}\,\sqrt[4]{\varepsilon^2-1}}{\varepsilon+\sqrt{\varepsilon^2-1}}, \text{ where } \varepsilon = \tfrac{1}{4}\left(M+\frac{1}{M}\right).$$

Since $\mu + \frac{1}{\mu}$ cannot be less than 2, it is easy to see that, when there is a minimum, $M + \frac{1}{M}$ cannot be less than 4, and therefore M cannot be less than $2 + \sqrt{3}$, or 3.732.

As an example, let $M + \frac{1}{M} = 6$. Then, at a perpendicular incidence, one-half the incident light will be reflected. The minimum will be when $i = 65° 36'$, and at this angle only $\frac{7}{16}$ of the incident light will be reflected. The value here assumed for the refractive index is that which Sir J. Herschel (*Treatise on Light*, Art. 594), assigns to mercury; but if my ideas be correct, it is far too low for that metal.

The only person who supposes that the refractive index of a metal is not a large number, is M. Cauchy. It has always been held as a maxim in optics, that the higher the reflective power of any substance, the higher also is its refractive index. But M. Cauchy completely reverses this maxim; for, as I have elsewhere shown (*Comptes Rendus*, tom. viii. p. 964), it follows from his theory that the most reflective metals are the least refractive, and even that the index of refraction, which for transparent bodies is always greater than unity, may for metals descend far below unity. Thus, according to his formula, the index of refraction for pure silver is the fraction $\frac{1}{4}$, so that the dense body of the silver actually plays the part of a very rare medium with respect to a vacuum. It appears to me that such a result as this is quite sufficient to overturn the theory from which it is derived. The formulas, however, which he gives for the intensity of the reflected light, are identical with the empirical expressions which I had given long before, and are at least approximately true.

In framing my own empirical theory (see *Proceedings*, vol. i. p. 2), two suppositions relative to the value of the refractive index presented themselves. Putting M for the *modulus*, and χ for the *characteristic*, I had to choose between the values $\text{M} \cos \chi$ and $\frac{\text{M}}{\cos \chi}$. The latter value is that which I adopted; the former, which is M. Cauchy's, was rejected because I saw that it would lead to the result above mentioned.

Another result of M. Cauchy's, which he has given twice in the *Comptes Rendus* (tom. ii. p. 428, and tom. viii. p. 965) requires to be noticed. When a polarized ray is reflected by a metal, the phase of its vibration is altered, and if the incidence be oblique, the change of phase is different, according as the light is polarized in the plane of incidence, or in the perpendicular plane. But when the ray is reflected at a perpendicular incidence, it is manifest that the change is a constant quantity, whatever be the plane of polarization. In fact, the distinction between the plane of incidence and the perpendicular plane no longer exists, and the phenomena must be the same in all planes passing through the ray. Yet M. Cauchy, in the two places above quoted, asserts it to be a consequence of his theory, that in this case the alterations of phase are different for two planes of polarization at right angles to each other, and that the difference of the alterations amounts to half an undulation. The same singular hypothesis had been previously made by M. Neumann (*Poggendorff's Annals*, vol. xxvi. p. 90), whom M. Cauchy appears to have followed; but M. Neumann has since admitted it to be erroneous (*Ibid.* vol. xl. p. 513).

Mr. J. Huband Smith communicated to the Academy some particulars connected with the recent discovery of a cairn containing cinerary urns, which appears to have been accompanied by some circumstances not unworthy of notice.

It took place at Loughanmore, in the county of Antrim, the seat of Mr. Thomas Adair, in a field which was being ploughed, in the spring of 1840. After a few urns had been found, there being some difficulty in preserving them entire, Mr. Adair, with a commendable desire to avoid the destruction of remains so full of interest, caused the cairn, in which these urns were found, to be closed carefully, and restored the ground to its former state as nearly as might be, in order to leave it to some skilful and experienced antiquary to explore the entire in a more deliberate and scientific manner.

The discovery was occasioned by one of the horses which were in the plough suddenly stumbling, one of his legs having sunk nearly up to the knee in a deep hole. On examination it was found he had put his foot into a fine sepulchral urn, which, it need hardly be stated, was broken into shivers.

On a slight further search a second urn was discovered. Every effort was made to preserve this one entire, but in vain; it fell to pieces in the hands of the person who took it up. A third urn was then exposed, when Mr. Adair finding it impossible to save them, put a stop for the time to the further opening of the cairn.

The cairn in which these urns were found is situated in the townland of Loughanmore, and not far from the *Loughan* or lake (now drained) from which the townland derives its name. It lies within a field called the cove-park, there being one or more artificial caves, or coves (as they are termed by the Antrim peasantry), within it. And from a hollow sound which the ground gives, other caves, as yet unopened, are confidently supposed to exist near where the urns were found.

The cairn in question is indicated by so very slight an elevation of the surface, that it was in course of being ploughed over without any *particular* notice, till the finding of the urns drew Mr. Adair's attention to it. This elevation was then observed to have a circumference of some twelve or fourteen feet, perhaps a little more; and on closer examination proved to be composed of loose field-stones mixed with earth, apparently laid in, upon, and around the urns, with just so much care as not to break them.

It will not fail to be noticed, that in this latter circumstance this cairn seems to differ remarkably from most others, for instance Deveril Barrow in Dorsetshire, which has been thought worthy of an elegant descriptive work, and many other of the Wiltshire Barrows, so carefully and scientifically opened by an eminent and accomplished English antiquary, the late Sir Richard Colt Hoare; and also from the very important cairn opened at Mount Stewart, near Grey-Abbey, in the county of Down, about the year 1807. In these the urns have almost invariably been protected by a kist or stone chest formed of flags, enclosing a considerable space. We have the authority of our distinguished Irish antiquary, Mr. George Petrie, for saying that "the sepulchral urns of Ireland are superior in ornament to any found in England. The ornaments of gold frequently found in them are richer and more numerous." And he does not hesitate to infer from these and other facts, that "the pagan Irish were superior in the arts of civilized life to their British neighbours."

These urns found at Loughanmore were found to have been all placed with the mouth downwards. They lay rather closely together, scarce eighteen inches apart from each other, the smaller urns appearing to surround the larger one, which was that broken by the horse.

The two smaller sized urns were of the same size, and would hold probably eight or nine quarts of liquid each.

No metallic remains of brass or bronze; no flint arrowheads, stone adzes, or any other remains were found. Every probability exists of future discoveries of a most interesting description being made on a stricter examination of this cairn.

Opportunities such as this daily offer themselves in this country, of pursuing an inquiry of deep historical interest; which if they were to occur at the other side of the Irish channel, would be grasped at with avidity by the untiring zeal of many an English antiquary, who, while he cultivates assiduously, and under circumstances of extreme difficulty, the meagre opportunities which England affords to the study of ancient *British* and Celtic remains, cannot but look with a feeling of astonishment (akin perhaps to contempt), on the apathy with which in Ireland we suffer daily the tangible and unquestionable proofs of the early civilization of our country, to which we have long proudly laid claim, actually to perish before our eyes, from the most disgraceful negligence.

The Chair having been taken, *pro tempore*, by the Rev. J. H. Todd, D. D., V. P., the President communicated the following proof of the known law of Composition of Forces.

Two rectangular forces, x and y, being supposed to be equivalent to a single resultant force p, inclined at an angle v to the force x, it is required to determine the law of the dependence of this angle on the ratio of the two component forces x and y.

Denoting by p' any other single force, intermediate between x and y, and inclined to x at an angle v', which we shall suppose to be greater than v; and denoting by x' and y' the rectangular components of this new force p', in the directions of x and y, we may, by easy decompositions and recompositions, obtain a new pair of rectangular forces, x'' and y'', which are together equivalent to p', and have for components

$$x'' = \frac{x}{p} x' + \frac{y}{p} y';$$

$$y'' = \frac{x}{p} y' - \frac{y}{p} x';$$

the direction of x'' coinciding with that of p', but the direction of y'' being perpendicular thereto. Hence,

$$\frac{y''}{x''} = \frac{xy' - yx'}{xx' + yy'};$$

that is,

$$\tan^{-1}\frac{y''}{x''} = \tan^{-1}\frac{y'}{x'} - \tan^{-1}\frac{y}{x};$$

or, finally,

$$f(v' - v) = f(v') - f(v), \qquad \text{(A)}$$

at least for values of v, v', and $v' - v$, which are each greater than 0, and less than $\frac{\pi}{2}$; if f be a function so chosen that the equation

$$\frac{y}{x} = \tan f(v)$$

expresses the sought law of connexion between the ratio $\frac{y}{x}$ and the angle v. The functional equation (A) gives

$$f(mv) = mf(v) = \frac{m}{n}f(nv),$$

m and n being any whole numbers; and the case of equal components gives evidently

$$f\left(\frac{\pi}{4}\right) = \frac{\pi}{4};$$

hence

$$f\left(\frac{m}{n}\frac{\pi}{4}\right) = \frac{m}{n}\frac{\pi}{4},$$

and ultimately,

$$f(v) = v, \qquad \text{(B)}$$

because it is evident, by the nature of the question, that while v increases from 0 to $\frac{\pi}{2}$, the function $f(v)$ increases therewith, and therefore could not be equal thereto for all values of v commensurable with $\frac{\pi}{4}$, unless it had the same property also for all intermediate incommensurable values. We find, therefore, that for all values of the component forces x and y, the equation

$$\frac{y}{x} = \tan v \qquad \text{(c)}$$

holds good; that is, the resultant force coincides *in direction* with the diagonal of the rectangle constructed with lines representing x and y as sides.

The other part of the known law of the composition of forces, namely, that this resultant is represented also *in magnitude* by the same diagonal, may easily be proved by the process of the Mécanique Céleste, which, in the present notation, corresponds to making

$$x' = x, \quad y' = y, \quad x'' = p,$$

and therefore gives

$$p = \frac{x^2 + y^2}{p}, \quad p^2 = x^2 + y^2.$$

But the demonstration above assigned for the law of the *direction* of the resultant, appears to Sir William Hamilton to be new.

It was resolved, on the recommendation of the Council, to present a congratulatory address to His Excellency the Lord Lieutenant; whereupon, the Academy having adjourned for a short interval, an address was prepared, which was afterwards agreed to.

A letter was read from M. Moreau de Jonnés, presenting to the Academy two volumes of the Agricultural Statistics of France.

DONATIONS.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Premier Semestre. 1841. Nos. 17–24.

Ordnance Map of the Queen's County, in 39 sheets, including Title and Index. Presented by His Excellency the Lord Lieutenant.

Journal of the Franklin Institute. Vol. I. Third Series. (1841).

Det Kongelige Danske Videnskabernes Selskabs Naturvidenskabelige og Mathematiske Afhandlinger. 8[de] *Deel.* (1841).

Commentationes Societatis Regiæ Scientiarum Gottingensis recentiores. Vol. VIII. (1832–1837).

Esop's Fables in Chinese. Presented by the Rev. David Thom.

An Account of the Magnetic Observations made at Harvard University. (U. S.) Presented by the American Academy.

Résumé des Observations sur la Meteorologie, sur le Magnetisme, &c., faites a l'Observatoire Royal de Bruxelles en 1840. Par le Directeur A. Quetelet. Presented by the Author.

Memoire sur la Diathermansie Electrique des Couples Metalliques:

Des Travaux et des Opinions des Allemands sur la Pile Voltaique:

Essai Historique sur les Phénoménes et les Doctrines de l'Electro-Chimie. Par Professeur C. F. Wartmann. Presented by the Author.

Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider. 1 Aaret, 1839–40.

Report of the Council of the Zoological Society of London. April 29, 1841.

Report on the Observations by the self-registering Anemometer, in 1837–40. By A. F. Osler, Esq. Presented by the British Association.

Abstract of the Magnetic Observations made at the Travandrum Observatory in May, 1841. By John Caldecott, Esq. Presented by the Author.

Extrait du Tom. VIII. No. 6, *des Bulletins de l'Academie Royale de Bruxelles.* (*"Physique du Globe."*) Presented by M. Gudele.

Rapport Decennal des Travaux de l'Academie Royale de Bruxelles depuis 1830. Par M. A. Quetelet, Hon. M. R.I.A., &c. &c.

Annuaire de l'Academie Royal de Bruxelles. 7^{me} *année.*

Annuaire de l'Observatoire Royale de Bruxelles, pour l'An 1841. Par M. Quetelet. Presented by the Author.

Des Moyens de soustraire l'Exploitation des Mines de Houille aux Chances d'Explosion. Recueil de Memoires et de Rapports publié par l'Academie Royale de Bruxelles. Presented by the Academy.

Traité élémentaire des Fonctions Elliptiques. Par P. F. Verhulst. Presented by the Author.

Statisque de la France (*Agriculture*). Tom. I. II. Par M. De Jonnés. Presented by the Author.

First Publication of the Irish Archæological Society. Presented by the Society.

Memoires couronnes de l'Academie Royale de Bruxelles. Tome XIV. 2^{me} Partie (1839–40).

Nouveaux Memoires de l'Academie Royale de Bruxelles. Tome XIII. (1841).

Bulletins de l'Academie Royale de Bruxelles. Nos. 9, 12 (1840). Nos. 1, 6 (1841).

Transactions of the Zoological Society of London. Vol. II. Part 5.

Meteorological Observations made in Dublin. By Thomas H. Orpen, M.D., M.R.I.A. Presented by the Author.

Journal of the Statistical Society of London. Vol. IV. Part 3.

Seventh Annual Report of the Poor-Law Commissioners (1841).

Report of the Poor-Law Commissioners on Medical Charities in Ireland. (1841). Presented by George Nicholls, Esq.

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. (1839).

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1841. No. 32.

November 30. (Stated Meeting.)

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The following communication "on the Compound Nature of Nitrogen," by George J. Knox, Esq., was read by Dr. Kane.

Soon after the discovery of the bases of the alcalies and earths by Sir Humphrey Davy, the compound nature of nitrogen began to be a subject of discussion amongst chemists; but the arguments in favour of this supposition, deduced principally from the nature of the ammoniacal amalgam, led to no satisfactory physical results.

The experiments of Sir Humphrey Davy on the ammoniacal nitruret of potassium, and those of Despretz and Grove on the compounds of nitrogen with iron, copper, &c., have shown that the metals singly (even when aided by the most powerful electrical induction) have not the power of decomposing nitrogen. There is one experiment, however, by Sir Humphrey Davy, from which one might deduce its compound nature.

Upon heating ammonia-nitruret of potassium in an iron tube, he obtained more hydrogen, and less nitrogen, than the ammonia ought to have given.

Again: on mixing this substance with a greater proportion of potassium, he obtained still more hydrogen, and less nitrogen; whereas, on heating the same substance in a tube of *platinum*, the potassium alloyed with the platinum, and the ammonia was given off almost entirely undecomposed.

How can these experiments be explained except upon the supposition that the potassium and the iron had *conjointly* decomposed the nitrogen? The latest experiments which bear upon this subject, and from which I received the idea which led me to this investigation, are those of Doctor Brown, "upon the conversion of Carbon into Silicon," an explanation of phenomena which appears to me most unreasonable, and contrary to all chemical analogy; whilst the supposition of the carbon having reduced the nitrogen is not only a simple but an unavoidable conclusion to arrive at, if nitrogen be a compound substance. To determine, by experiment, the correctness or incorrectness of this idea, it were only necessary to reduce nitrogen by some other substance than charcoal; and should silica result from its decomposition, the problem might be considered to be solved.

Exp. I.—A considerable quantity of ammonia-nitruret of potassium was formed, by passing ammonia over potassium heated in an iron tube; the part which had not been in contact with the tube, having been examined for silica, contained none.

Exp. II.—Ammonia was passed for several hours over pure iron, heated to a dull red heat; examined for silica, it contained none.

Exp. III.—Ammonia-nitruret of potassium was heated with pure iron in an iron crucible, for one half hour, over a large Rose's lamp; the contents of the crucible, on examination, gave silicon and silica, the weight of which was not registered, as it might have been said to have derived a portion of silica from the inner surface of the crucible.

Exp. IV.—Twenty grains of ammonia-nitruret of potassium were heated with twenty grains of pure iron in the *same* iron vessel for one half hour; when treated with nitric and muriatic acids there remained insoluble a small quantity of a brownish colour, which, when fused with carbonate of potash, gave of silica 0.10. The solution, supersaturated with potash, filtered, neutralized, evaporated to dryness, gave of silica 1.450; sum total of silica 1.550.

From these experiments, together with those of Sir Humphrey Davy mentioned above, one might infer that nitrogen is either a compound of silicon and hydrogen, or of silicon, hydrogen, and oxygen; to determine which, synthetically, a current of dry muriatic acid gas was passed over siliciuret of potassium (formed by heating silica with potassium), placed in a bent tube of Bohemian glass, the extremity of which dipped into a cup of mercury, lying on the bottom of a vessel filled with water. The atmospheric air had been previously expelled from the apparatus by a current of hydrogen.

The gases insoluble in water having been collected, were found, on examination, to be hydrogen and nitrogen, the relative proportions of which varied in different experiments.

In two experiments the proportions of hydrogen to nitrogen were four of the former to one of the latter.

In a third experiment, as six of hydrogen to one of nitrogen.

In a fourth, as five of hydrogen to four of nitrogen.

Observation.—White fumes appeared occasionally in the tube, indicating the presence of muriate of ammonia.

Professor Lloyd exhibited a specimen of Rock from Terre Adele.

Professor Mac Cullagh communicated to the Academy a very simple geometrical rule, which gives the solution of the problem of *total reflexion*, for ordinary media and for uniaxal crystals.

First, let the total reflexion take place at the common surface of two ordinary media, as between glass and air, and let it be proposed to determine the incident and reflected vibrations, when the refracted vibration is known. It is to be observed, that the refracted vibration (which is in general elliptical) cannot be arbitrarily assumed; for, as may be inferred from what has been already stated (Proceedings of the Academy, vol. ii. p. 102), it must be always similar to the section of a certain cylinder, the sides of which are perpendicular to the plane of incidence, and the base of which is an ellipse lying in that plane and having its major axis perpendicular to the reflecting surface, the ratio of the major to the minor axis being that of unity to the constant r. The value of r, as determined by the general rule in p. 101, is

$$r = \sqrt{1 - \frac{1}{n^2 \sin^2 i}},$$

where i is the angle of incidence, and n the index of refraction out of the rarer into the denser medium. The ellipse is greatest for a particle at the common surface of the media; and for a particle situated in the rarer medium, at the distance z from that surface, its linear dimensions are proportional to the quantity $e^{-\frac{2\pi r z}{\lambda}}$; so that for a very small value of z the refracted vibration becomes insensible.

Now, taking any plane section of the aforesaid cylinder to represent the refracted vibration for a particle situated at the common surface of the two media, let OP and OQ be the semiaxes of the section, and let them be drawn, with their proper lengths and directions, from the point of incidence O; through which point also let two planes be drawn to represent the incident and reflected waves. Then conceive a plane passing through the semiaxis OP, and intersecting the two wave-planes, to revolve until it comes into the position where the semiaxis makes equal angles with the two intersections; and in this position let the intersections be made the sides of a parallelogram, of which the semiaxis OP is the diagonal. Let OA and OA′, which are of course equal in length, denote these two sides. Make a similar construction for the other semiaxis OQ, and let OB, OB′, which are also equal, denote the two sides of the corresponding parallelogram. Then will the incident vibration be represented by the ellipse of which OA and OB are conjugate semidiameters, and the reflected vibration by the ellipse of which OA′ and OB′ are conjugate semidiameters. And the correspondence of *phase* in describing the three ellipses will be such that the points A, A′, P will be simultaneous positions, as also the points B, B′, Q.

The same construction precisely will answer for the case of total reflexion at the surface of a uniaxal crystal, which is covered with a fluid of greater refractive power than itself. It is to be applied successively to the ordinary and extraordinary refracted vibrations, and we thus get the *uniradial* incident and reflected vibrations, or rather the ellipses which are similar to them. And as any incident vibration may be resolved into two which shall be similar to the uniradial ones, we can find the reflected vibration which corresponds to it, by compounding the uniradial reflected vibrations.

It may be well to mention that, in a uniaxal crystal, the plane of the extraordinary refracted vibration is always perpendicular to the axis, and therefore the ellipse in which the vibration is performed may be easily determined by the remark in p. 102. The plane of the ordinary vibration has no fixed position in the crystal; but if we conceive the auxiliary quantities ξ_1, η_1, ζ_1, (p. 98) to be compounded into an ellipse (as if they were displacements), the plane of this auxiliary ellipse will be perpendicular to the axis of the crystal.

Whether the preceding very simple construction, for finding the incident and reflected vibrations by means of the refracted vibration, extends also to the case of *biaxal* crystals, is a point which has not yet been determined, on account of the complicated operations to which the investigation leads, at least when attempted in any way that obviously suggests itself.

Joseph Huband Smith, Esq. was elected a Member of the Committee of Antiquities, and Dr. Aquilla Smith was elected Treasurer of the Academy, in the room of Dr. Orpen, resigned.

The following Address was presented on the 13th November to the Lord Lieutenant:

" *To His Excellency the Right Hon. Thomas Philip Earl De Grey, Lord Lieutenant-General and General-Governor of Ireland.*

" May it please your Excelllency,

" We, the President and Members of the Royal Irish Academy, have the honour to present to your Excellency our very sincere congratulations on your arrival in our metropolitan city, as the representative of our most gracious Sovereign.

" It has been the pleasure of her Majesty to declare herself the Patron of the Institution of which we are members ; and, in virtue of the charter which was granted to us by one of her royal predecessors, King George the III., the office of Visitor of the Academy has become vested in your Excellency, as Lord Lieutenant of Ireland.

" We cannot but think ourselves fortunate in an official connexion with a nobleman who, in his private career, has shown himself so much attached to arts and letters as your Excellency is known to be.

" The objects of the Royal Irish Academy are Science, Polite Literature, and Antiquities; and in the tranquil pursuit of these objects, the importance of which is appreciated by your Excellency, we have had the pleasure of seeing fostered within our body those feelings of mutual good-will, which are, perhaps, scarcely less highly to be prized than the pursuit of knowledge itself.

(Signed)

" William Rowan Hamilton, President."

To which His Excellency was pleased to return the following answer:

"Mr. President, and Members of the Royal Irish Academy,

"I thank you for your congratulations on my arrival in Ireland.

"It is a source of pleasure to me to feel that a part of my public duty, as the Representative of her Majesty, will bring me into such immediate connexion with the body of scientific and learned gentlemen forming the Royal Irish Academy.

"The duties of a visitor lose the austerity of official character, and merge into those of friendship and association, when the person who is invested with them has the honour of being received with the warmth which has distinguished your reception of myself.

"You are pleased to estimate my fitness and talents beyond their value; but I can assure you that you cannot attach more importance than I do to the welfare and prosperity of such institutions as yours. As you justly observe, the pursuit of the objects principally cultivated by the Royal Irish Academy enables you to foster within your body feelings of mutual good-will; and when I see enrolled amongst your members those who conscientiously entertain a difference of opinion upon points of the very highest importance, I cannot withhold my conviction of the public utility of a society which affords them a point of union, and holds out to them an object upon which they can honestly coincide."

DONATIONS.

Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königl. Preuss. Akademie der Wissenschaften zu Berlin. Vom Juli 1840 bis Juni 1841.

Transactions of the Cambridge Philosophical Society. Vol. VII. Part. 2.

Astronomische Nachrichten. Nos. 413–432.

Magnétisme terrestre. Par M. Quetelet. Extrait du tom. VIII. No. 9, des Bulletins de l'Academie Royale du Bruxelles. Presented by the Author.

Nouveaux Memoires de l'Academie Royale des Sciences et Belles-Lettres de Bruxelles. Tome. XIV.

Memoires Couronnés par l'Academie Royale des Sciences et Belles-Lettres de Bruxelles. Tome XV. 1ere partie 1840–41.

Memoire sur différens Procédes d'Integration, par lesquels on obtient l'attraction d'un ellipsoïde homogene dont les trois axes sont inégaux, sur un point extérieur. Par M. J. Plana. Presented by the Author.

The Fishes of the Dukhun. By Lieut.-Col. W. H. Sykes, F. R. S. Presented by the Author.

Notes on India before the Mahommedan Invasion. By Lieut.-Col. W. H. Sykes, F. R. S. Presented by the Author.

Proceedings of the Royal Society. Nos. 44–48. 1840–41.

Supplemental Instructions for the Use of the Magnetical Observatories. Presented by the Royal Society.

On the Character of Sir John Falstaff. By James O. Halliwell, Esq. Presented by the Author.

A Plan of Medical Reform and Reorganization of the Profession. By Richard Carmichael, Esq. Presented by the Author.

December 13.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The President read the following letter from the Right Hon. Sir John Newport, Bart., presenting to the Academy a manuscript containing an account of the Loans of Money to King Charles I.

" *New Park,*
" *12th November,* 1841.

" I desire, Sir, to offer for acceptance of the Royal Irish Academy, of which I have, during many years, had the honour of being a member, a volume, which, as it respects a most interesting period of British history, and materially tends to elucidate transactions which had a powerful influence in producing the calamitous results, in the reign of Charles the First, that immediately succeeded, may be deemed not unworthy of admission into the Library of the Institution.

" The volume contains correct copies of the orders of the Lords of the Council, and letters addressed to the Lord Lieutenants of the counties of England, and others, directing the assessment and collection of what was called a voluntary loan, according to the annexed lists, from the several landholders, merchants, and merchant strangers of England, and the citizens of the cities and towns therein, including the judges and law officers, but specially excluding all members of the peerage, ' with whom it was not purposed to deal for the present.'

" The original documents, of which this volume is a transcript, were found during the period whilst I held the office of Comptroller-General of the Exchequer, amongst a large collection of papers deposited in the Pells Office; and as I considered them to afford interesting materials to elucidate the history of that eventful period, I directed two copies to be made of them; one of these I sent to the British Museum, and now offer the other to the acceptance of the Royal Irish Academy.

" The great inequality of the extent of the demand on the several parties thus assessed, varying in a great degree with their capacity of resistance to its enforcement, will be quite apparent on examining the lists; as will also the urgency of the measure, from the repetition of the letters from the Lords of the Council, at a short interval of time, deprecating further delay, and censuring what had already occurred.

One name in the list of contributors from the town of Cambridge, that of Hobson the carrier, celebrated by some lines of Milton, has, from that circumstance, attracted attention, from the sum demanded and the nature of his occupation.

"The original papers have been injured by damp, and rendered in some degree, but not materially, defective.

"In order to render the papers more accessible for perusal, I have sketched out a table of reference which I enclose, and avail myself of the kindness of my valued friend, the Lord Bishop of Cashel, for their transmission to Dublin.

"I am, Sir,
"Your obedient Servant,
"JOHN NEWPORT.

"*Sir William R. Hamilton,*
President R. I. Academy,
&c. &c. &c."

The special thanks of the Academy were voted to Sir J. Newport.

A paper was read by William Roberts, Esq., F. T. C. D., "on the Rectification of Lemniscates and other Curves."

Let a curve be traced out by the feet of perpendiculars dropped from a fixed origin upon the tangents to a given curve: and from this new curve, let another be derived by a similar construction, and so on. Also let a curve be imagined which is constantly touched by perpendiculars to the radii vectores of the given curve, drawn at the points where it is met by these radii, and from this let another be derived by a similar mode of generation, and so on.

Then if s_n denote the arc of the curve which is n^{th} in order in the former series, and s_{-n} that of the n^{th} in the latter, we shall have

$$ds_{\pm n} = \frac{\pm nr\frac{d^2\omega}{dr^2} + (1 \pm n)\frac{d\omega}{dr} + r^2\frac{d\omega^3}{dr^3}}{\left(1 + r^2\frac{d\omega^2}{dr^2}\right)^{\frac{\pm n + 1}{2}}} \left(r\frac{d\omega}{dr}\right)^{\pm n - 1} rdr,$$

$F(r, \omega) = 0$ being the polar equation of the given curve.

It is convenient to distinguish the curves of the two series by calling those of the former *positive*, and those of the latter *negative;* we may also generally denote their polar coördinates by the symbols $r_{\pm n}$, $\omega_{\pm n}$.

If the given curve, which may be denominated the base of either system, be an ellipse whose centre is the origin, it will be found, by applying the above formula, that the negative curves will in general have their arcs expressible by elliptic integrals of the first and second kinds, whose modulus is the eccentricity of the base-ellipse. The arc of the first will involve only a function of the first kind: a result which has been given by Mr. Talbot in a letter addressed to M. Gergonne, and inserted in the *Annales des Mathematiques*, tom. xiv. p. 380.

A function of the third kind, with a circular parameter $-1 + b^4$, where b is the semiaxis minor of the ellipse, its semiaxis major being unity, and the modulus of which is the eccentricity, enters into the arcs of all the positive curves; and their general rectification depends only on that of the ellipse, and of the first derived, both positive and negative.

The quadrants of the ellipse, and of the first two curves, positive and negative, are connected by the following relation:

$$(\mathrm{s}_{-1} + \mathrm{s}_1)\, \mathrm{s}_{-1} = (3\,\mathrm{s} - \mathrm{s}_{-2})\,(2\mathrm{s} - \mathrm{s}_2).$$

It is worthy of notice, that if the eccentricity be $\frac{\sqrt{5}-1}{2}$, the functions of the third kind disappear, and the rectification of both series depends only on that of the ellipse and of the first negative curve.

If the base curve be a hyperbola, whose centre is the origin, the arcs of all the curves of the negative series will depend only on elliptic functions of the first and second kinds. But the general expression for the arc in the positive series contains a function of the third kind, the parameter of which is alternately circular and logarithmic: the curves of an odd order involving the same function of the circular kind, and those of an even order the same of the logarithmic kind, if the real axis of the base-hyperbola be greater than the imaginary, and *vice versa*.

Mr. Roberts also shows, that besides the case of the equilateral hyperbola, in which the first positive curve is the lemniscate of Bernouilli, and which has been the only one hitherto noticed, at least as far as he is aware, there are two others, in which the arc of the first positive curve can be expressed by a function of the first kind, with the addition of a circular arc in one case, and of a logarithm in the other. The first of these occurs when the imaginary semiaxis is equal to $\frac{\sqrt{5}-1}{2}$ (the distance between the centre and focus being unity), and this fraction is the modulus of the function. The other case is furnished by the conjugate hyperbola, and the modulus is complementary. In both these cases functions of the third kind disappear from the arcs of the positive curves.

If the hyperbola be equilateral, and its semiaxis be supposed equal to unity, the general equation of the derived curves of both series may be presented under the form

$$r_{\pm n}^{\frac{2}{\pm 2n-1}} = \cos\left(\frac{2\omega_{\pm n}}{\pm 2n-1}\right).$$

The successive curves represented by this equation are very curiously related to each other. The following property appears worthy of remark:

Let P_{n-1}, P_n, P_{n+1} be corresponding points on the

$(n-1)^{th}$, n^{th}, and $(n+1)^{th}$ curves of the positive series respectively, and v their common vertex, which is also that of the hyperbola, then will

$$\text{arc } \mathrm{VP}_{n-1} + \text{right line } \mathrm{P}_{n-1}\,\mathrm{P}_n = \frac{2n-1}{2n+1} \text{ arc } \mathrm{VP}_{n+1}.$$

Mr. Roberts states that he has demonstrated the property in a manner purely geometrical.

This equation shows that the arcs of all the curves of an odd order will depend only on that of Bernouilli's lemniscate, or the function $\mathrm{F}\,\{\sqrt{\tfrac{1}{2}}, \phi\}$, and those of an even order only on the arc of the second of the series. This latter arc is three times the difference between the corresponding hyperbolic arc and the portion of the tangent applied at its extremity, which is intercepted between the point of contact and the perpendicular dropped upon it from the centre: and the entire quadrant is three times the difference between the infinite hyperbolic arc and its asymptot.

Also, S_n, S_{n+1}, denoting the quadrants of the n^{th}, and $(n+1)^{th}$ curves, the following very remarkable relation exists between them,

$$\mathrm{S}_n\,\mathrm{S}_{n+1} = (2n+1)\frac{\pi}{4}.$$

The curves of the negative series enjoy analogous properties.

Lastly, let the base curve be a circle, the origin being within it: and it appears that the rectification of the curves of both series, which are of an even order, can be effected by the arcs of circles; and that those of an odd order, which belong to the positive series, will involve elliptic integrals of the first and second kinds in their arcs. The negative curves of an odd order contain a term depending on a function of the third kind, which is however reducible to a function of the first kind and a logarithm.

By the particular consideration of the first negative curve in this case, Mr. Roberts was led to a very simple demonstration of the equation which results from the application of Lagrange's celebrated scale of reduction to elliptic functions of the second kind, and which is nothing more than the analytical expression of Landen's theorem.

Professor Mac Cullagh exhibited to the Academy some Roman Denarii, from the collection of Mrs. Alexander of Blackheath (Coleraine).

These coins (twenty-eight in number) were found in the year 1831, along with an immense quantity of others of the same kind, weighing altogether about eight pounds, by a labourer who was digging in a field on the Faugh Mountain, near Pleaskin, one of the headlands of the Giant's Causeway. According to an account published at the time in the Belfast News' Letter (June, 1831), and communicated to the Academy by the Rev. Dr. Drummond, they were found under a flat stone which was turned up by the spade. Nearly 200 of them (says this account) were sold for a trifling sum to an English gentleman at Coleraine, and some of the remainder were bought by the Rev. R. Alexander. Of the twenty-eight coins that were exhibited, only seventeen have their legends legible, and these are of the times of the emperors, from Vespasian to the Antonines. The following list of them has been supplied by Dr. Aquilla Smith, with references to the catalogue of the University Cabinet, published by the Rev. J. Malet, F.T.C.D.

1. Vespasian, . . .	*Malet*, 384.
2. Vespasian, . . .	Reverse, a winged Caduceus.
3. Domitian, . . .	*Malet*, 452.
4. Domitian, . . .	Reverse, Minerva.
5. Nerva, ...	*Malet*, 467.
6. Trajan, 7. Trajan, . . .	*Malet*, 513.
8. Trajan, ...	Reverse, Minerva.
9. Trajan, ...	Reverse, a Female seated.
10. Hadrian, ...	*Malet*, 548.

11.	Hadrian, . . .	*Malet*, 552,
12.	Antoninus Pius, .	*Malet*, 615.
13.	Antoninus Pius, .	*Malet*, 621.
14.	Antoninus Pius, .	*Malet*, 623.
15.	Antoninus Pius, .	Re. a Female holding a Cornucopia.
16.	Faustina the Elder,	*Malet*, 670.
17.	Faustina the Younger,	*Malet*, 723.

Dr. Smith remarks, that the coin of Hadrian, No. 11, is interesting, as having on the reverse a star and crescent, resembling those on the *Irish* coins of King John.

The Rev. Dr. Drummond then gave an account of other Roman coins that had been found in Ireland; and in some preliminary observations he dwelt on the utility of preserving a knowledge even of such an insulated fact as the discovery of a coin, for though of little importance in itself, it might prompt to farther research, and lead both the historian and antiquary to consequences which could scarcely have been anticipated.

In England, almost every year is bringing to light various monuments of Roman antiquity, but in Ireland they are exceedingly rare; though, perhaps, of more frequent occurrence than is generally known. Ancient coins and other articles have been repeatedly found by persons ignorant of their real value, and sold as mere metal by their weight, without regard to their age and character. Thus, we read in Mason's Parochial Survey, that in the parish of Dunaghy were found a number of silver coins, which were sold at Ballymena before any one had an opportunity of examining or describing them. Again, the Rev. Alexander Ross informs us, that a person on whose veracity he could depend, assured him, that about thirty years prior to the time of his writing, two or three men, in digging an old fort near Cashel, found an earthen pot, which might contain four or five quarts, filled with gold coins of different sizes (Par. Survey, II. p. 304).

The same writer states that "a fine copper coin of the Emperor Nero was found some years ago, and is now in Mr. A. Ogilby's collection, the head finely relieved, and in perfect preservation." In the collection of the Royal Dublin Society are three Roman copper coins of the Cæsars, dug up in Fermanagh, and presented by Sir C. Coote. But the most curious fact in connexion with the coins exhibited by Mr. Mac Cullagh, is that of a Roman gold coin being found many years previous, nearly in the same locality. The Rev. Robert Trail, in his statistical account of Ballintoy (Mason's Par. Survey), says, "within these few days a gold coin of Valentinian was brought to me in perfect preservation, and is now in my custody. It is about the size of half a guinea, and on the head side is the following inscription D. N. VALENTINIANUS, P. F. AUG. On the reverse RESTITUTOR REIPUBLICÆ. As Valentinian succeeded Jovian in 364, and died in 375, this money must have been struck during that period, but how it came into this parish I cannot conjecture."—(II. p. 155).

A single coin might be accidentally dropped and lost by some collector or virtuoso, on his tour to the Giant's Causeway; but we cannot account in this way for a large collection of coins of ancient date. They must have been placed where they were found, by some careful hand, probably in times of turbulence and danger, as in a place of safety, whence they might be removed at a more favourable season.

A few years ago, G. Putland, Esq., of Bray, had occasion to build piers for a gate contiguous to the sea-beach, on the north side of Bray Head. His workmen, on digging for a foundation, were surprised to meet with the skeletons of several human bodies, which, on farther examination, they found to be placed, not confusedly heaped together, as the slain on a battle field, but in graves placed regularly side by side, and separated each from its neighbour, by thin partitions of flag or of stone. On the exposure to the air, the bones crumbled to atoms; the teeth alone were more durable, and in tolerable preservation.* The most remarkable circumstance connected with these skeletons was a number of Roman copper coins, one or two of which lay on or beside the breast of each. Of these coins, which were about the size of our penny pieces, some bore the image and superscription of Adrian, and others those of Trajan, in clear and distinct relief. Several were greatly corroded, and rendered altogether illegible. A few of the best of these coins were for a short time in Dr. Drummond's possession. He shewed them to the late lamented Dean of St. Patrick's, who said that he had seen a coin precisely similar, which was found in the island of Lambay.

As the Romans never formed any settlement in Ireland, the question naturally arises, how came these coins to be placed in this locality, and under such circumstances? The ready reply is, that the bodies here interred were probably those of mariners, the crew of some Roman galley that had been stranded and lost on the shores of Bray, and that some of the survivors who had escaped, performed the funeral rites. Among the Romans it was deemed an act of great impiety to leave a corpse unburied; and hence Horace introduces the shade of the drowned Archytas, imploring the passer by to sprinkle a little dust on his body, which had been cast on the shores of Tarentum. Palinurus, in Virgil, makes a similar request.

The coins, it is presumed, were the fee designed for the grim ferryman; a part of the funeral rites of the greatest importance, and by no means to be neglected, for the shades of those who had not the proper fee, as well as of those whose

* Sir William Hamilton, in a paper in the Archæologia (vol. iv. p.161), observes that the teeth of some skeletons of soldiers, found at Pompeii, were remarkably sound. "Perhaps," says he, "among the ancients, who did not use sugar, they might not be so subject to decay as ours."

bodies remained unburied, were condemned to wander a hundred years on the banks of the Styx.

Thus may we account for the Roman coins found at Bray; but how shall we account for those dug up at Fermanagh, or discovered at Dungiven, Ballintoy, and the neighbourhood of the Giants' Causeway?

Though the Romans never had any permanent station in Ireland, they were well acquainted with its geographical position, its passages, and its harbours, as we learn from the unquestionable testimony of Tacitus; and though this and other testimonies were wanting, it might be fairly presumed that the Roman fleets which encompassed Great Britain, sailed beyond the Orkneys, and boasted that they had arrived at the *Ultima Thule,* could not be ignorant of Ireland and its coasts, though not induced by the spirit of commerce or adventure. The mariners would sometimes be tempted to land, if not to repair their shattered vessels, to procure wood, water, and provisions.

Tacitus informs us that Agricola obtained information concerning the state of Ireland, from one of its chiefs, who, for disaffection or rebellion, had been driven into exile, and sought refuge from the Roman commander. It is to be lamented that our native Irish historians, as far as the writer has been able to ascertain, are completely dark on this subject. Though an eminent Irish scholar, profoundly versed in our ancient MSS., can produce one passage—but it is the only one he ever met with—which seems to countenance the idea that the Romans had subjected any sept of the Irish to their yoke. He states that in discussing the means by which Conor Mac Nesa, King of Ulster, and cotemporary with Christ, discovered the crucifixion of the Saviour, a writer, in an old Irish MS., in the library of T.C.D., says that "he learned it from the Druid Bachrach, or from Altus the Consul, who came from Octavin to ask the tribute from the Gaels."

Roman coins might find their way to Ireland in the common intercourse of trade. They may have been brought by the early Christian missionaries, or by men who fled hither, as to an asylum, from persecution. It is universally admitted, says Lanigan, that there were Christian congregations in Ireland before the mission of Palladius in 431, though it is impossible to determine who first introduced Christianity.—It is reasonably conjectured, that during the persecution of Diocletian and Maximian, the only one recorded as having extended to Britain, some Christians, and particularly those of the clerical order, sought refuge in Ireland; and it is a fair presumption that they would bring with them such articles as were most precious and most easily carried, among which coins and jewels are the chief. There is yet another mode of accounting for these remains of antiquity, not less plausible. The early Irish, like the neighbouring nations, were fond of making predatory excursions. They often landed on the shores of England and Wales, and carried off whatever spoil fell into their hands. They also assisted their friends, the Albanian Scots, whose country they colonized under Carbre Riada, in their wars with the Romans, and may have sometimes returned enriched with treasure, obtained by the sword.

Of the spoils, by which they were sometimes enriched, it may suffice to mention an instance, extracted from O'Flaherty's Ogygia. Crimthan Nianair, the 111th Monarch of Ireland, towards the end of the first century, returned from a "foreign expedition, in which he obtained a very rich booty; among which was a golden chariot; a pair of tables, studded with 300 brilliant gems; a quilt, of various colours; a cloak, interwoven with threads of gold; a sword, engraved with various figures of serpents, which were of the purest gold; a shield, embossed with refulgent silver studs; a spear, which always gave an incurable wound; a sling, so unerring, that it never missed; two hounds coupled with a chain, which, being made of silver, was worth 300 cows, with other valuable rarities."—*Ogygia*, II. pp. 182–183.

The same author informs us that about the middle of the third century, Cormac, the 126th Monarch of Ireland, "equipped a large fleet, which he sent to the North of Britain, where he was committing depredations for three years."—p. 238.

He also states, on the authority of Ammianus Marcellinus and Claudian, that the Saxons, in conjunction with our countrymen the Scots and Picts, made frequent excursions to Britain a long time before they made settlements in that country. Ammianus, he says, writes that "the Scots (i. e. the Irish) and Picts, not only invaded those places in Britain that were adjacent to the Roman boundaries, but that in the first year of the Emperor Valentinian, A.D. 364, a combined army of the Picts, Saxons, Scots, and Attacots, reduced the Britains to the utmost distress." Hence, he concludes, there was a common league between them, with intermarriages and commercial intercourse.

According to Dr. Drummond, when we consider the various modes in which Roman coins may have found their way into Ireland, the wonder perhaps should be, not that so many, but that so few, have been discovered.

The Rev. G. Sidney Smith, D. D., M. R. I. A., read "an Account of some Characters found on Stones on the top of Knockmany Hill, county Tyrone."

On the top of Knockmany hill, in the parish of Clogher, and demesne of the Rev. Francis Gervais, there are some interesting remains of ancient times. Besides two moats, one internal to the other, there is an ancient chamber or kystvaen, consisting of upright flag-stones, about six feet high. It includes a space fourteen feet long by seven wide. Its position with respect to the moats is represented in the ground plan, fig. 1. The stones marked by a darker shade are

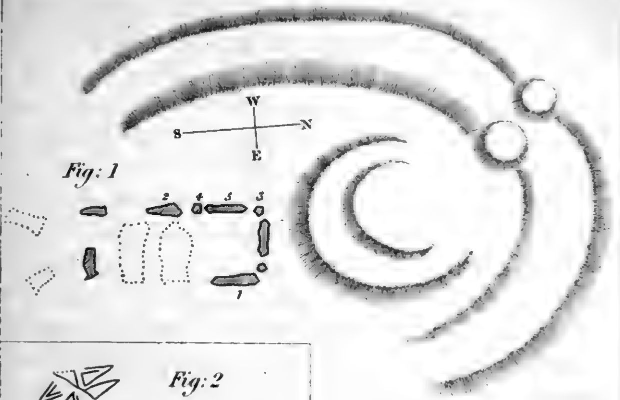

Fig: 1

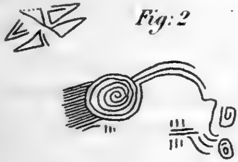

Fig: 2

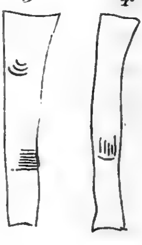

Fig: 5

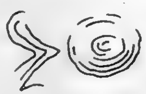

Fig: 3

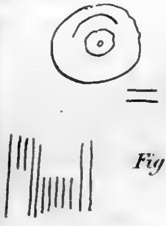

Fig: 4

Fig: 6

standing, and those in dotted lines have been thrown down. On five of the stones characters are found, which seemed to be well worth copying, which I have accordingly done, and represented them in the accompanying figures. The most remarkable of these characters occur on the stone marked No. 1, in the ground plan. Those represented in fig. 2, are on the lower part of the stone, and those in fig. 3, on the upper; there may have been other intermediate characters, but they are effaced. The spiral in fig. 2, is about nine inches in diameter, and that in fig. 3, about twelve inches. Fig. 4 represents the characters on stone No. 2, and fig. 6, those on No. 5, on the same scale as in figs. 2 and 3; and fig. 5 represents the stones marked 3 and 4, which are six feet high. It will be observed that in the spirals and other marks, there is some resemblance to the New Grange characters, and in fig. 4, we have a close approach to the Ogham. The copies were made with great pains, and are I believe exact in the small details.

On the difficult subject of these ancient characters little can be done until a greater mass of facts shall have been collected; and hitherto few have been observed in the North of Ireland. Mr. Windele and other zealous antiquarians have prosecuted the subject in Munster with great zeal and success.

Mr. S. Ferguson exhibited some gold beads found in the county of Donegal.

January 10.

Rev. HUMPHREY LLOYD, D. D., Vice-President, in the Chair.

William Andrews, Esq., John Thomas Banks, Esq., Robert Bateson, Esq., John Burrowes, Esq., Rev. Samuel Butcher, F. T. C. D., Fleetwood Churchill, M. D., Alexander Clendinning, Esq., Rev. Reginald Courtenay, Durham Dunlop, Esq., Alexander Ferrier, Esq., Wrigley Grimshaw, M. D., William Hogan, Esq., William John Hughes, Esq., and William Roberts, Esq., F. T. C. D., were elected members of the Academy.

Resolved,—On the recommendation of Council,—"That henceforth, at every annual election of officers, the President for the expiring year be considered as eligible to any one of the Committees of Council."

Mr. Ball, referring to his paper read before the Academy in November, 1839, relative to a Loligo, to which he gave the specific name of Eblanæ, exhibited the following Acetabuliferous Cephalopoda, with the view of showing the increased knowledge of species of the Irish seas, and of placing on record the very interesting discovery of two of the genus Rossia, which he had reason to believe had not before been noticed. He then exhibited specimens of

1. Sepia officinalis. Dublin bay.

2. Sepia Rupellaria. ? A dorsal plate, being one of three specimens found by G. Hyndman, Esq., at Magilligan. See Ferussac and D'Orbigny's Cephalopoda, plate 3 of Sepia.

3. Loligo vulgaris. Dublin, &c.

4. Loligo sagittata. Leith. Obtained by W. Thompson, Esq., of Belfast.

5. Loligo sagittata, var. ? This was in the former paper considered as a variety, but on comparison with the true sagittata, No. 3, it seems to be a distinct species. It was obtained by G. Allman, Esq., on the coast of Cork.

6. Loligo subulata, var. ? Was obtained by John Montgomery, Esq., of Locust Lodge, on the coast of the County Down.

7. Loligo subulata, var. No. 2. Somewhat shorter than No. 5. Youghal, 1832.

8. Loligo media. Youghal, 1819.

9. Loligo media, var. · It approaches the form of sagittata in the termination of its visceral sac.

10. Loligo Eblanæ. Of the former paper. Obtained by T.W. Warren, Esq., in 1836; and other specimens of greater beauty and larger size obtained in the bays of Belfast and Dublin by W. Thompson, Esq., and Mr. Ball. As it now appears that the animal possesses both eyelids and a lacrymal sinus, characters not ascribed to the genus Loligo, it may require to be placed in another genus.

11. Eledone ventricosa. Youghal, 1820, and Dublin. A very fine specimen was found by Mrs. Lyle at Kingstown.

12. Octopus vulgaris. Plymouth, 1841. Mr. Ball.

13. Sepiola Rondeletii. Youghal, 1819. Dublin, 1829. Mr. Ball.

14. Rossia Owenii. Was obtained in 1839 by Mr. Ball, from a fishwoman who had found it in a Dublin bay fishing boat. It is remarkable for the great size and distinctness of its acetabula, which are placed on long peduncles, and may be compared to the pearls in a diadem: they are ranged in three rows, those of the centre row being not more than half the diamater of those on each side; on the first pair of arms the acetabula are more numerous, more equal in size, and smaller than on the others. The specific name has been given in honour of R. Owen, Esq., the founder of the genus Rossia.

15. Rossia Jacobii. Was obtained from the same woman as the foregoing, in 1840, by A. Jacob, Esq., M.D., who kindly sent it to Mr. Ball. It is much larger, but differs considerably in its proportions from Rossia Owenii; its acetabula are smaller; its arms proportionably shorter; the membrane round the mouth forms a hexagonal figure, from each angle of which a ridge runs, which is decurrent in six cases; on the second, third, and fourth pair of arms, and in the seventh the ridge passes upon the web between the first pair of arms, where it bifurcates, and runs out on each side. Its specific name is given in honour of Dr. Jacob, from

whom Mr. Ball has in many instances received valuable aid in zoological pursuits. The fins of both these species of Rossiæ are like in form and position to those of Sepiola Rondeletii.

16. Spirula australis. Shell found at Youghal, 1820.

The following are the Measurements of the Rossiæ in Inches:

	Rossia Owenii.	Rossia Jacobii.
Length of body,	1·7	2·1
Breadth over fins,	2·0	2·7
Length of fin,	0·7	1·5
Extreme breadth,	0·45	0·7
Breadth between eyes,	0·9	1·2
Extreme breadth of head,	1·1	1·4
Length of head,	0·5	0·7
Length of tentaculæ,	4·0	5·7
Portion of tentaculæ occupied by Acetabula,	0·9	1·5
Length of first pair of arms, counting from top of head,	2·1	2·2
Ditto, second ditto, ditto,	2·4	2·3
Ditto, third ditto, ditto,	2·7	2·6
Ditto, fourth ditto, ditto,	2·3	2·4
Depth of fin between first pair of arms,	0·2	0·4
Ditto, first and second do.	0·3	0·5
Ditto, second and third do.	0·42	0·6
Ditto, third and fourth do.	0·4	0·8
Ditto, fourth do.	0·04	0·03

William Roberts, Esq., F.T.C.D., read a paper on a class of spherical curves, the arcs of which represent the three species of elliptic transcendents.

A cone of the second order, whose vertex is upon the surface of a sphere, and one of whose principal axes is a diameter, will intersect the sphere along a curve which admits of several varieties, according to the nature of the sections of the cone parallel to its principal planes, and the position of its internal axis. This curve may be made to furnish, by means of its arc, a geometrical representation of the three species of elliptic trancendents, including the two cases of the third.

In the course of the investigations alluded to, Mr. Roberts was also led to consider two species of the curve called the spherical conic, which appear to possess many remarkable analogies to the properties of the equilateral hyperbola. These cases occur when the axis minor is a quadrant, and when the semi-axes a and b are connected by the relation

$$\sin a = \tan b.$$

The following extract of a letter from Andrew Durham, Esq., to the Marquess of Downshire, was read to the Academy by Sir William Betham, with his Lordship's permission:

" *Belvedere, Lisburn,*
" *29th December,* 1841.

" My Lord,

" As your Lordship and party were prevented from at tending the interesting search at Drumboe Tower, I beg to inform your Lordship that about seven feet below where we commenced excavating, we found a skeleton, *in situ*, lying by compass N.W. by W., wanting both legs and feet from the knees, and also the right arm. The earth we removed was of a blackish colour, as if composed of decomposed vegetable matter, full of stones, many of which, from the mortar on them, must have fallen from the top and the entrance, which is about five feet from the external level; and on the eastern side, it also abounded in bones of different animals, and a few bones seemingly of black cattle. Under this earth we came to a surface of mortar; this induced us to proceed still more cautiously; and immediately under this mortar we first discovered the skull, in good preservation, together with the teeth; we then laid bare the whole body, a work of no little difficulty, from the wetness and adhesiveness of the soil. We were much inclined to leave the body as we found it, but were obliged to raise it to continue our search. We excavated to the very foundation of the Tower, without finding anything else, with the exception of many pieces of charcoal. The skull was lying on the right side, and the dorsal and cervical vertebræ were considerably decomposed.

"The diameter of the Tower inside is nine feet. The skeleton was not placed exactly in the centre, but the head was so near the side that there would have been room sufficient for the body with its legs and feet, had it been placed in the centre. The mystery seems increased by the want of the arm. None of the bones found had been acted on by fire.

"There was *no flag-stone*, nor floor either above or below the body. The layer of mortar seems intended as a substitute for a floor.

"There were several jawbones, apparently pigs', from the size of the tusks; but no skulls, with the exception of one of a bird.

"The external circumference of the Tower is fifty-one feet; the wall being four feet thick.

"I believe I have mentioned every thing of importance; I leave others to draw conclusions."

Sir W. Betham stated that he considered this tower had been opened before, and that the skeleton was then dislocated. The propensity of searching for treasure may have led to the violation of this tomb, as it had to that of others, as Cashel, from which the bones had all been removed; but at Ardmore and Cloyne the skeletons were found really *in situ;* the floor of mortar, both above and below, being perfect. The Tower of Abernethy in Scotland has also been examined with the same results as at Ardmore and Cloyne. The stones, with mortar attached to them, found in Drumboe, were certainly part of the concrete course of mortar covering the earth in which the body reposed, which was broken up by the violaters of the tomb.

A notice of the occurrence of a Metallic Alloy in an unusual state of aggregation and molecular arrangement, was read by Robert Mallet, Esq., M. R. I. A.

Amongst the several classes of substances which chemistry at present considers as simple, the metals stand preeminently marked by their almost invariable possession of a nearly fixed and striking group of sensible qualities, which together constitute the well known "metallic character." Some of these, such as lustre and fusibility, are common to every metallic body; but by the occasional variation of nearly every other sensible quality of the metals, the law of continuity remains unbroken, which unites them in different directions with the other classes of material bodies. Thus opacity, which is probably mechanically destroyed in gold leaf, is lost in selenium; and so, in this most prevalent of their properties, the metals, through tellurium, selenium and sulphur, become translucent, and mingle with the nonmetallic elements. So also their solidity, at common temperature, is lost in mercury; their great density, in sodium and potassium; their malleability, in bismuth, antimony, and arsenic; while in tellurium, the power to conduct electricity is nearly wanting; and, lastly, hydrogen, to all intents a metal in its chemical relations, yet possesses not a single physical quality in common with these, but exists as an invisible and scarcely ponderable gas.

But although *different* metals thus vary in sensible qualities, those which collectively belong to *the same* individual metal are as remarkable for their permanence.

Unless selenium be admitted to be a metal, no approach to dimorphism has hitherto been recognized in any body of the class; the only case recorded, that by Dufresnoy, of the occurrence of cast iron in cubes and rhomboids, not having been given by him with certainty, nor since verified by other observers. Hence any instance of such a character, or tendency towards it, is worthy of attentive consideration; and it was with this view that the author brought before the Academy the following notice of the occurrence of an alloy of copper, in two states, having totally different sensible and physical qualities, while identical in chemical constitution. The alloy in question, in its original or normal condition, was in fact a species of brass; and the particular specimen presented to the Academy was a portion of one of the brass bearings, or beds, in which the principal shaft of a large steam engine revolved.

The bearing, or bed of a shaft (as is generally known), consists of a hollow cylinder, generally of brass, divided in two by a plane passing through the axis; its inner surface is finely polished, and sustains the shaft, during its revolution, which is also polished; the cavity of the brass being completely filled by the shaft, which, in the present instance, was of cast iron, and about nine inches in diameter.

It frequently happens, notwithstanding the polish of both metallic surfaces, and the application of oil, that the friction due to their rapid passage over each other, while exposed to undue or irregular pressure, produces a considerable rise of temperature, and the brass becomes abraded. Its particles have no coherence, and much resemble the "bronze powder" used by painters.

In an instance, however, which some time since came under the author's notice, a different result took place. The minute particles of abraded brass were by the motion of the shaft, during a few hours, impacted into a cavity, at the junction of the two semicylinders of the bearing, where they became again a coherent mass, and when removed presented all the external appearance of an ingot or piece of brass, which had been poured in a state of fusion into the cavity. On more minute examination, however, the mass was found to differ much in properties from the original brass, out of which it was formed.

The mass or ingot of brass, thus formed by the union of particles at a temperature which had never reached that of boiling water, and a fragment of which was presented, possessed on that side which had been in contact with the shaft, a bright polished metallic surface, like that of the original metal from which it had been formed: its other surfaces bore the impress of the cavity in which it was found. It was hard, coherent, and could be filed or polished like ordinary brass. It was, however, perfectly *brittle;* and when broken, the fracture, in place of possessing a sub-crystalline structure, and metallic lustre, like that of the normal brass or alloy, was nearly *black*, and of a fine grained *earthy* character, and *without any* trace of *metallic lustre* or appearance.

Examined with a lens, some very minute pores or cavities are found throughout its substance, which is uniformly of a very dark brown or nearly black colour, and devoid of all metallic character, except when cut or filed—that is, in mineralogical language, its colour is earthy black, and its streak metallic.

The author remarked that the observed cases of aggregation in solid particles, without the intervention either of a solvent or of fusion, are extremely rare, and as bearing upon the little understood subject of cohesive attraction, are of much interest.

The property of welding, which is possessed by all bodies, whether metallic or not, which pass through an intermediate stage of softness or pastyness previous to fusion, and is not found in any substance which readily crystallizes, and hence passes " per saltum" from the solid to the liquid state by heat, forms a " frontier instance" of cohesive forces, being enabled to act in the aggregation of bodies, by only an approach to liquidity, or by a very small degree of intermobility.

Aggregation may also take place between portions of a body merely *softened* by a solvent, which is afterwards withdrawn, as in the familiar instance of Indian Rubber, softened by naptha for the manufacture of waterproof cloths; where the former, after being moulded or united in any way required, is left in its pristine condition by the evaporation of the naptha from amongst its particles. But the cases of aggregation of solids, without such elevation of temperature, or the presence of solvents, are so rare, that but two or three have as yet been observed. Of these the most remarkable is that recorded by Pouillet, of the gradual, but complete, adhesion of surfaces of clean plate-glass, when left to repose on each other for a considerable time. It has also been stated, that clean plates of lead or of tin, if pressed together by a considerable force when cold, require a proportionably great force to separate them. The case presented to the Academy, therefore, is another added to these rare instances of molecular aggregation in solids, independent of solution or fusion: the author therefore thought it worth while to examine with a little care the properties both of the original brass, and of the mass thus curiously formed from it, or, as he thenceforth called them, of *the normal* and *the anomalous* alloy.

The normal alloy is of a bright gold colour, and sub-crystalline in structure, and of great toughness; its cohesive force is equal to 21.8 tons per square inch, which is above the average strength of any of the alloys of copper and zinc, or copper and tin, as found by my experiments on the cohesive power of these alloys, published in the Proceedings of the Academy, and elsewhere. The cohesive force of the anomalous alloy is only 1.43 tons per square inch, or only about one-fifteenth that of the former.

The specific gravity of the normal alloy is = 8.600; that of the anomalous only = 7.581.

On submitting both alloys to analysis, their constitution proved identical; it is as follows:

Copper	83.523
Tin	8.833
Zinc	7.510
Lead	0.024
Loss	0.110
	100.000

Uniting the small amount of lead with the tin, and dividing by the atomic weights, the nearest approach to atomic constitution is,

Copper	=	26.3 atoms.
Zinc	=	2.3
Tin	=	1.5

These alloys have therefore not a strictly definite constitution, but one more nearly so than is usually found in commerce.

Both alloys are equally good conductors of electricity. The author examined their relative powers of conducting heat by the method which Despretz has employed with so much accuracy, and found that of the normal to that of the anomalous alloy as 36 : 35, numbers which are so nearly equal as to render it likely the difference is only error of experiment. He also endeavoured to determine their relative specific heats, using the method of mixture, which was the only one which the small size of the metals permitted, and eliminating the errors incident to this mode by first plunging the alloy hot into cold water, and then cold into hot water. In this way, if

W and t = the weight and temperature of the water,
M and t' = the weight and temperature of the metallic alloy,
m. . . . = the mean temperature of both,
S . . . . = the specific heat of the alloy,

there are two values, one where the metal is the hotter,

$$s = \frac{w\,(m - t)}{M\,(t' - m)};$$

and another where the water is the hotter body,

$$s = \frac{w\,(t - m)}{M\,(m - t')};$$

the mean of which is the specific heat of the alloy pretty exactly. The result gave the specific heat of the normal alloy = .0879, water as unity, and that of the anomalous alloy = .0848; both of which are below the specific heat assigned by Dalton to brass.

The normal alloy is malleable, flexible, ductile, and laminable. In the anomalous alloy there is an absolute negation of all these properties.

The normal alloy readily amalgamates with mercury, at common temperatures; the anomalous alloy will not amalgamate with mercury even at 400° Fahr.

When the anomalous alloy is heated to incipient redness in a glass tube, a minute trace of water, and of a burned organic substance, probably adherent oil, are discoverable; it suffers no change, however, but a slight increase of density. The normal alloy suffers no change when so treated. The normal alloy, treated on charcoal with the blow-pipe, fuses at once into a bead. On treating the anomalous alloy so, the fragment swells rapidly to more than twice its original bulk, on becoming bright red hot; it then glows, or becomes spontaneously incandescent, in the way that hydrated oxide of chrome and some others do, and instantly contracts to less than its original bulk, and becomes a fluid bead, which, on cooling, differs in no respect from the original alloy.

The anomalous alloy, when pulverized in an agate mortar, forms a *black powder*, devoid of all appearance of a metal; its filings also are quite *black;* while those of the normal alloy, produced by the same file, possess the usual metallic lustre. These facts, in connexion with the black colour and fine earthy appearance of the fracture, bring to mind the case recorded by Sir David Brewster, of a piece of smoky quartz, the fracture of which was absolutely black, and yet was quite transparent to transmitted light, and whose blackness, he found, arose from the surfaces of fracture, consisting of a fine down of short and slender filaments of transparent and colourless quartz, the diameter of which was so small (not exceeding the one-third of the millionth part of an inch), that they were incapable of reflecting a single ray of the strongest light. In describing this, Sir David Brewster predicted, that " fractures of quartz and other minerals would yet be found which should exhibit a fine down of different colours depending on their size."

It seems, therefore, extremely probable, that the cause of the near approach to blackness in the fracture and filings of this alloy, arises from the excessive minuteness of its particles, and thus fulfils the foregoing prediction; the brownish tinge being produced by the reflexion of a little red light.*

The polish and power of reflecting light of the anomalous alloy are not quite so great as those of the normal, but are still remarkable; and, as it seemed a matter of some interest to determine whether both reflected the same quantity or intensity of light at equal angles, the author endeavoured to ascertain this point as respects heat, by means of Melloni's pile for the galvanometrical determination of temperature, assuming, as suggested to him by Professor Mac Cullagh, that what would be true of heat in this respect, would also be so of light; but from the small size of the reflecting surfaces he had at his command, he found it impossible to arrive at

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* Since this paper was read, Professor Lloyd suggested to the author, the analogy between the appearance of the powder and filings of the anomalous alloy and Platina Mohr, and those powders obtained by reduction of other metals by hydrogen. None of these, however, are coherent, which constitutes the peculiarity in the present case.

any trustworthy result. He is, however, inclined to believe, that both metals reflect most at a perpendicular incidence.

From the foregoing detail of the properties, in several respects so different, of this substance in its normal and anomalous states, the author thinks he is warranted in pronouncing it the first observed instance of an approach to dimorphism in a metallic alloy; and one, the mode of production and characteristics of which present several points of interest.

The conditions under which the alloy was aggregated, involved extremely minute division of the metal, great pressure in forcing the divided particles into contact, and nearly the exclusion of air. Considerable electrical disturbance may have also co-operated; such, together with induced magnetism, being the constant accompaniments of motion in heavy machinery. By re-establishing these conditions, under suitable arrangements, the author hopes to repeat the results thus accidentally first obtained, and so produce possibly dimorphous states of other metals or their *definite* combinations.

There is but one body which occurred to the author, presenting an analogy to this anomalous alloy, namely, indigo; whose fracture, it is well known, is fine earthy, and of the usual blue colour, but becomes coppery, or assumes the metallic lustre on being rubbed or burnished.

DONATIONS.

Uber den Galvanismus gegen ortliche Krankheiten, von Dr. Gustav Crusell.

Recueil des Acts de la Seance Publique de l'Académie Imperiale des Sciences de St.Petersbourg, tenue le 29 Decembre, 1840.

Memoires de l'Academie Imperiale des Sciences de St. Petersbourg. 6me Série. *Sciences Politiques, &c.* Tome IV. Livraison 6, and Tome V. Livraisons 1–4.

Sciences Mathematiques, &c. Tome IV. Premiere partie, Livraisons 5ere et 6eme ; Tome VI. Seconde partie, Livraisons 1–5.

Proceedings of the Committee of Commerce and Agriculture of Royal Asiatic Society, 1841.

Journal of the Royal Asiatic Society. No. 12.

Prælection on the Studies connected with the School of Engineering in Trinity College, Dublin. By the Rev. Humphrey Lloyd, D. D. Presented by the Author.

The Chronicle of William de Rishanger. By Richard O. Halliwell, Esq., Hon. M.R.I.A., &c. Presented by the Editor.

Ordnance Survey of Wexford, in eighty-six sheets. Presented by the Lord Lieutenant.

Sketch of the Loan Fund System in Ireland. By Charles Piesse, Esq. Presented by the Author.

Catalogue of the Miscellaneous Literature in the Library of the Royal Society. (1841).

Proceedings of the Royal Society, 1841. Nos. 46–50.

Supplemental Instructions for the use of Magnetical Observatories. 1841.

Phil. Transactions for 1841. Parts 1 and 2.

Edinburgh Astronomical Observations. Vol. IV: 1838.

Memoires de l'Académie Royale des Sciences de l'Institut de France. Tome XII.

Memoires présentés par divers savans a l'Academie des Sciences Mathematiques et Physiques. Tome IV.

The American Almanack for 1842.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1842. No. 33.

January 24.

REV. HUMPHREY LLOYD, D. D., Vice-President, in the Chair.

RESOLVED,—On the recommendation of Council,—That it shall be the duty of the Committee of Publication to report on Papers intended for publication in the Transactions.

RESOLVED,—On the recommendation of Council,—That the Treasurer be authorized to sell stock of the Academy to the amount of £300, for payment of the Printer's bill and other arrears.

The Rev. Charles Graves, F. T. C. D., read a paper "on the Motion of a Point upon the Surface of a Sphere."

When the motion of a material point is limited to a given plane, the circumstances of its motion are commonly investigated by means of the equations,

$$\text{X}dt^2 = d^2x, \quad \text{Y}dt^2 = d^2y,$$

x and y being rectangular coordinates in the given plane. Mr. Graves shows that, in like manner, the motion of a material point, constrained to move on the surface of a sphere, whose radius $= 1$, may be discussed by means of the similar equations,

$$\mathrm{X}dt^2 = d\left(\frac{dx}{1 + x^2 + y^2}\right) \ (1) \quad \mathrm{Y}dt^2 = d\left(\frac{dy}{1 + x^2 + y^2}\right) \qquad (2)$$

in which x and y are used to denote *the rectangular spherical coordinates* of the moving point (vid. page 127), and X, Y, the moments, in the planes of the x and y arcs of reference, of the resultant of the forces acting upon the point. The reaction of the surface being taken into account, this resultant is tangential to the sphere, and so may be conceived to act along a great circle passing through the point.

From equations (1) and (2) we derive a third,

$$(\mathrm{X}y - \mathrm{Y}x)\,dt^2 = d\left(\frac{ydx - xdy}{1 + x^2 + y^2}\right) \qquad (3)$$

which leads to important consequences.

It appears from the second formula in p. 129 that, if the equations (1) (2) and (3) be multiplied respectively by

$$\frac{2\,dx}{1 + x^2 + y^2}, \quad \frac{2\,dy}{1 + x^2 + y^2}, \quad \text{and} \quad \frac{2(ydx - xdy)}{1 + x^2 + y^2},$$

they will give for the velocity, v, of the moving point,

$$2\int \frac{\mathrm{X}[dx + y(ydx - xdy)] + \mathrm{Y}[dy + x(xdy - ydx)]}{1 + x^2 + y^2} = v^2. \qquad (4)$$

Now, if the resultant tangential force R act always along a great circle which passes through the origin, that is, if we consider the case analogous to that of a central force in the dynamics of the plane,

$$\mathrm{X} = \mathrm{R}\frac{x}{(x^2 + y^2)^{\frac{1}{2}}}, \text{ and } \mathrm{Y} = \mathrm{R}\frac{y}{(x^2 + y^2)}.$$

In this case, therefore, which for simplicity we may call that of a *central* force, equation (3) gives

$$\frac{ydx - xdy}{1 + x^2 + y^2} = hdt, \qquad (5)$$

and equation (4) is reduced to

$$2\int \frac{\mathrm{X}dx + \mathrm{Y}dy}{1 + x^2 + y^2} = v^2. \tag{6}$$

It is easy to show that these two latter equations are equivalent to the two following,

$$\sin^2\rho d\omega = hdt, \tag{7}$$

$$2\int \mathrm{R}d\rho = v^2, \tag{8}$$

in which ρ is the vector arc drawn from the origin to the moving point, and ω is the angle between it and the x arc of reference. Let us now describe the circle of the sphere which osculates the trajectory along which the point P moves, and let C be the arc of the great circle passing through P and the origin, and intercepted within the osculating circle; then it may be shown that

$$\mathrm{R} = \frac{v^2}{\tan \frac{1}{2} \mathrm{C}}. \tag{9}$$

If p denote the arc of the great circle drawn from the origin perpendicular to the arc touching the trajectory at P, we may deduce from (7) that

$$v^2 = \frac{h^2}{\sin^2 p}. \tag{10}$$

By the help of equation (9) it may be proved that "A material point may be made to describe a spherical conic if it be urged by a force, acting along the arc of a great circle drawn from the *focus* to the point, and varying inversely as the square of the sine of the vector arc ρ."

Also: "A material point may be made to describe a spherical conic by the agency of a force, acting along the arc of a great circle drawn from the *centre* to the point, and varying as $\tan\rho \sec^2\rho$."

In the dynamics of a point constrained to move on the surface of a sphere, we have, for the discussion of the inverse problem of *central* forces, the following equation,

$$\text{R} = h^2(1+u^2)\left(u+\frac{d^2u}{d\omega^2}\right),$$

in which u is the cotangent of ρ.

The analogy between the formulæ given in this paper and those usually employed in discussing the motion of a point on a plane is very striking. The former too become identical with the latter when the portion of the sphere on which the trajectory is described becomes infinitely small in comparison with the radius.

The Rev. H. Lloyd V. P. read the following paper "on a New Magnetical Instrument, for the Measurement of the Inclination, and its Changes."

In order to know all that relates to the earth's magnetic force, at a given place, observation must furnish the values of three elements. Those which naturally present themselves for immediate determination are, the *intensity* of the force itself, and the two angles (the *declination* and *inclination*) which determine its direction. We may substitute for these, however, any other system of elements which are connected with them by known relations. Thus, we have hitherto preferred to observe the *declination*, and the *two components* (horizontal and vertical) *of the intensity;* and, in general, the main considerations which should guide us in our choice are, the exactness of the observed results, and the facility of their determination.

In this point of view, the *declination* and the *horizontal component of the intensity* leave us nothing to desire, their determination being now reduced to a degree of precision, hardly (if at all) inferior to that of astronomical measurements. The same thing, however, cannot be said respecting the third element, as hitherto observed. In the Dublin Magnetical Observatory, and in the Observatories since established by order of the Government and of the East India Company upon the same plan, the third element chosen for observation has been the *vertical component of the intensity*, the instrument for the measurement of which has been already submitted to the notice of the Academy. The principle of this instrument, it will be remembered, is to balance the vertical component of the magnetic force by a fixed weight, and to observe the changes of the position of equilibrium, under the action of the changing force. Unexceptionable as this principle is in theory, the accuracy of the results has not been commensurate with that of the other two instruments. This inferiority is to be traced to the large influence which the unavoidable errors of workmanship must necessarily have on the position of equilibrium of a magnet supported on a fixed axle. It has been shown that the effect of magnetizing a bar, under the most advantageous circumstances of form, and at the part of the globe where the vertical component of the magnetic force is greatest, is the same (as to its position of equilibrium) as if its centre of gravity had been transferred about the $\frac{1}{40}$th of an inch towards the north end; so that the moment of the force, exerted by the vertical component of the earth's magnetism, can never exceed this small quantity multiplied by the weight of the bar. Now, in order to render the results of this instrument comparable to those of the horizontal-force magnetometer, it should enable us to measure changes of the vertical force, amounting to the $\frac{4}{100,000}$dth part of the whole; i. e. we have to measure effects, such as would be produced by shifting the centre of gravity through the *one-millionth of an inch*. It will be easily understood, from this statement, how great must be the effect of a minute disturbance of the relative parts of the instrument, or of inequalities in the bearing points of the axle; and experience has accordingly shown that it is altogether unavailable for the determination of changes of long period.

The same difficulties, and from the same source, have been found to attach to the usual method of observing the *magnetic inclination,* and its changes, however refined the construction of the instrument. The sources of error seem, in fact, to be inherent in every direct process of determining the third element; and it is only by an *indirect* method that we can hope to evade them.* Of this character is the method now proposed.

If a soft iron bar, perfectly devoid of magnetic polarity, be held in a vertical position, it immediately becomes a temporary magnet under the inducing action of the earth's magnetic force, the lower extremity becoming a north pole, and the upper a south pole. Accordingly, if a freely-suspended horizontal magnet, whose dimensions are small in comparison with those of the bar, be situated near, in a plane passing through one of these poles, it will be deflected from the magnetic meridian. The deflecting force is the induced force of the bar, which may be regarded as proportional to the energy of the inducing cause, i. e. to the *vertical component* of the earth's force; while the counteracting force is the *horizontal component* of the same force, acting directly on the magnet itself, to bring it back to the magnetic meridian. Thus the magnet will take up a position of equilibrium, under the action of these opposing forces; and this position will serve to determine the ratio which subsists between them. When the right line connecting the centre of the horizontal magnet, and the acting pole of the bar, is perpendicular to the magnetic meridian, the tangent of the angle of deflection will measure the ratio of the two forces, and will therefore be proportional to the *tangent of the magnetic inclination.* Accordingly, by observing the changes of

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* Two such indirect methods of determining the inclination have been proposed in Germany, one by Professors Gauss and Weber, the other by Dr. Sartorius von Walterhausen. That now suggested bears a close analogy, in principle, to the former of these: it differs from it, however, not only in the means employed, but also in the end in view,—the main object of the present method being the determination of the inclination-changes.

position of the horizontal magnet, so circumstanced, we can infer those of the inclination itself.

But the iron bar may have (and generally will have) a certain portion of *permanent* magnetism, which will concur with the induced magnetism in producing the deflection; and it becomes necessary to institute the observations in such a manner, as to be able to eliminate the effects of this extraneous cause. For this purpose we have only to invert the bar, so that the acting pole, which was uppermost in one part of the observation, shall be lowermost in the other. The induced polarity will, under these circumstances, be opposite in the two cases; and the acting force will in one case be the *sum* of the *induced* and *permanent* forces, and in the other their *difference.*

Let X and Y denote the horizontal and vertical components of the earth's magnetic force, M the intensity of the permanent magnetism in the acting pole, and m the magnetic moment of the suspended magnet. The intensity of the induced magnetism is, by hypothesis, equal to

$$k\mathrm{Y},$$

k being an unknown constant; and when this is of the same name as the permanent magnetism, the intensity of the acting force, at the unit of distance, is

$$k\mathrm{Y} + \mathrm{M}.$$

Accordingly, the moment of this force to turn the suspended magnet is $(k\mathrm{Y} + \mathrm{M})\, mr \cos u$, u being the angle of deflection, and r a constant depending on the distance; or, making, for abridgment, $kr = p$, $\mathrm{M}r = q$,

$$(p\mathrm{Y} + q)\, m \cos u.$$

But this deflecting force is resisted by the earth's horizontal force, the moment of which to turn the magnet is

$$\mathrm{X}m \sin u\,;$$

and the magnet will rest when these moments are equal. Hence the equation of equilibrium is

$$p\text{Y} + q = \text{X} \tan u. \tag{1}$$

By the same reasoning it will appear, that when the induced and permanent magnetisms are of contrary names, there is

$$p\text{Y} - q = \text{X} \tan u'; \tag{2}$$

in which u' is the new angle of deflection when the bar is inverted. And adding these equations together, and observing that $\text{Y} = \text{X} \tan \theta$, θ being the inclination, we have

$$2p \tan \theta = \tan u + \tan u'. \tag{3}$$

This equation would furnish at once the inclination sought, provided we knew the value of the constant k. In order to determine it, we have only to place the iron bar *horizontally* in the magnetic meridian, its acting pole remaining in the same place as before, but pointing alternately to the north and south. The inducing force is, in this case, the *horizontal component* of the earth's magnetic force; and it will be readily seen that the equations of equilibrium are similar to (1) and (2), substituting X for Y. If therefore v and v' denote the angles of deflection in these positions, we have

$$2p = \tan v + \tan v'; \tag{4}$$

and dividing (3) by this,

$$\tan \theta = \frac{\tan u + \tan u'}{\tan v + \tan v'}. \tag{5}$$

Thus, from the deflections produced in these four positions of the bar, we obtain the inclination.

In order to determine the *changes* of the inclination, it is not necessary to observe the deflections in the horizontal position of the bar. Let equation (1) be differentiated, X, Y, and u being all variable, and let the resulting equation be divided by (3). We thus obtain the following equation, from which p and q are both eliminated:

$$\frac{\Delta Y}{Y} = \frac{2\Delta u}{\cos^2 u(\tan u + \tan u')} + \frac{2\tan u}{\tan u + \tan u'} \cdot \frac{\Delta X}{X}.$$

But from the relation $Y = X\tan\theta$, we have

$$\frac{\Delta Y}{Y} = \frac{\Delta X}{X} + \frac{\Delta\theta}{\sin\theta\cos\theta};$$

and substituting,

$$\frac{\Delta\theta}{\sin 2\theta} = \frac{\cos u'\Delta u}{\cos u\sin(u + u')} + \frac{1}{2}\frac{\sin(u - u')}{\sin(u + u')}\frac{\Delta X}{X}. \qquad (6)$$

The second term of the right-hand member of this equation contains a correction required for the simultaneous changes of the horizontal intensity; but this correction will be generally small, and, when the bar has no permanent magnetism, will vanish altogether. In this latter case, in fact, it appears from (1) and (2) that $u' = u$; so that the preceding equation is reduced to

$$\Delta\theta = \frac{\sin 2\theta}{\sin 2u}\Delta u. \qquad (7)$$

We must remember that the angle u in the preceding formulæ, being the deviation of the suspended magnet from the position which it would assume under the action of the earth alone, its changes are the *differences* between the observed changes of position of the suspended magnet, and the *corresponding changes of declination.* Let a denote the deviation of the suspended magnet, measured from some *fixed line,* and a' the corresponding angle when the iron bar is removed; then

$$u = a - a', \quad \Delta u = \Delta a - \Delta a'.$$

But $\Delta a = kn$, $\Delta a' = k'n'$; in which n denotes the number of divisions of the scale of the instrument corresponding to the angle Δa, n' the number corresponding to the angle $\Delta a'$, as shown by the declinometer, and k and k' the arc-values of a single division in each instrument. Hence

$$\Delta u = kn - k'n'. \qquad (8)$$

I now proceed to the construction of the apparatus employed in these measurements.

The magnet is cylindrical; its length is three inches, and diameter one-fourth of an inch. A mirror is attached to the stirrup by which it is suspended, by means of which the varying position of the magnet may be observed with a telescope at a distance, after the method of Gauss. This mirror is of course vertical; and it has a motion round a vertical axis, by means of which it may be adjusted to any desired position of the observing telescope. The mirror is circular, and is three-fourths of an inch in diameter. The moveable part of the stirrup to which it is attached has the form of a cross; and it is rendered vertical by means of three screws, near the extremities of three of the arms of the cross, the heads of which project and hold it. The mirror is maintained in contact with these heads by springs at the back.

The box is octagonal; the interval between the opposite sides is four inches, and that between the top and bottom two inches. The top and bottom, and the connecting pillars, are formed of gun-metal; the eight sides are closed by moveable pieces, three of which are of glass, and the rest of ebony. To the top of the box is attached an upright tube of glass, eight inches in length, which encloses the suspension thread. The suspension apparatus at the top of the tube is of the usual construction; the circular piece to which it is attached has a movement of rotation, and its outer surface is graduated to 5°, for the purpose of determining the effect of torsion of the suspension thread.

The base of the instrument is a circle of gun-metal, six inches in diameter, graduated on the edge. The box is connected with this circle by a short conical stem, forming the axis of a second plate, which revolves upon the fixed one. This moveable plate carries two verniers, by which the angle of rotation may be read off to minutes. Two tubular arms, slightly inclined to one another, are attached to this plate; and their other extremities are connected by a cross-piece, which carries a short scale at a distance of eighteen inches from the mirror. This part of the apparatus is employed in determining the total angles of deflection.

The soft iron bar is a cylinder, twelve inches long, and three-fourths of an inch in diameter. One of its extremities is enclosed in a hollow cylinder of brass, connected with a horizontal pivot which revolves in a fixed socket. The axis of this pivot being in the line passing through the centre of the suspended magnet, and perpendicular to the magnetic meridian, it is obvious that the bar has a movement of rotation in the plane of the magnetic meridian itself. The distance of the axis of the bar from the centre of the magnet is about five inches; and it is so placed that the induced pole is in the direction of the axis of the pivot, and thus remains fixed during the movement of the bar.

The changes of position of the suspended magnet are observed at a distance by means of a fixed telescope and scale. The scale, whose divisions are reflected by the mirror, is attached above the telescope to the support near the eye-end.

Dr. Fulton made some observations on Grecian and Roman Architecture.

February 14.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Captain Stirling, 73rd Regt., Rev. Thomas Stack, F.T.C.D., Joseph Nelson, Esq., Q.C., and Rev. Robert Chatto, were elected members of the Academy.

Dr. Anster read a paper, by the Rev. J. Wills, upon Mr. Stewart's attempt to explain certain processes of the

Human Understanding, on the supposition that it acquires, by habit, an acceleration in the succession of ideas, so great as to escape the consciousness.

After having observed that Mr. Stewart's error consisted, not in his reasoning, but in having failed to observe that his facts are themselves complex results which demand a minute analysis, and having also dwelt upon some elementary errors to which he mainly attributed the entire of Mr. Stewart's theory, the author proceeded to a detailed investigation of the several examples brought forward in its support.

He first stated the case of a player on the harpsichord, whose rapidity of execution is adduced to illustrate the proposition that so many separate acts of will and attention, as it seems to involve, are so accelerated as to take place without any consciousness of their separate occurrence. On this he observed, that, to a very great extent, the separate acts assumed could have no existence, by reason of the absolute coincidence, in point of time, of the rapid and complex movement of the musician's hand; from which he inferred, that some other law must be sought for to explain the phenomena. To discover this law, the author proceeded to examine the process of the mind in the acquisition of the art by which the complex and simultaneous movements are effected. These are, he observed, first separately attended to and separately executed; but so long as this separateness continues, it is evident that the required result is not attained. Slowly, however, and by frequent repetition of the same set of ideas presented in combination, this combination itself becomes the object of perception; and from being separate ideas and movements, they become simultaneous, and assume the new form of a single complex conception, executed by a complex movement. In confirmation of this inference, he observed, that the slightest attempt to attend to any of the component parts would disconcert the best skill. He also observed, that Mr. Stewart had been in some degree misled by having generally fixed his attention on examples in which the component ideas are successive in the order of occurrence. He observed upon a considerable class of cases which are decisive against Mr. Stewart, being composed of very complex acts, of which the separate parts are never recognized, such as the class of movements called "mechanical."

The author next entered on a detailed view of Mr. Stewart's example of a person reading, and showed that the same reasoning is applicable. He noticed the complication of trains of thought, which, according to Mr. Stewart's theory, must be simultaneously proceeding; and also observed, that his theory could not stop short at any point of these; and that wherever he might attempt to stop, an explanation should be given, which ought to supersede his whole theory. He then pursued the inquiry as in the previous example, by investigating the mind's progress in learning to read, and deduced similar conclusions. These he also confirmed, by noticing the various errors which occur in reading and printing; of these he showed, that they illustrate the effect of the combinations or complex conceptions previously formed to supply even the want of many of the component parts; so that the letter is inferred from the general form of the syllable, and the syllable from that of the word, rather than the contrary process. From this example he concluded, that the mind, by repeated acts of attention, acquires a stock of syllabic and vocal associations, of which the act of reading is a combined result; that by a further extension, written sentences may become combined with a process of thought, and that every reader possesses some range of thought thus symbolized by habit; and finally, that the general inference to be drawn from this and other similar examples is, that by means of habit, groups of signs, of movements, facts, thoughts, sensations or phenomena, may acquire varied relations to each other; and that these being acquired, the combination alone becomes the object of notice. He then pursued the application of the same reasoning to some other examples, not noticed by Mr. Stewart, which he observed were better adapted for illustration; and then proceeded to notice briefly the application of the same principles to the other examples adduced by Mr. Stewart.

He then reverted to an explanation of Mr. Stewart's and of other writers, concerning the perception of the distance of visible objects; and after noticing the fallacy which it involved, he showed it to be explicable by the same general process as in the former cases.

He next observed that the numerous errors arising from the same law of habit might be made use of to illustrate or prove the same conclusions; and explained, at some length, the illusion of faces and other visual phenomena framed by the imagination.

After several observations on the comparative difficulties of Mr. Stewart's method and his own, the author noticed the distinction between the previous cases, in which there is an apparent character of combination, and others in which a difficulty must seem to arise from continuity. He then went at considerable length to apply the same reasoning to the case of the orator, as adduced by Mr. Stewart, and more fully described by Lord Brougham. He lastly adverted to Mr. Stewart's explanation of dreams, and showed that it involved some important contradictions and inconsistencies; and that, contrary to Mr. Stewart's assertion, it implies a new law of mind. He then showed that it could be explained by the same method which he had already applied to the other examples. And after some explanations of the manner in which the law of suggestion operated in dreams, he observed, in conclusion, that Mr. Stewart had set out with a notion adapted to lead him astray; which he thought to be a subject of regret, as the line of investigation which he had selected would otherwise have offered a clearer and better evidenced foundation for metaphysical science than any which had been previously adopted.

DONATIONS.

Catalogue of the Works of Art in the Possession of Sir Peter P. Rubens, at the Time of his Decease. Presented by Dawson Turner, Esq.

Ueber die Himjaritische Sprache und Schrift. Von Dr. W. Gesenius. Presented by the Author.

A Descriptive Vocabulary of the Language of the Aborigines of Western Australia. By G. Fletcher Moore, Esq. Presented by the Author.

Magnetische und Meteorologische Beobachtungen zu Prag. Vom 1 Juli 1839, bis 31 Juli 1840. By Karl Kreil. Presented by the Author.

Proceedings of the American Philosophical Society. Vol. II. No. 19.

A Record of the Case of Mary Jobson. By W. R. Clanny, M. D., &c. Presented by the Author.

February 28.

REV. HUMPHREY LLOYD, D. D., Vice-President, in the Chair.

Dr. Evory Kennedy read a paper on the peculiar System of Generation, and Habits, observed by him to prevail in certain Acephalocysts, parasitical animals inhabiting the human body, and belonging to the class of hydatid entozoa.

Having considered their animal nature, and their primary formation, as involving the question of spontaneous generation, he described generally the methods of reproduction adopted in this class of animals, and adduced the explanations and opinions offered by the best authorities on the subject, but particularly those of Bremner, Lænnec, and Owen, by which acephalocystic reproduction is referred to imperfect ovation or generation. Dr. Kennedy went on to show that the uterine hydatid or hydrometra hydatica of Wiesmantel, which should more correctly be termed the "Acephalocystis Hysterobia vel uterina," multiplies by *fissiparous generation*, and that the creatures still continue adherent to, or connected with each other by filiform bands or elongations of the strictured parts of their bodies. Dr. Kennedy exhibited several preparations and drawings in which this mode of reproduction by subdivision was perceptible in different stages of progress, and having alluded to an imperfect division, observed also to occur in infusorial animalcules, recommended that the system of reproduction which he described should be termed "fissiparo-coherent."

A paper "on the colouring Matters of the Persian Berries" was read by Dr. Kane.

These berries, the fruit of the dyer's buckthorn, *Rhamnus Tinctoria*, are imported from the Levant, and from the south of France, for the use of dyers, to whom they furnish a yellow colour of great brilliancy, though not so permanent as some others. The appearance of the berries, as found in commerce, varies considerably; some samples, and those the most valuable, being larger, fuller, and of a light greenish olive colour, whilst others are smaller, as if shrivelled, and dark brown in tint. The former Dr. Kane considers to have the appearance of being gathered before complete ripening, whilst the latter owe their altered character to being allowed to remain longer on the stem, or to having been incautiously dried.

The colouring matter in these two kinds is essentially different. The unripe berries yield but little colour to pure water, and when digested in ether give abundance of a rich golden yellow substance, to which Dr. Kane has given the name of *chrysorhamnine*. The dark coloured berries contain little of the substance soluble in ether, but give out to boiling water an olive yellow material, to which, in its pure form, Dr. Kane gives the name of *xanthorhamnine*. This substance is produced, however, only by the decomposition of the former; thus, if the unripe berries be boiled for a few minutes in water, they, when dried, yield to ether scarcely traces of *chrysorhamnine*, this principle being, by contact of air and hot water, changed into *xanthorhamnine*.

Omitting the details of methods of purification, and of analysis, the properties and composition of these bodies may be expressed as follows :

Chrysorhamnine is of a rich golden yellow colour, of a crystalline aspect, and may be obtained in brilliant stellated tufts of short silky needles. It is but very sparingly soluble in cold water, and when boiled with water the portion which dissolves does not separate on cooling, but is found to be changed into xanthorhamnine. It dissolves in alcohol, but is not obtained by its evaporation, without being much altered. In ether, however, it dissolves abundantly, and by the spontaneous evaporation of its solution is deposited in a pure form. It has no acid reaction, but dissolves in alkaline solutions, in which, however, it appears also to be mostly altered.

Dried at 212° Fahr. it consisted of

	I.	II.
Carbon	58.23	57.81
Hydrogen	4.77	4.64
Oxygen	37.00	37.55
	100.00	100.00

These numbers give the formula $C_{23}\ H_{11}\ O_{11}$, by which there should be

C_{23}	=	138	58.23
H_{11}	=	11	4.64
O_{11}	=	88	37.13
		237	100.00

On adding an alcoholic solution of chrysorhamnine to a solution of acetate of lead, a rich yellow precipitate is formed, which, when dried at 212°, was found to be expressed by the formula $C_{23}\ H_{11}\ O_{11} + 2\ PbO$, the numbers being as follow :

	Theory.		Experiment.
Carbon	138.0	29.98	29.62
Hydrogen . . .	11.0	2.39	2.19
Oxygen	88.0	19.11	19.59
Oxide of lead . .	223.4	48.52	48.60
	460.4	100.00	100.00

A little water appears to have been lost in the analysis, which, however, does not affect the formula deduced.

By the decomposition of a more basic acetate of lead, a yellow precipitate is obtained, which consisted of one equivalent of chrysorhamnine united to three equivalents of oxide of lead.

The chrysorhamnine may be easily observed in its natural state of deposition in the berry; it lines the interior of the capsule-cells, with a brilliant resinous-looking pale yellow, and semitransparent coating.

Xanthorhamnine is formed by boiling chrysorhamnine in water, in a capsule, so as to admit of free access of air. It dissolves with an olive, yellow colour, and on evaporating to dryness, remains as a dark, extractive looking mass, quite insoluble in ether, but abundantly soluble in alcohol and water. It may be procured also from the berries, without previous separation of the chrysorhamnine, by similar treatment, but it is then rendered impure by a gummy substance being mixed with it. It is very difficult to determine when this substance can be considered anhydrous. Prepared by evaporation over sulphuric acid in vacuo, it is quite dry, and may be powdered, but if heated it liquefies below 212°, and continues giving out watery vapour until the temperature is raised to 350°, beyond which the organic matter itself cannot be heated without decomposition. On cooling it reassumes its perfectly dry aspect, and may be easily powdered.

It was hence analyzed in all these stages of desiccation, with the following results. It contained:

Dried in vacuo.		Formula deduced.			
Carbon	34.74	C_{23}	=	138	34.78
Hydrogen . . .	6.93	H_{27}	=	27	6.80
Oxygen	58.33	O_{29}	=	232	58.42
	100.00			397	100.00

Dried at 212°.			Formula deduced.			
Carbon . .	49.97	51.20	C_{23}	=	138	50.92
Hydrogen .	5.18	5.28	H_{13}	=	13	4.80
Oxygen .	44.85	43.52	O_{15}	=	120	44.28
	100.00	100.00			271	100.00

Dried in an oil bath at 320°.		Formula deduced.			
Carbon	52.55	C_{23}	=	138	52.67
Hydrogen . . .	5.15	H_{12}	=	12	4.58
Oxygen	42.30	O_{14}	=	112	42.75
	100.00			262	100.00

By adding a solution of xanthorhamnine to solutions of acetate of lead, two combinations may be formed, one by neutral acetate of lead, the other by using the tribasic salt. But it is difficult to obtain either unmixed with some traces of the other, and thence the analysis of both vary a little from the true atomic constitution. Thus the tribasic salt gives

Dried at 212°.			Formula deduced.		
Carbon . .	26.58		C_{23} =	138.0	26.93
Hydrogen .	2.86		H_{15} =	15.0	2.93
Oxygen . .	25.97		O_{17} =	136.0	26.54
Oxide of lead	45.36	44.59	2. PbO =	223.4	43.60
	100.00			512.4	100.00

The tribasic salt gives

Dried at 212°.			Formula deduced.		
Carbon . .	21.89	22.07	C_{23} =	138.0	21.20
Hydrogen .	3.06	2.82	H_{1} =	18.0	2.76
Oxygen .	23.75	23.73	O_{20} =	160.0	24.57
Oxide of lead	52.30	51.38	3. PbO =	335.1	51.47
	100.00	100.00		651.1	100.00

If we consider the xanthorhamnine, as dried in the oil-bath, to be then anhydrous, the bodies analyzed become

Xanthorhamnine, dry = $C_{23} H_{12} O_{14}$.
do. dried at 212°. = $C_{23} H_{12} O_{14}$ + Aq.
do. dried in vacuo = $C_{23} H_{12} O_{14}$ + 15 Aq.

1st lead salt, $C_{23} H_{12} O_{14}$ + 2. PbO + 3 Aq.
2nd lead salt, $C_{23} H_{12} O_{14}$ + 3 PbO + 6 Aq.

The xanthorhamnine is thus formed by the addition of one equivalent of water and two of oxygen to the chrysorhamnine, as $C_{23} H_{11} O_{11} + HO + O_2 = C_{23} H_{12} O_{14}$. And if we were to consider the substance dried in the oil-bath at 320° still to retain an atom of water, it should be simply oxidated chrysorhamnine, being, when dry,

$$C_{23} H_{11} O_{11} + 2 O.$$

The Rev. H. Lloyd, V. P., read a supplement to a former communication "on a New Magnetical Instrument, for the measurement of the Inclination and its Changes."

Having, on a former occasion, explained the principle of this instrument, and given the details of its construction, it remains only that I should now describe the observations made for the purpose of testing its performance. I shall pass over for the present those which relate to the *absolute inclination*, because they have yielded results which can be regarded only as approximations to the truth, and I have not succeeded as yet in tracing the errors to their source. It is manifest, however, that an instrument may be a good *differential* instrument, while it is incapable of yielding absolute results; and there are special reasons why this should be the case with the apparatus now under consideration. Accordingly its failure in the latter respect, even though established, would furnish no ground for despairing of its success in the former.

It is obvious that the apparatus is wholly free from the sources of error already noticed, belonging to magnetical instruments moving on a fixed axle; and the only doubt of its performance must relate to the changes of induced magnetism in the iron bar. Thus it might be questioned, before trial, whether such a bar receives in all cases an amount of free magnetism proportional to the inducing force;—whether, again, the minutest changes in the latter are accompanied by corresponding changes in the former;—and whether, lastly, the changes thus produced are instantaneous, or, at least, demand no appreciable time for their development.

In the first experiments which I made, for the purpose of determining these questions, the induced magnetism of the iron bar was altered by means of a permanent magnet, placed in the same right line with the bar, and at a known distance from it. The effect produced upon the position of the suspended magnet being observed, the distance was altered by a known amount, and a new observation taken; and so on, at many different distances. Then, the law of action of the inducing magnet being known, we may calculate the changes of deflection of the suspended magnet, on the supposition that the changes of the induced force of the bar are proportional to those of the inducing action, and then compare them with the changes of deflection observed. The calculated and observed results of many series of observations, taken in this manner, were found to accord as nearly as the accuracy of the observations themselves allowed.

In making this comparison, however, it is necessary to take into account the effect of the *direct* action of the fixed magnet upon the suspended one. The axis of the former magnet being not far from the vertical passing through the centre of the latter, its action upon it and upon the iron bar follow, nearly, the same law; so that its direct effects upon the position of the suspended magnet are, very nearly, proportional to those which it produces through the medium of the induced force of the bar. On this principle the observed results may be cleared, approximately, of those parts of the changes which are foreign to the question. Still it must be admitted that such a complication of the results tends to weaken their evidence; and it was therefore desirable to obtain further proof, in a manner less exceptionable.

The object being to alter the inducing action according to a known law, and to observe the changes of the induced force, as shown by the position of the suspended magnet, it is manifest that it may be attained by simply varying the angle which the iron bar makes with the direction of the earth's magnetic force, the distance of its pole from the suspended magnet remaining unchanged. In fact, it will be seen, by pursuing the same reasoning as before, that if R denote the total force of the earth, and ψ the angle which the bar makes with its direction, the equation of equilibrium of the suspended magnet is

$$p\text{R}\cos\psi + q = \text{X}\tan u\,;$$

the line connecting the pole of the bar with the centre of the suspended magnet being, as before, perpendicular to the magnetic meridian. Hence, if the bar be devoid of permanent magnetism (or $q = 0$), and if the forces R and X remain unchanged during the experiments, we have

$$\tan u = a \cos\psi,$$

a being a constant.

In order to observe whether the deflections of the suspended magnet obeyed this law, a small divided circle was attached to the piece upon which the iron bar moved, in such a manner that the axis of the pivot passed through its centre. The circle being fixed, and the bar connected with the moveable arm carrying the vernier, we have the means of determining the angle through which it is moved. The plane of the motion coinciding with the magnetic meridian, the inclination of the bar to the vertical was altered by 5° between the successive observations of the position of the suspended magnet. The following Tables contain the results of two such series of observations. The first column of each gives the inclination of the bar to the vertical; the second, its inclination (ψ) to the direction of the magnetic force, i. e. the former angle increased by the complement of the magnetic inclination (19° 10′). The third column contains the observed readings of the scale, corresponding to the positions of the suspended magnet; the fourth, the differences between each of these readings and the reading belonging to the vertical position of the bar, converted into angular measure; the fifth, the actual deflections; the sixth, the *calculated* deflections, as deduced by the formula given above; and the seventh, the differences.

In order to derive the numbers of the fifth column from those of the fourth, it is necessary to know the deflection corresponding to the vertical position of the bar. This angle is determined by placing the bar vertically, with its acting pole above and below successively, and noting the readings of the horizontal circle, when the same division of the moveable scale, reflected by the mirror, was brought to coincide with the fixed wire of the telescope. The differences between each of these readings, and the similar reading when the bar is removed, are double the deflections corresponding to the two positions of the bar; and, when they are nearly equal, the mean of these deflections may be taken as that due to the induced force.

FIRST OBSERVATION.

Acting end of bar a south pole, reading = 14° 8′, deflection = 17° 0′
" north pole, . 82 51, " = 17 22
Bar removed, . 48 7, mean = 17 11

Inclination to vertical.	ψ.	Reading of Scale.	Angular Differences.	u Observed.	u Calculated.	Difference.
+ 14° 30′	33° 40′	2·2	− 1° 56′.2	15° 14′·8	15° 14′·5	+ 0′·3
+ 10 0	29 10	13·2	− 1 12·4	15 58·6	15 57·2	+ 1·4
+ 5 0	24 10	23·1	− 33·0	16 38·0	16 37·8	+ 0·2
0 0	19 10	31·4	0·0	17 11·0		
− 5 0	14 10	37·5	+ 24·3	17 35·3	17 36·7	− 1·4
− 10 0	9 10	42·8	+ 45·4	17 56·4	17 54·7	+ 1·7
− 13 30	5 40	45·8	+ 57·3	18 8·3	18 2·7	+ 5·6

SECOND OBSERVATION.

Acting end of bar a south pole, reading = 14° 23′, deflection = 16° 36′
" north pole, . 82 15, " = 17 20
Bar removed, . 47 35, mean = 16 58

Inclination to vertical.	ψ.	Reading of Scale.	Angular Differences.	u Observed.	u Calculated.	Difference.
+ 15° 0′	34° 10′	2·6	− 2° 1′·8	14° 56′·2	14° 57′·8	− 1′·6
+ 10 0	29 10	14·4	− 1 14·8	15 43·2	15 45·0	− 1·8
+ 5 0	24 10	24·8	− 33·4	16 24·6	16 25·2	− 0·6
0 0	19 10	33·2	0.0	16 58·0		
− 5 0	14 10	40·0	+ 27·1	17 25·1	17 23·3	+ 1·8

In the preceding observations a telescope of low power was employed, and the arc-value of a single division of the scale (which was at the distance of eighteen inches from the mirror) was 3′.98. The differences of the observed and calculated results, therefore, do not in general exceed the amount which may be fairly ascribed to errors of observation; and the accordance is sufficient to establish the fact, that the changes of the induced force of the bar are, within the observed limits, proportional to those of the inducing action. It is important to observe also that the changes of the induced force, produced artificially in these experiments, are much greater than any which are likely to arise from the variations of the vertical component of the earth's magnetic force, and therefore that the experiments may be regarded as severe tests of the performance of the instrument.

The preceding observations further showed, that the changes in the inducing force were *instantly* followed by their effects upon the suspended magnet; so that the changes of induced force required no appreciable time for their development. It remained only to ascertain, in a somewhat fuller manner, how far the bar was susceptible of minute magnetic changes, from very small variations of the acting force. For this purpose, a series of readings of the scale was taken, the inclination of the bar to the vertical being altered by half a degree between the consecutive readings. The *mean* difference of the successive readings was found to agree, very exactly, with the calculated difference; while the *partial* differences deviated from the mean by an amount not exceeding the limits of error of observation. It may be presumed therefore, that the changes of the induced force in the iron bar are continuous; and, accordingly, that the sensibility of the instrument is only limited by the optical power, which is applied to observe the changes of position of the suspended magnet.* In the experiments above described, the arc-value

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* Against this conclusion is the fact, that considerable changes in the induced force of the bar seem to be attended with some *permanent* changes of polarity; and it may be presumed that the same thing will take place, in a proportionate

of the divisions of the scale was 3′.98; with the modifications since introduced into the reading part of the apparatus, the scale divisions have nearly the same value as in the instrument for the measurement of the declination, so that the readings may be made with certainty to less than the tenth of a minute. The present value of the inclination in Dublin is about 70° 50′; and the mean deflection produced by the iron bar in its actual position being about 19°, it follows from (7) that the changes of inclination are inferred with the same degree of precision, very nearly, as the observed changes of angle.

The last test to which the instrument was subjected, was, to employ it for some time in the regular observation of inclination changes, for which it is destined; and to ascertain how far the mean results of the observations of successive weeks agreed in exhibiting the law of the diurnal variation. The instrument was accordingly observed for five successive weeks, every second hour during the day and night, and the means calculated, omitting those days in which the series was broken by changes of adjustment during experiment. The curves now laid before the Academy represent the projected results of the observations of each of these weeks, together with that of the mean of the whole. An inspection of them is sufficient to show that the curves of the separate weeks accord with one another, and with the mean, as nearly as can be expected in the results of such limited series, the discordances being only such as are due to the known irregularities in the direction of the earth's magnetic force.

A communication from the President was read, containing some remarks supplementary to the account which he had given at a former meeting, of his Researches respecting Fluctuating Functions, (see Proceedings, June 22nd, 1840).

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degree, with the minute changes induced by the variations of the earth's force. It remains for future examination to determine how far such permanent changes, if they occur, may impair the accuracy of the results.

The following general observations are extracted, on the nature and history of this branch of analysis :—

Lagrange appears to have been the first who was led (in connexion with the celebrated problem of vibrating cords) to assign, as the result of a species of interpolation, an expression for an arbitrary function, continuous or discontinuous in form, between any finite limits, by a series of sines of multiples, in which the coefficients are definite integrals. Analogous expressions, for a particular class of rational and integral functions, were derived by Daniel Bernouilli, through successive integrations, from the results of certain trigonometric summations, which he had characterized in a former memoir as being *incongruously true*. No further step of importance towards the improvement of this theory seems to have been made, till Fourier, in his researches on Heat, was led to the discovery of his well known theorem, by which any arbitrary function of any real variable is expressed, between finite or infinite limits, by a double definite integral. Poisson and Cauchy have treated the same subject since, and enriched it with new views and applications; and through the labours of these and, perhaps, of other writers, the theory of the development or transformation of arbitrary functions, through functions of determined forms, has become one of the most important and interesting departments of modern algebra.

It must, however, be owned that some obscurity seems still to hang over the subject, and that a further examination of its principles may not be useless or unnecessary. The very existence of such transformations as in this theory are sought for and obtained, appears at first sight paradoxical; it is difficult at first to conceive the possibility of expressing a perfectly arbitrary function through any series of sines or cosines; the variable being thus made the subject of known and determined operations, whereas it had offered itself originally as the subject of operations unknown and undetermined. And even after this first feeling of paradox is removed, or relieved, by the consideration that the number of the operations of known form is infinite, and that the operation of arbitrary form reappears in another part of the expression, as performed on an auxiliary variable; it still requires attentive consideration to see clearly how it is possible that none of the values of this new variable should have any influence on the final result, except those which are extremely nearly equal to the variable originally proposed. This latter difficulty has not, perhaps, been removed to the complete satisfaction of those who desire to examine the question with all the diligence its importance deserves, by any of the published works upon the subject. A conviction, doubtless, may be attained, that the results are true, but something is, perhaps, felt to be still wanting for the full rigour of mathematical demonstration. Such has, at least, been the impression left on the mind of the present writer, after an attentive study of the reasonings usually employed, respecting the transformations of arbitrary functions.

Poisson, for example, in treating this subject, sets out, most commonly, with a series of cosines of multiple arcs; and because the sum is generally indeterminate, when continued to infinity, he alters the series by multiplying each term by the corresponding power of an auxiliary quantity which he assumes to be less than unity, in order that its powers may diminish, and at last vanish; but, in order that the new series may tend indefinitely to coincide with the old one, he conceives, after effecting its summation, that the auxiliary quantity tends to become unity. The limit thus obtained is generally zero, but becomes on the contrary infinite when the arc and its multiples vanish; from which it is inferred by Poisson, that if this arc be the difference of two variables, an original and an auxiliary, and if the series be multiplied by any arbitrary function of the latter variable, and integrated with respect thereto, the effect of all the values of that variable will disappear from the result, except the effect of those which are extremely nearly equal to the variable originally proposed.

Poisson has made, with consummate skill, a great number of applications of this method; yet it appears to present, on close consideration, some difficulties of the kind above alluded to. In fact, the introduction of the system of factors, which tend to vanish before the integration, as their indices increase, but tend to unity, after the integration, for all finite values of those indices, seems somewhat to change the nature of the question, by the introduction of a foreign element. Nor is it perhaps manifest that the original series, of which the sum is indeterminate, may be replaced by the convergent series with determined sum, which results from multiplying its terms by the powers of a factor infinitely little less than unity; while it is held that to multiply by the powers of a factor infinitely little greater than unity would give an useless or even false result. Besides there is something unsatisfactory in employing an apparently arbitrary contrivance for annulling the effect of those terms of the proposed series which are situated at a great distance from the origin, but which do not themselves originally tend to vanish as they become more distant therefrom. Nor is this difficulty entirely removed, when integration by parts is had recourse to, in order to show that the effect of these distant terms is insensible in the ultimate result; because it then becomes necessary to differentiate the arbitrary function; but to treat its differential coefficient as always finite is to diminish the generality of the inquiry.

Many other processes and proofs are subject to similar or different difficulties; but there is one method of demonstration employed by Fourier, in his separate Treatise on Heat, which has, in the opinion of the present writer, received less notice than it deserves, and of which it is proper here to speak. The principle of the method here alluded to may be called the *Principle of Fluctuation*, and is the same which was enunciated under that title in the remarks prefixed to this paper. In virtue of this principle (which may thus be considered as having been indicated by Fourier, although not expressly stated by him), if any function, such as the sine or cosine of an infinite multiple of an arc, changes sign infinitely often within a finite extent of the variable on which it depends, and has for its mean value zero; and if this, which may be called a *fluctuating function,* be multiplied by any arbitrary but finite function of the same variable, and afterwards integrated between any finite limits; the integral of the product will be zero, on account of the mutual destruction or neutralization of all its elements.

It follows immediately from this principle, that if the factor by which the fluctuating function is multiplied, instead of remaining always finite, becomes infinite between the limits of integration, for one or more particular values of the variable on which it depends; it is then only necessary to attend to values in the immediate neighbourhood of these, in order to obtain the value of the integral. And in this way Fourier has given what seems to be the most satisfactory published proof, and (so to speak) the most natural explanation of the theorem called by his name; since it exhibits the actual process, one might almost say the interior mechanism, which, in the expression assigned by him, destroys the effect of all those values of the auxiliary variable which are not required for the result. So clear, indeed, is this conception, that it admits of being easily translated into geometrical constructions, which have accordingly been used by Fourier for that purpose.

There are, however, some remaining difficulties connected with this mode of demonstration, which may perhaps account for the circumstance that it seems never to be mentioned, nor alluded to, in any of the historical notices which Poisson has given on the subject of these transformations. For example, although Fourier, in the proof just referred to, of the theorem called by his name, shows clearly that in integrating the product of an arbitrary but finite function, and the sine or cosine of an infinite multiple, each successive positive portion of the integral is destroyed by the negative portion which follows it, if infinitely small quantities be neglected, yet he omits to show that the infinitely small outstanding difference of values of these positive and negative portions, corresponding to a single period of the trigonometric function introduced, is of the second order; and, therefore, a doubt may arise whether the infinite number of such infinitely small periods, contained in any finite interval, may not produce, by their accumulation, a finite result. It it also desirable to be able to state the argument in the language of limits, rather than in that of infinitesimals; and to exhibit, by appropriate definitions and notations, what was evidently foreseen by Fourier, that the result depends rather on the *fluctuating* than on the *trigonometric* character of the auxiliary function employed.

The same view of the question had occurred to the present writer, before he was aware that indications of it were to be found among the published works of Fourier; and he still conceives that the details of the demonstration to which he was thus led may be not devoid of interest and utility, as tending to give greater rigour and clearness to the proof and the conception of a widely applicable and highly remarkable theorem.

Yet, if he did not suppose that the present paper contains something more than a mere expansion or improvement of a known proof of a known result, the Author would scarcely have ventured to offer it to the Transactions* of the Royal Irish Academy. It aims not merely to give a more perfectly satisfactory demonstration of Fourier's celebrated theorem

* Sir William Hamilton's Essay on Fluctuating Functions, will be found in the Second Part of volume xix. of the Transactions of the Academy.

than any which the writer has elsewhere seen, but also to present that theorem, and many others analogous thereto, under a greatly generalized form, deduced from the principle of fluctuation. Functions more general than sines or cosines, yet having some correspondent properties, are introduced throughout; and constants, distinct from the ratio of the circumference to the diameter of a circle, present themselves in connexion therewith. And thus, if the intention of the writer have been in any degree accomplished, it will have been shown, according to the opinion expressed in the remarks prefixed to this paper, that the development of the important principle above referred to gives not only a new clearness, but also (in some respects) a new extension, to this department of science.

DONATIONS.

Memorie dell' Imperiale Regio Instituto del Regno Lombardo-Veneto. Vols. 1–5.

Memorie dell' Instituto Nazionale Italiano. Vol. 1, 4 Parts, vol. 2, 2 Parts.

Maxwell's Narrative of the Prince's Expedition. (1745). Published by the Maitland Club. Presented by John Smith, Esq., Secretary M. C.

Bibliotheca Scoto-Celtica. By John Reid, Esq. Presented by the Author.

Hints for the better Construction of Dwellings for small Farmers, &c. By W. J. Hughes, M. R. I. A. Presented by the Author.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1842. No. 34.

March 16. (Stated Meeting).

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

On the recommendation of Council, Charles Wheatstone, Esq., was elected an honorary member of the Academy.

The Secretary of Council read the following Report, which was ordered to be entered on the Minutes:

"The affairs of the Academy during the past year will require but a brief review, as the interval has not been very fertile in results. The second part of the nineteenth volume of our Transactions has not yet been published; and the Essay on the Round Towers (which is to make the twentieth volume) is still advancing slowly through the press, its progress being necessarily retarded by the great number of illustrations which are required from the nature of the work.

"The subscription which was opened last year, under the management of the Committee of Antiquities, for the purchase of the collection of the late Dean of St. Patrick's, has not hitherto answered the expectations that were formed of it. Of the sum of one thousand pounds, which the Dean's representatives agreed to accept for the collection, little more than one-half has been raised. Notwithstanding this circumstance, however, the Council are persuaded that public feeling is in favour of the project, and that a little more energy, on our part, is all that is required to ensure success. It would indeed be a disgrace to us, if, for want of proper exertions, this fine collection should be lost to the country.

"Meanwhile, the small cabinet in the possession of the Academy has been augmented by some valuable articles, from the fund of two hundred pounds set apart for that purpose. Among these are a gold *torquis*, weighing upwards of twelve ounces; and a gold *collar* of the most elegant form and workmanship, weighing four and a-half ounces. The latter beautiful specimen of ancient art was lately dug up in a bog, by a common labourer, and but for the existence of the fund above mentioned, which allowed it to be secured at once for the Academy, it would probably have been condemned to the crucible; the usual fate of such old ornaments as possess a high intrinsic value.

"As this fund, however, is but small, and in the present state of our finances cannot be expected to be permanent, while the resources of private subscription, to which we have so often had occasion to resort, must be considered as now almost exhausted, the Council have thought it advisable to try whether it might not be possible to obtain some public assistance towards carrying out an object which is admitted to be one of great public interest. They have therefore presented a memorial to the Lord Lieutenant, praying his Excellency to recommend to her Majesty's Government the addition of £100 a year to our usual grant, for the sole purpose of purchasing antiquities; this additional sum to be strictly accounted for every year. Should the proposal be favourably received by the Government, the Academy will be in a position to accomplish its designs in this department, at a very trifling expense to the public.

"In order that a greater number of the members of the Academy may be induced to take a lively interest in its affairs, by enjoying a share of its honours, the Council have thought it expedient to recommend that there should in future be an annual change in the list of Vice-Presidents, the senior Vice-President going out of office after the stated meeting in March, and they hope that every future President will consent to act upon this suggestion in the appointment of Vice-Presidents. But as it is proposed, by this arrangement, that no person should be appointed as Vice-President more than four times successively, so it is not intended to recommend that any Vice-President should be displaced, who may have been appointed less than four times successively.

"Among the deaths that have occurred in our body, during the past year, we have had to regret that of the Very Rev. Robert Burrowes, D. D., Dean of Cork, and formerly Fellow of Trinity College. Though not an original member, Dr. Burrowes was among the very first members of the Academy. He filled the office of Secretary for several years, and contributed some very elegant papers, in the department of Polite Literature, to the early volumes of our Transactions.

"Within the last few days we have had to lament the death of another distinguished member of the Academy and Council, the Rev. Cæsar Otway, the author of several well-known works illustrative of the history and antiquities of his native country, and abounding in graphic sketches of Irish scenery, and vigorous delineations of Irish character and manners.

"In the list of honorary members, we have lost an eminent Botanist, Aylmer Burke Lambert, Esq. He was the author of a magnificent work on Pines, in three volumes, the last of which, more recently published than the rest, contains some fine contributions from the Californian collections of our countryman and fellow-academician, Dr. Coulter.

"The other members deceased within the year are:

Peter Burrowes, Esq., Q. C.	Isaac D'Olier, LL. D.
J. H. Blake, Esq., Q. C.	

"And the new members elected within the year are:

William Monsell, Esq.	J. H. Jellett, Esq., F. T. C. D.
Robert Tighe, Esq.	William Andrews, Esq.
W. E. Hudson, Esq.	J. T. Banks, Esq.
G. Fitzgibbon, Esq.	Robert Bateson, Esq.
William Phibbs, Esq.	John Burrowes, Esq.
Rev. James Reid.	Rev. Samuel Butcher, F. T. C. D.
William Lee, Esq., F. T. C. D.	Fleetwood Churchill, M. D.
Robert Jones, Esq.	Alexander Clendinning, Esq.
Thomas Wilson, Esq.	Rev. Reg. Courtenay.
Beriah Botfield, Esq.	Durham Dunlop, Esq., Jun.
W. T. Mulvany, Esq.	Alexander Ferrier, Esq.
Oliver Sproule, Esq.	Wrigley Grimshaw, M. D.
James Thompson, Esq.	William Hogan, Esq.
James Patten, M. D.	W. J. Hughes, Esq.

William Roberts, Esq., F. T. C. D.
Captain A. C. Sterling.
Rev. Thomas Stack, F. T. C. D.
Joseph Nelson, Esq.
Rev. Robert Chatto."

Resolved,—That we have heard, with deep regret, of the death of our fellow Academician, the Rev. Cæsar Otway, and that, while we wish to record our sense of the value of his services to the Academy, and our opinion of his merits as an author, who, possessing in his own person many of the best traits in the Irish character, has by his lively and interesting sketches powerfully assisted in drawing public attention to the history, scenery, and antiquities of his native land; we desire also to convey to his afflicted family the assurances of our sincere sympathy in their sorrow for one whose private virtues rendered him the delight of the domestic circle, as his talents and information made him valuable as a member of our Institution.

Resolved,—That the Academy have heard, with regret, that Dr. Aquilla Smith, having found his attendance on the Council inconsistent with his professional pursuits, has tendered the resignation of his place as a member of Council; and they desire to express their sense of the valuable assistance they received from him during the time they had his cooperation in advancing their objects.

The ballot for the Annual Election having closed, the scrutineers reported that the following gentlemen were elected Officers and Council for the ensuing year:

President—Sir William Rowan Hamilton, LL.D.

Treasurer—James Pim, Jun., Esq.

Secretary to the Academy—Rev. Joseph H. Singer, D.D.

Secretary to the Council—J. Mac Cullagh, Esq. LL.D.

Secretary of Foreign Correspondence—Rev. Humphrey Lloyd, D.D.

Librarian—Rev. William H. Drummond, D.D.

Clerk and Assistant Librarian—Edward Clibborn.

Committee of Science.

Rev. Franc Sadleir, D.D., Provost of Trinity College; Rev. Humphrey Lloyd, D.D.; James Apjohn, M.D.; James Mac Cullagh, LL.D.; Rev. William Digby Sadleir, A.M.; Robert Ball, Esq.; Robert Kane, M.D.

Committee of Polite Literature.

His Grace the Archbishop of Dublin; Rev. Joseph Henderson Singer, D.D.; Samuel Litton, M.D.; Rev. William Hamilton Drummond, D.D.; Rev. Charles Richard Elrington, D.D.; Rev. Charles William Wall, D.D.; Rev. Thomas H. Porter, D.D.

Committee of Antiquities.

George Petrie, Esq.; Rev. James Henthorn Todd, D.D.; Henry J. Monck Mason, LL.D.; Samuel Ferguson, Esq.; Joseph Huband Smith, Esq.; James Pim, Jun. Esq.; Captain Larcom, R.E.

The President then appointed, under his hand and seal, the following Vice-Presidents:

His Grace the Archbishop of Dublin; the Rev. Humphrey Lloyd, D.D.; the Rev. James Henthorn Todd, D.D.; the Rev. Joseph Henderson Singer, D.D.

The auditors appointed by Council to examine the Treasurer's accounts reported as follows:

"We have examined the above accounts,* with the vouchers produced, and have found it to be correct; and we find that there is a balance in bank, amounting to £169 17*s.* 1*d.* sterling.

"(Signed,)

"THOMAS HUTTON,
"JOSEPH CARSON.

"*March* 16, 1842."

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* Entered in Treasurer's book.

"The Treasurer reports, that there is £1052 6*s*. 8*d*. in 3 per Cent. Consols, and £1609 4*s*. 9*d*., in 3½ per Cent. Stock, the latter being the Cunningham Fund.

"(Signed,)

"AQUILLA SMITH.

"*March* 16, 1842."

April 11.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Rev. Richard Butler, Robert Law, M. D., and John Toleken, M. D., F. T. C. D., were elected members of the Academy.

Mr. Ferguson read a paper by the Rev. Arthur B. Rowan, A. M., M. R. I. A., on the ancient Church of Kilmelchedor.

This church stands in a small hamlet and parish of the same name, in the barony of Corkaguiny, county of Kerry, at the foot of Brandon mountain, and near the harbour of Smerwick. At the top of the neighbouring mountain is a small ruined oratory, and a well of great reputed sanctity, which are dedicated to St. Brandon, or Brendan, the founder of the Diocesan Cathedral of Ardfert; and the neighbourhood is further remarkable for some of those small stone-roofed cells or chapelries which are supposed to belong to a very remote age, and of which one that has been described and engraved by Smith, in his History of Kerry, still remains in complete preservation. The church derives its name from St. Melchedor, who is mentioned in a catalogue of saints in the book of Ballimote; also in a MS. calendar in the Library of the Academy, where, under the date May 14, he is commemorated as "Melchedar, son of Ronan, son of the King of Ulster, of Kilmeilche[dor?], on the sea shore, at Knock-

Brennaun in the west." For this information the author acknowledges himself indebted to Mr. Owen Connellan. He then proceeds to the description of the church, of which plans and drawings are given. "The building," he says, "stands due east and west, and consists of two parts, the nave and choir, separated by a richly carved semicircular archway. The former is twenty-six feet long, by sixteen feet wide, and thirteen feet high to the springing of the stone roof. The choir is, as usual, much smaller, being but sixteen feet long, by twelve wide, and eleven feet high to the roof, which was also of stone. There are five windows, one in the eastern gable, and one at each side in the nave and choir; all of them having the round arch of the same style of architecture as the ornamented doorways. The entrance to the church is at the western end, through a richly ornamented doorway of the Anglo-Norman, or, as it is more correctly called, the Lombardic style of architecture. Making allowance for the greater size and profusion of ornament, I find in the arches of the western door and nave of Rochester Cathedral, the nearest model for the doorways of Kilmelchedor church. In Ireland, the account given by Grose, in his Antiquities, of Cormac's Chapel or Crypt at Cashel, may, *pro tanto*, be copied as a description of Kilmelchedor. Thus he tells us, 'it is a stone-roofed chapel,' with 'a nave and choir,' with 'columns supporting the grand arch leading into the choir; the columns short and thick; the portal *semicircular*, with *nail-head* and *chevron mouldings;* the windows also round.' So far the descriptions of both buildings exactly agree."

The roof of Kilmelchedor seems to have been constructed on the same principle as the roofs of the ancient and curious stone hermitages in its neighbourhood; one stone overlapping the other, with sufficient bearing to sustain the weight as the work advanced. But the chief peculiarity of this church is the elaborate ornament of the interior nave, which is of a kind to attract attention even if found in one of our most richly adorned churches, but much more so in a building in this remote situation. At the height of about four feet from the floor, the nave shows, on each side through its whole length, a series of square pannelled compartments, separated by short massive pilasters projecting from the wall. These compartments, twelve in number, are in perfect preservation, and appear to have been originally executed in polished stone. The nave windows occupy a compartment at each side, and are surmounted by plain round arches.

Within the choir, and springing directly from each side of the doorway, there are small arched apertures, the use of which the author is at a loss to conjecture. The semicircular head of the western doorway is filled with a single stone, on the inner side of which is a projecting effigy, now too much defaced to admit more than a conjecture as to what it represented. In the church-yard stands a rude gigantic cross, formed of a single stone; another, less rude, lies half prostrate, and has been built into the wall of a tomb. Ogham stones are found at several places in the neighbourhood; there is one, much effaced, in the churchyard.

Having noticed the vulgar tradition that the church "was built long ago by the Spaniards," the author offers some conjectures as to the probable date of its erection, which he concludes to have been in the eighth or ninth century, "when the Danes had intercourse with this and with other parts of Ireland;" but he supposes that it was ornamented and finished in its present style at a subsequent period.

The following notice of an ancient Boat, found near Drogheda, was read by W. I. Hughes, Esq.

During the progress of the works carried on by the Corporation of Drogheda for the improvement of the port and harbour, it was found necessary to deepen the bed of the River

Boyne below the bridge, towards the sea, which left that part of the river above the bridge, towards Oldbridge, quite dry. At this part (in the Summer of 1837), the boat, the subject of the present notice, was found by some workmen who were engaged taking gravel from the river, close by the obelisk erected to commemorate the battle fought between James the Second and William the Third, about two miles from the town of Drogheda.

Its extreme length is eighteen feet nine inches, and breadth two feet eight inches, tapering to a breadth of fourteen inches at the back, and to nine inches in the front, being flattened at either end; no oars seem to have been used in propelling it, there being no marks on the sides, or places for dowells used in modern boats to secure the oars, but at either end a groove is perceptible where oars were placed to steer or scull with. Paddles may have been used in the same manner as the Indians manage their canoes. Some of the paddles have been found, but they are of a very rough kind, having the appearance of the branch of a tree, feathered at one end, without any attempt at shape.

Along with this cott was found what I shall call an anchor; it is four feet in length, and three feet across, having two arms, to one of which a rope was attached to secure the boat.

The Royal Dublin Society have one of those ancient cotts in their possession, which differs from that now described in shape and size; the cott found at Drogheda being flattened at both ends, whilst that belonging to the Dublin Society has one end flat and the other pointed, being of the shape of a modern boat. Its length is twenty-one feet two inches, breadth one foot, and depth ten inches; being scarcely sufficient for a person to sit in. There is no keel to either of the boats.

Another was found lately in a bog, on the estate of Sir Charles Kennedy, in the county of Waterford; it is only eight feet six inches long, and two feet ten inches broad, and is round at the bottom, having a keel.

Ware, in his work on the Antiquities of Ireland, states it as his opinion, that the Phœnicians were the original colonisers of this country, and that they used boats made of osiers or wicker work, and covered with skins, in which they navigated the bays and the mouths of the rivers. The ancient Irish, he says, made use of another kind of boat in the rivers and lakes, formed out of an oak wrought hollow, which is called by the Irish *coiti*, and by the English *cott*, a vessel well known to antiquity under other names. Pliny calls boats hollowed out of a single beam, *Monoxylæ*, from a Greek word of that import, and describes them to be— lintres ex uno ligno excavatæ, i. e. boats formed out of one piece of timber wrought hollow. And in another place Pliny relates that the German pirates sailed in boats hollowed out of single trees, each of which they made so large as to contain thirty men.

April 25.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The Rev. Dr. Kennedy Bailie commenced the reading of a paper containing an Account of his Researches in certain parts of Asia Minor.

The Rev. Dr. Robinson gave an account of the casting of the great six-foot Speculum by the Earl of Rosse.

The publication of this account is deferred, for the present, by Dr. Robinson. On a future occasion he expects to lay before the Academy a statement of the performance of the telescope when it shall be turned, for the first time, to the heavens. The history of the casting of the speculum, of the performance of the telescope, and of the machinery by which it is moved, will then appear in the Proceedings.

May 9.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

William Blacker, Esq. and the Rev. James Booth were elected members of the Academy.

James Mac Cullagh, Esq. was elected Secretary of the Academy, in the room of the Rev. Dr. Singer, resigned; and Dr. Kane was elected Secretary of Council.

A paper, by the Rev. Dr. Hincks, "On the True Date of the Rosetta Stone," was read.

The date usually assigned to this monument, on the authority of Dr. Young, is the 27th March, 196 B. C., according to the proleptic Julian reckoning; the true date, as determined by Dr. Hincks, is the 27th March, 197 B. C. Taking the former date for granted, M. Letronne has drawn from it a great many inferences, which the error of a single year entirely vitiates. These inferences relate to the history of Ptolemy Epiphanes, and to the mode of computing the years of his reign and of the reigns of other Egyptian kings; as also to the various priesthoods of royal personages that are mentioned on the Ptolemaic monuments. The conclusions of M. Letronne, and those which are to be deduced from the corrected date, are exhibited by the author in parallel columns.

The President made some remarks on the day of the Vernal Equinox at the time of the Council of Nice.

It has been stated by some eminent writers on astronomy, for example by Brinkley and Biot, and seems to be generally supposed, that the vernal equinox in the year 325, A. D.

fell on the 21st of March. But Sir W. Hamilton finds that Vince's Solar Tables (or Delambre's, from which those are formed) conduct to about $2\frac{1}{4}$ hours before the Greenwich mean noon of the 20th of March, as the true date of the equinox in that year; which thus appears to have been assigned to a wrong day, by some erroneous computation or report, perhaps as long ago as the time of the phenomenon in question.

As this result is curious, Sir W. Hamilton conceives that it may not be uninteresting to confirm it by a very simple process of calculation, derived from the Gregorian Calendar. According to that calendar, 400 years contain 146097 days, being a number less by 3 than that of the days in four Julian centuries; and if the farther refinement be adopted, which some have suggested, of suppressing the intercalary day in each of the years, 4000, 8000, &c., then, in the calendar thus improved, 4000 civil years will contain 1460969 solar days. Assuming then, as a sufficiently near approximation, that such is the real length of 4000 tropical years; multiplying by 3, and dividing by 8, we find that 1500 tropical years are equivalent to 547863 days and a fraction; which fraction of a day, according to this simple arithmetic, would be equivalent to 9 hours. But 1500 Julian years contain 547875 days, that is, 12 more than the number last determined; and these 12 days are precisely the difference of new and old styles in the present century. If, then, we neglect the fraction, the new-style date of an equinox in any year of the nineteenth century ought to be the same with the old-style date of the same equinox in the corresponding year of the fourth century; and in particular the vernal equinox of 325 ought to have fallen on the 20th of March, because that of 1825 fell on the day so named: while the fraction of a day above referred to, though not entirely to be relied on, renders this result a little more exact, by throwing back the equinox from the evening to a time more near to noon.

The following communication from the Rev. Thomas Knox was read:

"River Glebe, Toomavara,
"April 27, 1842.

"An application of the Daguerreotype process to astronomical purposes occurred to me last autumn. It is well known that an inscription on a building which it would require a telescope to read, from its smallness or distance, can (if a view of that building be taken in the camera on one of Daguerre's plates) be read by a microscope, though invisible on the plate to the naked eye; also, that the internal structure of some insects can be as well studied by examining the image of the object on the plate by a microscope (that image having been formed from the oxyhydrogen microscope).

"From these known facts it is extremely probable that were an image of a double star, or of one of the nebulæ, taken on a Daguerre plate in the focus of a telescope of moderate power, but which of itself could not divide the star or resolve the nebula; that by then examining the plate by a strong microscope, the state of that star, &c. might be ascertained, as well as if it had in the *first* place been examined by a telescope of very high power.

"That the light of the fixed stars possesses chemical rays, and would therefore affect Daguerre's plates, there can be little doubt; and I feel certain in my own mind that the image thus formed would reveal to the microscope as much as a telescope of equal power could in the first instance have ascertained.

"I am aware that theorising this way is very unprofitable, but I do not possess instrumental means for trying the experiment myself, my equatorial not having any clock motion adapted to it. On the *accuracy* and *steadiness* of the *clock* movement *all* would depend; any small telescope, or perhaps even a single lens, equatorially mounted, would do the rest. The plates need not exceed in size the pencil of rays, and may be very small.

"If this succeed, we might gain great advantages by thus mapping the stars and nebulæ, and examining their state at our leisure, in our study, and being able to take advantage of what every practical astronomer knows to occur so seldom in our climate, namely, a state of the atmosphere favourable for delicate observation.

"To try it, some easily divided star, such as ζ Ursæ, might be first used, and, if the plate registered it as a *double* star, we might then proceed to other more difficult objects."

DONATIONS.

A Letter on the State of Schools of Chemistry in the United Kingdom. By Wm. Gregory, M. D., M. R. I. A., &c. &c. Presented by the Author.

A volume of Tracts relating to the Historical Society of Dublin. Presented by G. A. Kennedy, M. D., M. R. I. A. &c. &c.

Journal of the Franklin Institute. Third Series. Vol. II.

Eleventh Report of the British Association for 1841. (*Plymouth*). Presented by the Association.

Account of the Magnetical Observatory of Dublin. By the Rev. H. Lloyd, D. D., &c. Presented by the Author.

A View of the Coinage of the Heptarchy. By John Lindsay, Esq. Presented by the Author.

Mémoires de la Societe Géologique de France. Tome IV. Second Part.

Transactions of the Royal Society of Copenhagen. Vol. VI. (1841).

On the Use and Study of History. By W. Torrens M'Cullagh, LL. B. Presented by the Author.

May 23.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The Rev. Dr. Kennedy Bailie, late F. T. C. D., concluded a paper which he had commenced on the last meeting but one of the Academy, the subject of which was a general statement of his researches in certain parts of Asia Minor, relative to Inscriptions of the Græco-Roman era. The following is an outline of his communication.

He commenced with some brief notices of what has been done by scholars in this department of classical literature, and with remarking on its importance, as illustrative of the language, the history, and the institutions of the people who have bequeathed these monuments to after-ages. In this section, the labours of Chandler, Pococke, Spon, Clarke, and Professor Böeckh, were particularly commemorated.

Next followed an account of the rules by which he was guided, in forming his collection of inscriptions, during a tour which he had recently made in the countries bordering on the Mediterranean.

The third section embraced notices of the inscriptions which he copied in six of the Apocalyptic sites, namely, Ephesus, Philadelphia, Sardes, Thyatira, Pergamus, and Smyrna, and of a few others which he found in some neighbouring localities, viz. two sepulchral, from the sites of the ancient Cotyaion, and three from the Turkish town of Kîrkagatch, situated on the road from Thyatira to Pergamus.

The Ephesian monuments related chiefly to circumstances connected with the Artemisiac festivals. They were three in number; one, a psephisma, or decree of the senate and people of Ephesus; the two remaining, honorary tituli.

Of the four inscriptions found at Philadelphia, the most remarkable was a fragment of a titulus, which, in all probability, had been inscribed on the pedestal of a statue of the eunuch Eutropius, after the downfall of the power of that favourite of Arcadius.

In support of this opinion, Dr. Kennedy Bailie entered at some length into that part of the history of the period which concerns the expedition against Trigibild the Ostrogoth, under the auspices of Eutropius, which terminated in the discomfiture and death of the general whom he had selected.

This inscription was found in an extremely mutilated state; and an attempt has been made by the author of the paper to restore it, on the basis of the historical notices derivable from Claudian's two books against Eutropius.

It was metrical: the lines alternately hexameter and pentameter.

The inscriptions found at Thyatira were nine in number, of which four at least were entaphial. The others were chiefly honorary tituli, and of these, the most perfect which Dr. Kennedy Bailie found, was one which had been inscribed on the pedestal of a statue erected in memory of the skill and prowess of a distinguished Thyatirene athlete, Menander the son of Paullus, by the youths of the first Heraclean Gymnasia.

The most perfect amongst the sepulchral epigraphs was found on a soros which had been the property of a distinguished citizen of Thyatira, named Fabius Zosimus. In this are recited, at full length, the intentions of the owner, the legal sanction under which they were to be carried into effect, the names of the Proconsul and Registrar, as also the date.

It contains, moreover, some interesting notices relating to the astyography of the ancient site amongst the ruins of which it was found.

Of the Sardian monuments, the most remarkable was one which appeared to have been destined to commemorate the munificence of Tiberius, Trajan, and, most probably, of Hadrian also, to the citizens of Sardes.

This record was found by the author in a most mutilated state; but sufficient of it fortunately remained, to enable him to connect its notices with the accounts given by Tacitus, Spartianus, and Dio, of the liberality of those emperors to the distressed States of the Proconsular Asia, which had been devastated by a succession of earthquakes in the region of the Katakekaumene.

The most remarkable of the Pergamenian incriptions were those in honour of Hadrian, both after his assumption of the purple, and during the life-time of Trajan. One of these may be regarded as peculiarly valuable, the great probability being, that it still exists amongst the inedited monuments of the Græco-Roman era, and that it bears most strongly on the historical doubt originated by the above-mentioned Dio, on the subject of Hadrian's adoption.

Two other inscriptions, which were copied at Pergamos, appear evidently to belong to the period of the Lower Empire. They have, however, been allowed a place in this collection, as tending to illustrate the taste and style of the age in such matters. Both are honorary, and one entaphial.

The Smyrnæan Tituli are five in number, viz. a fragment of a decree, or treaty; a notice of the officers of the customs of the port of the ancient city; a votive epigraph, on a stele; a fragment of an inscription from the frieze of a temple; lastly, an epitaph.

On these the author of the essay dwelt at considerable length, more especially on the third, in which he pointed out a circumstance which appeared to have escaped the notice of former writers: amongst these, of Mr. Arundell, whose work on the Apocalyptic Churches appeared in 1828. This remark concerned the metre, and led to a conversation with a gentleman present, who expressed an interest in Mr. Arundell's discoveries, and a wish to be informed on the subject of the accuracy of that traveller's statements.

Dr. Kennedy Bailie's reply was: that his sole concern, at present, was the literature of inscriptions; that therefore he felt not at liberty to venture any observation on either the style or the accuracy of the reverend gentleman's volumes, excepting so far as related to that subject; and that he was bound in candour to confess, that the form in which his collection of inscriptions has been offered to the public is not one on which any reader could rely as a scholar-like representation of the original monuments.

The inscriptions of the Turkish town of Kîrgagatch and Cotyaion, next occupied the author's attention. The first of these, three in number, comprised an honorary titulus, in favour of Hadrian, inscribed on a block of marble, which was most probably brought from Stratonicea. Secondly, a decree of the senate and people of that city in honour of Diodorus Philometor, son of Nicander, in consideration of his public services. Thirdly, a dedication of a church, in the age of the Lower Empire, or what appears to have been such, for the characters had been very much effaced.

Of these the author read a detailed account, and stated his reasons for supposing that the more ancient tituli had been brought from Stratonicea in Caria, thus establishing some connexion between that site and the Turkish town. This is the more remarkable, inasmuch as there exist no architectural remains in Kîrkagatch to lead to the supposition that it occupied any known ancient site.

Two inscriptions from Kûtaïah (Cotyaion) concluded the series, both of which were copied from grave-stones in the Armenian cemetery. They were sepulchral tituli, and the stones themselves, on which they were engraved, most probably fragments of Sarkophagi.

The Secretary read a letter from Dr. Hunter, presenting to the Academy three mathematical works, by the Nuwab Shums-ool-oomrah of Hyderabad.

"*Dublin, Royal Barracks,*
"*May* 23, 1842.

"SIR,

"I beg to present to the Library of the Royal Irish Academy the three accompanying works on scientific subjects, printed in the Persian language and character, and the composition of a native prince.

"They were brought home by me three years ago, on my return from India, where I was serving with my regiment, and were given me by the Prince for the purpose of being presented to some scientific Institution.

"They are the composition of Nuwab Shums-ool-oomrah of Hyderabad, in the Nizam's Country; a prince who has distinguished himself much by his scientific acquirements, his original genius, and general love of literature. He has great curiosity about every European invention, and his house is set round with every sort of mechanical contrivance. These works were printed by himself in his lithographic printing press. The large work is on geometry and trigonometry; the two smaller are on spherical trigonometry and logarithms.

"I remain, Sir, &c.

"THOMAS HUNTER, M.D.,
"Assistant-Surgeon, 12th Royal Lancers.

"*To the Secretary of the*
"*Royal Irish Academy.*"

DONATIONS.

Three Lithographed Manuscripts in Persian, on Geometry, Trigonometry, and Logarithms. By the Prince Shums-ool-oomrah, of Hyderabad. Presented by Thomas Hunter, M. D., &c.

Ordnance Survey of Kilkenny, in 49 *Sheets.* Presented by His Excellency the Lord Lieutenant.

Statistical Returns of the Dublin Metropolitan Police for 1841. Presented by the Commissioners.

Nouveau Catalogue des principales Apparitions d'Etoiles Filantes. Par M. Quetelet. Presented by the Author.

Annuaire de l'Academie Royale de Bruxelles (1842).

Bulletins de l'Academie Royale de Bruxelles (1841).

The Manuscript Rarities of the University of Cambridge. By James Orchard Halliwell, Esq. Presented by the Author.

Notes on the United States of North America in 1838–9–40. By George Combe, Esq., Hon. M. R. I. A. Presented by the Author.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1842. No. 35.

June 13.

REV. HUMPHREY LLOYD, D.D., Vice-President, in the Chair.

Maria Edgeworth was elected (by acclamation) an Honorary Member of the Academy.

Arthur B. Cane, Esq., B. J. Chapman, Esq., Francis M. Jennings, Esq., and Sir Thomas Staples, Bart., were elected Ordinary Members.

Mr. J. Huband Smith read a paper descriptive of the recent discovery of a vast number of Cinerary Urns at the Hill of Rath, within a few miles of Drogheda, on the road to Collon.

At the foot of the hill a quarry had been opened to procure stones for the repair of the road. In the beginning of spring the tenant in the occupation of the farm proceeded to level this quarry, by carrying down the earth from the brow of the hill; and in the progress of his work he discovered from 150 to 200 urns of unbaked clay, of various sizes, almost all placed in an inverted position, and covering, each of them, a considerable quantity of human bones.

As it seemed probable that a more careful examination of the portion of this interesting rath or tumulus which yet remained undisturbed might be productive of some discovery calculated to throw light upon the still unsettled question of the date of this mode of interment, as well as "the authors of these sepulchral memorials," Mr. Smith was induced to undertake it, and accordingly proceeded to the spot for that purpose on the 30th of November last.

The rath appears to have occupied the declivity of a hill, sloping gently to the west, and was originally enclosed by a breastwork of earth, of inconsiderable elevation, all trace of which had nearly disappeared, but which, according to report, may have once enclosed a space of five or six acres. The soil upon the surface having been found to consist of rich clay, had been from time to time spread over the poorer land adjoining. It was not, however, till the process of levelling was begun that urns were discovered; they were then found at a depth of from four to five feet beneath the original surface, resting upon the till, or gravelly subsoil.

Mr. Smith proceeded to a part of the hill pointed out to him as not having been yet disturbed, and, with the assistance of a few labourers, very soon had the satisfaction of laying bare four or five, or more urns. They were placed apparently without any regularity, about two or three feet asunder, and having been imbedded in yellow clay, without any flags or other stones to protect them, had in most cases been pressed in, and broken to pieces, by the superincumbent earth. One, however, which remained whole, Mr. Smith, by the utmost care in freeing it from the moist clay which surrounded it, and by allowing it to dry for two or three hours before he ventured to move it, was enabled to carry away entire, and he now presented it, with its contents, to the Academy.

These urns varied in size, and were in general from about eight to fifteen inches in height. Closely adjoining one of the larger ones, in fact crushed against it, lay two smaller, measuring probably but two or three inches each in diameter; these latter ones did not appear to have held bones. In another instance a group of three or more urns, of a larger size, appeared pressed together. On removing the broken pieces of each urn the bones appeared in a little conical heap within, in very small fragments, the larger ones having fallen to the sides, mixed at bottom with black unctuous earth, and occasionally small morsels of charred wood. In the very large and fine urn which had been found previous to Mr. Smith's visit to the tumulus, and which he now presented to the Academy in the name of Mr. Kelly of Drogheda, by whom it had been disinterred, some very interesting matters had been found mixed up with a very considerable quantity of human remains which it contained. These consisted of a flint arrow head, a curious curved needle of bone, one end of which was flattened and perforated, and some small stone tools, one of which seemed likely to have been used in making the indentations or rudely sculptured patterns by which this urn, in common with all the others, was ornamented; and lastly, a small, thin scale of copper, pierced with a small hole. No other metallic remains of any kind were discovered, nor upon the closest inquiry does there seem any ground for supposing that any ornaments, either of silver or gold, such as have been so frequently obtained in barrows and other sepulchral tumuli, both here and in England, were found in this rath. This last mentioned urn, which was the largest discovered here, measures seventeen inches in height, and the same in extreme breadth; and would probably contain about eight gallons of liquid.

The most remarkable differences between this tumulus and most other repositories of the ashes of our pagan predecessors, both in this country and in England, appear to be the vast number of urns which were found here, in one vast cemetery, and the total absence of any kist of flags, or other cavity formed to receive and protect the urns from the pressure of the earth either laterally or from above.

A paper entitled, "An Inquiry as to the Coefficient of Labouring Force in Overshot Water-Wheels, whose diameter is equal to, or exceeds the total descent due to the fall; and of Water-Wheels moving in Circular Channels," was read by Robert Mallet, Esq., Mem. Ins. C. E., M. R. I. A.

This paper is partly mathematical and partly experimental. The investigation which it describes, the results of which are given in ten tables, had in view principally to obtain definite experimental answers to the following questions:

1st. With a given height of fall and head of water, or in other words, with a given descent and depth of water in the pentrough, will any diameter of wheel *greater* than that equal to the fall give an increase of labouring force (i. e. a better effect than the latter), or will a loss of labouring force result from such increase of diameter?

2nd. When the head of water is necessarily variable, under what conditions will an advantage be obtained by the use of the larger wheel, and what will be the maximum advantage?

3rd. Is any increase of labouring force obtained by causing the loaded arc of an overshot wheel to revolve in a closely fitting circular race or conduit, and if so, what is the amount of advantage, and what the conditions of maximum effect?

The author briefly reviews the history of our knowledge of this branch of hydrodynamics, the experimental researches of Da Borda, Smeaton, &c., and the more recent improvements in the theory of water-wheels, due to the analytic investigations of German and French engineers, and the admirably conducted experiments of Poncelet, Morin, and the Franklin Institute.

Smeaton, in his paper on water-wheels, read to the Royal Society in May, 1759, and Dr. Robison of Edinburgh, in his treatise on water-power, lay down as a fixed principle, that no advantage can be obtained by making the diameter of an overshot wheel greater than that of the total descent, minus so much as is necessary to give the water a proper velocity on reaching the wheel. The author, however, contends that the reasoning by which the latter writer upholds this is inconclusive,—that there are some circumstances which he points out necessarily in favour of the larger wheel, and that conditions may occur in practice in which it is desirable to use the larger wheel, even at some sacrifice of power; and that hence it is of importance to ascertain its value in use, as compared with Smeaton's size for maximum effect.

The author states the general proposition, "that the labouring force (*travail* of French authors, or mechanical power of Smeaton) of any machine, transferring the motive power of water, is equal to that of the whole moving power employed, minus one-half of the *vis viva* lost by the water on entering the machine, and minus one-half of the *vis viva* due to the velocity of the water on quitting it." He then obtains general equations expressing the relations between the fall, the velocity, the weight of fluid, the power, &c. in overshot water-wheels, at whatever point the water may first reach the wheel, and whether the latter move naked, or in a circular channel or course. From these he deduces, that—

1st. If the portion of the total descent passed through by the water, before reaching the wheel, be given, the velocity of the circumference should be one-half that due to this height.

2nd. If the velocity of the circumference be given, the water must descend through such a fraction of the whole fall, before reaching the wheel, as will generate this velocity.

3rd. The maximum of labouring force is greater as the velocity of the wheel is less, and its limit theoretically approaches that due to the whole fall; general equations are then given, expressing the amount of labouring force in all the conditions considered by the author, and their maxima.

One of the principal advantages of using an overshot wheel *greater* in diameter than the height of the fall, is the capability thus given of making any additional head of water occurring at intervals, by freshes or any other cause, available, by letting the water on the wheel at higher and higher levels.

The first course of experiments is devoted to the determination of the comparative value of two water-wheels, the one whose diameter is equal to the whole fall; the other to the head and fall, or to the total descent. By the head, the author always means the *efficient head,* or that due to the *actual velocity* of efflux at the sluice or shuttle, as determined by Smeaton's experimental method,—this was equal to six inches in all cases.

The apparatus employed in these researches consisted of two accurately made models of these wheels, with curved buckets, made of tin plate, the arms, &c. of brass, and the axes of cast iron, working on brass. Special contrivances were adopted to measure the weight of water passed through each wheel in each experiment, which was in every case 1000 lbs. avoirdupoise; and others, to preserve the head of water quite constant,—to determine the number of revolutions made per minute, and thence the speed of the wheels. One wheel was 25.5 inches diameter, the other 33 inches diameter. The value of the labouring force was determined directly by the elevation of known weights to a recorded height by a silken cord over a pulley; the altitude was read off, on a fixed rule placed vertically against a lofty chimney. The relative power of the wheels was determined by the speed of rotation of a regulating fly or vane.

All the principal results given in the ten tables are the average of *five good experiments.* From the accurate workmanship and large size of these models, the peculiar contrivances for ensuring accuracy of observation, and the care taken in the experiments, the author reposes considerable confidence in his results as practical data.

The velocity, in reference to maximum effect, is determined, and found to be lower than that deduced by Smeaton from his experiments, which the author presumes arises from the better construction of apparatus, and better form of bucket used in the present case.

The author then ascertains, by another train of experiments on both wheels, the value of the circular conduit or race, and finds, in round numbers, that there is an economy of labouring force, amounting to from eight to eleven per cent. of the power of the fall, obtained by its use. This conduit acts by retaining the water in the buckets at the lower portion of the loaded arc. The velocity of a water-wheel working thus, he finds may vary through a greater range without a material loss of power than when working naked, and that a steady motion is also continued to a much lower velocity.

The author arrives at the following practical conclusions:

1st. When the depth of water in the reservoir is invariable, the diameter of the water-wheel should never be greater than the entire height of the fall, less so much of it as may be requisite to give the water a proper velocity on entering the buckets.

2nd. When the depth of water in the reservoir varies considerably and unavoidably in depth, an advantage *may* be obtained by applying a larger wheel dependent upon *the extent of fluctuation* and *the ratio in time* that the water is at its highest and lowest levels during a given prolonged period; if this be a ratio of equality in time there will be no advantage, and hence in practice the cases will be rare where any advantage will be obtained.

3rd. If the level of the water in the reservoir never fall below the mean depth of the reservoir, when at the highest and lowest, and the average depth be between an eighth and a tenth of the height of the fall, then the *average labouring force* of the large wheel will be greater than that of the small one, and it will of course increase this advantage at periods of increased depth of reservoir.

Hence the author affirms that Dr. Robison's conclusions must henceforth receive a limitation.

Having shown that a positive advantage is obtained by the use of the circular conduit, amounting to about eleven per cent. of the total power, and that this value increases with an increase in the velocity of the wheel up to six feet per second, or more in large wheels, the author contends, that it is practicable to increase the efficiency of the best overshot wheels as now usually made, at least ten per cent. by this application. The only objections ever urged against the conduit were of a merely practical character, and the author shows that improved workmanship, and the modern use of cast iron, of which the conduit may be constructed, and provided with adjustments, render these no longer tenable.

Drawings of the apparatus used in these researches, and the tabulated results, were exhibited to the Academy.

Professor Lloyd read a paper "on the Phenomena of Thin Plates in Polarized Light."

The author stated, that his attention had been drawn to this subject by a letter which he had received from Sir David Brewster, describing a large class of hitherto unobserved phenomena. Sir David Brewster having expressed his desire, in this letter, to know whether the wave-theory could furnish an explanation of the facts which he had observed, Professor Lloyd was thus led to undertake the investigation which formed the subject of the present communication.*

Mr. Airy had long since inferred, from a consideration of the form of Fresnel's expression for the intensity of reflected light, that when light, polarized perpendicularly to the plane

* The present paper was read in the Mathematical Section of the British Association, last year; and a summary of the results was published in the *Athenæum*, of August, 1841. The author deferred submitting it to the Academy, in the hope of being able to add an experimental confirmation of some of the conclusions not noticed by Sir D. Brewster. He has, however, been compelled, by the pressure of other duties, to postpone still further this branch of the investigation.

of incidence, was incident upon a thin plate bounded by media of unequal refractive powers, a remarkable change in the reflected light should take place, when the angle of incidence was intermediate to the polarizing angles of the two surfaces of the plate. This theoretical anticipation was fully verified by experiment. When a lens of low refracting power was laid upon a plate of high refracting power, the rings which were formed appeared with a *black centre*, when the angle of incidence was less than the polarizing angle of the low refracting substance, or greater than the polarizing angle of the high refracting substance; while, when the incidence was intermediate to these two angles, the rings were *white-centred*, and the whole system was *complementary* to what it had been before. At the polarizing angle itself the rings disappeared, there being no light reflected from one of the surfaces of the plate, and therefore no interference.

The examination of this subject has since been resumed by Sir David Brewster; and he has repeated the experiments of Mr. Airy in a more general form, the incident light being *polarized in any plane*. He has thus been led to many new results. The rings are found to *disappear* under circumstances in which light is reflected from *both* surfaces of the plate; and there are many remarkable peculiarities in the transition of the rings into the complementary system.*

It was to the theoretical explanation of these phenomena that Professor Lloyd now invited the attention of the Academy. In the conduct of the investigation he has generalized the methods followed by M. Poisson and Mr. Airy on the same subject. The incident vibration being resolved into two, one in the plane of incidence, and the other in the perpendicular plane, each portion will give rise to an infinite series of reflected vibrations, into which it is subdivided at the bounding surfaces of the plate. The expression of the resultant intensity, for each portion, being then deduced, the

* The researches of Sir David Brewster are now published in the Philosophical Transactions for 1841.

actual intensity of the reflected beam is the sum of these intensities. Its value is found to be expressed by the formula

$$\text{I} = \cos^2\gamma \frac{u^2+2uu'\cos a+u'^2}{1+2uu'\cos a+u^2u'^2} + \sin^2\gamma \frac{w^2+2ww'\cos a+w'^2}{1+2ww'\cos a+w^2w'^2},$$

in which u and u' denote the ratios of the reflected to the incident vibration at the two surfaces of the plate, when the light is polarized in the plane of incidence; w and w' the corresponding quantities for light polarized in the perpendicular plane; and a the difference of phase of the successive portions of the reflected beam. The values of u, u', w', w, are,

$$u=\frac{\sin(\theta-\theta')}{\sin(\theta+\theta')},\ u'=\frac{\sin(\theta'-\theta'')}{\sin(\theta'+\theta'')},\ w=\frac{\tan(\theta-\theta')}{\tan(\theta+\theta')},\ w'=\frac{\tan(\theta'-\theta'')}{\tan(\theta'+\theta'')}$$

where θ denotes the angle of incidence on the first surface of the plate; θ' the corresponding angle of refraction, or the angle of incidence on the second surface; and θ'' the angle of refraction at the second. The value of a is

$$a=\frac{4\pi}{\lambda}\text{T}\cos\theta';$$

T being the thickness of the plate, and λ the length of the wave.

When the obliquity of the incident pencil is not very great, the squares and higher powers of u, u', w, w', may be neglected in comparison with unity, and the expression of the intensity has the approximate value,

$$\text{I}=\cos^2\gamma(u^2+2uu'\cos a+u'^2)+\sin^2\gamma(w^2+2ww'\cos a+w'^2)$$

This quantity will be independent of the phase a, and therefore the intensity will be *constant*, and the rings *disappear*, when

$$uu'\cos^2\gamma + ww'\sin^2\gamma = 0;$$

that is, when the azimuth of the plane of polarization has the value given by the formula,

$$\tan^2\gamma = -\frac{uu'}{ww'} = -\frac{\cos(\theta-\theta')\cos(\theta'-\theta'')}{\cos(\theta+\theta')\cos(\theta'+\theta')}.$$

In this formula $\cos(\theta-\theta')$ and $\cos(\theta'-\theta'')$ are always positive;

and accordingly the resulting value of $\tan\gamma$ will be real, and therefore the disappearance of the rings possible, only when $\cos(\theta+\theta')$ and $\cos(\theta'+\theta'')$ are of opposite signs; i. e. when the angles of incidence on the two surfaces are, in the one case greater, and in the other less, than the polarizing angle. The media at the two sides of the plate, therefore, must have different refractive powers.

Again, the *phases* of the two portions of the reflected beam, and which are polarized respectively in the plane of incidence and in the perpendicular plane, are given by the formulas,

$$\tan a' = \frac{u'(1-u^2)\sin a}{u(1+u'^2)+u'(1+u^2)\cos a},$$

$$\tan a'' = \frac{w'(1-w^2)\sin a}{w(1+w'^2)+w'(1+w^2)\cos a}.$$

The phases, a' and a'', are consequently in general different, and therefore the resulting light will be, in general, *elliptically polarized.* The author entered into some developments connected with this part of the subject, which does not appear to have been noticed by Sir D. Brewster in the course of his experimental inquiries; and he concluded by stating the important bearings which it may possibly have upon the phenomena of elliptical polarization by metals.

Professor Lloyd having, in the preceding communication, thrown out the idea that the elliptical polarization of metals might possibly be identified with that which is produced by a thin film on the surface of a reflecting body, Professor Mac Cullagh took occasion to observe that an analogous, but far more general, hypothesis had occurred to himself some years ago, among the various conjectures by which he had sought to account for the remarkable difference between the action of metals and that of transparent media in reflecting light. In his theory of crystalline reflexion he had found it allowable to suppose that the change in the elasticity of the ether, in passing out of one medium into the other, takes place *abruptly* at their common surface; and he had thought it not unlikely that the supposition of a *gradual* change of elasticity, taking place within a *very small* space at one or both sides of the surface of a metal, might afford an explanation of the peculiar phenomena of metallic reflexion. Such a supposition would be mathematically equivalent to the hypothesis that an immense number of films, of which the refractive powers vary between given limits according to some law, compose a very thin stratum at the surface of a polished metal; and it would be in accordance with the inference drawn by Professor Mac Cullagh from certain formulas (Transactions R.I.A., vol. xviii. p. 70) that the law of equivalent vibrations is not observed in metals; an inference which, indeed, originally suggested to him the hypothesis in question. He had not yet compared the hypothesis with his formulas, but it was easy to see that it would explain the non-existence of an angle of complete polarization for metals, as well as the general fact of elliptical polarization; and perhaps the metallic brilliancy, difference of colour, &c. might be occasioned by the great number of reflexions in the variable stratum at the surface, and the endless variety of interferences produced by them.

The above was only one of the conjectures which had been formerly made by Professor Mac Cullagh in relation to this subject, and it was mentioned on this occasion chiefly on account of its analogy with the view taken by Professor Lloyd. Another and very different hypothesis, which was the first that had occurred to him, as being immediately suggested by the imaginary form which he had assumed for the velocity of propagation in a metal, will be found stated in the *Comptes Rendus* of the French Academy, tom. viii., p. 962, in a letter to M. Arago, dated May 11, 1839. It consisted in supposing the amplitude of the vibration within the metal to be proportional to a certain exponential of which the value is there given, accompanied with the remark that this expression for the vibration, if introduced into the differential equations (at that time unknown) which subsist at the confines of two media, would probably explain the peculiar phenomena of metallic reflexion, such as change of phase, &c. Very soon after that date the equations were discovered which hold good at the common surface of two *transparent* media (see Proceedings R. I. A. vol. i., p. 378); and it is certainly not a little singular that these equations, with the help of the aforesaid expression for the vibration, not only explain the change of phase, but lead to the precise formulas which had been previously given for the case of metallic reflexion (Transactions R. I. A. vol. xviii. p. 71). The application of the equations, however, to this case, cannot be regarded as legitimate without further proof; and the hypothesis is attended by another difficulty, the nature of which may be seen in the letter alluded to.

On the whole, Professor Mac Cullagh did not consider himself warranted, as yet, in choosing between his two hypotheses, nor even in concluding that one or other of them must be the right one. Before constructing any refined theory, he thought it necessary that the formulas to which he had referred, and which, if they are correct, must be the foundation of the theory, should be tested by experiments more accurate than any that had yet been made, and this was a task to which he hoped he should soon have leisure to devote himself.

Professor Lloyd explained, that the hypothesis which he had suggested had not been offered by him as an exact physical representation of the optical constitution of metals; but rather as one which lent itself, with tolerable facility, to mathematical expression, and the results of which might possibly, by a suitable determination of the constants of the formulas, be found to coincide with the phenomena, and therefore with the results of a more rigid theory.

Resolved,—That, in future, when the office of Secretary of the Academy is vacant, the vacancy shall be filled up by express election.

June 27.

REV. J. H. TODD, D. D., Vice-President, in the Chair.

H. J. Monck Mason, Esq., LL.D., read an account of a visit which he had paid to the Tomb of the Volumnii at Perugia.

Mr. Mason then presented a gold fibula found in Ireland, as a contribution to the Museum of Antiquities, now in process of formation by the Academy.

The thanks of the Academy were voted to Mr. Mason for the donation.

A paper was read by Dr. Macartney "on the minute Structure of the Brain in the Chimpanzee and the human Idiot, compared with that of the perfect Brain of Man, with some reflections on the Cerebral Functions."

The author commenced by stating, that he had discovered the brain of all animals to be composed of a plexiform arrangement of white (or, as he termed them, *sentient*) filaments, the most delicate of which he found to pervade all the coloured substances of the brain. He attributed the higher sensorial powers of the cerebral organ to the disposition and intercommunication of these filaments, more especially where they exist in the coloured substances. The mode he employs for rendering the finer filaments evident is to moisten the different substances during the dissection with a solution of alum in water, which, causing a slight coagulation, makes the filaments opaque and visible. The author accounted for the fact that the existence of the most delicate plexuses had hitherto escaped observation, from the circumstance that other anatomists had not used any fluid to coagulate them. He considers the shape and magnitude of the different parts of the brain as merely subservient to the proper arrangement and number of the plexuses of the sentient substance.

The principal object of the paper was to point out the first gradations from the perfect structure of the brain in man, and for this purpose the author related the dissection of the brain of the chimpanzee (*simia troglodytes*, Lin.) and of two human idiots, from which he was led to conclude that the primary deviations in the anatomy of the brain were to be found in the *essential structure* of the *locus niger*, of the *corpus fimbriatum*, and of the *corpora olivaria*,—in *the existence* of the *white striæ* in the fourth ventricle, of the *corpora candicantia*, and of calcareous granules in the *pineal gland*,—in the degree of intermixture of the *white filaments* of the *arbor vitæ*, the distinction of the *anterior crura* of the *fornix*, and lastly the *decussations* of the *pyramids*. By the dissections it was evident that the brain of the chimpanzee possessed a superior structure to that of the natural human idiot.

As the author had previously ascertained that all the plexuses in the brain are conjoined, and all the cerebral and spinal nerves are incorporated with the parts from which they are said to arise, he was led to infer that the functions of the brain are not confined to particular parts of the surface, but that all the parts exercise a mutual influence on each other, that its powers and operation are systematic and harmonious, instead of the effect of different parts of the brain acting independently and often in opposition to each other. He stated a number of facts contradicting the opinion of the cerebellum being designed to produce the sexual instinct, as taught by Gall and his followers. He ascribed the origin of all instincts to the organs to the operations of which the instincts are subservient. He argued that if instinctive impulses were to originate in the brain, they would interfere with all its higher functions. The author further considered the perfect continuity and incorporation of the nerves with central parts of the system, as sufficient to account for the functions of sensation and voluntary motion, without the interposition of nervous fluid.

Dr. Macartney exhibited a drawing of the base of the brain of an idiot, in which there was a singular deficiency of the cerebellum; and also a cast of the brain of the chimpanzee, and one of the human brain. These two, making allowance for the size, almost perfectly agreed with regard to external appearances.

J. Huband Smith, Esq., by command of His Excellency the Lord Lieutenant, presented to the Academy an ancient gold semilunar ornament of considerable value, found in the county of Roscommon.

The thanks of the Academy were voted to His Excellency for this donation.

A considerable number of ancient bronze articles, consisting of portions of chain armour, a spear head, a lance blade, with some coins, found near Headfort, County Galway, were presented to the Museum on the part of Richard J. Mansergh St. George, Esq.

Mr. St. George received the thanks of the Academy.

The collection of Antiquities of the late Dean of St. Patrick's was presented to the Academy in the name of the Subscribers.

Resolved,—That the List of Subscribers be printed as an Appendix to the Proceedings.*

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* See Appendix, No. I.

August 4.

REV. C. W. WALL, D. D., in the Chair.

The President made a communication respecting a method which had been lately proposed by Professor Badano of Genoa, for the solution of algebraical equations of the fifth and higher degrees.*

Lagrange has shown that the function

$$t^5 = (x' + \omega x'' + \omega^2 x''' + \omega^3 x^{IV} + \omega^4 x^V)^5$$

receives only twenty-four different values, for all possible changes of arrangement of the five quantities, $x', \ldots x^V$, if ω be an imaginary root of unity, so that

$$\omega^4 + \omega^3 + \omega^2 + \omega + 1 = 0.$$

Professor Badano has proposed to express these twenty-four values by certain combinations of quadratic and cubic radicals, suggested by the theory of biquadratic equations, and having the following for their type:

$$\begin{aligned} t^5 = {} & \mathrm{H}_1 + \sqrt{\mathrm{H}_2} + \sqrt[3]{\mathrm{H}_3 + \sqrt{\mathrm{H}_4}} + \sqrt[3]{\mathrm{H}_5 - \sqrt{\mathrm{H}_6}} \\ & + \sqrt{\left\{\mathrm{H}_7 + \sqrt{\mathrm{H}_8} + \sqrt[3]{\mathrm{H}_9 + \sqrt{\mathrm{H}_{10}}} + \sqrt[3]{\mathrm{H}_{11} - \sqrt{\mathrm{H}_{12}}}\right\}} \\ & + \sqrt{\left\{\mathrm{H}_{13} + \sqrt{\mathrm{H}_{14}} + \theta\sqrt[3]{\mathrm{H}_{15} + \sqrt{\mathrm{H}_{16}}} + \theta^2\sqrt[3]{\mathrm{H}_{17} - \sqrt{\mathrm{H}_{18}}}\right\}} \\ & + \sqrt{\left\{\mathrm{H}_{19} + \sqrt{\mathrm{H}_{20}} + \theta^2\sqrt[3]{\mathrm{H}_{21} + \sqrt{\mathrm{H}_{22}}} + \theta\sqrt[3]{\mathrm{H}_{23} - \sqrt{\mathrm{H}_{24}}}\right\}}\,; \end{aligned}$$

θ being here an imaginary cube root of unity. He contends that the twenty-four quantities, $\mathrm{H}_1, \ldots \mathrm{H}_{24}$, are all symmetric functions of the five quantities $x', \ldots x^V$; and that they are connected among themselves by the sixteen relations $\mathrm{H}_3 = \mathrm{H}_5$, $\mathrm{H}_4 = \mathrm{H}_6$, $\mathrm{H}_7 = \mathrm{H}_{13} = \mathrm{H}_{19}$, $\mathrm{H}_8 = \mathrm{H}_{14} = \mathrm{H}_{20}$, $\mathrm{H}_9 = \mathrm{H}_{15} = \mathrm{H}_{21}$, $\mathrm{H}_{10} = \mathrm{H}_{16} = \mathrm{H}_{22}$, $\mathrm{H}_{11} = \mathrm{H}_{17} = \mathrm{H}_{23}$, $\mathrm{H}_{12} = \mathrm{H}_{18} = \mathrm{H}_{24}$, $\mathrm{H}_9 = \mathrm{H}_{11}$, $\mathrm{H}_{10} = \mathrm{H}_{12}$.

* Nuove Ricerche sulla Risoluzione Generale delle Equazioni Algebriche del P. Gerolamo Badano, Carmelitano scalzo, Professore di Matematica nella R. Universita di Genova. Genova, Tipografia Ponthenier, 1840. See also an "Appendice" to the same work.

Sir W. Hamilton examines, in great detail, the composition of the two conjugate quantities H_4, H_6, which are each of the thirtieth dimension relatively to the five original quantities $x', \ldots x^V$; and arrives at the conclusion that neither H_4 nor H_6 is a symmetric function of those five quantities $x', \ldots x^V$, though each is symmetric relatively to four of them. He finds also that these two quantities H_4 and H_6 are not generally equal to each other, but differ by the sign of an imaginary radical, namely,

$$(\theta-\theta^2)(\omega-\omega^2-\omega^3+\omega^4)=\sqrt{-15},$$

when they are fully developed, in consistency with Professor Badano's definitions. Analogous results are obtained for the two quantities H_3, H_5; and these general results are verified by applying them to a particular system of numerical values of the five quantities $x', \ldots x^V$. It is shown also that the three quantities H_7, H_{13}, H_{19}, are neither independent of the arrangement of those five quantities x, nor (generally) equal to each other. And thus, although H_1 is symmetric, and H_2 vanishes, Sir W. H. conceives it to be proved that Professor Badano's expressions, for the twenty-four values of Lagrange's function t^5, give no assistance towards the solution of the general equation of the fifth degree, and therefore that the same method could not be expected to resolve equations still more elevated, even if we were not in possession of an *à priori* proof that no root of any general equation above the fourth degree can be expressed as a function of its coefficients, by any finite combination of radicals and rational functions.

DONATIONS.

Three Silver Coins, found at Rockingham, the seat of Viscount Lorton. Presented by C. T. Webber, Esq.

Copper Medal, " The glorious attempt of LXIV. to preserve the Constitution." MDCCXLIX. Dublin. Presented by Miss A. Clibborn.

The past and present Statistical State of Ireland exhibited in a Series of Tables. By Cæsar Moreu, Esq., F. R. S. Presented by James Hardiman, Esq.

Proceedings of the Royal Society of Edinburgh, Nos. 19, 20, for 1841–2.

Transactions of the Royal Society of Edinburgh. Vol. XV. Part 2 (pp. 265–334).

Memoirs of the Literary and Philosophical Society of Manchester. Vol. VI. New Series.

Statistical Returns of the Dublin Metropolitan Police for the year 1841. Presented by the Commissioners.

Lecture on the Application of Science to Agriculture. By Charles Daubeny, M. D. Presented by the Author.

Proceedings of the American Philosophical Society. From November, 1841, to April, 1842.

The New County Book of Tipperary. By Jeffries Kingsley, M. R. I. A. Presented by the Author.

Proceedings of the Geological Society of London. Vol. III. Part II. 1841–42. Nos. 77 to 83.

Fourth Annual Report of the Commissioners of the Central Loan Fund Board of Ireland. (Act 1 & 2 Vict. c. 78.) Presented by Mr. Piessé.

Transactions of the American Philosophical Society held at Philadelphia.

Flora Batava, door Jan Kops. Nos. 123 and 124.

Niewe Verhandelingen Van het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte te Rotterdam. Achtste Deel. Tweede Stuk.

Copy of an Inscription found in Babylon by Harford Jones, Esq. Presented by Professor H. H. Wilson.

Abhandlungen der Philosophisch-Philolog. Classe der Kœniglich Bayerischen Akademie der Wissenschaften, Drit-

ten Bandes Zweite Abtheilung, in der Reihe der denkschriften der XVIII. Band.

Philosophical Transactions of the Royal Society of London for the Year 1842. Part I.

Abhandlungen der Mathematisch-Physikalischen Classe der Kœniglich Bayerischen Akademie der Wissens-chaften, Dritten Bandes Zweite Abtheilung, in der reihe der denkschriften der XVI. Band.

Ueber das Magnetische Observatorium der Königl. Sternwarte bei München. Von Dr. J. Lamont. Presented by the Author.

A Piece of Leather, found in taking up Part of the old City of Dublin Wall, adjoining the old Tower in the lower Castle Yard, by Mr. Johnson, *and which is supposed to have lain there since the Year* 1202. Presented by W. Farren, Esq.

Memoires de l'Institut de France. Academie des Sciences Morales et Politiques. Savans Etrangers, Tome I.

Academie des Sciences Morales et Politiques. Tome III.

Memoires presentés par divers Savans à l'Academie Royale des Sciences de l'Institut de France. Sciences Mathematiques et Physiques. Tome VII.

Memoires de l'Institut de France, Academie Royale des Sciences. Tome XVIII.

Notices et Extraits des Manuscrits. Tome XIV. 2nd Partie.

Archæologia. Vol. XXIX.

Journal of the Statistical Society of London. Vol. V. Part 2. July to September, 1842.

Archives du Musée d'Histoire Naturelle. Tome I. Liv. 1, 2, 3, 4; and Tome II. Liv. 1 and 2.

The South Australian Almanack for 1842. By James F. Bennett. Presented by George Davies, Esq., T. C. D.

Proceedings of the Zoological Society of London. Part IX. 1841.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1842. No. 36.

November 14.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

The Secretary read a paper by Sir David Brewster, "on the Compensations of Polarized Light, with a description of a Polarimeter for measuring Degrees of Polarization."

The author first directed attention to the difference of opinion between him and most other philosophers, as to the constitution of partially polarized light; it being generally supposed that such light is a mixture of common light and perfectly polarized light, whilst he considers that the entire quantity of light undergoes a physical change by approximating more or less to the condition of light completely polarized. Upon this view he had long since explained the laws of polarization discovered by himself, but he had been anxious to obtain experimental evidence capable of deciding between the two ideas, and in this he considers that he is now successful.

By means of experiments,—described in the paper,—the author points out that when two portions of light oppositely polarized compensate each other, the proportions and conditions necessary are not those which could result from mixtures of common light with fully polarized light, and hence infers that the pencils must be wholly in different physical conditions. These experiments led him to the invention of an instrument termed the *Compensating Rhomb*, by means of which he considers decisive evidence of the correctness of his views has been obtained.

In order to determine if this principle be general, and to ascertain the laws of the compensation of polarized light, Sir David Brewster constructed an instrument for measuring the degrees of polarization. This he calls a *Polarimeter*. It consists of two parts, one of which is intended to produce a ray of compensation, having a physical character susceptible of numerical expression, and the other to produce polarized bands, or rectilinear isochromatic lines, the extinction of which indicates that the compensation is effected. The details of the construction of the instrument are fully given in the memoir, and numerous experiments made with it, and confirmatory of the author's views, are described.

In conclusion, Sir D. Brewster points out as the general results of his inquiries, as follows:

" 1. The first and most important result of this inquiry is, that it affords a new and independent demonstration of the laws of the polarization of light by reflexion and refraction, given in my papers of 1830. As this result has been already referred to, I shall merely mention the following general proposition.

" When a ray of common light is incident at any angle upon the polished surface of a transparent body, the whole of the reflected pencil suffers a physical change, bringing it more or less into a state of complete polarization; in virtue of which change, its planes of polarization are more or less turned into the plane of reflexion, while the whole of the refracted pencil has suffered a similar, but opposite change, in virtue of which, its planes of polarization are turned more or less into a plane perpendicular to the plane of reflexion.

" 2. As the light of the sky and the clouds is more or less polarized, the employment of the light which they reflect may, in delicate experiments, be a serious source of error, if we are not aware of its properties. By the principle of compensation, however, we may convert this partially polarized light into common light, and thus make experiments with as great accuracy in the day-time, as we can do with the direct light of a flame. If the light from a particular part of the sky be admitted into a dark room, or otherwise employed, we have only to compensate its polarization either by reflexion or refraction, and employ, as *unpolarized* or *common light*, that part of the light which corresponds with the neutral line.

"3. The laws of the compensation of polarized light enable us to investigate the polarizing structure of the atmosphere, and to ascertain the nature and extent of the two opposite polarizing influences, which I have found to exist in it, and by the compensation of which the neutral points are produced. But, as I shall soon submit to the Society the results of my observations on this subject, I shall not add any thing further at present.

"4. In every case where reflected or refracted light reaches the eye of the observer, whether it comes from bodies near us, or from the primary or secondary planets of our system, the doctrine of compensation enables us to obtain important information respecting the phenomena presented by light thus polarized. The nature of the reflecting or refracting surface, the angles of reflexion or refraction, and the nature of the source of illumination, may, in certain cases, be approximately ascertained.

"5. When the light of the sun, or any self-luminous body, is reflected from the surface of standing water, such as the sea or a lake, it is polarized according to laws which are well known; but when the partially polarized light of the sky (light polarized in every possible plane, passing through the sun and the observer) is reflected, a variety of curious compensations take place, which, when the position of the observer is fixed, vary with the season of the year, and the hour of the day. In some cases, there is a perfect compensation, the partially polarized light of the sky being restored to common light by the reflection of the water. In other cases the light of the sky has its polarization increased by reflexion from the water in the same plane in which it was itself polarized; and in other cases, the compensation is effected only in particular planes. At sunset, for example, the light reflected from the sea at a great obliquity in two vertical planes inclined 45° to a vertical plane passing through the sun and the observer, is compensated in these two planes, or the plane of its polarization is inclined about 45° to the reflecting surface. The same observations apply to the light of the two rainbows when reflected from the surface of water.

"6. When the light of the sky, or of the rainbow, is reflected from surfaces not horizontal, such as the roofs of houses, sheets of falling water, or surfaces of smoke and vapour, the compensations are more varied, and a perfect neutralization of the light by the second reflexion is more frequently obtained."

Professor Lloyd mentioned some circumstances which appeared to be opposed to Sir David Brewster's views.

Professor Kane commenced the reading of a paper "on the Tannin of Catechu, and the chemical Substances derived from it."

The abstract of this paper will be printed when the conclusion has been read.

DONATIONS.

Transactions of the Zoological Society of London. Vol. III. Part 1. 1842.

Reports of the Auditors and Council of the Zoological Society of London, April 29th, 1842, *and List of Members.*

Proceedings of the Royal Society. Nos. 52, 53.

Supplementary Appendix to the Report of the Poor Law Commissioners of the Medical Charities in Ireland, with Indexes. 1841. Presented by the Commissioners.

A pamphlet entitled, " Is Selenium a true Element?" Presented by Septimus Piesse.

November 30. (Stated Meeting.)

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

John Anster, LL.D., was elected a member of the Committee of Polite Literature, in the room of the Rev. Dr. Porter, who had resigned.

RESOLVED,—On the recommendation of Council,—That Mr. E. Curry be employed to make a Catalogue of the Irish MSS. in the Library of the Academy, for the sum of £100.

The Secretary read a letter from George Birch, Esq., presenting to the Academy an ancient tombstone, from the Abbey of Monahinchy, with an inscription in the Irish character.

RESOLVED,—That the thanks of the Academy be given to Mr. Birch for his donation.

Rev. Dr. Todd, V.P., gave the following account of the Proceedings of the Committee for the purchase of the late Dean of St. Patrick's collection of Irish Antiquities, which had been recently presented to the Academy.

" It has been thought fitting that some record should appear in the Proceedings of the Academy of the successful efforts that have been made under the direction of the Committee of Antiquities, for raising the subscription, which has preserved from dispersion, and placed in the safe keeping of this Society the invaluable Collection of Irish antiquities belonging to our late lamented Vice-President, the Dean of St. Patrick's.

"It was well known to all his intimate friends that one of the principal motives that influenced him in the formation of his Museum, next to the zeal for the preservation and study of antiquities which characterized him, was a wish to have his collection preserved for public use, under the care of the Royal Irish Academy.

"As soon as it was ascertained, therefore, that he had died intestate, and consequently without making any provision for carrying these his often expressed wishes into effect, many of his personal friends, knowing how deeply he would have deprecated the dispersion of his Collection, felt anxious, were it only as a testimony of respect to his memory, that the Irish part at least of the Museum should be obtained for the Academy; and in this they were warmly seconded by all who were aware of the value of the Collection, and who felt the great importance of a National Museum of Antiquities to the study of our ancient history.

"Accordingly, at the Stated Meeting of the Academy in November, 1840, soon after the lamented death of the Dean, the subject was brought forward, and the Committee of Antiquities were requested to take immediate steps towards opening a subscription for the purchase of the Irish part of the collection.

"The Committee met immediately after, and their first act was to publish in the principal newspapers of Dublin a short address, for the purpose of ascertaining the state of public feeling on the subject. A circular was also prepared, and sent to the principal nobility and gentry of Ireland, to all in short, as far as they could be ascertained, who were thought likely to take an interest in the design.

"This was all that could be done at that time. The absence of Mrs. Dawson on the Continent, and the consequent difficulty of ascertaining the wishes of the Dean's family, rendered it impossible to discover what sum they were likely to accept for that portion of the Museum which the Committee were commissioned to purchase, or indeed whether they would consent at all to separate the Irish part of the Collection from the rest.

"From this unavoidable delay, the zeal of many appeared to cool, and the subscription for a time proceeded but slowly; but at length, on the 27th of March, 1841, the Committee took the bold step of authorizing Mr. Petrie and Dr. Aquilla Smith to offer £1000 for the Collection.

"I should have mentioned that this sum was decided upon after an exact valuation of the whole. The coins were valued by Dr. Aquilla Smith, and the other antiquities, at Mrs. Dawson's special request, by Mr. Petrie; and the sum at which these gentlemen fixed the value of the Collection was £1060. The Committee were of opinion, therefore, that in offering the sum of £1000, they were dealing fairly with the public fund entrusted to them; while by striking off about six per cent. from the amount of the valuation, they were only allowing for the necessary expenses which would have attended the sale of the Museum had it been submitted to a public auction.

"It was not, however, until the 26th of June following that a final answer was obtained from the Dean's family to the proposal of the Committee. On that day Dr. Smith reported that Mrs. Dawson had consented to accept the offered sum, and also that she was willing to allow three months from that date for its collection.

"New efforts were then made by the Committee: circulars were again sent out, and an address to the public was inserted in the newspapers; a deputation was appointed to wait on His Excellency the Lord Lieutenant, who contributed £20 to the fund; and in short every exertion was made to rouse the friends of Ireland to the importance of the great national object that was in view.

"The success that has crowned these efforts is mainly owing to the zealous manner in which the exertions of the Committee were seconded by some other members of the Academy, who aided them by their advice and counsel, and also by their invaluable and indefatigable labours. Of these it is impossible to avoid naming Mr. Carr and Mr. Hutton, as the individuals to whose cooperation the Committee were most deeply indebted for the success of their undertaking; and although it is obviously improper to allude to any individual of those who were members of the Committee itself, yet I feel sure I shall be pardoned in departing from strict propriety so far as to say, that to the exertions of Dr. Aquilla Smith and Mr. Petrie, their intimate knowledge of the contents and value of the Collection, and their good offices with the family of the Dean, the Academy and the country are mainly indebted for the possession of the treasures which have been added to our Museum.

" Still, however, the subscriptions for some time came in so slowly, that it became necessary to solicit more time for collecting the money than was originally agreed upon; and this request was acceded to by Mrs. Dawson, with a liberality for which she deserves the gratitude and the thanks of the Academy.

" At length on the 9th of April of the present year, the first instalment of £500 was paid to Mrs. Dawson, and the Collection was soon after removed to the Academy House, under the superintendence of Dr. Aquilla Smith.

" A guarantee for the payment of the remaining half of the purchase money having been given to Mrs. Dawson by certain subscribers to the fund, the Antiquities were at first placed under the custody of those gentlemen; who bound themselves to hand over the Collection to the Committee as soon as the debt for which they had made themselves responsible was discharged.

" On the 31st May the whole remainder of the purchase money was paid to Mrs. Dawson, and the gentlemen who had so liberally come forward to guarantee its discharge were released from their obligation. It was found also, that after the payment of all the incidental expenses, a balance remained at that time in favour of the fund to the amount of £24 17*s.* 6*d.* This balance was subsequently increased by some subscriptions that afterwards came in, and the whole overplus has been applied, under the direction of the Committee, to the purchase of some valuable antiquities, which have been added to the Collection.

" In recording this last stage of the proceedings of the Committee it is necessary to remark, that but for the public spirit of the individuals who came forward to give their personal security to Mrs. Dawson for the payment of the purchase money, all would have been lost, and the Museum would necessarily have been sent for public sale to London. For although at that time the stipulated sum had been very nearly promised, yet many of those who had put down their names had not paid their subscriptions, and the time necessary for collecting the money would have exceeded the limit to which the Committee had bound themselves to Mrs. Dawson; and thus she would have been left at liberty to take other means for disposing of the Museum. It is necessary, therefore, that the Academy should know that the gentlemen who came forward to rescue the Committee from a dilemma which would have made vain all their previous exertions, and to whom we are therefore so particularly indebted for the great step that has been made towards the formation of a National Museum, are George Carr, Esq., Dr. Aquilla Smith, Professor Mac Cullagh, Thomas Hutton, Esq., and Robert Callwell, Esq.

"The thanks of the Academy are also due to Mr. Clibborn for his invaluable services throughout the whole of these transactions, and particularly in the last stage of them, when it became necessary to make exertions to call in the subscriptions that had been promised, and to take steps, after the Museum had come into our possession, for the arrangement and safe keeping of its contents. To him also we are indebted for the ingenious plan for a new Board Room, which has received the approval of the Council, and is submitted to your consideration this evening: a plan which will enable us to convert the room in which we are now assembled into a Museum, where the treasures of which we are now the guardians, may be displayed in a manner useful to the public, and their permanent security duly provided for.

"The special thanks of the Academy are also due to Messrs. Boyle, Low, Pim, and Co., who kindly permitted subscriptions to be paid at their house, without any charge whatsoever to the fund; and who also offered to advance to the Committee any sum that might be required as a temporary accommodation, during the necessary delay that attended the collection of the subscriptions. This liberal offer the Committee were compelled to avail themselves of, by drawing upon Messrs. Boyle and Co. for a sum of £53 15*s.* 5*d.* on the 1st of June last, a sum which was not entirely repaid for upwards of two months afterwards.

"It is proper to mention here, that His Excellency Earl De Grey, in addition to his subscription to the fund for the purchase of the Dawson Collection, has also been pleased to present to the Academy a valuable Aision of gold, which was recently found in the county of Roscommon, and of which His Excellency became the purchaser, for the express purpose of placing it in our Museum. Mr. H. J. Monck Mason also, in addition to his subscription, presented a very beautiful gold Fibula, of considerable weight and value.

"It should be distinctly understood, that the subscriptions received have enabled the Committee to pay all the expenses attendant upon these transactions, without any charge whatsoever to the funds of the Academy.

"The Academy, as a body, have had nothing whatsoever to do with the purchase of the Museum, and there will be found among the subscribers very many names of gentlemen who are not members of, or in any way connected with our Society. The Museum, therefore, strictly speaking, is the property of the subscribers, and is by them presented to the Academy, to be kept by us in trust, for the benefit of the public. The Academy, as a Corporation, have contributed nothing to the purchase, except so far as their consenting to take the charge of so valuable a gift, and to provide a room for its exhibition, may be considered, as it doubtless is, a most important contribution to the great end which the subscribers have had in view.

"The accounts of the Committee have been audited by Messrs. Callwell and Hutton; they are in the hands of Mr. Clibborn, and are open, of course, to the inspection of any of the contributors.

"It may be well now to say a few words on the value and contents of the Museum of which we are thus become the guardians.

"The Museum contains no less than ninety-seven ornaments of solid gold, whose total weight amounts to 98 oz. 14½ dwt. It possesses also 252 articles of pure silver, and 1674 bronzes and other antiques, composed of pottery, amber, glass, and the baser metals.

"This enumeration does not include the coins and medals, which are of singular interest and value, and of which a catalogue, in the handwriting of Dean Dawson, is now on the table.

"To specify the various articles of value and interest more particularly, so far at least as to give any detailed account of them, would be too great a trespass on your time, even if I could feel myself fully competent to the task; but it is impossible to close this Report without endeavouring to give you some rough and general view at least of the treasure which we have now obtained.

"Among the gold ornaments are twenty-seven fibulæ, one of them of considerable size; three perfect torques, and fragments of some others; two gorgets; two singular hollow balls or beads of gold, which were found with eleven others in the County of Roscommon, and which the Dean saved from the crucible of the goldsmith; a most interesting collection of ancient finger rings, and sixteen specimens of the small solid rings of gold, which are believed to have been the current money of the ancient inhabitants of Ireland.

"The collection of silver finger rings and of ancient seals, is of great interest and value. Among them will be found the matrices of the seals of the O'Neills and other Irish chiefs, with several ecclesiastical seals of various periods.

"There is a remarkable collection of the ancient Irish bells, whose uses and history our friend Mr. Petrie has so ably discussed; some of these are the large bells, which once, perhaps, were suspended in the Round Towers; others are the small altar bells, many of them exhibiting proofs of great antiquity. One of the large bells contains an Irish inscription, which proves it to be as old as the ninth century.

"The collection of military weapons and other antiques connected with the warfare of our ancestors is of great extent and value. It contains a great variety of specimens, in excellent preservation, of the flint arrow heads and spear heads, which are supposed to have been the most ancient weapons in use in Ireland; a large number of the peculiar weapon, in stone and bronze, called celts, of all the sizes and forms in which they are found; and a magnificent collection of swords and spear heads, from many of the remarkable fields of battle recorded in the history of Ireland.

"It would be drawing too much on your patience to enter more particularly into a description of particular objects of interest in this Collection; at some future time it might perhaps be an entertaining, as well as an instructive task (if some of our antiquaries would undertake it), to exhibit to the Academy, from time to time, the more remarkable and important articles of our Museum, with remarks on their history, and use. But a more fitting occasion for this will perhaps be found, when THE DAWSON COLLECTION is properly arranged and displayed, as I hope it soon will be, in a room fitted for its reception.

"I must say a few words of the coins and medals before I can conclude this Report.

"They may be divided into three classes:

"1. *The Danish Irish coins of the ninth and tenth centuries.*

"This series comprehends the coins of Domnald and some of the sovereigns unknown; a coin of Ivar, A. D. 872, and a large collection of the Dublin coins of Sitric, A. D. 980 and 989. Also the Dublin coins of Æthelred, and some of great singularity and rarity, which bear the impress of the Dublin mint, and which the Dean, on grounds however admitted by himself to be doubtful, was at one time disposed to refer to the reign of Æthelstan.

"2. *The coins struck in and for Ireland by British sovereigns.*

"Among these are a magnificent series of the coins of John, minted in Dublin, Waterford, and Limerick, between the years 1177 and 1199; and a singularly perfect series of the coins struck in Ireland from the reign of John to that of George IV., containing many varieties of great rarity and value.

"3. *A series of medals struck in Ireland.*

"The most complete that has ever been collected. This series is particularly interesting to the Academy, because the late Dean, a very short time before his decease, contributed to our Transactions a valuable paper on the subject of Irish Medals, in which the most remarkable of these very medals are noticed and described.

"On the whole, I would congratulate the Academy, and not the Academy only, but the country, on the possession of this important and invaluable Collection. As one of those who enjoyed the privilege of an intimate acquaintance with its late lamented owner, I cannot help expressing the gratification which I feel in the reflection that this, the national part of his Museum, is saved from dispersion, secured to Ireland, and presented to the Academy, for which he had destined it. I feel a melancholy satisfaction, in which his friends will sympathize with me, in having (in however humble a degree) taken a part in bringing about the fulfilment of the wish I have often heard him utter, that his Museum might be here; and in the assurance that here his name will live as a benefactor to his country, and an example to our gentry, by whom the study and preservation of our antiquities have been (I must say) disgracefully neglected.

"But on public grounds, most of all, I would congratulate the Academy on having now laid the foundation of a National Museum, which will doubtless be the means of preserving many articles of value and interest from destruction—of bringing together the many curious relics of the past, which are now in the hands of private families or individuals, and perhaps also of awakening the attention of the Government of the country, to the importance (too long forgotten or overlooked) of forming, upon a liberal and extensive basis, a really National Museum of the Antiquities of Ireland."

Resolved,—That this Report be entered on the Minutes, and published in the Proceedings.

Resolved,—That the special thanks of the Academy be given to those subscribers to the Dawson Fund who are not members of the Academy.*

Resolved,—On the recommendation of Council,—That the plan of the new Board Room proposed by Mr. Murray and Mr. Owen, be approved of by the Academy.

December 12.

SIR Wm. R. HAMILTON, LL.D., President, in the Chair.

Rev. Dr. Todd, V.P. on the part of the Knight of Glin, presented to the Academy a gold coin, with an Arabic inscription, found in the wall of a house in the townland of Killeny, near Glin.

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* See List of Subscribers in Appendix No. I.

The thanks of the Academy were presented to the Knight of Glin for his donation.

Dr. Apjohn read a paper by Dr. Andrews, "on the Heat developed during the Formation of the Metallic Compounds of Chlorine, Bromine, and Iodine."

The author confines his attention in the present paper to the combinations of zinc and iron, which metals, he shows, will not combine at ordinary temperatures with chlorine, bromine, or iodine, unless water is also present. The reactions which take place when an excess of iron in a state of fine subdivision is agitated with any of the three elements just mentioned, are rather complicated,—a sesqui-compound ($Fe_2 Cl_3$, $Fe_2 Br_3$, $Fe_2 I_3$) being first formed, which afterwards combines with an additional atom of iron, and becomes converted into a proto-compound ($Fe_3 Cl_3$, &c.) The heat developed during this process consequently arises from three distinct causes:—first, the union of Fe_2 with Cl_3; secondly, the solution of the compound so formed in water; and thirdly, its conversion into $Fe_3 Cl_3$ by its combination with Fe. The heat arising from the two latter causes being determined by separate experiments, and taken from that obtained during the original reaction, the remainder will be evidently the heat due to the union of Fe_2 and Cl_3; and by a similar method, the heat developed during the union of Fe_2 with Br_3, and of Fe_2 with I_3, may also be determined. Referred to the number of degrees of Fahrenheit's scale, through which one grain of water would be heated by the combination of one grain of iron in each case, the heat evolved during the formation of $Fe_2 + Cl_3$ is 3246°; during that of $Fe_2 + Br_3$, 2302°; and of $Fe_2 + I_3$, 834°. The reaction which occurs when zinc is treated in a similar manner is much simpler, and the heat developed, referred to the zinc as unit, is 2766° for $Zn + Cl$; 2284° for $Zn + Br$; and 1474° for $Zn + I$.

The author also proves, by direct experiments, that when solutions of the sesqui-chloride, sesqui-bromide, or sesqui-iodide of iron are converted into the corresponding proto-compounds of iron, by combining with iron, the heat in all cases is the same for the same quantity of iron dissolved.

The method by which these numerical results were obtained, and the apparatus employed, are minutely described in the original communication.

Dr. Kane inquired how far he considered the final results obtained by Dr. Andrews to affect the ideas of thermo-chemical combination, founded on the experiments of Despretz and Dulong?

Dr. Apjohn stated that the results of Dr. Andrews were quite opposed to their experiments, as he found the quantities of heat not to bear any relation to the atomic weight of the combining bodies.

The Secretary read a paper by the Rev. Edward Hincks "on the Chronology of the Eighteenth Dynasty of Manetho."

The object of this paper is to determine the period at which the eighteenth dynasty of Manetho flourished, by the recorded dates, in months of the wandering year, of facts, which must, from their nature, have occurred at known seasons of the solar year. Three such dates are brought forward: two of them relating to the time of the commencement of campaigns; and the third, to that of the inundation: and they all concur in depressing the epochs of the eighteenth dynasty about 350 years below those, which the Champollions and Rosellini have adopted. An approximation to the dates of the accession of many monarchs of the dynasty is attempted. For example, the year B. C. 1278 is fixed upon as very nearly, if not exactly, that of the accession of Amenothph III.

Mr. Mallet having become acquainted with the recent improvements effected by Mr. Bessemer in the art of glass-making, for optical and other purposes, gave a short account of them to the Academy.

The improvements consist chiefly in—

1st. The use of platina bottoms to earthen melting pots, and heating these in improved furnaces *from below*, so as to produce circulation in the fluid glass.

2nd. In preserving the liquid glass from all contamination from without by "tears," &c. and from the dome of the furnace, as well as from deoxidation of the lead salts by contact of carbon.

3rd. In an improved mode of cutting off, by a platina blade, the upper portion of the fluid glass, without disturbance of the remainder; thus separating the whole of the impure dross at top, which was heretofore stirred down into the mass just previous to casting.

4th. In a beautiful and effective mode of removing the air bubbles, or "seeds," as they are called, from the liquid glass, by placing the ignited glass pot of liquid metal within an exhausted receiver, so contrived that it can be rapidly placed within, and withdrawn from the vacuum vessel.

Mr. Mallet was not aware that as yet any specimen of glass prepared by these improved processes had been wrought for any optical purpose, the inventor's efforts having been as yet principally directed to the manufacture of plate glass; but he considered that the practical nature of these improvements, and their capability of being applied upon a large scale, gave good hope of their extension to the making of optical glasses also.

Rev. Dr. Robinson made some remarks with reference to Mr. Faraday's experiments on the manufacture of glass for optical purposes, and described the processes adopted at Munich in selecting the portions of glass of which lenses are formed.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1843. No. 37.

January 9.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Stewart Blacker, Esq., Thomas Cather, Esq., William V. Drury, M. D., William Gore, M. D., Thomas Hodder, Esq. R. N., Rev. John Homan, Henry Hutton, Esq., Robert Leslie Ogilby, Esq., the Hon. Frederick Ponsonby, and George Salmon, Esq., F.T.C.D., were elected members of the Academy.

Rev. H. Lloyd, V. P., read a paper "on the Determination of the Intensity of the Earth's Magnetic Force in absolute Measure."

The means of determining the intensity of the earth's magnetic force in absolute measure consist, it is well known, in observing the time of vibration of a freely-suspended horizontal magnet, under the influence of the earth alone, and then employing the same magnet to act upon another, which is also freely-suspended, and noting the effects of its action combined with that of the earth. From the former of these observations we deduce the *product* of the horizontal component of the earth's magnetic force into the moment of free magnetism of the first magnet,—from the latter, the *ratio* of the same quantities; and, the product and the ratio being thus known, the two factors are absolutely determined. The former part of this process involving no difficulty which may not be overcome by due care in observing, we shall confine our attention, in the present communication, to the latter.

Two methods have been proposed for this second observation, one by Poisson, and the other by Gauss. The method of Poisson consisted in observing the *time of vibration* of the second magnet, under the combined action of the first and of the earth, the acting magnet having its axis in the magnetic meridian passing through the centre of the suspended magnet. In the method of Gauss, which is now universally adopted, we observe the *position of equilibrium* of the second magnet, resulting from the action of the same forces. The acting magnet being placed transversely with respect to the suspended one, the latter is deflected from the meridian, and the amount of this deflection serves to determine the ratio of the deflecting force to the earth's force. The position chosen by Gauss for the deflecting magnet is that in which its axis is in the right line passing through the centre of the suspended magnet, and perpendicular to the magnetic meridian, in which case the tangent of the angle of deflection is equal to the ratio of the two forces. From this ratio it remains to deduce that of the magnetic moment of the deflecting bar to the earth's force.

The difficulty of this process arises from the form of the expression of the force of the deflecting bar. This force being expressed by a series descending according to the negative odd powers of the distance, with unknown coefficients, it is evident that observation must furnish as many equations of condition, corresponding to different distances, as there are terms of sensible magnitude in the series; and from these equations the unknown quantities are to be deduced by elimination. Now, the greater the number of unknown quantities thus eliminated, the greater will be the influence of the errors of observation on the final result; and if, on the other hand, the distance between the magnets be taken so great, that all the terms of the series after the first may be insensible, the angle of deflection becomes very small, and the errors in its observed value bear a large proportion to the whole.

It fortunately happens, that at moderate distances (distances not less than four times the length of the magnets) all the terms beyond the second may be neglected. The expression for the tangent of the angle of deflection is thus reduced to two terms, one of which contains the inverse cube of the distance, and the other the inverse fifth power; that is, if u denote the angle of deflection, and D the distance,

$$\tan u = \frac{Q}{D^3} + \frac{Q'}{D^5};$$

in which Q and Q′ are unknown coefficients, the former of which is double of the ratio sought. Accordingly, the method recommended by Gauss consists in observing the angles of deflection, u and u', at two different distances, D and D′, and inferring the coefficient Q by elimination between the two resulting equations of condition.

It is evident, however, that if the coefficient of the inverse fifth power of the distance be evanescent,—or, more generally, if the ratio of the two coefficients be known *à priori*,—the quantity sought may be obtained, without elimination, from the results of observation at one distance only. For if $Q' = hQ$, h being a known quantity, the preceding expression becomes

$$\tan u = \frac{Q}{D^3}\left(1 + \frac{h}{D^2}\right);$$

and accordingly the value of Q is obtained, from the result of observation at a single distance, by the formula

$$Q = \frac{D^3 \tan u}{1 + hD^{-2}}.$$

And, not only is the labour of observation thus diminished, but (which is of more importance) the accuracy of the result is increased. In order to show this, the author entered into an examination of the amount of the probable error in the two methods, from which it appeared that the probable error of Q, arising from an error in the observed deflection, will be less than in the usual method in the ratio of 1 to 5.563, even when the latter is employed in the manner most conducive to accuracy. In fact, the ratio of the probable error to the entire quantity is found to be expressed, in the two cases, by the formulæ

$$\frac{\Delta Q}{Q} = \frac{\Delta u}{u}, \quad \frac{\Delta Q}{Q} = \frac{\sqrt{q^{10}+1}}{q^2-1}\,\frac{\Delta u}{u}$$

where q denotes the ratio of the two distances; and the *least* value of the factor $\frac{\sqrt{q^{10}+1}}{q^2-1}$ is 5.563, and corresponds to the ratio $q = 1.32$.

In order to know the ratio h, it is necessary to determine the moment of the force exerted by the deflecting magnet upon the suspended magnet, extending the approximation to the terms involving the fifth power of the distance. The axis of the deflecting magnet being supposed to lie in the right line joining the centres of the two magnets, and the axis of the suspended magnet forming the angle ψ with that line, this moment is found to be

$$\frac{2MM'}{D^3}\sin\psi\left\{1+\left(2\frac{M_3}{M}+3(5\cos^2\psi-1)\frac{M'_3}{M'}\right)\frac{1}{D^2}\right\};$$

in which M and M', M_3 and M'_3, denote certain integrals depending on the distribution of free magnetism, in the deflecting and suspended magnets, whose values are

$$M=\int_{-l}^{+l} mr\,dr, \quad M_3=\int_{-l}^{+l} mr^3 dr,$$

m being the quantity of free magnetism in any transverse section of the magnet, r its distance from the centre, and l half the length of the bar. The form of this result exhibits the advantage of the method of deflection recently proposed by Professor Lamont, in which $\psi = 90°$, or the deflecting bar perpendicular to the suspended bar.

In the ordinary method, $\psi = 90° - u$; and, the moment of the force exerted by the earth being $\mathrm{XM}' \sin u$, where X denotes the horizontal component of the earth's magnetic force, the equation of equilibrium is

$$\tan u = \frac{2\mathrm{M}}{\mathrm{X}} \left\{ \frac{1}{\mathrm{D}^3} + \left(2\frac{\mathrm{M}_3}{\mathrm{M}} - 3\frac{\mathrm{M}_3'}{\mathrm{M}'} + 15 \sin^2 u \frac{\mathrm{M}_3'}{\mathrm{M}'} \right) \frac{1}{\mathrm{D}^5} \right\}.$$

The angle of deflection, u, being small, the term involving the square of its sine may be neglected, in comparison with the others; and the equation assumes the form already adverted to, namely,

$$\tan u = \frac{\mathrm{Q}}{\mathrm{D}^3} \left(1 + \frac{h}{\mathrm{D}^2} \right);$$

in which we have made, for abridgment,

$$\frac{2\mathrm{M}}{\mathrm{X}} = \mathrm{Q}, \quad 2\frac{\mathrm{M}_3}{\mathrm{M}} - 3\frac{\mathrm{M}'_3}{\mathrm{M}'} = h.$$

In order to apply this result, we must know, at least approximately, the law of magnetic distribution, or the function of r by which m is represented. Almost the only knowledge which we possess on this subject is that derived from the researches of Coulomb. From these researches M. Biot has inferred, that the quantity of free magnetism, in each point of a bar magnetized by the method of double touch, may be represented by the formula

$$m = \mathrm{A}(\mu^{l-r} - \mu^{l+r});$$

μ being a quantity independent of the length of the magnet, and A a function of μ and l. M. Biot has further shown, that when the length of the magnet is small, the relation between m and r is approximately expressed by the simple formula

$$m = m' \frac{r}{l};$$

the curve of intensities becoming, in that case, very nearly a right line passing through the centre of the magnet.

Employing then this approximate formula, we have

$$M = \tfrac{2}{3} m' l^2; \quad M_3 = \tfrac{2}{5} m' l^4.$$

The ratio of these quantities is $\frac{M_3}{M} = \frac{3}{5} l^2$, a value independent of m'; and substituting in the expression of h above given, and designating the half lengths of the deflecting and of the suspended magnets by l and l', respectively,

$$h = \tfrac{3}{5}(2l^2 - 3l'^2);$$

an expression whose value may be exactly known, independently of experiment. This value vanishes, when $l^2 = \frac{3}{2} l'^2$, or

$$l = 1{\cdot}224\, l';$$

and in this case, therefore, the quantity sought is given by the simple formula

$$Q = D^3 \tan u.$$

The author concluded his paper with an account of a series of deflection experiments, instituted for the purpose of confirming these results. The magnets employed were cylindrical, their lengths being 3 inches and $3\frac{2}{3}$ inches, and their diameter 3–10ths of an inch. The observations were made with every precaution necessary to insure exactness, and at times when the fluctuations in the direction and intensity of the magnetic force were very small; and their results verify the conclusions above obtained, as applied to the case of small magnets.

Dr. Apjohn next read the following letter, which he had received from Captain Boileau, superintendent of the Magnetic Observatory at Simla, in India.

"*Simla, March*, 7, 1842.

"My dear Sir,

"I have the pleasure of forwarding to you, through the Government of India, a complete set of hygrometric tables, computed by my assistant, from your last formula, to which I have added a vapour table, computed by Biot's formula, from Dalton's experiments, which is the same that Pouillet has used in the last edition of his *Traité de Physique*, that I have seen. Every one of the numerical values in this table (No. 3) has been computed directly from the formula to seven places of decimals, five of which only have been retained. In like manner, in part 1, each of the numerical values for depressions to one-tenth of a degree Fahrenheit, has been directly computed for twenty and for thirty inches of pressure, and the intermediate values obtained by addition. All the work has been checked by differences, and examined by three separate computors.

"Accompanying, are also sent the separate observations of the wet and dry bulb thermometers, of Daniell's hygrometer, and of the standard barometer, with notice of the weather for the twelve term days of 1841, which have been taken specially for your own use, and which you will, I think, find to confirm the views you had already taken upon the subject. There is one point which strikes at first sight, viz., that with very few exceptions, the dew-point, by the hygrometer, is too high. It is a difficult instrument to use. It requires the observer to approach near to it; and, even with the utmost care, it is difficult to prevent an effect sensible at times to a prejudicial extent, upon the hygrometric condition of the surrounding air. None of these difficulties occur with the wet and dry thermometers, which have one still greater advantage, viz., the ease with which the wet ball can, under almost any circumstances, be moistened.

"During several months, we observed the hygrometer hourly on term days, but finding that this gave much trouble, and was likely to prejudice the readings of the magnetometer, I discontinued the practice, and had since but one observation every two hours.

During this year, I regret to say, that a failure in ether has prevented any readings on either January or February term days, and of a supply of five pints just had up under order of Government, nearly three and a-half pints have evaporated on the journey. So much for an Indian climate, and bottles not hermetically sealed. You will oblige me by acknowledging the receipt of this packet, either through our mutual friend Professor Lloyd, or through the Military Secretary at the East India House, Philip Melvill, Esq.; and if you wish me to alter the system adopted, you have only to say so, and I will endeavour to meet your views. I hope to continue the regular series from this month again without interruption.

"Believe me to remain, with kind regards,
"My dear Sir,
"Yours very truly,
"S. BOILEAU.

"P. S.—You can make any use of the accompanying document you may please to do."

Dr. Apjohn then observed, that availing himself of the permission given him by Captain Boileau, he would make a few remarks upon the hygrometric observations made on the magnetic term days for 1841. These observations were highly interesting to meteorologists, having been made by an officer of great scientific attainments, of extensive experience as an observer, and with the aid of first-rate instruments: but his (Dr. Apjohn's) reason for considering them particularly important was, that they furnished the means of estimating the relative merits of the two hygrometric processes at present in use, viz., that according to which, the dewpoint is directly got by the aid of Mr. Daniell's instrument, and that which conducts to the same conclusion through the application of the well known formula,

$$f'' = f' - ,01147\,(t - t') \times \frac{p - f'}{30}$$

* In this expression f'' is the force of vapour at dew-point, f' the force of

to the temperatures indicated by a wet and dry thermometer.

The observations for the April term day, were those to which it was his intention to advert, as they exhibited higher values for $t—t'$, than those made in any other month. Now upon looking through these which amount to 24, the first fact which at once presents itself is, that in every instance but *two*, the observed dew-points are higher than obtained by the formula, and in some instances, by as many as nine degrees Fahrenheit. One or other series, therefore, must be erroneous. That the observed dew-points are inaccurate, Dr. Apjohn inferred, on the ground of their being inconsistent with each other; for he held it as quite certain, whether the hygrometric expression be correct or not, that when in the case of any two distinct observations, t and t' have the same values, that upon both such occasions the air includes the same amount of moisture, or has the same dew-point. Tried by such a criterion, the results obtained with Daniell's instrument are defective, as is well illustrated by the following extract from the April observations.

	t	t'	t'' *ob.*	t'' *calc.*		
10	70	51	43.5	34.7	9.5	1.4
11	71.2	51	34	33.3		
7	63	47	31	31.6	6.6	1.2
17	62	47	36.6	32.8		
2	55	42.5	30.5	28.9	2.5	0.9
24	55	42.2	33	28		

From what has been just said, it is obvious, that observations 10 and 11 should give nearly the same dew-point. This is true of the dew points got by the formula, but not at all of the direct determinations by the hygrometer, as those

vapour at t', the temperature by the wet thermometer, and t the temperature of the air.

differ 9°.5. In 7 and 17, the dew-points are necessarily nearly the same. The results got by the formula differ by only 1°.2, while the instrumental ones differ by 6°.6. Again, 2 and 24 should give g.p. the same dew-point. This is true of the formula, but not at all of the hygrometer, as the temperatures it yields differ by 2°.5. The preceding instances, the number of which might be greatly augmented, were, Dr. Apjohn conceived, quite sufficient to show, that even in the hands of Captain Boileau, Daniell's instrument has not given correct conclusions; and that, therefore, generally it cannot be relied upon for determining, accurately, the hygrometric relations of the atmosphere.

With respect to the column of results obtained by Captain Boileau, from the wet bulb process, Dr. Apjohn could not entertain the slightest doubt of their exactness, having found that his formula stood the severest experimental tests to which he could subject it. These experiments, however, (see Transactions Royal Irish Academy, vol. vi.) were, he admitted, all made under pressures, at or about 30: and hence it always appeared to him desirable, that they should be repeated at such diminished pressures, as are met with at elevated points on the earth's surface. In this point of view, the Simla observations appeared at first highly important, the pressure there being but little over 23; but as no reliance can be placed on the dew-points directly got, they cannot be used to test the accuracy of the hygrometric expression.

Dr. Apjohn then expressed a hope, that no one who heard him would misunderstand him to assert, that the dew-point could not be accurately got by Daniell's instrument. He knew it could, and he had explained elsewhere how to use it, so as to arrive at a correct result. What he had, however, asserted before, and would again repeat, was, first, that it was an instrument very difficult to observe accurately with; and second, that when Mr. Daniell's rule is attended to, namely, to take as dew-point, the mean of the temperatures indicated by the inner thermometer at the instant of the deposition of the dew, and at that of its disappearance, the result is necessarily higher than the truth.

Dr. Apjohn concluded, by drawing attention to the great value of the other tables alluded to in Captain Boileau's letter, the construction of which, must have been a work of immense labour. Two of these greatly simplify the calculations necessary in applying the hygrometric formula, as the arithmetical operations are thereby reduced to mere addition and subtraction.

The third table gives the force of vapour to tenths of a degree Fahrenheit, throughout the entire range included between —3° and + 146, Fahrenheit, calculated *de novo* by the well known method of Biot, from the experiments of Dalton and Ure. It does not materially differ, except in its greater extent and minuteness, from the table of the tension of aqueous vapour which Dr. Apjohn has hitherto used, and the superior accuracy of which, as compared with the table of Kaemtz, and that not long since published by the Meteorological Committee of the Royal Society, has been rendered highly probable by Professor Lloyd.

Professor Mac Cullagh read a paper on the Catalogue of Egyptian Kings, which is usually known by the name of the *Laterculum* of Eratosthenes.

This Catalogue, which the distinguished mathematician and philosopher whose name it bears drew up by command of Ptolemy Euergetes, contains a long series of kings who reigned at Thebes in Upper Egypt; and has been preserved to us in the *Chronographia* of Georgius Syncellus, a Greek monk of the eighth century. It is a document which has been made much use of by chronologers; by some of whom, as by Sir John Marsham for example, who calls it "*venerandissimum antiquitatis monumentum,*" it has been reckoned of the very highest authority; but it is extremely corrupt in the latter part, owing to the carelessness with which it was transcribed either by Syncellus himself or his immediate copyists. The writers on Egyptian antiquities have in consequence been much perplexed in settling the chronology of the reigns in which the errors exist, and the attempts that have been made to remove the confusion have only served to increase it. It was the object of the author to restore the document to its original state, and he showed that this might be effected, with complete certainty, by a proper attention to the manuscripts of Syncellus. Of these only two are known; one has been used by Father Goar, the first editor of the Chronographia (Paris, 1652); the other, which is a much better one, has been collated by Dindorf, the second and latest editor. Dindorf's edition was published at Bonn, in the year 1829, as part of the *Corpus Scriptorum Historiæ Byzantinæ*, and on its first appearance Mr. Mac Cullagh had satisfied himself as to the original readings of the Catalogue, and had seen how to account for the errors which, probably from Syncellus's own negligence, had crept into it; but he did not publish his conclusions at the time, thinking that similar considerations could not fail to occur to some of the numerous writers who were then giving their especial attention to such subjects. This, however, has not been the case. Chronologers have continued to follow in the footsteps of Goar, a man of little learning, and of no critical sagacity, who corrected the Catalogue most injudiciously, and whose corrections, strange to say, are left without any remark by Dindorf. Thus Mr. Cory, in his *Ancient Fragments*, a work much referred to, merely transcribes Goar's list; and Mr. Cullimore, in attempting to reconcile ancient authors with each other and with the monuments, has adopted an hypothesis respecting the identity of two sovereigns, which is not tenable when the true version of the Catalogue is known. Even in Goar's edition, however, there was quite enough to have led a person of ordinary judgment to the correct readings of the Catalogue, though perhaps they could not be said to be absolutely certain without the additional light obtained from that of Dindorf.

The Catalogue in question professes to contain the names of thirty-eight sovereigns, with the years of their reigns; the whole succession occupying, as is stated, a period of 1076 years; but it is only in the last eight reigns that the errors and inconsistencies occur. The thirty-second prince is called Stamenemes β, that is, Stamenemes the Second, though there is, at present, no other of that name in the list; and the beginning of his reign—as appears from the years of the world, which Syncellus has annexed according to the Constantinopolitan reckoning—follows the termination of the preceding one by an interval of twenty-six years. Jackson, in his *Chronological Antiquities,* is positive that this prince is called the Second by a mistake, and adds the years that are wanting to the reign of his predecessor, as Goar had previously done. In the first part of this view all authors, without exception, are agreed, though they do not explain how a mistake, so very odd, could have originated; but the learned Marsham,—who, having adopted the short chronology of the Hebrew Bible, is so hard pressed to find room for the Egyptian dynasties that he is obliged to begin the reign of Menes the very year after the Deluge,—is glad to omit the twenty-six years altogether, thus reducing the sum of all the reigns to 1050 years, contrary to what is expressly stated by Syncellus. The natural inference from the state of the MSS. is, however, simply this: that the thirty-second king was Stamenemes I., that he reigned twenty-six years, and was succeeded by Stamenemes II. We may easily conceive that the eye of the transcriber, deceived by the identity of names, passed over the first, and rested on the second, thus occasioning the error. Indeed there can now be no doubt that this was the fact; because, in the MS. marked (B) by Dindorf, the next king is numbered as the thirty-fourth, the next but one as the thirty-fifth, and so on; which shows that a name had dropped out, and this name could be no other than that of Stamenemes I., who must have filled the vacant interval, and must consequently have reigned the number of years that has been assigned to him.

As neither Goar nor any other writer perceived this omission, the successor of Stamenemes II. has always been reckoned as the thirty-third in the list, and the next following as the thirty-fourth, &c. But as one error begets another, the omission was compensated by the insertion of an anonymous king, who is placed thirty-sixth in the list, with a reign of fourteen years; the insertion being necessary to complete the number (thirty-eight) which the Catalogue ought to contain. And, by a further error, these fourteen years are taken out of the reign of the thirty-seventh sovereign, who ought to have nineteen years instead of the five that have been hitherto assigned to him. This last error was occasioned by an ignorant correction of a mistake which is found in both the MSS., and which therefore probably arose from the carelessness of Syncellus himself. The thirty-seventh king and his predecessor are stated to have begun to reign in the same year of the world, and to have reigned the same number of years (five). Now from what goes before it is plain that both these numbers belong to the thirty-sixth king; and from the year of the world in which the thirty-eighth and last king began to reign, it is clear that the thirty-seventh reigned nineteen years. The mistake in the MSS. is one which might easily be made by a thoughtless writer; for the Catalogue is given in detached portions—a few reigns at a time—separated by a great quantity of other matter, and the name of the thirty-sixth king ends one of these portions, while that of the thirty-seventh begins another; so that, not having both before his eyes at the same moment, a person so careless as Syncellus might, without being conscious of it, attach the same reign and date to the two names, by transcribing twice over the same line of numbers in the Catalogue which he was copying; the whole of which Catalogue, in all likelihood, he had previously drawn up in a tabular form, with the years of the world annexed according to his own chronology, that it might be ready, as any portion of it was wanted, for immediate transference to his pages. Such seems to be the natural account of the matter; but, as usual, it does not occur to Goar, who takes the opportunity, which the confusion affords him, of foisting in his supplementary king between the two last mentioned, giving each of these five years, as in the MS., by which means he obtains room for him, while on the other hand he alters the year of the world attached to the thirty-seventh king, so as to make it suit his hypothesis.

The following is a view of the last eight reigns, as they appear to have stood in the original document, compared with the erroneous list of Goar. The years of the world are omitted, as being of no importance, except so far as they are useful in the preceding argument.

I. Goar's List.		Years.	II. Corrected List.		Years.
31. *Peteathyres*	reigned	42	31. *Peteathyres*	reigned	16
32. *Stamenemes*	,,	23	32. *Stamenemes* I.	,,	26
33. *Sistosichermes*	,,	55	33. *Stamenemes* II.	,,	23
34. *Maris*	,,	43	34. *Sistosichermes*	,,	55
35. *Siphoas*	,,	5	35. *Maris*	,,	43
36. Anonymous	,,	14	36. *Siphoas*	,,	5
37. *Phruoro*	,,	5	37. *Phruoro*	,,	19
38. *Amuthartæus*	,,	63	38. *Amuthartæus*	,,	63

The interval of time which has been shown to belong to the first Stamenemes, and which was added by Goar to the reign of Peteathyres, is differently disposed of by Mr. Cullimore, in a chronological table which he has given in the second volume of the Transactions of the Royal Society of Literature. His object being to compare the lists of Eratosthenes, Manetho, &c., with the supposed hieroglyphical series, he makes Saophis, the fifteenth in Eratosthenes' Catalogue, the same as a king whose name is read Phrathek Osirtesen; but the forty-third year of the latter is mentioned on the monuments, whereas Saophis has only twenty-nine years in the Catalogue. To escape from this difficulty, therefore, Mr. Cullimore adds the unappropriated interval to the reign of Saophis, thus giving him fifty-five years instead of twenty-nine. But it now appears that such a supposition is altogether inadmissible, and consequently the two personages in question cannot be identified; a circumstance which proves that there is some fault in Mr. Cullimore's assumptions, and that his other conclusions, at least in this part of his table, cannot be relied on.

The corrections here given do not interfere with the inferences drawn by Professor Mac Cullagh from the Catalogue of Eratosthenes in a former paper on Egyptian Chronology (Proceedings of the Royal Irish Academy, vol. i. p. 66), because the portion of the Catalogue with which he was there concerned terminates with the reign of Queen Nitocris, the twenty-second in the list. The corrections, indeed, though not hitherto published, were made long before the date (April, 1837) of that paper, but not before he had adopted the hypothesis therein proposed, as an answer to the old and ever-recurring question—Who were the Egyptian sovereigns that were contemporary with Moses? For it was in consequence of this hypothesis, which had suggested itself to him at a very early period, that he was led to examine the Catalogue minutely, in order to discover whether his chronology was affected by its errors.

Having been led to refer to his hypothesis, Mr. Mac Cullagh took occasion to observe that, in the interval which had elapsed since it was published, he had not met with any facts that were opposed to it: on the contrary, the more he considered it, the more he was inclined to believe in its reality; though it was entirely different from every other that had been proposed, either by modern chronologers or by the early Fathers of the Church, in their manifold attempts to connect the narrative of Moses with the remaining fragments of Egyptian history. The hypothesis, indeed, is the *only* one which, while it gives a probable date for the Exodus, also satisfies what Mr. Mac Cullagh conceives to be the necessary conditions of the question; namely, a very long reign —of at least eighty years—during which the Israelites were persecuted, succeeded by a very short one—apparently not more than a year—during which their deliverance was wrought; and it is interesting in itself, on account of the remarkable connexion which it establishes between sacred and profane history, and the highly dramatic character of the events which are thus, for the first time, brought into view.

Mr. Petrie exhibited a drawing, on a large scale, of an ancient inscribed grave stone at Clonmacnoise, which he considered as interesting, not only as a characteristic example of the usual sepulchral memorials of the Irish, from the sixth to the twelfth century,—and of which Mr. Petrie has collected upwards of three hundred examples,—but also as a monumental record of a person very eminently distinguished for his learning in Ireland in the ninth century.

This stone, which is about four feet in length, and three in breadth, though never squared or dressed, exhibits a very richly carved cross, and the following simple inscription:

c·
SVIBINE. m̄ MAILCAE HVMAI·

SUIBHNE, THE SON OF MAILÆHUMAI.

Of the celebrity, in his day, of the person who is thus recorded, the Irish Annals, as well as those of England and Wales, bear abundant evidence.

In the Chronicon Scotorum his death is thus recorded at the year 890: Suibne mc Maoilhuma, ancorita Cluana mac noir, deg.

Thus also in the Annals of Ulster at the same year, or more correctly 891: Suibne mac Maele humai, Ancorita, et scriba optimus Cluana mac nois, dormiuit.

To the latter entry, Doctor O'Conor, in his *Rerum Hib. Scriptores*, appends the following note:

" *Suibneum* hunc *Annales* Anglosaxonici *Suifnethum* appellant.—Vide *Chron. Saxon.* ad ann. 891, 'Tres Scoti de Hibernia, ad Ælfredum regem Anglorum venerunt, *Dubslanus, Maccebethus,* et *Mælinmunus, Swifneth* etiam, præcipuus doctor qui inter Scotos fuit, decessit,'—concordat *Fabius Æthelwerdus,* qui tertium appellat—'*Magilmumenum artibus frondentem, littera doctum, magistrum insignem Scotorum.*'—Chron. l. 4, c. 3. Eadem habet *Wigorniensis* ad ann. 892, et *Mathæus Florilegus,* ad ann. 891. Huc etiam referenda sunt quæ habet Caradocus ad ann. 889, 'Suibnion Cubin Doctorum Scotiæ maximus obiit.' "

Sir James Ware, in his *Irish Writers*, tells us, that "his works, and the titles of them, are lost."

Mr. Griffith presented, on the part of the Shannon Commissioners, a collection of antiquities discovered in the Shannon, and gave the following account of the locality and other circumstances attending the discovery.

The object of my present communication is to notice the discovery of certain ancient arms in an excavation made in the bed of the river Shannon at the ford of Keelogue, four miles below Banagher, in the King's County.

The ford at Keelogue, and that of Meelick, which is immediately below it, is the first point of the river Shannon which was anciently passable except by boat, above the falls at Killaloe, a distance of thirty British, or nearly twenty-five Irish miles; and consequently, previously to the construction of roads, and the erection of bridges at Portumna and Banagher, this ford must have been the main pass between the northern portion of the county of Clare, and the southern portion of the county of Galway, with the counties of Tipperary, King's County, &c. &c. Hence it is probable that at a former period the ford at Keelogue, which is the shallowest on the river, and much better than that of Banagher, was the principal point of communication between the districts above enumerated; and even in modern times, in common with the passes by the bridges of Banagher, Shannon Bridge, and Athlone, the defence of the pass at Keelogue and Meelick was considered of sufficient importance to induce the British Government to erect two towers, mounted with cannon, on the King's County side, to guard the passes of the river from the west.

The fall of the river Shannon at Keelogue and Meelick amounts to ten feet; and to render the river navigable, the commissioners appointed to direct the improvements of the navigation of the Shannon, have agreed with contractors for the construction of a lock of very large dimensions, a stone weir to regulate the discharge and the level of the water, and for the deepening of the river at Keelogue ford, by excavating the bed to the depth of six feet below the present bottom, so as to give a depth of full seven feet six inches for navigation when the works shall have been completed.

Towards deepening this ford the contractors dammed off a portion of the river 100 feet in width, and 700 feet in length, and have commenced an excavation of nearly six feet in depth; the material to be excavated consisted at the top of two feet of gravel, loose stone, and sand, and at the bottom of four feet of a mass, composed of clay and rolled limestone, which in some parts was found to be so solid and compact, that it became necessary to blast it with gunpowder, in preference to excavating, according to the ordinary system, through detrital matter.

This compound of clay and rolled limestone, and limestone gravel, is similar to that which forms the bed of the Shannon at all the other fords over which bridges have been erected, as at Banagher, Shannon Bridge, Athlone, &c., and these gravel banks in most cases are in connexion with, and in fact form a part of those low, but steep, ridges or hills, composed of clay and rolled limestone, which occur so abundantly in the King's, Queen's County, and the counties of Westmeath and Longford, on the east side of the river, and in the counties of Clare, Galway, and Roscommon, on the west. These gravel ridges, or *eskers*, as they are generally called, usually affect an east and west, or north-west and south-east direction, and consequently cross the river Shannon, whose direction between Athlone and Killaloe is north-east, south-west, nearly at right angles; hence the fords, which, particularly at Athlone, Shannon Bridge, &c., are merely gaps cut through the eskers by the action of the water, run directly across the river, and present shallow, having deep ponds of water on either side, so that when the falls are not considerable, as at the fords of Banagher, Shannon Bridge, &c., the excavation of the bed of the river at the ford will bring the water on both sides to a level, and there will still remain ample depth above for the purposes of navigation.

But to return to Keelogue, I have already mentioned that the upper part of the excavation consisted of two feet of loose stones, gravel, and sand, and the lower part of four feet of a very compact mass, composed of indurated clay and rolled limestone. In excavating in the loose material of which the upper two feet was composed, the labourers found in the shallowest part of the ford, a considerable number of ancient arms, consisting of bronze swords, spears, &c., in excellent preservation, which are similar to those which have been frequently discovered in other parts of Ireland; and towards the lower part of the upper two feet they discovered a great number of stone hatchets, also similar in many respects to those which have been so frequently met with in different parts of this country. In regard to the stone hatchets, I would merely observe, that the greater number, which are black, are composed of the siliceous rock called Lydean Stone, which occurs in thin beds, interstratified with the dark gray, impure limestone called Calp, which is abundant in the neighbourhood of Keelogue and Banagher; but the others, some of which present a bluish gray, and some a yellowish colour, are composed of a subcrystalline, and apparently igneous porphyritic rock, none of which occurs in the neighbourhood, or possibly in the south of Ireland. Hence it is probable that the latter, which are much more perfectly executed than the black, or those composed of Lydean Stone, were brought from a distance, and probably from a foreign country.

The important and interesting subject for consideration in the antiquities before us is, that they are evidently the relics of very different, and probably distant periods. Owing to the rapidity of the current at Keelogue ford, it is extraordinary that any comparatively recent deposit should have been formed, and at all events the annual increase must have been inconsiderable; hence, though not more than one foot of silty matter may be found between the stone weapons of a very remote age, and the swords and spears of another period still remote from us, yet under the circumstances described centuries may have intervened between the periods of mortal strife which must have taken place in the river probably between the Leinster men and Connaught men of old, disputing the passage of the river at two distinct and no doubt very distant periods.

I am not sufficiently versed in the ancient Irish history to say whether any records are in existence of a battle having been fought at the fords of Meelick and Keelogue; but if any such exist I have no doubt that many members of the Academy, and lovers of ancient lore, will be enabled to enlighten us on the subject. I have only further to mention, that I have been deputed by my brother Commissioners for the improvement of the Shannon Navigation to present these ancient relics to the Royal Irish Academy, for the purpose of being added to their already important and valuable collection of Irish antiquities.

DONATIONS.

Supplementary Appendix to the Report of the Poor Law Commissioners of the Medical Charities in Ireland, with Indexes. 1841. Presented by the Commissioners.

A pamphlet entitled, " Is Selenium a true Element?" Presented by Septimus Piesse.

Transactions of the Zoological Society of London. Vol. III. Part 1. 1842.

Reports of the Auditors and Council of the Zoological Society of London, April 29th, 1842, *and List of Members.*

Su la Falsita dell' Origine Scandinava di Jacopo Graberg di Hemso.

Sunto della Letteratura Svezzese.

Degli Ultimi Progressi della Geografia (two copies).

Saggio Istorico su Gli Scaldi o Antichi Poeti Scandinavi.

Occhiata Sullo stato della Geografia nei Tempi Antichi e Moderni.

Specchio Geografico, e Statistico dell' Impero di Marocco. Presented by the Author.

A copy of the Ordnance Survey of the County of Waterford, in forty-two sheets, including the Title and Index. Presented by His Excellency the Lord Lieutenant.

Extraits du Tome XV. et XVI. des Memoires de l'Academie Royal de Bruxelles, with Notes. Presented by the Academy.

Examinations at the University of London for M.D., B. M., B. L., M. A., and B. A., (six pamphlets). Presented by the University.

Memoires de l'Institut Royal de France. Tome Quinzieme. Presented by the Institute.

Specimen de l'Imprimerie de Bachelier. Presented by the Author.

Memoirs of the Royal Astronomical Society. Vol. XIV. Presented by the Society.

Memoire sur la Chaleur des Gas Permanens. Par Jean Plana. Presented by the Author.

Proceedings of the Royal Society, &c. 30th Nov. 1842. Presented by the Society.

Revista de Espana y del Estrangero. B. Fezuier Gonzalo Moror. Tomo I. Presented by the Author.

Geological Report of Londonderry. By Captain Portlock, M.R.I.A., &c. Presented by the Master General and Board of Ordnance.

Archives du Muséum d'Histoire Naturelle de Paris. Tome III. Liv. 1 and 2. Presented by the Museum.

Address to the Geological Society of London. By Roderick Impey Murchison, F.R.S., &c. Presented by the Author.

Report of the Twelfth Meeting of the British Association, held at Manchester in 1842. Presented by the Association.

Statutes relating to the Admiralty, to the eighth Year of George III. Presented by Captain Portlock.

Ancient Irish Pavement Tiles, with Introductory Remarks. By Thomas Oldham, Esq. Presented by the Author.

Proceedings of the Glasgow Philosophical Society, 1841, 1842. Presented by the Society.

Memoires publies par la Société Hollandaise des Sciences. Second Serie. Tome II. Presented by the Society.

Proceedings of the American Philosophical Society. Vol. II. Nos. 24 and 25.

Transactions of the American Philosophical Society. Vol. VIII. New series. Parts 2 and 3. Presented by the Society.

Fifth Annual Report of the Loan Fund Board of Ireland. 1843. Presented by the Commissioners.

Communication to the Right Hon. Sir Robert Peel, Bart.

By Jeffries Kingsley, Esq., M.R.I.A. Presented by the Author.

Bulletin des Séances de la Société Vaudoise des Sciences Naturelles. Nos. 1–4. Presented by the Society.

Sur les Figures Roriques et les Bandes Colorées produites par l'Electricité. Par M. P. Riess. Presented by the Author.

Expériences sur la non caloricité propre de l'Electricité.

Sur les relations qui lient la lumiere a l'Electricité.

Sur les travaux récents qui ont eu pour objet l'etude de la vitesse de propagation de l'Electricité. Par M. le Prof. Elie Wartmann. Presented by the Author.

Journal of the Franklin Institute. Vols. III. and IV. Third Series. Presented by the Institute.

Proceedings of the Zoological Society of London. Part 10. 1843. Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1842. No. 38.

January 23.

Rev. JAMES H. TODD, D. D., Vice-President, in the Chair.

Mr. G. J. Allman, read the following paper on the Muscular System of certain fresh water ascidian Zoophytes, being the first of a series of memoirs which he proposed presenting to the Academy on the physiological and zoological history of the zoophytes of fresh water.

"The subject on which I have now the honour of addressing the Academy, belongs to a hitherto but little investigated department of zoology, the structure of the ascidian zoophytes* of fresh water. Our present knowledge of these minute creatures is chiefly due to Raspail, the distinguished French naturalist and chemist, whose researches into the structure of Alcyonella Stagnorum, are characterized by much patient observation,† while in these countries the subject has been totally neglected. Not so, however, with the ascidian zoophytes of the ocean; these interesting animals have had both here and on the continent some able investigators, among whom none deserve to be mentioned before

* The zoophyta ascidioida of Johnston are synonymous with the bryozoa of Ehrenberg, and the ciliobrachiata of Farre, and include all those zoophytes whose organization is referrible to the molluscan type.

† Compte rendu des seances de l'Academie des Sciences. 4 Fevrier, 1839.

Milne Edwards, and Farre, and it is especially to the latter indefatigable and accurate observer that we are indebted for a knowledge of the minute anatomy of these most curious and highly organized polypes. Though in my own investigations into the anatomy of the fresh water zoophytes of this order, I have not restricted myself to any particular structures, I yet intend, in the following remarks, confining my observations to their muscular system; reserving for some other occasion the pleasure of directing the attention of the Academy to those points of their anatomy not dwelt upon in the present paper.

"In the remarks which I am about to offer, it will be seen how closely the ascidian zoophytes of our fresh waters correspond in organization with the marine species; and though in minute anatomical detail certain differences will be observed, yet these differences are far from invalidating the unity of the type of structure,—a unity which will be found from the following observations to pervade, in a remarkable degree, the entire order. I would wish it to be understood too, that if I should in any respect differ from the statements of Dr. Farre, I offer no opposition whatever to his observed facts, but solely to one or two of the conclusions to which they have induced him to arrive.

"The animal of the present order, to the muscular anatomy of which I have chiefly attended, is one which has not as yet been recorded as a native of the British Islands. About two years since I was sent, by Mr. William Thompson of Belfast, to whose researches into the natural history of this country we are so much indebted, a small portion of the dried polypidom of a zoophyte, which he found, in September, 1837, cast upon the shore of Lough Erne. From the dried condition of the fragment,—a condition in which the fresh water zoophytes lose all their most interesting characters,—I was unable at the time to arrive at anything satisfactory in the investigation of the species; I therefore contented myself by sketching in my note-book, the few imperfect external characters which continued visible on the dry and shrivelled zoophyte. No farther than this did my knowledge of Mr. Thompson's discovery extend, when an opportunity fortunately occurred in October last, of obtaining living specimens of the animal. These I discovered in the Grand Canal, near Dublin, and have thus been enabled to pursue my investigations, from which I find the species to be one of great interest. I find, moreover, that although it has been hitherto unnoticed, as a British animal, it is identical with the alcyonella articulata of Ehrenberg, for which Gervais, who found the animal near Paris, subsequently constituted a new genus, under the name of Paludicella.* It is also noticed by Van Beneden, who met with it near Louvain, and gives a figure of it,† which, though not very good, will yet be found of use in the identification of the species. Though Ehrenberg's appellation possesses the claim of priority, yet, as it refers the zoophyte to a genus into which its structure will not admit it, it must be rejected, and I shall accordingly adopt the name Palludicella, by which it has been designated by Gervais.

"In the following remarks upon the muscular system of the fresh water ascidian zoophytes, my description of this system is chiefly derived from observations made upon Paludicella articulata, as there are certain points in the muscular anatomy of other species, upon which I cannot as yet speak with certainty, and for completing my observations on which, I must wait until the approaching Spring shall afford me fresh objects for investigation.

"In describing the muscles of these animals, I have availed myself of Dr. Farre's phraseology, applying to the several sets of muscles in the fresh water ciliobrachiate zoo-

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* Bulletin de l'Acad. Roy. de Bruxelles, an. 1839.

† Mem. de la Société d'Hist. Nat. de Paris, tom. 4.

phytes, the same terms which Farre has given to the analogous sets in the ciliobrachiates of the sea.

"In Paludicella then, three groups of muscles may be detected. These are strictly analogous to muscles which have been demonstrated in the salt water zoophytes of the same order, and for a description of which, we are indebted to an admirable paper of Dr. Farre, in the Philosophical Transactions, an. 1837. The first of these groups to which I shall direct your attention, corresponds with the anterior set of retractor muscles of Farre. It may be observed (fig. 3 and 4, *h*, *h*) to take its origin from the internal surface of the walls of the cell near the middle, and thence to pass upwards in order to be inserted into the margin of the tentacular disk, and upper part of the pharynx. The action of this group is obvious, it is the true retractor apparatus of the polype, and it is worthy of remark, that neither in this nor in any other fresh water zoophyte whose anatomy I have studied, could I detect muscular fibres analogous to those described by Farre, as inserted into the remote extremity of the stomach in those zoophytes of the sea which had come under his observation.

"The second set of muscles to be described in Paludicella, consists of four bundles of fibres (fig. 3 and 4, *i*, *i*, *i*) which arise from the inner walls of the cell near the top, two at each side, having the tubular orifice between them. From this origin, they pass towards the aperture of the cell, slightly converging, and are inserted by distinct attachments, which are all placed in the same plane, into the inner surface of the tube near the margin of the orifice. These are in every respect analogous to the muscles which Farre describes under the name of opercular, and to which he ascribes the office of assisting in the inversion of the polype tube drawing in its margin after the retreating polype, and by their continued action, closing the orifice of the cell. Reasons will presently be given for dissenting from this view of the action of the opercular muscles, and in the meantime I shall proceed to the description of the third group.

"The third group is analogous to one detected by Dr. Farre, in the ascidian zoophytes of the sea, and to which he has given the name parietal. The parietal muscles take a transverse course, and originate and terminate in the internal membrane of the cell. In paludicella (fig. 3 and 4, *k*, *k*, *k*, *k*) they are rather numerous, and consist of short fibres of variable length, which pass transversely round the internal tunic, being capable of detection through nearly the entire length of the cell, and sometimes passing one another in their course, they may be seen to surround the cell with a contractile tissue. Dr. Farre is of opinion, that these muscles in the zoophytes which he has examined, are attached by their extremities only, being free in the intermediate space. In paludicella however, I saw nothing which would lead me to suspect, that in this zoophyte such was their disposition. I shall not here, however, speak positively, as it will require more extensive observations before any decisive conclusion can be arrived at.

"Such are the three great groups of muscles which I have succeeded in detecting in paludicella, and so far as my observations have gone, analogous groups are to be found in the other fresh water ciliobrachiates. It will at once be seen, by any one acquainted with Dr. Farre's paper, that while the muscles just described correspond in all their important features with those of the ascidian zoophytes of the sea, thus beautifully demonstrating the unity of type by which the order is characterized, yet in the details of the several groups, some remarkable modifications will be found to exist.

"The first thing which strikes us is the absence, probably among all the fresh water ascidian zoophytes of that well-developed fasciculus of muscular fibres, which is observed in those of the sea, to arise from the bottom of the cell, and pass upwards to be inserted into the fundus of the stomach. It is true, that Trembley describes in alcyonella stagnorum, a certain appendage to the fundus of the stomach, to which he assigns the office of a retractor muscle; "J'ai vu," says Trembley, "distinctement, lorsque les polypes à panache etaient bien au dehors de leur cellules un fil qui tenait d'un côté a l'extrémité inferieure de l'estomac et de l'autre au fond de la cellule."* Raspail supposes this an erroneous observation, and conceives that Trembley mistook for a distinct organ, the appearance presented under the microscope, by a fold of the reflected tunic.† Notwithstanding, however, the criticism of Raspail, I believe the observation of the celebrated historian of the green polype to be perfectly correct, though his reasoning is erroneous.

"I have myself witnessed in Plumatella repens, an organ in every respect corresponding to Trembley's description; I believe this organ to be an ovary, though from its position and attachments, Trembley's opinion might at first appear correct, and the structure in question might be supposed analogous to the posterior set of retractor muscles in the ciliobrachiate zoophytes of the sea. This supposition, however, is untenable, and I have satisfied myself by repeated observations, that no such function is performed by it; it is observed to undergo no contraction, and its motions are entirely passive and dependant on those of the body of the polype.

"In the same animal, Trembley also describes as retractor muscles, filaments attached by one extremity to the base of the plume of tentacula, and by the other to the bottom of the cell;‡ but this, likewise, is considered by Raspail as an error, and referrible to the same source as the former. Here again I must dissent from the French naturalist; the fila-

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* Hist. des Polypes d'Eau douce, p. 216.

† Mem. de la Soc. d'Hist. Nat. de Paris, tom. 4, p. 92.

‡ Op. cit. p. 216.

ments alluded to by Trembley correspond closely with fasciculi described above, as existing in paludicella, and which I have also witnessed in other fresh water zoophytes; and I cannot but think, notwithstanding the high authority of Raspail, that they are really such as Trembley describes them. It is worth remarking, that Raspail denies the existence of retractor muscles in alcyonella, believing that, with the general contractility of the animal, such a contrivance would be superfluous. I have not yet succeeded in obtaining any specimens of alcyonella, so that upon this point I cannot speak from direct observation. Since these muscles, however, are particularly well marked in all the fresh water ascidian zoophytes, whose anatomy I have studied, as well as in those of the ocean, I must still adhere to the original observation of Trembley; for it can hardly be supposed, that a genus so nearly allied to those in which the system in question is well developed, and which Raspail, by the way, would consider but as a different grade of evolution, should be altogether destitute of them.

"In Plumatella repens I have examined, with much care, the retractor apparatus. In this species it consists of two fasciculi of muscular fibres, which arise from the sides of the cell near the bottom; and thence passing upwards symmetrically, one along each side of the body of the polype, receive an extensive attachment, being inserted into the wide part of the tentacular crescent, into the pharynx for its entire length, and into the upper part of the stomach; a few fibres appear detached at each side from the main fasciculus, to be inserted more externally near the base of the tentacular lobes. The function of these muscles is evident, acting from their more fixed attachment to the side of the cell, they become powerful retractors, by which the body of the polype is drawn inwards and concealed in the more internal parts of the polypidom.

"In the opercular muscles, paludicella offers no remarkable deviation from the general arrangement of these muscles in the salt water species. In plumatella repens, however, and perhaps in most other species of fresh-water ciliobrachiates, their arrangement is very peculiar. In this zoophyte, they consist of a series of about twenty-five distinct delicate fasciculi, which arise from the internal surface of the cell at regular intervals, and in a plane perpendicular to its axis, and thence radiating inwards are inserted into the opposed surface of the reflected tunic.

"In assigning their proper office to the muscles which have been already described as the true retractor apparatus of the polype, no difficulty whatever is met with; neither can we be at a loss in discovering the true function of the parietal muscles, for these acting upon the flexible internal tunic of the polype cell, must necessarily, by their contraction, diminish transversely the space included between this tunic and the body of the polype, a function the great importance of which, in the economy of the little animal, will presently be apparent. When, however, we attempt to explain the action of the opercular muscles, the task will perhaps be found not quite so easy. It has been stated that Dr. Farre assigns to these muscles the office of drawing in the flexible portion of the polype tube after the retreating polype, and by their continued action closing the orifice of the cell. I cannot help thinking, however, that in ascribing this office to the opercular muscles, Dr. Farre is correct but to a very limited extent, and that their chief use is directly opposite to that assigned to them by this excellent observer. The use which I would assign to the opercular muscles is, first, that of assisting the polype in its protrusion, an office which they accomplish by fixing and preserving in the axis of the polype tube that portion of the reflected tunic (fig. 4, *c*, *c*) which is included, during the retracted state of the animal, between the summit of the fasciculus of approximated tentacula, and the orifice of the cell; and, secondly, what is a still more important function, that of affording to the respiratory surface, when the polype is retracted within the recesses of its cell, a constant supply of fresh water, of which the little animal would be deprived, were it not that some means existed of dilating the tubular reflection of the tunic, an office to the performance of which these muscles are fully adequate, acting then in a state of antagonism to the parietal muscles, which tend to keep the orifice of the tube closely shut.

"My objections to Dr. Farre's view of the function performed by the muscles in question are referrible to three heads: first, want of necessity in ascribing to them the office for which this anatomist believes them destined; secondly, their inability to perform the function which he ascribes to them; and thirdly, the possibility of assigning to them another office in full accordance with the necessities of the animal.

"That we are not obliged to seek for opercular muscles, in order to account for the closing of the orifice when the polype has retired into the recesses of its cell, is evident, if we give the slightest consideration to the action of the true retractor muscles. It is quite plain that the retraction of the polype itself, which is effected by the muscles which act directly upon it, is amply sufficient to produce the complete invagination of the flexible termination of the cell; and, accordingly, observation will convince us that this invagination follows exactly the retraction of the polype, and is evidently related to the latter action as an effect to a cause. That the opercular muscles cannot, except in a very partial manner, produce the effect ascribed to them by Dr. Farre, is also evident, when we reflect upon their course and attachments. Arising from the circumferential portion of the cell, and thence passing inwards, to be inserted into a point nearer to the axis, they must, after the invagination of the tunic has proceeded beyond the plane of their insertion, possess upon the reflected tunic a decidedly *dilatable* action,—an action which is antagonized, first, by the parietal muscles, as will be presently explained, and, secondly, by the true retractor muscles; for these muscles, acting through the medium of the polype, in most instances nearly centrally, or in the axis of the tube, will not, in their ordinary action, possess any dilating power, but, on the contrary, will tend to close the aperture by approximating the sides of the tubular reflection of the cell.

" Since we have thus seen that the opercular muscles are incapable of producing the closure of the orifice, it becomes an interesting subject of inquiry to determine by what means the act in question is performed, and indeed a slight consideration will render manifest the simple yet effective mechanism appropriated to this purpose. The great agents by which the closure of the cell is effected are to be found in the parietal muscles, for these fibres, by pressing the fluid of the cell against the tube of invaginated membrane (fig. 4, *c*, *c*), will approximate the sides of this tube to one another, at the same time that the membrane will be thrown upwards against the aperture of the cell, thus completely closing the orifice, and enabling the little animal to rest secure from all intrusion in the recesses of the polypidom.

" After this account of the muscular system of the polypes, the mechanism will now be easily understood by which the animal is protruded from its cell when hunger calls it forth to seek its food in the surrounding medium, or when desirous of exposing its respiratory surface still more perfectly to the vivifying influence of the aerated water.

" Previously to the discovery of the parietal muscles no satisfactory explanation had been given of the protrusive act of the polype, and even since the detection of these muscles by Dr. Farre, their share in effecting the protrusion of the animal would appear to be underrated. Dr. Farre considers their influence in this respect as of secondary importance, and would seem to attribute the act in question mainly to the straightening of the œsophagus, which in the ciliobrachiates of the sea is bent upon itself during the retracted state of the polype. In none of the fresh water species, however, which I have examined, with the exception of Paludicella articulata, does this curvature of the œsophagus appear to exist; we therefore cannot in these instances have recourse to its agency in accounting for the phenomenon now under consideration, and we are consequently driven to the parietal muscles, or to the general contractibility of the internal tunic, as the only provision by which this important act can be effected. I mention the general contractibility of the internal tunic as a probable agent in protrusion, for I do not think the existence of the parietal muscles throughout the entire order as yet sufficiently established.

"We shall now suppose the polype withdrawn into the recesses of its cell, and that hunger or some other stimulus impresses on it a desire of protrusion. The parietal muscles, which appear to me to be the direct agents in effecting the protrusive act, now begin to contract, and thus exercise a pressure on the fluid which surrounds the polype, and is included between the latter and the internal membrane of the cell. The compressed fluid in its turn acts upon the polype, and by its upward pressure against that portion of the flexible tunic which is carried in by the animal during its retreat, will tend to produce an eversion of this membrane, which, in the completely retracted state, constitutes a tube of some length between the summit of the fasciculus of approximated tentacula and the orifice of the cell. The opercular muscles at the same time coming into play will, by their nicely adjusted action, keep the invaginated tunic exactly in the axis of the orifice, and thus materially assist in effecting the necessary protrusion, which, by the continued action of the parietal muscles, will go on increasing till the complete evagination of the reflected membrane has taken place. This, then, I conceive to be the true account of the protrusive act, and that the apparatus just mentioned is amply sufficient for the purpose, without having recourse to the agency of the bent œsophagus,—an agency which in plumatella repens, and other fresh water zoophytes, which I have examined, assuredly does not exist, as in these the œsophagus is straight during the retracted state of the animal. In the remarks now offered, however, I do not deny that some influence is exercised by the straightening of the œsophagus in those species in which this tube is bent upon itself previously to the commencement of protrusion; I merely wish to assert that we are not necessarily obliged to have recourse to this agency, but that in some instances, at least, the parietal muscles, or, in their absence, the general contractility of the internal tunic, are agents perfectly effective.

"Such are the observations which I have had an opportunity of making on the muscular system of the ascidian polypes of fresh water. I am fully aware that they are far from being perfect, but for this my excuse must be found in the extreme difficulty of such investigations, made, as they all necessarily are, under a high power of the microscope, with an illumination most carefully adjusted, and which can by no means be at all times obtained, in order that structures of such extreme tenuity and transparency may not entirely escape detection. The observations have all been made on the living animals, and no one who has not devoted himself to such investigations can form any idea of the close and patient attention which they require,—the constant watching to obtain the animal in the exact condition or position, in which alone certain peculiarities of structure are apparent; and, finally, the mortification of finding the conclusions to which we had arrived on one day, after hours of painful attention, invalidated by some more favourable observation on the next.

"In the present communication I have confined myself to the muscular system; on some other occasion I may perhaps again entreat the indulgence of the Academy, while I lay before it my observations upon other not less interesting parts of the structure of these curious animals."*

Description of the Plate.

Fig. 1. Paludicella articulata; natural size.

Fig. 2. Portion of the polypidome magnified.

Fig. 3. A cell with the polype exserted.

a, a, a. The polype cell.

b. The orifice of the cell.

c. That portion of the internal tunic which is carried out by the polype during its egress from the cell.

d. The stomach of the polype.

e. The rectum.

f. The œsophagus.

g. The crown of tentacula exserted and expanded.

h, h. The proper retractor muscles of the polype; they are now relaxed, and carried out by the animal in the act of protrusion.

i, i. Two of the four sets of opercular muscles, also in a state of relaxation.

k, k, k, k. The parietal muscles, preserving, by their contraction, the membrane *c*, in a state of tension, and thus maintaining the exserted condition of the polype.

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* After the present account had been written, I happened to meet with a paper by M. Dumortier, in the Bul. Ac. Brx. an. 1835, on the *Polype à Panache* of Trembley, a polype belonging to the order now under consideration, and for which M. Dumortier constitutes a distinct genus under the name *Lophopus*, characterized by the tentacula, being destitute of cilia. So remarkable an exception, however, would this character offer to that of the entire order, that I cannot but suppose Dumortier in error; an opinion in which I believe myself fully born out by the phænomena subsequently described by this naturalist, and which are evidently the result of imperfectly observed cilia.

Dumortier details, at considerable length, the anatomy of the zoophyte, and has witnessed fibres corresponding with the retractor and opercular muscles described in the present communication. His paper is well worth perusal, though some of his statements will require further corroboration.

Fig. 4. A cell with the polype retracted.

a, a, a. The polype cell.

b. The orifice of the cell.

c, c. The inverted membrane, which, in the completely retracted condition of the polype, consists of that portion of the internal membrane which had been carried out in the act of exsertion, together with the more flexible termination of the external tunic of the cell.

d. The stomach of the polype.

e. The rectum.

f. The œsophagus. Both rectum and œsophagus are here curved upon themselves, and thus accommodated to the retracted state of the polype.

g, g. The crown of tentacula retracted, and the tentacula approximated into a close fasciculus.

h, h. The proper retractor muscles of the polype in a state of contraction.

i, i, i. The opercular muscles also contracted.

k, k, k, k. The parietal muscles relaxed.

Dr. Robinson gave a brief account of meteors observed at Armagh on the 10th of August, 1842, apologizing for the imperfect nature of the observations, while he felt that it was desirable that they should be placed on record.

The sky had been overcast, but became clear a little after ten, of which Dr. R. was availing himself to try an eye-piece of a peculiar construction, when the appearance of two large meteors, travelling in nearly the same direction, reminded him of the peculiar character of the 10th, and in conjunction with T. F. Bergin, Esq. and another observer, he proposed to watch for others. The roof of the dwelling-house afforded an excellent position. Mr. Bergin looked south-west; he (Dr. R.) east; and the third north. From $10^h.55^m$. Armagh time, till 12^h, seventy-eight were seen; of which about twenty were in Dr. Robinson's district, and fifty in Mr. Bergin's. With scarcely any exception, their tendency was in tracks converging at ζ Ophiuchi. The greater part of them were larger than ordinary falling stars, and left a red train; in some instances a luminous cloud marked for a few seconds the place of their disappearance, and then was faint Aurora towards north-west. The night was occasionally cloudy, and after twelve became completely overcast.

DONATIONS.

Report of the Limerick Philosophical and Literary Society. Presented by Dr. Gore.

Supplementary Appendix to the Report of the Poor Law Commissioners on the Medical Charities, Ireland. Presented by the Commissioners.

February 13.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Robert Culley, Esq., James Magee, Esq., and H. L. Renny, Esq., were elected members of the Academy.

A paper on the Action of certain Salts as Manures, by the Rev. Thomas Knox, was read by the Secretary of Council.

"A small meadow, containing about an English acre, was divided into six plots, and in last Spring, were manured as follows:

1st.	2nd.	3rd.	4th.	5th.	6th.
Ashes.	Stable manure.	Burned gypsum, 4 stone.	Muriate of ammonia, 6 lbs.; pearl ash, 6 lbs.; 8 lbs. of bones, burned and dissolved in half a pint of sulphuric acid, and diluted largely.	Guano, 2 stone.	$2\frac{1}{2}$ barrels of lime mixed with earth.

Plots 1st, 2nd, 3rd, and 6th, were top dressed in March; plots 4th and 5th in April. Mr. Knox first remarks, about the composition of No. 4, that the quantity of muriate of ammonia was calculated (according to Liebig) on the supposition that the decomposition of the ammonia furnished all the nitrogen required for the plant, and was sufficient to give a heavy crop with the addition of the ammonia derived from the rain. The quantity of bones was sufficient to furnish all the phosphates required, at the rate of from three to four tons to an acre, and were, as Liebig suggested, first dissolved in sulphuric acid, and having been mixed with a large quantity of water, were sprinkled evenly over the land. At first, plots 1st and 2nd, those manured with ashes and stable manure, appeared much the most luxuriant, and even up to the time of cutting, that top dressed with manure seemed far a finer and heavier crop, and had a richer colour. When ripe, the plots were mowed and saved quite separately, and that there might be no mistake, pegs had been driven down deep into the ground at the time of laying on the top dressing. When the hay was quite dry and saved, the produce of each plot was weighed separately, and I was then surprised to find, that though the stable manure was to all appearance the best, yet the plot manured with the mixed salts and dissolved bones much surpassed it; also that on which the ashes had been used. This, in case of plot 1st, I consider to be due to the potash (which the ashes contain), enabling the plant to take up more silica from the soil; and in the case of plot 4th, to the potash and phosphates, by which greater firmness of stalk was acquired by the plant, and it was prevented from losing weight in drying, as the one that was top dressed with the stable manure did. I was prevented at that time from determining this analytically, which might have been done, simply by weighing the ashes resulting from burning equal weights of hay. I here give the weights of hay, the exact quantity of land, which was regularly surveyed, and also the weight of hay calculated at what it would be per acre.

1st Plot.	2nd Plot.	3rd Plot.	4th Plot.	5th Plot.	6th Plot.
Hay, 8½ cwt. Land, 24½ perch	Hay, 9½ cwt. Land, 27½ perch	Hay, 8¼ cwt. Land, 25¼ perch	Hay, 8 cwt. Land, 22 perch.	Hay, 6 cwt. Land, 21½ perch	Hay, 5 cwt. Land, 20 perch.
Produced at the Rate per Acre,					
Ton Cwt. St. 2 15 4	Ton Cwt. St. 2 15 1	Ton Cwt. St. 2 9 7	Ton Cwt. St. 2 18 2	Ton Cwt. St. 2 4 6	Ton Cwt. St. 2 0 0

"The results of the above experiments point out the advantage of the salts of ammonia and potash when combined with dissolved bones, but the nature of the land and crop to which it is applied, must be considered, as it might be positively injurious in some cases. In the instance given above, the meadow was an old one, which had not been broken up for many years, and the grass was close and fine in texture, so that great advantage was gained by the additional silica and phosphate of lime; but in the case of a new meadow, the hay is often, for the first year or so, too strong and wiry. In such a case, were the same applied, it would be rendered too coarse for the use of horses or cattle; it might, therefore, be found better, for the first two seasons, to apply simply the salts of ammonia, which would increase the sappiness of the plant and the general growth, without adding to the harshness of texture.

"I hope to be able, on some future occasion, to lay before the Academy the result of further experiments on the subject, and (should time permit me) accompanied with an accurate analysis of the ashes of the plant in each case."

Mr. Webber made an inquiry as to the cost of the manures mentioned, and suggested that Mr. Knox should be requested to annex to his paper, a statement of the relative expenses of the manure employed.

Dr. Kane and Dr. Apjohn made some remarks on the general subject.

Mr. J. Huband Smith gave an account of some ancient tiles found in the ruins of Bective Abbey, near Trim, and exhibited specimens of some raised and incaustic tiles, with drawings of others.

Dr. Todd, V. P., gave an account of an ancient Irish MS. preserved in the Bodleian Library, Oxford.

This MS., which is a large quarto on vellum, was formerly in the collection of Archbishop Laud, by whom it was presented to the Bodleian. It was also once in the possession of Sir George Carew, as appears from the autograph "G. Carew" on the margin of the first page. It contains a large collection of miscellaneous pieces, historical, genealogical, theological, and poetical, in different hands, and of different dates; such a collection was called by the ancient Irish "*a Psalter*," and in an entry, which shall be considered presently, this volume is called "the Psalter of Mac-Richard Butler."

Pasted down on the inside of the cover is the following note:

"*Oxford* y^e^ 9^th^ *of August* 1673.

"This booke is a famous coppie of a greate part of Saltair Caisil, the booke of S^t^ Mochuda of Rathin & Lismore, and the chronicles of Conga; wherein is contained many divine thinges, and y^e^ most part of y^e^ Antiquities of y^e^ ancientest houses in Ireland, a Cathologue of their Kings, of the coming in of y^e^ Romans vnto England, of y^e^ coming of y^e^ Saxons, and of their lives and raygne; a notable Calender of the Irish Saints composed in verse eight hundred yeares agoe, w^th^ the Saints of ye Romane breviary vntill that tyme; a Cathologue of y^e^ Popes of Roome; How y^e^ Irish and English were converted to y^e^ Catholique faith; w^th^ many other things as the reader may finde, and soe understanding what they containe lett him remember

"Tully Conry.

"Tuileagna o Maolċonaire."

This account of the contents of the volume is very inadequate, as well as erroneous. There seems but little reason to think that the book contains a copy of any part of the Psalter of Cashel, although that celebrated Collection is sometimes referred to or quoted; no traces of the book of St. Mochuda, or the Chronicles of Cong, are now to be found in the volume; if Tully Conry therefore was not mistaken, there is ground to suspect that the MS. may have lost something since the foregoing account of its contents was written.

On the upper and lower margins, in several places, there are entries and memorandums by various possessors of the book, which serve to give us its history, and to fix the date of a great part of the documents of which it consists. The most remarkable of these entries must now be noticed.

1. On the lower margin of fol. 4, *b*, there is the following note, which is here given in the original, with a translation:

Or annso do siġraiḋ mc. seain, mc. torna, mc. ṁaoilin moir ui mail-conaire, fil ag lerugad an libairse do muiris mc. tomais .i. iarla desmuṁan, gur se an e ar geiḃtine a . . . . taiti na bealltaine tar eis deisceart erinn da riarugad iter gall agus gaeidil.

A prayer here for Sighraidh son of John, son of Torna, son of Mailin Mor O'Mulconry; who is restoring this book for Maurice, son of Thomas, i. e. the Earl of Desmond, who is now residing at Askeaton . . . . . at the beginning of May, after the south of Ireland has submitted to him both English and Irish.

2. Another entry of a similar kind occurs on the lower margin of fol. 34, as follows:

Or. inso dom fetir .i. Muiris mc tomais, mc semais, in ti d'ar leirugius an becso tuas le droċ instrumentaib.

A prayer here for my patron (?), i. e. Maurice, son of Thomas, son of James, the person for whom I am restoring the little portion above, with bad instruments.

The Maurice mentioned in these extracts was the tenth

Earl of Desmond, who succeeded his elder brother James in the Earldom in 1481. He was the son of Thomas, the eighth Earl, who was beheaded at Drogheda, 5th February, 1467. He died 1497, according to O'Clery's book of Pedigrees: and as the foregoing entries were manifestly made during his life-time, it is evident that this volume was of some antitiquity, so as to require the ink to be revived and restored, in the latter end of the fifteenth century. This was a process very common with Irish scribes, as is evident from the inspection of our ancient vellum MSS., many of which have suffered great damage by ignorant attempts to restore them.

3. A memorandum of peculiar interest occurs on the upper margin of fol. 110, *b*. It is as follows:

Saltair mc ruisderd buitiler .i. Emonn buitiler, ind t-saltair seo, no go d-tucad maiḋm baile in spoill ar iarla urṁuman agus ar mc ruisderd buitiler le iarla desṁuman .i. tomas, agus do baineaḋ in leaḃar so agus leaḃar na carruigi ar fuarglaḋ mc ruisderd, agus is se in mc ruisderd sin do chuir na leaḃair sin da scriḃaḋ do fein, no gur ḃain Tomas [de iad].

This Psalter was the Psalter of Mac Richard Butler, i. e. Edmond Butler, until after the defeat at Bally-in-spoill, of the Earl of Ormond and of Mac Richard Butler, by the Earl of Desmond, i. e. Thomas; and this Book and the Book of Carrick were given in ransom of Mac Richard, and it is this Mac Richard that caused these books to be transcribed for himself, until Thomas took them from him.

Thus it appears that this book, and the book of Carrick, (now unknown) were in the fifteenth century considered as a sufficient ransom for the person of a great chieftain,—a remarkable proof of the preservation of a love of literature amongst the native Irish nobles, in the midst of all their war and faction at that period. Nor is this a solitary instance in Irish history. The Leabhar na h-Uidhri, a manuscript of the twelfth century, in the collection of Messrs. Hodges and Smith, contains an entry of a similar kind.

The foregoing memorandum, however, shows that this volume was written originally for Sir Edmund, son of Richard, Butler, commonly called Mac Richard; and that on his defeat by Thomas, eighth Earl of Desmond, who, as we have already seen, was beheaded in 1467, it passed into the hands of the Desmond family.

In the book of Pedigrees of the O'Clerys, an unpublished work, of which the autograph MS., in the original Irish, is in the Library of this Academy, the following account of Thomas, eighth Earl of Desmond is given (p. 247):

"The fate of Thomas, son of James, Earl of Desmond, i. e. the ninth [eighth] Earl. Thus did it happen unto him, viz. John Tipto [Tiptoft] Earl of Worcester, came into Ireland as Lord Justice, called by proclamation of the English of Ireland to the great Council at Drogheda. And bad was the counsel there agreed upon, viz. to behead Thomas, son of James, the Earl, without impeachment of crime, right, or law, but merely from envy and hatred; the man of best mien and form, wisdom, and intelligence of either English or Irish of his time. No praise bestowed upon him could be too high. The sorrow and affliction of that death was felt equally by the English and the Irish. This Thomas the Earl invariably overthrew and put down his enemies and opponents on every occasion whenever he fought with them. Great indeed was the battle in which he overthrew the Butlers, on the Suir, and innumerable were the hosts of them that were slain and drowned on that occasion. He likewise gave several overthrows besides, that are not here enumerated. A Lord intellectual and learned in Latin, English, and ancient Irish writings, was that Thomas. It was he that gave the great overthrow to the Mac Carthys at Reidh-an-Eich-bhuidhe. The 5th day of February the Earl was beheaded, and 42 years was his age at that time. At Tralee was he buried, 1467."*

* This is a strictly literal translation of the original Irish.—See Grace's

This extract, taken in connexion with the entry in the Oxford MS., is exceedingly curious, as it notices the fact that Thomas Earl of Desmond was learned in ancient Irish writings; and therefore incidentally confirms the probability of his accepting ancient MSS. as a ransom for the Mac Richard. The place called Bally-in-spoill is now unknown; but from the record in the Book of Pedigrees it seems probable that it was a village on the banks of the Suir.

4. Another interesting entry, which enables us to date one portion of the volume, occurs on fol. 86, *a*, in the handwriting of the original scribe, at the end of a very valuable fragment of Cormac's Glossary:

Is h-e analad in tiġerna in uair do scribaḋ in sanasan so na saltraċ, .i. mile bliaḋan agus ceiṫri .c. bliaḋan agus tri bliaḋna dec, agus da .xx. in cuiced la do mi Febra agus in toċtmad la don esca. Misi seaan buiḋi o cleiri do scrib, agus d'emann buitiler m^c ris-terd do scribaḋ.

The year of our Lord when this Glossary of the Psalter was written, was 1453; on the 5th day of the month of February, and the eighth day of the moon. I am John Boy O'Clery who wrote it, and for Edmund Butler Mac Richard was it written.

It appears therefore that this portion of the volume was transcribed (doubtless from much more ancient documents, perhaps from the veritable Psalter of Cashel itself) in the middle of the fifteenth century for Sir Edmund Butler, commonly called Mac Richard; and that it subsequently passed into the family of Desmond, having been received in ransom of Mac Richard by Thomas Earl of Desmond.

This MS. having been for the last two centuries in England, appears to be wholly unknown to our historians. The rules of the Bodleian Library do not permit its MSS. to be lent, and as there is no accurate catalogue of the valuable,

Annals, printed by the Irish Archæological Society, p. 165, note [s], for a further mention of Earl Thomas.

but unknown, and, in Oxford, unappreciated collection of Irish MSS. which it contains, the MSS. there preserved are almost as inaccessible for the purposes of Irish historical research, as those of the Vatican or the Escurial.

Dr. Todd did not pretend to give a complete account of the contents of the "Psalter of Mac Richard," as it may perhaps for convenience be called. He was able only to carry away a very few memoranda of such articles as appeared, on a very hasty inspection, likely to prove most interesting.

On fol. 7 is a religious tract, known as the Life of St. Margaret, a work of no value, except to the philologist.

Fol. 9. The Genealogy of St. Mochoemog.

Fol. 11, *b*. A religious tract, entitled, in Irish, "The History of the Image of our Lord," and also, in Latin, "Incipit Libellus Anastasii [Athanasii] Archiepi Alexandriæ urbis, de passione imaginis Dni. nri. Jhu. X^{i}." This is probably an Irish version of the tract attributed to St. Athanasius at the second Council of Nice, although now admitted to be spurious. It is published in Greek and Latin in the Benedictine edition of the works of St. Athanasius.

Fol. 14, *a*. A curious legend of Donogh O'Breen, abbot of Clonmacnois. The story is, that having gone on a pilgrimage to Armagh, he was miraculously detained there until his death, A. D. 987. He is said to have been the last of the Irish saints who performed the miracle of raising the dead.—See Annals of the Four Masters in an. 987.

Fol. 15. An account of the ancient tract called the Felire, or Festilogium, of Angus the Culdee; being a Martyrology, or Calendar of the Saints' days observed in the ancient Irish Church, compiled in the eighth century.

Fol. 18, *b*. "The Destruction of Jerusalem by Titus, son of Vespasian, in revenge for the Blood of Christ."

There is a copy of this tract in the Leabhar Breac in the Library of the Academy, and a fragment of it in the Book of Lismore.

Fol. 23. A legend of the Infancy and Life of Christ, as revealed by the Virgin Mary to St. Bernard.

Fol. 29. A sermon in Irish on the text, "Omnia quæcunque vultis ut faciant vobis homines, et vos facite illis."

" Fol. 30, *b*. A sermon on the text, " Cum ergo facies elimosinam."

There are copies of these sermons in the Leabhar Breac.

Fol. 33, *a*. The celebrated Chronological Poem of Giolla Cœmgin, beginning with the Creation, and carried down to the year 1072, when its author flourished.—See O'Reilly's Irish Writers (Trans. Hiberno-Celtic Soc. vol. i.), p. lxxx.

There is a very ancient copy of this poem in the Library of Trinity College Dublin, MS. H. 2, 18.

Fol. 38 to 42. Genealogies of the Irish Saints.

Fol. 43, *a*. The three sons of Moses, &c.

——— *b*. " Incipit inventio sanctæ crucis."

Fol. 57, *b*. A tract containing the fabulous history of Ireland before the Deluge, as related by Fintan, one of the ante-diluvian colonists of Ireland, who, under various transmigrations, is supposed to have survived the deluge. This work ends with an account of a convocation of the states of Ireland held at Tara, in the sixth century, under Dermot M'Cearbhaill (Carroll). There is a fine copy of it in the Library of Trinity College, MS. H. 2, 16.

Fol. 58. The history of Mac Datho's hog. Mac Datho was king of Leinster in the first century. He invited the kings of Connaught and Ulster to a feast, with a view to sow dissensions between them for his own political ends. At this feast there was served up an enormous hog, the cutting up of which, and the assigning to each chieftain his proper share, became a matter of fierce contention between the guests, and produced the effect intended by their crafty entertainer.

There are two copies of this legend in the Library of Trinity College, MS., H. 2, 18, and H. 3, 18.

Fol. 59. A very fine and ancient copy of the Felire, or Festilogium of Angus the Culdee. This part of the volume is much more ancient than the rest, and was probably written in the twelfth century. It ends fol. 72, *a*.

There is a fine copy of this work, with the gloss, in the Leabhar Breac.

Fol. 72, *b*. A poem addressed to Cormac Mac Cuillionan, king and bishop of Cashel, in the ninth and beginning of the tenth century, on the duties of a king.

There are good copies of it in the Library of Trinity College, MS., H. 2, 18, and H. 3, 18.

Fol. 73, *b*. A poem on the sons of Oillil Olum, king of Munster in the third century.

There is a good copy of it in the Library of Trinity College, MS., H. 2, 18.

Fol. 74, *a*. A poem on the succession of the kings of Emania, by Cinaeth O'Hartigan, who died A. D. 975. It begins Fianna batar in emain. This poem appears to have been unknown to O'Reilly.—*Irish Writers*, p. lxii.

Fol. 75, *a*. A tract beginning "Hibernia insola inter duos filios principales Militis, i. e. Herimon et Eber, in duas partes divisa est." The remainder is in Irish.

Fol. 81, *b*. An account of the great plague in A. D. 633, beginning Anno domince incarnationis dc.xxxiii. Ara mora hi saxain tuaiscert ond anbthine rucad paulinus edilberta illuing co cantia agus ro hairimed co honorach. "In the year of our Lord's incarnation 633, a great mortality in North Saxony, to avoid which Paulinus Edilberta was carried away in a ship to Kent, and was there honourably received."

After this are a number of short poems.

Fol. 83. An imperfect but very ancient copy of Cormac's Glossary, beginning with the word Mindech, which is thus explained, quasi mendic ab eo quod est mendicus. It ends fol. 86, *a*; after which is the entry already quoted, from which we learn a very remarkable fact, hitherto I believe unnoticed by our historians, that Cormac's Glossary was compiled from the notes or glosses added by Cormac Mac Cuilionan, the celebrated king and bishop of Cashel, to the miscellaneous compilation called the Psalter of Cashel. Cormac was killed in the battle of Belach Mughna, now Ballaghmoon, in the County of Kildare, near Carlow, A. D. 903.

Fol. 93, *b*. A tract, with the following Latin title, "De causis quibus exules aquilonensium ad mumonienses adducti sunt," beginning Iseḋ cetamus foċond toirgi, &c.

Fol. 94, *b*. The history of the war between Oilill Olum and Mac Con. This is a most valuable document. Oilill Olum was king of Munster in the third century. He deprived Mac Con, his stepson, of his lawful inheritance. Mac Con rebelled, assembled his followers, but was defeated by Oilill at the battle of Ceannabrat, a place on the borders of the counties of Cork and Tipperary. The defeated prince fled to Scotland, where he had influence enough to raise a large force of foreign adventurers, with whom he returned to Ireland, and again encountered the troops of his stepfather in the bloody battle of Moy Mocroimhe, in the county of Galway. In this battle Oilill was aided by Art, son of Conn of the hundred battles, then monarch of Ireland; but was defeated. Art was slain, and with him the six sons of Oilill, with the flower of the Irish chiefs. Mac Conn assumed the sovereignty of Ireland, and continued to reign until driven back to Munster by Cormac Mac Art, several years afterwards, who thus revenged the death of his father.

There is an imperfect copy of this tract (a MS. of the early part of the twelfth century) in the Library of Trinity College, Dublin, H. 2, 18.

Fol. 96, *a*. The history of the battle of Mucruimhe, beginning Luid eugan mor do ċath mucruime.

Fol. 99, *b*. The Expulsion of the Decies from Tara by Cormac Mac Art.

Fol. 102, *a*. The coming of St. Finian from abroad into Ireland with the Gospel.

Fol. 104. The History of Oriell, with the genealogies of many Irish families.

Fol. 109, *a*. A poem on the sons of Conor Mac Nessa, king of Ulster in the first century; by Mongan, a celebrated poet.

Fol. 109, *b*. Pedigrees of the families of Fermoy, County Cork.

Fol. 111, *a*. Pedigree of O'Dunlevey.

Fol. 112. Lists of Roman emperors, kings of Egypt, Assyria, and Israel; bishops of Rome, Armagh, &c.

In the margin of fol. 117, *b*, there is written in faint red ink, ꞃalꞇ. caıꞃıl: by which we may infer that the tract there transcribed was preserved also in the Psalter of Cashel. This is apparently the only reason for supposing that the present MS. contains extracts from the Psalter of Cashel.

Fol. 118. The actions and deeds of Finn M'Cumhaill.

Fol. 122. A very important tract, which appears from the handwriting to be much more ancient than any other part of the volume, containing the derivation of the names, local traditions, and other remarkable circumstances of the hills, mountains, rivers, caves, rocks, carns, and monumental remains in Ireland: more especially such as relate to the deeds of Finn Mac Cumhaill and his heroes.

There is an imperfect copy of this tract in the Book of Lismore, in the possession of His Grace the Duke of Devonshire, of which a copy was lately made for the Academy by Mr. Curry.

Fol. 127, *a*. A Finian tale, entitled, "The Elopement of the Daughter of the King of Munster with Oisin."

The remainder of the volume is occupied with a series of these tales, which are of great interest and importance. Many modern copies of them on paper are preserved, especially in the valuable collection of Messrs. Hodges and Smith, which is particularly rich in this branch of Irish literature: but with the exception of the fragment in the book of Lismore, the present volume is the only vellum MS. of such tales whose existence is known.

The special thanks of the Academy were voted to the Board of Ordnance and to Captain Portlock for the presentation of the Ordnance Geological Survey of Tyrone, Londonderry, and Fermanagh.

DONATIONS.

Abhandlungen der Akademie der Wissenchaften zu Berlin, 1840. Presented by the Academy.

Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königl. Preuss. Akademie der Wissenschaften zu Berlin. Presented by the Academy.

Account of the Induction Inclinometer and of its Adjustments. By the Rev. H. Lloyd, D.D., F.R.S., V.P.R.I.A. Presented by the Author.

Regulations of the School of Engineering in the University of Dublin, with a Syllabus of the Course. Presented by Professor Lloyd.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1843. No. 39.

February 27.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Sir William Betham exhibited to the Academy an ancient shoe, found in a bog on the property of Sir Nicholas Fitz-simon, in the King's County.

Professor Lloyd read a supplement to a former paper "on the Determination of the Intensity of the Earth's Magnetic Force, in Absolute Measure."

In a paper recently communicated to the Academy, the author had shown that the ratio of the coefficients of the first two terms, in the expression for the moment of the force exerted by a deflecting upon a suspended magnet, was generally given by the formula

$$h = 2\frac{M_3}{M} - 3\frac{M'_3}{M'};$$

in which M and M_3 denote certain integrals depending on the law of distribution of free magnetism in the deflecting magnet, and M' and M'_3 the corresponding quantities for the suspended magnet. It was further shown, that when the magnets were small, this formula was reduced to

$$h = \tfrac{3}{5}(2l^2 - 3l'^2);$$

l and l' denoting the half lengths of the two magnets. This ratio being thus known *à priori*, the two unknown quantities in the equation of equilibrium of the suspended bar are reduced to one; and we are thus enabled not only to dispense with the observations of deflection at two separate distances, but also to infer the quantity sought with much greater accuracy than in the received method, by superseding the process of elimination.

The preceding value of the ratio, h, has been derived from an approximate law of magnetic distribution, which can be regarded as physically exact only in the case of very small magnets; and the truth of the formula has been verified, in that case, by direct experiment. It was interesting to inquire, therefore, how far the same formula represented the law of action of large magnets, and whether, by any modification, it might be applied to the results obtained with such instruments.

For this purpose the following deflection experiments were made:—The magnets employed were rectangular bars, 12 inches, 9 inches, and $7\frac{1}{2}$ inches, in length; $\frac{7}{8}$ of an inch in breadth; and $\frac{1}{4}$ of an inch in thickness. The observations were made with the aid of the *Unifilar Magnetometer* of the Magnetic Observatory, which has been elsewhere described; and simultaneous observations were taken with the *Declinometer*, in order to eliminate the changes of declination which occurred in the interval of the opposite deflections. In the first and second series, the position of the suspended bar was observed by means of a collimator attached; in all the rest, it was observed by the help of a mirror connected with the stirrup, which reflected the divisions of a scale placed at a distance of nearly six feet.

The angles of deflection were calculated, in the case of the collimator bar, by the formula

$$\tan u = \tfrac{1}{2}(n_e - n_w)k;$$

where n_e and n_w denote the observed readings of the scale, with the marked end of the deflecting bar to the East and to the West respectively. The value of the constant k is given by the formula

$$k = \left(1 + \frac{H}{F}\right) \tan\theta;$$

θ denoting the angle corresponding to one division of the scale, and $\frac{H}{F}$ the ratio of the torsion force to the magnetic force. When the mirror is employed, the formulæ of reduction are similar, if only we substitute $2u$ and 2θ for u and θ. The following Table gives the values of the constants employed in the reduction:

l	θ	$\frac{H}{F}$	$\log k$
·5 (coll.)	49″·158	·00180	6·37795
·5 (mirr.)	58″·766	·00162	6·75643
·375 —	. . . . .	·00255	6·75684
·313 —	. . . . .	·00292	6·75700

The following Tables contain the calculated results: the values of $\frac{1}{2}(n_e - n_w)$ are corrected for the changes of declination which occurred in the interval of the two readings n_e and n_w.

Series I. and II. $l = l' = ·5$.

D.	I.		II.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
4.5006	194·78	2° 39′ 45″	194·22	2° 39′ 18″
6.0010	82·51	1° 7′ 43″	82·26	1° 7′ 30″·5

Series III. and IV. $l = ·5$, $l' = ·375$.

D.	III.		IV.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
4·0010	242·30	3° 56′ 25″	242·52	3° 56′ 38″
5·0015	123·31	2° 0′ 53″	123·50	2° 1′ 4″
6·0019	71·40	1° 10′ 4″·5	71·38	1° 10′ 3″

Series V. and VI. $l = \cdot 5$, $l' = \cdot 313$.

D.	V.		VI.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
4·0005	243·58	3° 57′ 44″·5	242·74	3° 56′ 56″
5·0008	123·65	2° 1′ 15″·5	123·36	2° 0′ 58″·5
6·0010	71·41	1° 10′ 6″·5	71·25	1° 9′ 57″

Series VII. and VIII. $l = \cdot 375$, $l' = \cdot 5$.

D.	VII.		VIII.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
3·3762	211·18	3° 26′ 10″·5	210·50	3° 25′ 30″·5
4·3754	97·88	1° 35′ 55″	97·56	1° 35′ 36″·5
5·3757	53·24	0° 52′ 13″	52·88	0° 51′ 51″·5

Series IX. and X. $l = l' = \cdot 375$.

D.	IX.		X.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
3·3766	212·37	3° 27′ 31″	212·52	3° 27′ 40″
4·37 60	97·52	1° 35′ 39″·5	97·55	1° 35′ 41″·5

Series XI. and XII. $l = \cdot 375$, $l' = \cdot 313$.

D.	XI.		XII.	
	$\frac{1}{2}(n_e - n_w)$	u	$\frac{1}{2}(n_e - n_w)$	u
3·3766	214·16	3° 29′ 21″	213·83	3° 29′ 1″
4·3760	98·05	1° 36′ 13″	97·90	1° 36′ 3″·5
5·3765	52·85	0° 51′ 54″	52·82	0° 51′ 52″

The following Table contains the calculated results of the foregoing observations. The values of the coefficients, Q and Q′, are deduced from the formula

$$\tan u = \frac{Q}{D^3} + \frac{Q'}{D^5}$$

by the method of least squares.

l	l'	Q	Q′	$\frac{Q'}{Q} = h.$
·5	·5	4·2800 4·2662	− 0·824 − 0·790	− 0·193 − 0S5
·5	·375	4·3934 4·3976	+ 0·293 + 0·293	+ 0·067 + 0·067
·5	·313	4·3791 4·3760	+ 0 887 + 0·692	+ 0·202 + 0·158
·375	·5	2·3830 2·3702	− 0·823 − 0·761	− 0·345 − 0·321
·375	·375	2·3407 2·3402	− 0·161 − 0·135	− 0·069 − 0·058
·375	.313	2·3456 2·3428	+ 0·027 + 0·005	+ 0·012 + 0·002

The values of h thus obtained are not adequately represented by the formula which has been already deduced for the case of small magnets, the differences between the calculated values and the means of the two observed results being, in general, greater than the differences of the latter *inter se.* It was accordingly natural to inquire whether the agreement might not be rendered more complete by pushing farther the approximation in the value of the function which represents the law of magnetic distribution. This was found to be the case on trial. But it was also found that the observed results were represented, with nearly equal exactness, by the empirical formula,

$$h = 2(l - c)^2 - 3(l' - c)^2;$$

a formula which agrees with the hypothesis, that the whole force of each magnet is concentred in two points, or poles, at given equal distances from the ends. If we expand the preceding formula, and add together the resulting equations, we have for the determination of c,

$$6c^2 + 2\Sigma(2l - 3l')c + \Sigma h - \Sigma(2l^2 - 3l'^2) = 0;$$

or, substituting the numerical values of the coefficients deduced from the preceding Table,

$$c^2 - 0{\cdot}625\,c + 0{\cdot}0425 = 0;$$

from which we deduce $c = {\cdot}078$.

The following Table contains the values of h thus calculated, together with the means of the observed results. The differences barely exceed the probable errors of the latter; and the corresponding error in the calculated value of Q is less than the probable error of the same quantity, as deduced in the ordinary method from the observed deflections at two distances.

l	l'	h (obs.)	h (calc.)	Diff.
·5	·5	− 0·189	− 0·178	+ ·011
·5	·375	+ 0·067	+ 0·092	+ ·025
·5	·313	+ 0·180	+ 0·191	+ ·011
·375	·5	− 0·333	− 0·358	− ·025
·375	·375	− 0·063	− 0·088	− ·025
·375	·313	+ 0·007	+ 0·011	+ ·004

It follows from the preceding formula, that the relation between the half lengths of the two magnets, which will cause the coefficient of the fifth power of the distance to vanish, is

$$l - c = 1{\cdot}224\,(l' - c);$$

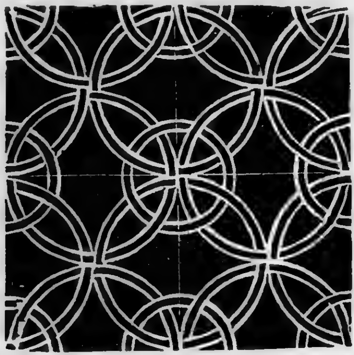
or, substituting for c its value,

$$l + {\cdot}0175 = 1{\cdot}224\,l'.$$

It will appear evidently from the foregoing results, that on account of the large probable error of h, its value should be determined in each case from the mean of a much greater number of observations, before we can obtain thereby a satisfactory verification of any formula for its calculation. As far as the comparison has been here carried, the results appear to indicate that the value of h cannot be obtained *à priori*, in the case of large magnets, with that precision which would justify us in superseding observation, although we may obtain thereby an approximate value, comparable in exactness with the result of a single observation.

Mr. T. Oldham read a paper "on the Tiles found in the ancient Churches in Ireland."

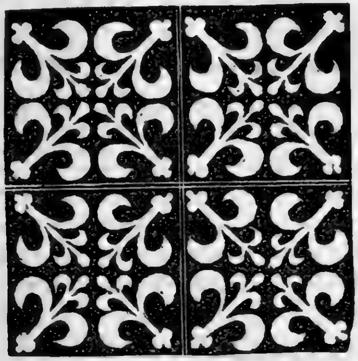
Mr. Oldham commenced by drawing attention to specimens of old tiles, from various places, which were on the table; and having alluded to the fact, that there has hitherto been no published representation of these tiles from any place in Ireland, proceeded to show that there were three distinct varieties:—1st. Impressed or indented, in which the pattern is formed by being sunk below the general surface of the tile. 2nd. Encaustic, in which the pattern is produced by a differently coloured substance inlaid; and 3rd. Tiles in relief, or embossed, in which the pattern is raised above the general surface or ground.



From the great simplicity of the patterns in the indented tiles, from their interlacing character (Fig. 1), and from the fact, that several of these patterns occur also in the more carefully formed encaustic tiles, it was shown that the impressed variety was the earliest in date; and, from a consideration of the history of the establishments where they occur, probably belonged to the twelfth century; that the encaustic variety was a subsequent improvement on this more simple form, and that the embossed tiles belonged to an era when the knowledge of the arts had very much declined. This was proved by several from Bective Abbey, the date of which was fixed by the occurrence of the tudor, or double rose, and by an heraldic tile from the same place, representing the arms of the Fitzgeralds, having the motto, " *Crom abo—Si Dien plet*," and the initials G. E. It was shown, from the history of this family, that the tile could only be referred to a date subsequent to 1496 (in which year the Earls of Kildare, previously attainted, were restored to their honours, and again allowed to use their motto), and to either Gerald the eighth or Gerald the ninth Earl, both of whom had wives whose Christian name was Elizabeth, corresponding to the initials G. E.—Gerald and Elizabeth.

The identity of several of the patterns from different places in Ireland, and the strong resemblance of many to those found in England and Normandy were then alluded to, and several peculiarities in the Irish pattern, which tended to prove that they were manufactured on the spot, were pointed out.

Speaking of the comparative cost of these tiles now and formerly, Mr. Oldham showed from the account of the repairs at Hampton Court in 1536, and allowing for the difference in the value of money, that the price at present charged was somewhat less than in the sixteenth century;



and concluded by soliciting the assistance of the members in bringing together as complete a series as possible of the patterns still remaining in many of the ruined churches of Ireland.

The President read a Supplementary Notice of his Examination of Signor Badano's Memoir on the Resolution of Equations of the Fifth Degree, and described the successful application to cubic and biquadratic equations of the method proposed by Badano, but which had been shown to be unsuccessful with equations of higher degrees than the fourth.

Rev. Dr. Marks, on the part of the Bishop of Cashel, presented the seal used by the latter as Dean of St. Patrick's.

March 16. (Stated Meeting).

SIR Wm. R. HAMILTON, LL.D., President, in the Chair.

The Secretary of Council read the following Report, which was ordered to be entered on the Minutes:

"The affairs of the Academy during the past year have been, for the most part, of a similar character to those which have formed the subjects of former Reports. It is, however, satisfactory to the Council to be able to state, that our proceedings have been distinguished by still increasing activity and zeal among our members, and that some important measures have been entered upon, and others brought to completion, which it is to be expected will tend permanently to sustain the reputation of the Academy, and extend its useful influence.

"The second part of the nineteenth volume of the Transactions of the Academy is now printed, and the Council is enabled to place before the Academy an early copy. In a few days it will be ready for distribution among the members.

"The twentieth volume, which will altogether consist of Mr. Petrie's Essay on the Round Towers, is progressing through the Press; and a portion of the twenty-first volume is in the hands of the printer.

"The Council have with great pleasure to report, that the valuable collection of Irish antiquities amassed by the late Dean of St. Patrick's, having been purchased by a subscription, has been presented by the subscribers to the Academy. The amount subscribed having slightly exceeded the cost of the Collection, the balance was applied to the purchase of some other valuable relics of antiquity, which were also presented to the Academy, and now form part of its Museum. The detailed circumstances connected with the collection and application of this subscription, and the eminent services rendered to the Academy and to Irish Archæology by various gentlemen, to whose exertions final success was mainly due, have already been brought under your notice in the Report drawn up by the Committee of Antiquities, and presented to the Academy in November last by Dr. Todd. The Council have therefore, on the present occasion, only to congratulate the Academy and the country on the acquisition of this Collection, which it is to be hoped will prove a centre to which may be attracted the various objects of antiquarian interest now scattered through the country, or which may hereafter be discovered, and thus be laid the foundation of a truly national Museum of Antiquities.

" Besides the actual Dawson Collection, our Museum has been enriched by donations from His Excellency the Lord Lieutenant, and from various private individuals, to whom on the several occasions of presentation well merited thanks were voted by the Academy.

" The necessity of arranging our Museum in such a form as should do justice to its intrinsic value, and adapt it for those purposes of reference and exhibition on which much of the influence it is calculated to exert must depend, has rendered the present accommodation of the Academy House totally inadequate to our wants, and the Council has consequently directed its attention to ascertaining how far our accommodation in rooms can be extended. It has been found that at a moderate cost the present Board Room may be converted into a Museum Room sufficient for our objects, and that under the Library and the adjoining spaces, there exists ground now of little use, on which a Board Room, rather larger than the present, may be constructed. A model and drawings of the arrangement proposed have been already laid before the Academy, and met with its approval, but circumstances connected with our tenure of this house have induced the Council to postpone for a short time entering upon any outlay in building.

" In the Report of the last Council, the Academy was informed that an application had been made to His Excellency the Lord Lieutenant, that he might recommend to the Government to increase our Annual Grant by the sum of £100, or to allow that sum per year, specially for the purchase of Irish antiquities. No decisive answer has been as yet received to that application, but it is to be hoped that as we have now made so excellent a beginning to our Museum, and that the sphere of our public utility has thus been much extended, so small an increase to our exceedingly scanty means may not be finally refused.

" In November last, the Academy authorized the Council to employ Mr. Curry to draw up a Catalogue Raisonné of the Irish manuscripts in the Library of the Academy. This work has been ever since in progress, but will still require some months for its completion.

" Some time ago the Council became aware that it was contemplated by Her Majesty's Government to withdraw from the Irish branch of the Ordnance Survey those grants of money which have hitherto been made to the departments of Geology and Natural History, as well as of Topographical Antiquities and Statistics, so that the future operations of the Survey should be limited to the completion of the Maps. Sensible of the great benefit that must accrue to the country at large by the continuance of those departments, for which already a vast body of materials have been collected, which, if publication were now abandoned, may be totally lost, and feeling that independent of its interest, as positively extending the domain of science, and of which so brilliant an example has been already presented to the Academy, on the part of the Board of Ordnance, by Captain Portlock, the Geological branch of the Survey is of the highest practical importance to Ireland, as making known the true position and limits of our mineral wealth, and guarding enterprize from those latent perils on which, from want of such scientific knowledge, it has been so often wrecked, the Council did not hesitate to interpose its voice against the relinquishing of that undertaking. A deputation of the Council waited on His Excellency the Lord Lieutenant with a memorial, in which the more evident reasons in favour of the continuation of this truly national work were embodied. His Excellency received the deputation with his usual courtesy, and was pleased to express his sympathy with its objects. He undertook to forward the memorial to the heads of the Government in London, and the Council is not without sanguine hopes that the Memoir of the Ordnance Survey may be finally continued on its original extended scale.

" In obtaining this result, the Council believe that the voice of the Royal Irish Academy will have afforded some assistance.

" Since the date of the last Report, the Library of the Academy has been increased by numerous donations of books, for which thanks have been voted to the donors, at the meetings of the Academy. The Academy continues in communication with the principal scientific bodies of Europe and America, with which an interchange of Transactions and other publications is kept up.

"During the past year the accession of new members to the Academy has been such as to show, that notwithstanding the usually abstract nature of its proceedings, its importance is fully recognized. As honorary members, two have been elected on the recommendation of the Council: the one a philosopher of European eminence, Professor Wheatstone; the other, an Irish woman, whose name adorns the roll of the Academy, as her works have long shed lustre on the literature of her country, Miss Edgeworth. The names of the gentlemen who have been elected ordinary members of the Academy are:

Rev. Richard Butler.	W. V. Drury, M. D.
Dr. Robert Law.	W. R. Gore, M. D.
John Toleken, Esq., F.T.C.D.	J. E. Hodder, Esq., R. N.
William Blacker, Esq.	Rev. John Homan.
Rev. James Booth.	H. Hutton, Esq.
Arthur Cane, Esq.	R. Leslie Ogilby, Esq.
B. J. Chapman, Esq.	Hon. Frederick Ponsonby.
F. M. Jennings, Esq.	George Salmon, Esq., F.T.C.D.
Sir Thomas Staples, Bart.	Robert Culley, Esq.
Stewart Blacker, Esq.	James Magee, Esq.
Thomas Cather, Esq.	H. L. Renny, Esq.

"In a body so numerous as ours, it could not be expected that a year should pass away without the loss of some from amongst our ranks. Unhappily within the last twelve months we have had occasion to deplore the deaths of several valued members.

"From the list of honorary members three have been removed, Sir James Ivory, Mr. Allan Cunningham, and Professor Heeren. Of our ordinary members we have lost the Hon. Judge Foster, the Right Rev. Charles Dickenson, late Lord Bishop of Meath, Dr. Macartney, Mr. David Aher, and Mr. Bowles. It is fit to notice briefly their career and their connexion with this Academy.

"Sir James Ivory was a native of Dundee, and studied in the University of St. Andrew's, where he first distinguished himself in those mathematical studies on which the elements of his subsequent distinction rested. Although intended for the Church, circumstances threw him into the totally different career of managing an extensive flax and spinning concern. But even the engrossing nature of commercial industry could not wean him from scientific pursuits, and on the dissolution of the company he devoted himself exclusively to mathematical investigation. He passed to London, and was appointed Professor in the Military College of Sandhurst, which he retained until ill health, occasioned by his untiring researches, obliged him to resign. His merits were so well recognized that he received the retiring pension, although he had not served the time required by the War Office. Subsequently a royal pension was conferred upon him, and at the same time he received the honour of Knighthood of the Guelphic Order of Hanover.

" Sir James Ivory was elected by this Academy an honorary member on the score of his eminent mathematical discoveries. These it is unnecessary to detail. They embraced the solution, in abstract mathematics and in physical astronomy, of problems of the greatest difficulty and importance; and the Royal Society of London sufficiently indicated their opinion of his merits by awarding to him at different periods the Royal and the Copley medals.

" Mr. Allan Cunningham, although occupying a totally different field of intellectual exertion from that trod by Ivory, and cultivating rather the faculties of imagination and invention than those of logical thought, is also an example of learning, pursued as an enjoyment in the first instance to relieve the weary practice of a mechanical trade, and finally adopted as a profession. Born in Scotland, he was early apprenticed to a stone-mason, for whom he worked many years. His mind, imbued with the traditions and tales of the Border district in which he resided, soon applied its vigorous though somewhat rugged poetic faculties to their arrangement; and although it is said that many of the traditions he has rendered popular, had their first origin in his own fertile brain, yet there is no doubt but that his verses have preserved a great body of popular Scottish story, that otherwise might have been lost. Would that the abundant sources of poetical composition which the earlier chronicles of this country present were similarly utilized. The varied results of Mr. Cunningham's literary life need not here be detailed. He subsequently became connected with Sir Francis Chantrey, in whose workroom he acted as manager and superintendant. Called thus to intimate association with the most elevated in art, all his subsequent literary works had for object, more or less, its illustration, and his final labour, concluded but a few days before his death, was the life of his countryman and friend, Sir David Wilkie. Mr. Cunningham was elected an honorary member of this Academy on the score of his various literary merits.

"The death of Professor Heeren of Göttingen is felt through Europe as the removal of one of the brightest luminaries of classical literature. A reputation, already brilliant, bequeathed to him by his father, received additional lustre from his elaborate investigations into the commerce and social condition of the nations of antiquity. He was appointed first Professor of Philosophy, and afterwards of History, in the University of Göttingen; and his decease in the past year has added another to the crowd of illustrious dead, by whose memory that seat of learning is rendered sacred."

"Our recollection of those members whom we have lost from the ordinary roll of the Academy during the past year is yet so fresh, the time that has elapsed since they assisted at our meetings is so short, that the notice, necessarily so brief, that can be here made of their career must be imperfect, and may appear unjust. In the instances, however, of two eminent members, whose recent loss we all deplore, the Right Rev. the Lord Bishop of Meath, and the Hon. Justice Foster, it may be said, that although numbering them among its members, this Academy was not the scene of their labours or their glory; devoted to the pursuit of most important and engrossing professions, in which by their varied talents they attained the highest dignities, time was not available for the prosecution of any of those objects which this Academy has more especially in view. Neither contributed to our Transactions, but the purposes of this Institution, and its progress, were always subjects of their warm approbation and support.

"Mr. Bowles, a young member of the Academy, must be deeply regretted, as from his extensive knowledge of languages, and the enlightened assiduity with which he was, up to the period of his death, engaged in acquiring statistical information, much was to be expected.

"In Mr. David Aher the country has lost one well conversant, as a civil engineer, with its physical circumstances, and anxious and effectual in promoting industry. He was principally engaged in the working of the coal district of Kilkenny and the Queen's County, but was concerned in many other engineering operations in that neighbourhood. He supplied a great deal of valuable information embodied in the Reports on the Irish Bogs, drawn up by order of Government; and recently, I believe his last work, at the time when the plans for railway intercourse through Ireland were much discussed, he surveyed and proposed a line extending from Dublin to Kilkenny. Owing to the purely practical nature of Mr. Aher's labours, he did not contribute any memoirs to our Transactions, but his career was not on that account the less valuable. This Academy, necessarily limited in its scope to the more general and abstract contemplation of scientific questions, is still most fully cognizant of the merit, and anxious to express its admiration of those men, who practically developing the sources of useful employment and industrial wealth which our country holds, may become important agents in increasing the comfort and happiness of our people.

"Dr. James Macartney was born in March, 1770, in Armagh, where his family had long been resident. He was educated in the country, where he received the rudiments of an ordinary education, but was not at college, nor was he intended for a profession. Forced, however, in 1790, by the death of his father, to decide upon his future course of life, he chose the profession of surgery, 'not,' as he used to say, 'because he had any peculiar aptitude for the business, but that he thought it would harden his feelings, which he had found on many occasions painfully acute.' In 1794 he was apprenticed to Dr. Hartigan, who was at that time Professor of Anatomy to the Royal College of Surgeons in Ireland. Passing to London for the completion of his professional studies, he was appointed, in 1798, Demonstrator of Anatomy at Bartholomew's Hospital; and in 1800, having become a member of the Royal College of Surgeons in London, he began to lecture on Comparative Anatomy and Physiology, which he continued up to 1810. During the greater part of this time he was Surgeon to the Radnorshire Militia, which office, however, was not allowed to interfere with his scientific or professional pursuits. In 1811 he accompanied that Regiment to Ireland, and in 1813, the Professorship of Anatomy and Surgery in Trinity College having become vacant by the death of Dr. Hartigan, he presented himself as a candidate, and was elected.

" For twenty-four years Dr. Macartney discharged the duties of that important office with unexampled zeal and industry, and used his utmost exertions to improve medical education. He endeavoured to establish a course of lectures on Comparative Anatomy, but circumstances prevented his plan being at the time carried out. He was, however, successful in arranging a separate course on Pathology, and in conjunction with Dr. Jacob, then his Demonstrator, he instituted a dispensary for the special treatment of diseases of the eye and ear. As a lecturer, his manner, though unadorned by the arts of verbal eloquence, became highly popular from the sound ideas which he imparted, and the distinct and logical language in which they were clothed. His classes were always very large, and by his means the reputation of the Medical School of the University of Dublin was materially elevated.

" He resigned his Professorship in 1837, but still continued his application to scientific pursuits. On the 5th of the present month (March) he was seized with apoplexy, and died on the following morning.

" In a literary point of view, Dr. Macartney's contributions to medical and zoological science were numerous and important. In 1803 he commenced writing for Rees' Cyclopædia, to which he supplied the articles—' *Comparative Anatomy. Vegetable Anatomy. Bezoar. Anatomy of Birds. Classification of Animals. Anatomy of the Egg. Anatomy of Fishes. Incubation. Anatomy of Mammalia.*' In the Philosophical Transactions he published a memoir on Luminous Animals, and contributed many minor papers to the British Association, and to the Academie de Medicine of Paris. His large work on Inflammation, containing his chief discoveries in physiology and surgery, was published in Dublin in 1838; and in the Transactions of this Academy there are by him two valuable memoirs, the first in vol. xiii., on Curvature of the

Spine, and the second, on the Anatomy of the Brain of the Chimpanzee, inserted in the second part of the nineteenth volume, which has been this evening laid before the Academy, but of which, unfortunately, he did not live to witness the formal publication.

"Dr. Macartney was a Fellow of the Royal Society, and of the Linnean Society of London, and an Honorary Fellow of the King and Queen's College of Physicians in Ireland. He was also a Foreign Associate of the Academy of Medicine of Paris, and member of many of the most eminent scientific societies of the Continent of Europe and of America.

"The Reverend James Horner, D. D., engaged in the constant practice of the sacred duties of his profession, did not take any part in the proceedings of the Academy, but will be long remembered by many amongst us for the interest he always manifested in our success, the amenity of his manner, and the benevolence of his heart.

"The engrossing occupations of an active political life had also so completely removed the Right Hon. Sir John Newport, Bart. from the pursuits to which this Academy is devoted, that it is only necessary formally to record his loss, and that he had not contributed to our proceedings."

The Treasurer presented the following Abstract of his Account with the Academy for the year ending this 16th of March, 1843:

JAMES PIM, JUN., *Treasurer, in Account with the* ROYAL IRISH ACADEMY,

16TH MARCH, 1843.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To Balance, as per audit, 16th March, 1842,	169	17	1	By Sundries paid	636	13	11
,, Cash for sundries received,	7	16	1½	,, Balance in Bank of Ireland,	288	11	10
,, Annual Subscriptions,	275	2	0	,, Do. in Treasurer's hands,	2	11	9½
,, Life Compositions,	99	15	0				
,, Entrance Fees,	110	5	0				
,, Cash, per Boone & Co., Balance of Account,	8	17	4				
,, Rent of Stable for one year,	21	0	0				
,, Dividends on 3½ per cent. Stock,	56	13	5				
,, Do. 3 per cent. Consols,	31	13	11				
,, Treasury Warrants,	146	17	8				
	£927	17	6½		£927	17	6½

Signed,

JAMES PIM, JUN., *Treasurer.*

The auditors appointed by Council to examine the Treasurer's accounts reported as follows:

"We have examined the original Account,* with the vouchers produced, and found it to be correct; and we find that there is a balance in bank of £288 11*s.* 10*d.*, and in the Treasurer's hands, £2 11*s.* 9½*d.*, making a total balance of £291 3*s.* 7½*d.*

"(Signed,)

"FRANC SADLEIR.
"SAMUEL LITTON."

"*March* 16, 1843."

"The treasurer reports that there is £1085 17*s.* 1*d.* in 3 per Cent. Consols, and £1665 4*s.* 2*d.* in 3½ per Cent. Government Stock, to the credit of the Academy in the Bank of Ireland; the latter known as the Cunningham Fund. He also reports, that eleven members owe their annual subscriptions, due 16th March last, and that two members are owing their two years' subscriptions to the same date. There are no other arrears due. He has also to report, that the Annual Parliamentary Grant for the current year, amount £300, has not yet been placed to the credit of the Academy in the Bank of Ireland, but that there is no reason to doubt that it will be done within a few days.

"(Signed,)

"JAMES PIM, JUN.,
"Treasurer."

The ballot for the Annual Election having closed, the President requested the Rev. Charles Strong and Mr. Callwell to assist the officers in examining the balloting lists.

The Scrutineers reported that the following gentlemen were duly elected Officers and Council for the ensuing year:

President—Sir William Rowan Hamilton, LL.D.
Treasurer—James Pim, Jun., Esq.
Secretary to the Academy—J. Mac Cullagh, Esq. LL.D.
Secretary to the Council—Robert Kane, M. D.

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* Entered in Treasurer's book.

Secretary of Foreign Correspondence—Rev. Humphrey Lloyd, D.D.

Librarian—Rev. William H. Drummond, D.D.

Clerk and Assistant Librarian—Edward Clibborn.

Committee of Science.

Rev. Franc Sadleir, D.D., Provost of Trinity College; Rev. Humphrey Lloyd, D.D.; James Apjohn, M.D.; James Mac Cullagh, LL.D.; Rev. William Digby Sadleir, A.M.; Robert Ball, Esq.; Robert Kane, M.D.

Committee of Polite Literature.

His Grace the Archbishop of Dublin; Rev. Joseph Henderson Singer, D.D.; Samuel Litton, M.D.; Rev. William Hamilton Drummond, D.D.; Rev. Charles Richard Elrington, D.D.; Rev. Charles William Wall, D.D.; John Anster, LL.D.

Committee of Antiquities.

George Petrie, Esq., R.H.A.; Rev. J. H. Todd, D.D.; Henry J. Monck Mason, LL.D.; Samuel Ferguson, Esq.; Joseph Huband Smith, Esq.; James Pim, Jun. Esq.; Captain Larcom, R.E.

The President then appointed, under his hand and seal, the following Vice-Presidents:

Rev. Humphrey Lloyd, D.D.; Rev. James Henthorn Todd, D.D.; Rev. Joseph Henderson Singer, D.D.; James Apjohn, M.D.

April 10.

RICHARD GRIFFITH, Esq., in the Chair.

George James Allman, Esq., Henry Lindsay, Esq., John M'Mullen, Esq., Hon. and Very Rev. Henry Packenham, Dean of St. Patrick's, Goddard Richards, Esq., and John Wynne, Esq., were elected Members of the Academy.

Dr. Todd, V. P., read a translation of an Irish deed or agreement made in the year 1526, between Conla Mac Geoghegan, chief of the Kinel Fiacha, and Breasal Sionnach, alias Fox, chief of the Clan Tadgan,—both of Westmeath.

The agreement was, that Mac Geoghegan should be lord over Fox and his country under certain conditions, which are specified, and of which the principal is, that Mac Geoghegan is to do his best for the protection and defence of Fox and his country. The deed adds, "if Mac Geoghegan should on any occasion fail to do his best for the protection and sustainment of the Fox in his lordship, that he would do for himself; that he no longer have rent, nor privilege, nor lordship over him, but every one be for himself."

One passage proves that the custom of holding the half yearly assemblage (oıpeacταρ) on the 1st of November and the 1st of May was then kept up. "Every general assembly of Samhan [All Saints' day] or of Bealtine [May day] that shall be in Mac Geoghegan's country, shall be held at *Baileath-an-Urchair*, or at *Corr-na-Sgean*, and the Fox and the nobles of his country shall attend."

It is known from other sources that the Brehon laws, and the authority of the hereditary Brehons, were kept up in many parts of Ireland to a much later period: the following passage therefore, which contains an allusion to the Brehon, is not surprizing. "And whenever either an Englishman or an Irishman sues the Fox or any one of his country, they shall submit to pay whatever is decided upon by Mortogh Mac Egan, or whoever may be the Brehon at the time, &c."

The original of this deed, which is in Irish, is in the possession of Sir Richard Nagle, the lineal representative of Mac Geoghegan, who has kindly permitted a copy of it to be taken and deposited in the Library of the Academy.

The great body of the document is uninjured and legible; the only imperfection which occurs is in the following passage at the end, which contains the signatures and date of the agreement.

"These are they of the Foxes' country who are present with us, viz. the Fox himself, and the two sons of Edmund, viz. Murtogh and Phelim; and the two sons of Brian Fox, viz. Breasal and Cucogry; and Murtogh, son of Owen, son of . . . . . i. e. the Ollamh (poet or historian) of Fox . . . . and myself James O'Cionga [or king] the son of Carbry O'Cionga, who was present at the making of this agreement, and who wrote it. And it was on the Fast [i. e. the Eve] of St. Adamnan this agreement was made; and particularly on Wednesday; and it was on a Friday it was written. And this is the year of the Lord at this time, viz. six years, and twenty, five hundred and one thousand years [1526], and the 22nd day of the month of August.

"✠ I am the Mac Geoghegan. ✠ I am the Fox." [Here follows a line in the characters of the consonant Ogham, but so much effaced that although the key is known, it has been found impossible to decipher it. The last word only is legible, which is *Graine,* or Grace, a woman's name: then follows] "are in Ireland. ✠ We are the sons of Edmund Fox. ✠ We are the sons of Brian Fox."

Mr. Mallet gave a notice of recent improvements in the formation of Mosaic pavements.

April 24.

SIR WILLIAM BETHAM, in the Chair.

The Chairman informed the Academy, that Sir Richard O'Donnell had consented to deposit the *Cathach*, containing a MS. of the Psalms in Latin, by St. Colombkill, in the Museum of the Royal Irish Academy.

Resolved,—That the marked thanks of the Academy be returned to Sir Richard O'Donnell for his kindness.

Read, a letter from the Rev. T. R. Robinson, accompanying a box containing an original Pyrometer of Wedgewood, presented to the Academy by Miss Edgeworth, (H. M. R. I. A.)

"Dear Mac Cullagh,

"Our friend, Miss Edgeworth, has requested me to present from her to the Academy a Wedgewood's Pyrometer, which, as unfortunately I cannot attend this evening, I commit to your care. This instrument is remarkable, as being the first attempt to place within reach of the manufacturer and the chemist an easy method of measuring, at least approximatively, the temperature of their furnaces. It consists, as is well known, of a pair of converging bars, which measure, by a graduation on them, the contraction of clay cylinders that have been heated; this remains permanent, and were it, as Mr. Wedgewood supposed, a function of temperature alone, would suffice for all practical purposes. Many circumstances, however, have interfered with its general employment. The set of clay pieces which were used in the first instance were made of natural clay found in Cornwall. By these the numbers given in treatises of chemistry for the fusing points of the more refractory metals were determined, and I think it probable that Mr. Kirwan used them in his researches; Sir James Hall, I think, did not. Mr.

Wedgewood had stated in his memoir that the supply of the clay was inexhaustible; but when the stock first made was disposed of, he was unable to find the identical spot where it had been obtained, and the contraction of the new specimen was different. Had he used it as he did the other, and merely directed the employment of a number by which to multiply the indications of the scale, no inconvenience would have resulted; but he thought he might bring it to an identity by adding 'earth of alum,' obtained by precipitating alum by carbonate of potassa; a product which Apjohn or Kane will tell you is very far indeed from being pure alumina. This unhappily made the contraction irregular, and the clay pieces much less capable of resisting a high heat. Its indications were found to differ from those of the first set, and it fell into disuse, especially for two reasons. The first that Wedgewood had assigned to his degrees, a value enormously too large, so that he supposed the extreme heat of a furnace to be about 30000 of Fahrenheit, when it is only 4000. Many years since, in our Transactions, I had pointed out this error, and corrected it, with tolerable success, as was long afterwards confirmed by Daniell and Prinsep. The second, that a long exposure to a low heat produces the same contraction as a short exposure to a high. This is said by Sir James Hall to have been established by Dr. Kennedy, whose experiments, however, are no where published; and I confess that I doubt the fact. Guyton De Morveau has even made an observation which may account for the mistake. He found that similar pieces exposed for half an hour in a powerful furnace, one surrounded by siliceous sand, the other by powdered charcoal, marked 90 and 60, in consequence of the different conducting powers of these media. Now it is possible that the Scotch philosopher may have overlooked this influence, and not allowed time enough for the higher temperature to be fully transmitted. The pyrometers of Daniell and others which have since been contrived, are so much more cumbrous and elaborate than this, that I hope it may yet be revived; and if so, the chemists, who may construct pieces for themselves, would find it useful to compare them with Wedgewood's old standard. A single cylinder is sufficient for this, as after measuring a comparatively low temperature, it will still contract when submitted to a higher. This I know to have been one of the original and genuine set presented to the late Mr. Edgeworth by its inventor, and therefore, independent of its probable utility, precious as a relic of two such men, and still more so as the gift of our illustrious countrywoman to a body, of whose scientific triumphs she is proud, and in whose welfare I know her to be deeply interested.

"T. R. Robinson.

"*April* 24, 1843."

Resolved,—That the letter be referred to Council, for special notice and attention.

H. Smith, Esq. exhibited an ancient dress, found in a bog at a considerable depth, near the Abbey of Kilkenny.

A number of interesting antiquities, found at Ballyrowan, in the Queen's County, by Mr. Harrison, were presented by the Rev. B. I. Clarke, to the Academy.

The thanks of the Academy were presented to Mr. Clarke for his donation.

Sir Wm. Betham made a communication on the antiquity of certain languages.

DONATIONS.

Astronomical Observations made with Ramsden's Zenith Sector, and Catalogue of the Stars which have been observed at the different stations of the Ordnance Survey in England

and Scotland. London, 1842. Presented by the Master General of the Hon. Board of Ordnance.

Ordnance Survey of the County of Clare, in seventy-seven sheets, including the Title and Index. Presented by His Excellency the Lord Lieutenant.

Battle of Magh Rath. Presented by the Irish Archæological Society.

Memoires de la Société de Physique et d'Histoire Naturelle de Genéve. Ninth volume. 1841, 1842. Presented by the Society.

On the Public Institutions for the Advancement of Agricultural Science which exist in other Countries. By Charles Daubeny, M. D. Presented by the Author.

Transactions of the Cambridge Philosophical Society. Vol. VII. Part 3. Presented by the Society.

Proceedings of the Academie Royale de Bruxelles. Nos. 1 to 9 inclusive. Vol. IX.

Comptes Rendus des Seances de l'Academie des Sciences. Nos. 1 to 7 inclusive, from 2 Janvier to 13 Fevrier, 1843. Presented by the Academy.

Annales de l'Observatoire Royale de Bruxelles. Tome II. Presented by M. Quetelet.

Archives du Museum d'Histoire Naturelle de Paris. Livraison 3. Presented by the Museum.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1843. No. 40.

May 8.

SIR Wm. R. HAMILTON, LL.D., President, in the Chair.

I. G. Abeltshauser, Esq. was elected a member of the Academy.

The special thanks of the Academy were voted to Miss Edgeworth for her donation of Wedgewood's Pyrometer.

Professor Mac Cullagh read the following communication.

On the Laws of Metallic Reflexion, and on the Mode of making Experiments upon Elliptic Polarization.

Several years ago, as the Academy are aware, I made an attempt to investigate the laws according to which light is reflected at the surfaces of metals, and I then proposed certain formulæ which represented, with sufficient accuracy, all the facts and experiments which I was able to collect upon the subject (see the Proceedings of the Academy, vol. i. p. 2, October, 1836; Transactions, vol. xviii. p. 71, note). But in order to test these formulæ satisfactorily, it was necessary to obtain measurements far more exact than any that had previously been made; and for this end I devised an instrument, which was constructed for me by Mr. Grubb, and of which a brief description has been given in the Proceedings, vol. i. p. 159. I regret to say, however, that nothing of much consequence has yet been done with the instrument. Some preliminary trials of its performance were indeed made in the summer of 1837, and the results of one of these shall presently be given; but an accidental strain which it suffered, while I was preparing to undertake a series of experiments, caused me to discontinue the observations at the time; and being then obliged to superintend the printing of my essay on the Laws of Crystalline Reflexion and Refraction (Transactions R. I. A., vol. xviii. p. 31), my attention was drawn afresh to this latter subject, respecting which some new questions suggested themselves, which I thought it right to discuss in notes appended to the essay. I was not afterwards at leisure to take up the experimental inquiry, until the beginning of the year 1839, when I began to think of putting the instrument in order for that purpose. The strain which it had suffered rendered some slight alterations necessary; and I now resolved to make additions to it also, with the view of operating upon the fixed lines of the spectrum, as a few trials had convinced me that measures sufficiently precise could not be obtained without employing light of definite refrangibility. I wished, moreover, to take the opportunity which the nature of the proposed experiments presented, of verifying the theory of Fresnel's rhomb, or rather of verifying, by means of the rhomb, the formulæ which Fresnel has given for computing the effects of total reflexion, when it takes place at the common surface of two ordinary media. I wrote therefore to Munich for several articles which I wanted; among others, for a set of rhombs cut at different angles, out of different kinds of glass. But while I was waiting for these some months elapsed, and in the meantime I got sight of a new theory, which, from its connexion with my former researches, possessed more immediate interest, and the pursuit of which, in conjunction with other studies and various engagements, caused me again to suspend the inquiry respecting the laws of metallic reflexion. I allude to the Dynamical Theory of Crystalline Reflexion and Refraction, communicated to the Academy in December, 1839 (Proceedings, vol. i. p. 374). This was followed soon after by a general Theory of Total Reflexion (Proceedings, vol. ii. p. 96), founded on the same principles. The latter theory, forming a new department of physical optics, and involving the solution of questions not previously attempted, was *analytically* complete when it was communicated to the Academy in May, 1841; but its *geometrical* development has since required my attention from time to time, and has not yet been brought to that degree of simplicity of which it appears to be susceptible (see Proceedings, vol. ii. p. 174). Indeed I have found that, in this instance, the geometrical laws of the phenomena are by no means obvious interpretations of the equations resulting from the analytical solution of the problem; and in endeavouring to verify such supposed laws I have often been led to algebraical calculations of so complicated a nature that it has been impracticable to bring them to any conclusion, and I have been obliged, from mere weariness, to abandon them altogether. On returning, however, to the investigation, after perhaps a long interval of time, I have usually perceived some mode of eluding the calculations, or of directly deducing the geometrical law; and when the theory comes to be published in its final form, no trace of these difficulties will probably appear.

From the causes above-mentioned, combined with frequent absence from Dublin, the researches which I had entered upon, respecting the action of metals upon light, have been hitherto interrupted; and as it may still be some time before they are resumed, I venture, in the meanwhile, to submit to the Academy the results already spoken of, which were obtained on the first trial of the instrument, and which afford the best data th can yet be had for comparison with theory.

The results, it must be confessed, are those of very rough experiments, made one evening (about the month of July, 1837) in company with Mr. Grubb, before I had received the instrument from his hands, and merely with the view of showing him, when it was finished, the kind of phenomena that I proposed to observe with it, and the mode of observing them. But the instrument was so far superior (in workmanship at least) to any apparatus previously employed for this sort of experiments, that it was impossible, without great negligence in using it, not to obtain measures of considerable accuracy. I did not, however, at the time, set much value on these measures, because I expected shortly to possess a series of observations made with every possible precaution; but having chanced to preserve the paper on which they were noted down, I was tempted, a few days ago, to try how far they agreed with my formulæ; and the agreement turns out to be so close, that I think myself justified in publishing them. Besides, it will be curious hereafter to compare them with more careful measurements.

Before we proceed, however, to the details of the experiments, it may be well to give the formulæ in a state fitted for immediate application. The light incident on the metal being polarized in a certain plane, let a denote the azimuth of this plane, or the angle which it makes with the plane of incidence; and as the reflected light will be elliptically polarized, or, in other words, will perform its vibrations in ellipses all similar and equal to each other, as well as similarly placed, put θ for the angle which either axis of any one of these ellipses makes with the plane of incidence, and let β be another angle, such that its tangent may represent the ratio of one axis of the ellipse to the other. Then when the optical constants M and χ (of which I suppose the first to be a number greater than unity, and the second an angle less than 90°) are known for the particular metal, the angles θ and β may be computed for any value of a, at any given angle of incidence, by the following formulæ:

$$\left.\begin{aligned}\tan 2\theta &= \frac{(\nu'-\nu)\sin 2a}{2f+(\nu'+\nu)\cos 2a},\\ \sin 2\beta &= \frac{2g\sin 2a}{\nu'+\nu+2f\cos 2a};\end{aligned}\right\} \quad (\text{A})$$

in which f and g are constant quantities given by the expressions

$$f=\left(\text{M}-\frac{1}{\text{M}}\right)\cos\chi, \qquad g=\left(\text{M}+\frac{1}{\text{M}}\right)\sin\chi, \qquad (\text{B})$$

and ν, ν' are quantities depending on the angle of incidence i, in the following way. Let i' be an angle such that

$$\frac{\sin i}{\sin i'}=\frac{\text{M}}{\cos\chi}, \qquad (\text{C})$$

and put

$$\frac{\cos i}{\cos i'}=\mu, \qquad (\text{D})$$

then will

$$\nu=\frac{1}{\mu}-\mu, \qquad \nu'=\frac{f^2+g^2}{\nu}. \qquad (\text{E})$$

The angles θ and β are given by immediate observation with the instrument; and from their values at any incidence, and for any azimuth a of the plane of primitive polarization, we can find the constants M and χ, which we may afterwards use to calculate the values of θ and β for all other incidences and azimuths, in order to compare them with the observed values. It is indifferent, in the formulæ, whether θ be referred to the major or the minor axis of the elliptic vibration, as also whether $\tan\beta$ be the ratio of the minor to the major axis, or the reciprocal of that ratio; but in what follows we shall suppose θ to be the inclination of the plane of incidence to that axis, which, when a is 45° or less, is always the major axis; and β shall be supposed less than 45°, in order that its tangent may represent the ratio of the minor axis to the major.

When the azimuth a is equal to 45°, the formulæ (A) become

$$\tan 2\theta=\frac{\nu'-\nu}{2f}, \qquad \sin 2\beta=\frac{2g}{\nu'+\nu}; \qquad (\text{F})$$

from which we may deduce the remarkable relation

$$\frac{\tan 2\beta}{\cos 2\theta}=\frac{g}{f}, \qquad (\text{G})$$

showing that, in the case supposed, the ratio of $\tan 2\beta$ to $\cos 2\theta$ is independent of the angle of incidence. In the experiments which I made with Mr. Grubb this azimuth was always 45°; and the following Table contains the results of observation compared with those obtained by calculation from formulæ (F). The experiments were made upon a small disk of speculum metal; and in the calculations I have taken $M = 2.94$, $\chi = 64° 25'$.

Angle of Incidence.	Value of θ.		Value of β.	
	Observed.	Calculated.	Observed.	Calculated.
65°	27° 55′	27° 53′	28° 0′	28° 0′
70	15 41	15 44	33 7	33 1
75	− 8 45	− 9 16	34 10	34 6
80	−30 15	−29 25	27 0	26 53
84	−37 22	−37 25	16 47	17 17

The light used in these observations was that of a candle placed at a short distance, and was admitted through small apertures at the ends of the tubes. (See the description of the instrument in the Proceedings, vol. i. p. 159). The Nicol's prism in the first tube having been secured in a position in which its principal plane was inclined 45° to the plane of incidence, and the two arms having been set at the proper angle with the surface of the metal, the Fresnel's rhomb and the Nicol's prism in the second tube were moved simultaneously, until the image of the candle became as faint as possible. Had light perfectly homogeneous been employed, the image could have been made to vanish altogether; but instead of vanishing, it became highly coloured, and our rule in observing was to make the blue at one side of it, and the red at the other, equally vivid, so as to get results which should belong, as nearly as possible, to the mean ray of the spectrum. When this was done, the angles θ and β (subject however to certain corrections which will be hereafter explained) were respectively read off from the divided circles belonging to the rhomb and the prism. The observations were made at large incidences, because it is within the last thirty degrees of incidence that the phenomena go through their most rapid changes.

If we now cast our eyes on the above table, making due allowance for the uncertainty arising from the *dispersion* of the metal, we shall be struck with the agreement between the calculated and observed numbers. The differences are greatest in the last two observations, which however were really the first; for the observations were made in the inverse order of the incidences, and their accuracy may have improved as they went on. However that may be, the differences are quite within the limits of the errors of observation; and they are actually less than those which Fresnel found to exist between calculation and experiment in the much simpler case of reflexion at the surface of a transparent ordinary medium, when he proceeded to verify the formula which he had discovered for computing the effect of such reflexion.—See the Table which he has given in the *Annales de Chimie*, tom. xvii. p. 314.

It may seem extraordinary that these experiments should have been in my possession for nearly six years, before I became aware of their close agreement with my formulæ; but the fact is, that I did not regard them with much interest, because, from the circumstances in which they were made, I did not expect more than a general accordance with theory. And even now, I am in no haste to infer the absolute exactitude of the formulæ, though they are found to represent the phenomena so well. It was far more allowable to infer that the formula of Fresnel was exact in the case just mentioned, though it appeared to represent the phenomena less perfectly. For, to say nothing of the small number of our experiments, the present is a much more complicated case, and the phenomena depend on two constants instead of one, so that the formulæ might be slightly altered, and yet perhaps continue to agree very well with rough experiments. Where there is only one constant this is not so probable. Again, there is one of the quantities in the preceding formulæ which may be greatly altered without producing more than a slight effect on the values of θ and β. This quantity is the ratio of $\sin i$ to $\sin i'$, which, according to the value in formula (C), is a number so large as to make the angle i' always small, so that its cosine never differs much from unity; and therefore if the above ratio were taken equal to any other large number, the value of μ in formula (D) would remain nearly the same, and consequently the values of θ and β would be but slightly changed.

It is with regard to the value of μ as a function of the incidence that I entertain the greatest doubts, and if any defect shall be found in the formulæ I think it will be here. The relations (C) and (D), from which μ may be deduced in terms of i, were not indeed adopted without strong reasons; but I am not entirely satisfied with them, because, when we reverse the problem, and seek to determine the constants M and χ from the observed values of θ and β at a given incidence, the results are rather complicated and involved, though the approximate determination is easy enough. As the formulæ are in a great measure built upon conjecture, we must not be disposed to receive them without the strongest experimental proofs; and it will certainly require experiments of no ordinary accuracy to decide some of the questions which may be raised respecting them.

When plane-polarized light is incident on a metal, if its vibrations be resolved in directions parallel and perpendicular to the plane of incidence, the effect of the reflexion is to change unequally the phases of the resolved vibrations; and it may be useful to have the formulæ which express the difference of phase after reflexion, and the ratio of the amplitudes of vibration. Put ϕ for the difference of phase; and supposing, for simplicity, the incident light to be polarized in an azimuth of 45°, let σ be angle less than 45°, such that $\tan\sigma$ may represent the ratio of the reflected amplitudes respectively perpendicular and parallel to the plane of incidence; then we shall have

$$\tan\phi = \frac{2g}{\nu' - \nu}, \qquad \cos 2\sigma = \frac{2f}{\nu' + \nu}; \qquad \text{(H)}$$

from which we may infer that

$$\sin\phi \tan 2\sigma = \frac{g}{f}, \qquad \text{(I)}$$

or that the product on the left side of the last equation is independent of the angle of incidence. It is to be observed that the relations (G) and (I) are independent of the value of μ, and may hold good though that value should require to be changed.

All the preceding formulæ are merely mathematical consequences of those which I published long ago in the Transactions of the Academy (vol. xviii. p. 71). The formulæ which I had previously given in the Proceedings (vol. i. p. 2) are slightly different, and, I think, less likely to be exact, because they are less simple, and do not lead to any of the remarkable relations which may be deduced from the others.

Having had occasion, in the course of the few experiments which I made with the instrument before mentioned, to study the nature of Fresnel's rhomb, which constitutes an important part of it, I shall here describe the method which must be followed in order to obtain true results, when the rhomb is employed in observations on light elliptically polarized. A ray in which the vibrations are supposed to be elliptical is given, and what we want is to determine the ratio of the axes of the elliptic vibration, and their directions with respect to a fixed plane passing through the ray; in other words, to determine the angles which we have denoted by β and θ in the case of a ray reflected from a metal. For this purpose the ray is admitted perpendicularly to the surface at one end of the rhomb, and after having suffered two total reflexions within, passes out perpendicularly to the surface at the other end. Then causing the rhomb to revolve about the ray, we shall find two positions of it in which the emergent light will be plane-polarized, these positions being readily indicated by a Nicol's prism interposed between the rhomb and the eye; for such a prism, by being turned round the ray, can make the light totally disappear when it is plane-polarized, but not otherwise. These two positions of the rhomb will be exactly 90° from each other; in one of them the principal plane of the rhomb (the plane of reflexion within it) will be parallel to the major axis of the elliptic vibration, and the angle which it makes with the plane of incidence on the metal will be equal to θ: while in the same position the angle which the principal plane makes with the plane of polarization of the emergent ray (as given by the Nicol's prism) will be equal to β. In the other position, the principal plane will be parallel to the minor axis of the elliptic vibration, and the corresponding angles will be equal to $90°-\theta$ and $90°-\beta$ respectively. This, however, proceeds on the supposition that the rhomb is exact. When it is not so, which is of course the proper supposition, and a very necessary one in the experiments with which we are concerned, there will still be, generally speaking, two positions of it in which the emergent ray will be plane-polarized, or in which a disappearance of the light may be produced by the Nicol's prism; but these positions will no longer be 90° from each other, nor will the principal plane, in either of them, coincide with an axis of the elliptic vibration. If we now measure the angles between the different planes as before, and denote them by θ', β' in the first position, and by $90°-\theta''$, $90°-\beta''$ in the second, we shall find that θ' and θ'' are unequal, but we shall have β' equal to β''. The values of θ and β will then be given by the formulæ

$$\theta = \frac{\theta' + \theta''}{2}, \qquad \cos 2\beta = \frac{\cos 2\beta'}{\cos(\theta' - \theta'')}. \qquad (\text{K})$$

The error of the rhomb may easily be found. Supposing the vibrations to be resolved in directions parallel and perpendicular to its principal plane, the rhomb is intended to produce a difference of 90° between the phases of the resolved vibrations, or to alter by that amount the difference of phase which may already exist; but the effect really produced is usually different from 90°, and this difference, which I call ε, is the error of the rhomb. The value of ε is given by the formula

$$\tan \varepsilon = \frac{\sin(\theta' - \theta'')}{\tan 2\beta}; \qquad \text{(L)}$$

and as the error of the rhomb is a constant quantity, we have thus an equation of condition which must always subsist between the angles $\theta' - \theta''$ and β. For any given rhomb the sine of the first of these angles is proportional to the tangent of twice the second, and therefore $\theta' - \theta''$ constantly increases as β increases towards 45°, that is, as the axes of the elliptic vibration approach to equality. When β is equal to $45° - \frac{1}{2}\varepsilon$, we have $\theta' - \theta'' = 90°$; and for values of β still nearer to 45°, the value of $\sin(\theta' - \theta'')$ becomes greater than unity, that is to say, it becomes impossible, by means of the rhomb, to reduce the light to the state of plane-polarization. This is a case that may easily happen with an ordinary rhomb in making experiments on the light reflected from metals; because at a certain incidence, and for a certain azimuth of the plane of primitive polarization, the reflected light will be circularly polarized.

The rhomb which I used in the experiments tabulated above, was made by Mr. Dollond, and was perhaps as accurate as rhombs usually are; it was cut at an angle of $54\frac{1}{2}°$, as prescribed by Fresnel. Its error was about 3°, and the value of $\theta' - \theta''$, at the incidence of 75°, was about 7°. But in another rhomb, also procured from Mr. Dollond, and cut at the same angle, the value of $\theta' - \theta''$, under the same circumstances, was about 20°, and the value of ε was therefore about 8°. The angle given by Fresnel was calculated for glass of which the refractive index is 1.51; and the errors of the rhombs are to be attributed to differences in the refractive powers of the glass. I was not at all prepared to expect errors so large as these when I began to work with the rhomb, and they perplexed me a good deal at first, until I found the means of taking them into account, and of making the rhomb itself serve to measure and to eliminate them. The value of the rhomb as an instrument of research is much increased by the circumstance that it can thus determine its own effect, and that it is not at all necessary to adapt its angle exactly to the refractive index of the glass. It may also be remarked, that this circumstance affords a method of directly and accurately testing the truth of the formulæ which Fresnel has given for the case of total reflexion at the separating surface of two ordinary media; for we have only to measure the angle of the rhomb and the refractive index of the glass, and to compute, by Fresnel's formula, the alteration which the rhomb ought to produce in the difference between the phases of the resolved vibrations; which alteration of phase we may then compare with that deduced, by means of the formulæ (K) and (L), from direct experiment.

If, in each position of the rhomb, we measure the angle which the plane of polarization of the emergent ray makes with the plane of incidence on the metal, and call the two angles respectively γ', γ'', we shall have

$$\gamma' = \theta' - \beta', \qquad \gamma'' = \theta'' + \beta', \tag{M}$$

and therefore

$$\gamma' + \gamma'' = \theta' + \theta'' = 2\theta, \qquad 2\beta' = \gamma'' - \gamma' + \theta' - \theta''; \tag{N}$$

from which it appears that if the rhomb were perfectly exact, that is, if θ' and θ'' were equal to each other, the angle θ would be half the sum of γ', γ'', and the angle β half their difference. It would then be sufficient to measure the angles γ' and γ'', in order to get θ and β accurately. And if the rhomb were erroneous, the true value of θ would still be half the sum of γ', γ''; but the true value of β would not be discoverable without measuring the angles θ', θ'', by the help of which it can be deduced from the second of formulæ (N), combined with the second of formulæ (K). Nor can we discover whether the rhomb is erroneous or not, without measuring the angles θ', θ''; and therefore as these angles *must* be measured in any case, the former method of determining θ and β is to be preferred.

In making experiments on elliptically polarized light, a plate of mica or any other doubly refracting crystal, placed perpendicular to the ray, may be used instead of Fresnel's rhomb. If the thickness of the crystalline plate be such that the interval between the two rays which emerge from it is equal to the fourth part of the length of a wave, for light of a given refrangibility, the plate will, for such light, perform all the functions of the rhomb; the principal plane of the rhomb being represented by the plane of polarization of one of the emergent rays. But unless the light be perfectly homogeneous, this method is liable to great inaccuracy in practice, since the effect of the plate in producing or altering the difference of phase between the two rays which interfere on their emergence from it, is inversely proportional to the length of a wave, and will therefore be extremely different for light of different colours, and will change very perceptibly even within the limits of the same colour. It is true, the effect of the rhomb also varies with the colour of the light: but this variation is trifling compared with that which exists in the other case. It was for this reason that I employed the rhomb in my experiments, instead of a crystalline plate. The apparatus, however, is much simplified by using such a plate; and if any one chooses to do so, and to work with homogeneous light, he must take care to follow, in every respect, the directions which I have given for conducting experiments with the rhomb. The two cases are precisely similar; and if it be necessary not to neglect the errors of the rhomb, it is certainly not less necessary to take into account those which may arise from a want of accuracy in the thickness of the plate, considering how difficult it is to make the thickness correspond exactly to the particular ray which we wish to observe.

I have been induced to enter into these particulars, respecting the mode of making experiments on elliptic polarization, because the subject is one which has not hitherto been studied; nor does it seem to have occurred to any one that any precaution was requisite beyond that of getting the rhomb cut as nearly as possible at the proper angle, or the crystalline plate made as nearly as possible of the proper thickness. This, indeed, was quite sufficient for ordinary purposes. For example, light polarized in a plane inclined 45° to the principal plane of the rhomb or of the plate, would, as far as the eye could judge, be circularly polarized after passing through either of them. Notwithstanding a certain error in the angle of the one, or in the thickness of the other, such light would, when analysed by a rhomboid of Iceland-spar, give two images always sensibly equal in intensity. But an error which could not be at all detected in this way, might produce a very great effect in such experiments as those upon the metals, and, for the purpose of comparison with theory, might render them entirely useless, if in the first method of observing we relied upon one set of observations, taking (suppose) the values of θ' and β' for the true values of θ and β; or if, in the second method, we contented ourselves with merely measuring the angles γ' and γ''.

The necessity of attending to the foregoing rules and remarks will appear from an examination of the experiments of M. de Senarmont, published in the *Annales de Chimie*, tom. lxxiii. pp. 351–358. In these very elaborate experiments, which were made upon light reflected at various incidences from steel and speculum metal, the author followed a plan similar to that which I have adopted, and which, in a general way, I had previously sketched in the Proceedings of the Academy (vol. i. p. 159). There was this difference, however, that he used a plate of mica instead of Fresnel's rhomb. Now as he worked with common white light, the use of the mica plate must have rendered two kinds of errors unavoidable. In the first place, it would be impossible always to take the observations for the same ray of the spectrum; and next, as a consequence of this, the thickness of the plate would be generally inexact for the particular ray to which the observations happened to correspond. If the thickness of the plate were exact for a certain ray, it would be very sensibly inexact even for the neighbouring parts of the spectrum; and as the part of the spectrum to which the observations belonged was continually changing, the results obtained for different incidences and azimuths would not be comparable with each other, even though, in each separate case, the error of the plate were allowed for and eliminated. The values of θ, however, as determined by M. de Senarmont, would be correct, so far as *this* error is concerned; those of β alone would be erroneous. For the values of θ were determined in two ways: by measuring the angles θ', θ'', and taking their sum for 2θ; also by measuring the angles γ', γ'', and taking their sum for the same quantity. Now each of these methods gives a true value of θ, because by the preceding formulæ we have $2\theta = \theta' + \theta'' = \gamma' + \gamma''$; and this accounts for the agreement, shown by the tables of M. de Senarmont, between the values* of 2θ obtained by these different methods. But the values of β were deduced from the angles γ', γ'', by simply making their dif-

* Or rather the values of $180° + 2\theta$; because the angle ω, the double of which appears in the tables of M. de Senarmont, is equal to $90° + \theta$. The angles which he calls γ_1 and γ_2 are equal to $90° + \gamma''$ and $90° + \gamma'$ respectively. It therefore comes to the same thing, whether the one set of angles or the other is supposed to be measured. The letter β has the same signification in both notations.

ference equal to 2β; and we see by the second of formulæ (N) that, when the plate is not of the proper thickness, this value of 2β is erroneous by the whole amount of the angle $\theta' - \theta''$, the difference between β' and β being supposed so small that it may be neglected. As M. de Senarmont proceeded on the common assumption that when the thickness of the plate has been adjusted to that part of the spectrum to which the observations are intended to refer, it may afterwards, through the whole series of experiments, be regarded as exact, he necessarily conceived θ' and θ'' to be the same angle; and it was on the principle of taking an average between two measures of the same quantity, that he made the supposition $2\theta = \theta' + \theta''$, which happened to be correct. When therefore he found θ' and θ'' to be different, he of course looked upon the difference as merely an error of observation, which it would be superfluous to tabulate. Not having the values of this difference, therefore, we have not the means of immediately correcting the values of 2β. But as observations were made for several azimuths at each angle of incidence, we may use the values of θ to determine those of β; for when at any incidence (except that of maximum polarization, where $\theta = 0$ for all azimuths) the values of θ are known for two given values of α, we can deduce the corresponding values of β, without any other theory than that of the composition of vibrations. The values of β so deduced must indeed be expected to be very inaccurate, partly because of errors in the observed values of θ, partly because the observations in different azimuths do not answer to the same ray of the spectrum; but they will be accurate enough to show the great amount of the error committed by neglecting the difference $\theta' - \theta''$. For example, putting θ_0 and β_0 for the values of θ and β when $\alpha = 45°$, M. de Senarmont gives, at the incidence of 60° upon steel, $2\theta_0 = 64° \; 15'$ (taking the mean of his two determinations), and for the azimuths 55°, 30°, 25°, he gives 2θ equal to 88° 5′, 37° 2′, and 29° 36′ respectively. Combining these values of 2θ in succession with that of $2\theta_0$, we get for $2\beta_0$ the series of values $32° 38'$, $33° 28'$, $34° 30'$; the differences between which are to be attributed to the causes above stated. The mean value of $2\beta_0$ thus found is $33° 32'$; while its value, as given by M. de Senarmont, is only $28° 41'$. The difference $4° 51'$ is the value of $\theta' - \theta''$, which, divided by the tangent of $2\beta_0$, gives $7° 19'$ for the mean value of ε, the error of the mica-plate corresponding to that part of the spectrum which was observed at the incidence of 60°.

At incidences nearer the angle of maximum polarization, the errors are probably much greater. Beyond that angle they again diminish, and in some cases they almost vanish. Thus, at the incidence of 85° upon steel, with the value of $2\theta_0$ and the value of 2θ corresponding to $a = 20°$, we get, by computation, a value of $2\beta_0$ which differs only by a few minutes from that given by M. de Senarmont. Nearly the same thing happens at the same incidence when we take $a = 25°$. In these cases therefore the results belong to that particular ray for which the thickness of the plate was exact.

The observations of M. de Senarmont on speculum metal were not carried beyond the incidence of 60°. He states that he was unable to observe at higher incidences, on account of the uncertainty arising from the *dispersion* of the metal; but though this cause operated in some degree, his embarrassment must have been really occasioned by the increasing magnitude of the difference $\theta' - \theta''$, as he approached the angle of maximum polarization; that difference being perhaps twice as great as in the case of steel. My own experiments on speculum metal were all made, as has been seen, at incidences *greater* than 60°.

The experiments of M. de Senarmont do not at all agree with the formulæ; and therefore I have been obliged to analyse his method of observation, and to show that it could not lead to correct results. It is to be regretted that his method was defective, as the zeal and assiduity which he has displayed in the inquiry would otherwise have put us in possession of a large collection of valuable data.

I shall conclude by saying a few words respecting the intensity of the light reflected by metals. The formulæ for computing this intensity have been given in the Transactions of the Academy, in the place already referred to; but they may be here stated in a form better suited for calculation. If we suppose ψ and ψ' to be two angles, such that

$$\cot \psi = \frac{M}{\mu}, \qquad \cot \psi' = M\mu, \tag{O}$$

and then take two other angles ω, ω', such that

$$\cos\omega = \sin 2\psi \cos\chi, \qquad \cos\omega' = \sin 2\psi' \cos\chi, \tag{P}$$

we shall have

$$\tau = \tan \tfrac{1}{2}\,\omega, \qquad \tau' = \tan \tfrac{1}{2}\,\omega', \tag{Q}$$

where τ is the amplitude of the reflected rectilinear vibration, when the incident light is polarized in the plane of incidence, and τ' is the amplitude of the reflected vibration when the incident light is polarized perpendicularly to that plane; the amplitude of the incident vibration being in each case supposed to be unity. Hence when common light is incident, if its intensity be taken for unity, the intensity I of the reflected light will be given by the formula

$$I = \tfrac{1}{2}(\tan^2 \tfrac{1}{2}\,\omega + \tan^2 \tfrac{1}{2}\,\omega'). \tag{R}$$

If with the values of M and χ determined by my experiments we compute, by the last formula, the intensity of reflexion for speculum metal at a perpendicular incidence, in which case $\mu = 1$, we shall find $I = .583$. This is considerably lower than the estimate of Sir William Herschel, who, in the Philosophical Transactions for 1800 (p. 65), gives .673 as the measure of the reflective power of his specula. The same number, very nearly, results from taking the mean of Mr. Potter's observations (Edinburgh Journal of Science, New Series, vol. iii. p. 280). It might seem therefore that the formula is in fault; but I am inclined to think that the metal which I employed had really a low reflective power. Its angle of maximum polarization was certainly much less than that of the speculum metal used by Sir David Brewster (Phil. Trans. 1830, p. 324), who states the angle to be 76°, whereas in my experiments it was only about $73\frac{1}{2}$°; and any increase in this angle, by increasing the value of M, raises the reflective power. On the other hand, the maximum value of β (when $\alpha = 45°$) was greater than that given by Sir David Brewster, namely, 32°; and any increase in β tends also to increase the reflective power. Now it is not unreasonable to suppose that the highest values of both angles may be most nearly those which belong to the best specula; and accordingly if we take 76° for the incidence of maximum polarization, and retain the maximum value of β, namely 34° 37′, which results from my experiments, we shall get $M = 3.68$, $\chi = 66° 16'$, and the value of I at the perpendicular incidence will come out equal to .662, which scarcely differs from the number given by Herschel.

It is clear from what precedes that the optical constants are different for different specimens of speculum metal, and this is no more than we should expect, from the circumstance that the metal is a compound, and therefore liable to vary in its optical properties from variations in the proportion of its constituents; but I am disposed to believe that the same thing is generally true, though of course in a less degree, of the simple metals, so that in order to render the comparison satisfactory, the measures of intensity should always be made on the same specimen which has furnished the values of M and χ. There is one metal, however, with respect to which there can be no doubt that the experiments of different observers are strictly comparable, when it is pure, and at ordinary temperatures; I mean mercury. For this metal Sir David Brewster states the angle of maximum polarization to be 78° 27′, and the maximum value of β, when $a = 45°$, to be 35°; from which I find $\text{M}=4.616$, $\chi = 68° 13'$, and, at the perpendicular incidence, $\text{I} = .734$. Now Bouguer observed the quantity of light reflected by mercury, but not at a perpendicular incidence. His measures were taken at the incidences of 69° and 78½°, for the first of which he gives, by two different observations, .637 and .666; for the second, by two observations, .754 and .703, as the intensity of reflexion. (See his *Traité d'Optique sur la Gradation de la Lumière*, Paris, 1760; pp. 124, 126). If we make the computation from the formula, with the above values of M and χ, we find the quantities of light reflected at these two incidences to be, as nearly as possible, equal to each other, and to seven-tenths of the incident light, the intensity of reflexion being a minimum at an intermediate incidence; and if we suppose these quantities to be really equal at the incidences observed by Bouguer, we must take the mean of all his numbers, which is .69, as the most probable result of observation. This result differs but little from one of the two numbers given by him at each incidence, and scarcely at all from the result of calculation.

The angle at which the intensity of reflexion is a minimum, when common light is incident, may be found from the formula

$$\left(\text{M}+\frac{1}{\text{M}}\right)\left(\mu+\frac{1}{\mu}\right) = \left(\text{M}-\frac{1}{\text{M}}\right)\sqrt{(f^2+g^2)}-4\cos\chi, \qquad (s)$$

which gives the value of μ, and thence that of i. This incidence for mercury is, by calculation, 75° 15′, and the minimum value of I is .693, which is less than its value at a perpendicular incidence by about one-eighteenth of the latter. According to the formulæ, the reflexion is always total at an incidence of 90°.

Rev. Charles Graves communicated certain extracts from a work of the late Dr. Cheyne, on a Deranged State of the Faculty of communicating by Speech or Writing.*

Dr. Allman read a paper "on a New Genus of Hydraform Zoophytes."

The author discovered the animal on which he founded the new genus in the Grand Canal near Dublin, in October, 1842. The genus of which this zoophyte constitutes as yet the only known species, will find a place in the family of the *tubulariadæ,* and occupies a position between *coryne* and *tubularia,* differing from the former in the possession of a polypedome, and from the latter in the scattered arrangement of its tentacula. The tentacula, as in both the last mentioned genera, are filiform; and in this character a point of distinction is at once found between the new genus and *Hermia,* Johnst.

To the new zoophyte Dr. Allman assigned the name *Cordylophora lacustris.*

May 22.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Right Hon. the Earl of Dunraven was elected a member of the Academy.

Dr. Osborne read some observations on the deprivation of the faculty of speech while the intellect remains entire, and in which the defect does not arise from paralysis of the vocal organs. The communication was intended as a sequel

* This work having been since published, the extracts are not here given.

to Dr. Cheyne's observations read at the last meeting, and was chiefly intended to refer to a case published by Dr. Osborne, which afforded some peculiar opportunities of investigating the nature of this affection.

The subject of this case was a gentleman of about 26 years of age, and of very considerable literary attainments. He was a Scholar of Trinity College, and also a proficient in the French, Italian, and German languages. When residing in the country, one morning, after bathing in a neighbouring lake, he was sitting at breakfast, when he suddenly fell in an apoplectic fit. A physician was immediately sent for, and after being subjected to the appropriate treatment, he became sensible in about a fortnight. But although restored to his intellects, he had the mortification of finding himself deprived of speech. He spoke, but what he uttered was quite unintelligible, although he laboured under no paralytic affection, and pronounced a variety of syllables with the greatest apparent ease. When he came to Dublin his extraordinary jargon caused him to be treated as a foreigner in the hotel where he stopped; and when he went to the College in quest of a friend he was unable to express his wish to the gate-porter, and succeeded only by pointing to the apartments which his friend had occupied. The circumstance of his having received a liberal education, and his tractable disposition, rendered this case peculiarly favourable for ascertaining the true nature of the affection, and the result of Dr. Osborne's observations during several months were as follows:

1. He perfectly comprehended every word said to him, and his conduct and habits were those of a man in a sound state of mind, and were exactly those which his friends stated to be peculiar to him before the seizure. He had no paralysis, and the motions of his mouth and tongue were executed with the force and rapidity of ordinary health.

2. He perfectly comprehended written language. He continued to read his newspaper every day, and when passing events were spoken of, proved that he had a clear recollection of all that he read. Having procured a copy of Andral's Pathology in French, he read it with great diligence, having lately intended to embrace the medical profession.

3. He expressed his ideas in writing with considerable fluency, and when he failed it appeared to arise merely from the want of the association with spoken language, which caused confusion and uncertainty, the words being orthographically correct, but frequently not in their proper places. He translated Latin sentences accurately, and also wrote correct answers to historical questions.

4. His knowledge of arithmetic was unimpaired, he added and subtracted numbers of different denominations with uncommon readiness; also played well at the game of drafts.

5. His recollection of musical sounds appeared to be unimpaired, for when the tune of Rule Britannia was played he pointed to the shipping in the river.

6. His power of repeating words after another person was almost confined to certain monosyllables; and in repeating the letters of the alphabet he could never pronounce *k, q, u, v, w, x,* and *z,* although he often uttered those sounds in attempting to pronounce the other letters. The letter *i* also he was very seldom able to pronounce.

7. In order to ascertain and place on record the peculiar imperfection of language which he exhibited, the following sentence from the By-laws of the College of Physicians was selected, viz. "*It shall be in the power of the College to examine or not examine any Licentiate previously to his admission to a Fellowship, as they shall think fit.*" Having set him to read this aloud, he read as follows: "*An the be what in the temother of the trothotodoo to majorum or that emidrate ein einkrastrai mestreit to ketra totombreidei to ra fromtreido as that kekistret.*" The same passage was presented to him in

a few days afterwards, and he then read it as follows: "*Be mather be in the kondreit of the compestret to samtreis amtreit emtreido am temtreido mestreiterso to his eftreido tum bried rederiso of deid dat drit destrest.*"

We observe here those monosyllables which are of most frequent use in our language, as *the, be, what, in, that, his,* and *was,* along with several syllables almost peculiar to the German language, which he was engaged in studying at the time of the apoplectic seizure; but the main feature in the case was, that although he knew when he spoke wrong, yet that he was unable to speak right, notwithstanding he articulated very difficult and unusual syllables.

As in this case the recollection of the meaning of words was retained, and it was proved that there was no paralytic affection interfering with pronunciation, but that even in the act of endeavouring to imitate another person, he could not pronounce the right word, Dr. Osborne concluded that the affection was not (as has been usually described) a loss of the faculty of language or of the memory of names, while the memory of things remains, but that it consisted in *a loss of the recollection how to use the vocal apparatus.*

In stammering it is obvious that the patient knows the mode in which the word is to be pronounced; he begins it rightly, but is prevented from finishing it by debility or spasm on the part of the muscles, causing them to resist his efforts. In this patient, on the contrary, the words which he could write, and understood perfectly, he was unable to commence the first syllable of, and instead of them uttered words compounded from other languages. His ear afforded him very little assistance, as his attempts to repeat what had been read were scarcely better than his reading. The organs were not paralysed, neither were they affected by spasm, nor was he ignorant of the sounds to be uttered: it only remains then that he was ignorant of the art of producing those sounds, and as he was previously in possession of this art, we are justified in asserting that he forgot it.

It may appear unaccountable why we should be liable to forget the use of the vocal organs, but never forget the use of the other voluntary muscles. Thus while we have those instances of persons pronouncing one word when they intended another, we have no instance of an individual running when he wished to stand, or leaping when he wished to sit down. This, however, admits of being adequately explained, by the nerves concerned in the muscular apparatus of speech being derived from the brain and highest portions of the spinal cord, and consequently liable to be disturbed by apoplectic affections; while the nerves of the limbs being derived from the cervical plexus, or lower portions of the spine, are unaffected, except by such causes as may produce paralysis.

Dr. Osborne referred to the *Ephimerides Curiosæ* for a case in which the art of writing was retained, while that of speaking was lost; and also alluded to that of Zacharias in the Sacred Scriptures, who, although deprived of speech, is related to have written "The child's name is John."

Those instances which have been recorded of persons after wounds or apoplectic seizures ceasing to speak their usual language, and resuming the use of some other language with which they had been familiar at a former period, appear to be of the same nature as the present. The recollection of one language, and its train of associate actions being lost, it was most probable that the vocal organs should move in that train to which they had formerly been accustomed, and fall into the use of another language. It is highly probable that a similar occurrence would have taken place in this patient if he had only cultivated one language besides English, but having been conversant with five languages, the muscular apparatus ranged among them, forming a kind of polyglot jargon, which was formed without any rule, was inconsistent with itself, and wholly unintelligible.

Although Dr. Osborne did not enter upon the medical treatment of the case, yet he considered that the effect of the plan adopted to recover his speech afforded an additional proof that this patient had not lost the faculty of language, but only the art or *knack* of speaking. He commenced learning to speak *de novo* like a child, by repeating after another person first the letters of the alphabet, and subsequently words. This was a very laborious task. Sometimes he was able to pronounce words which at other times he found impracticable, but his progress may be estimated by his repeating after another the same By-law of the College of Physicians in the following terms: "*It may be in the power of the College to enhavine or not ariatin any Licentiate seviously to his amission to a spolowship as they shall think fit.*" A month or two afterwards he repeated the same By-law perfectly well, with the exception of the word *power*, which on this occasion he called *prier*. This gentleman soon afterwards went to the country, where in a few months he was carried off by a fever, and Dr. Osborne learned no further particulars respecting him after he left Dublin.

Sir William Hamilton remarked that Dr. Robinson's mean refractions, published in the second Part of the Nineteenth Volume of the Transactions of the Academy, might be represented nearly by the formula,

$$\text{R} = 57{,}546 \tan(\theta - 4'' \times \text{R}); \tag{1}$$

or by this other formula,

$$\text{R} \cot\theta + \text{R}^2 \sin 3'',8 = 57{,}346\,; \tag{2}$$

R being the number of seconds in the refraction corresponding to the apparent zenith distance θ, when the thermometer is 50°, and the barometer 29,60 inches.

The first formula seems to give a maximum positive deviation from Dr. Robinson's Table, of about a quarter of a second, at about 80° of zenith distance; it agrees with the

Table at about 83° 10′; is deficient by a second at about 84° 30′; and by $\frac{1}{3}''$ at 85°.

The second formula, which may be reduced to logarithmic calculation by the equations,

$$\left.\begin{aligned} \log \tan 2\rho &= \log \tan \theta + \bar{2},81296, \\ \log R &= \log \tan \rho + 3,24657, \end{aligned}\right\} \quad (3)$$

does not agree quite so closely with Dr. Robinson's Table, in the earlier part of it; but the error, positive or negative, seems never to exceed half a second, within the extent of the Table, that is, as far as 85°.

It appeared to Sir W. H. worth noticing, that the results of such (necessarily) long and complex calculations, as those which Dr. R. had made, could be so nearly represented by formulæ so simple: of which, indeed, the first is evidently analogous to Bradley's well known form, but differs in its coefficients. The second form is more unusual, and gives (approximately) the mean refraction as a root of a quadratic equation. It has been used (with other logarithms) by Brinkley, for low altitudes.

DONATIONS.

Address to the Geological Society of London. By Roderick J. Murcheson, F. R. S. A. Presented by the Author.

Report of the Meeting of the British Association held at Manchester in 1842. Presented by the Association.

Statutes relating to the Admiralty, to the 8*th of Geo. III.* Presented by Captain Portlock.

Proceedings of the Glasgow Philosophical Society. 1841-1842. Presented by the Society.

Memoirs published by the Society of Sciences in Holland. Vol. II. Second Series.

Proceedings of the American Philosophical Society. Vol. II. Parts 24 and 25.

Transactions of the American Philosophical Society. Vol. VIII. New series. Parts 2 and 3. Presented by the Society.

Fifth Annual Report of the Loan Fund Board in Ireland for 1843. Presented by the Commissioners.

Communication to the Right Hon. Sir Robert Peel, Bart. By Jeffries Kingsley, Esq. Presented by the Author.

Bulletin des Sciences de la Societé Vaudoise des Sciences Naturelles. Nos. 1–4. Presented by the Society.

Sur les Figures Roriques et les Bandes Coloriées produites par l'Electricité. Par M. P. Riess. Presented by the Author.

Expériences sur la non caloricité propre de l'Electricité.

Sur les relations qui lient la lumiere a l'Electricité.

Sur les travaux recents qui ont en pour objet l'etude de la vitesse de propagation de l'Electricité. Par M. Le Prof. Elie Wartmann. Presented by the Author.

Memoirs of the Literary and Philosophical Society of Manchester. New Series. Vol. VII. Part 1. Presented by the Society.

List of Premiums of the Society for the Encouragement of Arts, Manufactures, and Commerce, for 1843–45. Presented by the Society.

Transactions of the Geological Society of London. Second Series. Vol. VI. Part 2. Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1843. No. 41.

June 12.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Sir William Betham read the following letter from Sir Richard O'Donel, Bart.:

"*April 24th*, 1843.

"MY DEAR SIR WILLIAM,

"I have to apologise for all the trouble I have given you about the *Caah*, but several circumstances have come to my knowledge within the last few days, which induce me to desire that it should be placed in the Royal Irish Academy, next to the Cross of Cong; but I would not take any step in the matter without first consulting you, and having done so, I write you this note to request you will be so good as to make known my wishes to the Dublin Society upon the subject, and to have it removed to the Royal Irish Academy, upon their taking charge of it as my property, placing it during the day beside the Cross of Cong, and having it each night placed in a fire proof box.

"I again beg leave of you to pardon me for all this trouble, and to accept my thanks for your kindness at all times, and believe me,

"Dear Sir William,

"Very sincerely yours,

"RICHARD O'DONEL.

"*Sir William Betham,*
Record Tower, Castle."

Resolved,—That the thanks of the Academy be given to Sir Richard O'Donel, Bart., for his valuable deposit, and that the custody of it be accepted by the Academy on the terms proposed by him.

Sir Wm. Betham gave an account of the Caah.

Professor Kane read a notice of some recent Determinations of the Heat developed during the Formation of certain Compounds of Chlorine, by Dr. Andrews.

The present results were obtained by a similar method to that described in the last volume of the Transactions of the Academy. The chlorine, however, was employed in the dry state, and the compounds being formed without the presence of water, the heat of combination was deduced from a single direct experiment. In the case of potassium, an important modification of the apparatus was required, which will be described when the full details of the experiments are communicated to the Academy. The numbers in the first column are the immediate results of experiments, and express, in degrees of Fahrenheit's scale, the heat produced during each reaction, in reference to the chlorine as unit, that is, the degrees through which a weight of water equal to that of the combining chlorine would be raised by the heat developed in the formation of each compound. The numbers in the second column express the same heat, referred to the combining metal as unit, and are deduced by calculation from the others.

$$K + Cl \,..\, 5379^\circ \,..\, 5954^\circ.$$
$$Sn + Cl_2 \,..\, 1621^\circ \,..\, 1346^\circ.$$
$$Sb_2 + Cl_5 \,..\, 1570^\circ \,..\, 1145^\circ.$$
$$As_2 + Cl_3 \,..\, 1268^\circ \,..\, 898^\circ.$$

Dr. Allman read a notice of a new species of Linaria.

This plant was discovered growing on the banks of the River Bandon, and Dr. Allman considered it sufficiently distinct to entitle it to rank as a new species. Specimens of the plant collected by Dr. Allman were seen in London by Mr. H. C. Watson, who recognized them as identical in species with a Linaria, gathered by himself in two English localities, and, moreover, that they corresponded with the *Antirrhinum Bauhin* of Gaudin's Flora Helvetica, *L. Italica,* Koch. In accordance with these views, a paper by Mr. Watson appeared in the second Number of Sir W. J. Hooker's London Journal of Botany, adding L. Bauhini to the Flora of Britain.

To the claim, however, of L. Bauhini to be admitted into the British Flora, Dr. Allman could not assent; so far at least as this claim depended on the identity of the Irish with the Continental plant. He had carefully examined the Irish Linaria, and convinced himself not only of its distinctness from L. Bauhini, but of its claim to rank as a new species. To Linaria repens it is closely allied, indeed there is some difficulty in separating it from this plant as a distinct species. Dr. Allman, however, conceived that specific characters would be found in the flowers, which not only differ in colour from those of L. repens, but also in their larger size, and in the greater relative as well as absolute length of the spur. To the new Linaria he gave the specific name *sepium,* and described it as follows:

Linaria *sepium.* Lin. radice repente, foliis subglaucis lineari-lanceolatis, calcare incurvo corollam æquante, seminibus trigonis.

Radix repens. *Caulis* erectus simplex v. subramosus, paniculatus. *Folia* subglauca, lineari-lanceolata, sparsa, inferiora sæpe verticillata. *Bracteæ* lanceolatæ, pedicello breviores, *Calycis* laciniæ lanceolatæ. *Flores* in paniculam ex racemis erectis constantem dispositi, et odorem suavem at tenuem exhalentes. Calcar incurvum corollam æquans, labium superius, tubus et calcar grisei, striis palidé purpureis eleganter signati: labium inferius diluté luteum, striis palidé purpureis et parum distinctis notatum: palatium villis saturatè luteis vestitum, villis purpureis quemque marginem investientibus, *Capsula* globosa, dehiscens superne pluribus valvulis lanceolatis. Semina nigra, trigona, lateribus inæqualibus muricatis, marginibus in alas tres productis.

A L. repente differt hæc species calcare longiore, corollâ majori et labio inferiori luteo; a L. vulgari discrepat floribus minoribus corollâ striis signatâ et toto flore, præter labium inferius et palatium, coloris lutei experti: ad hoc semina trigona signum certum præstant quo hæc species a L. vulgari dignosci potest; ab Antirrhino Bauhini differt caule erectiori, foliis angustioribus, colore florum pistillo glabro et seminibus trigonis.

Habitat in sepibus juxta flumen Bandon.—Florebat Junio, Julio et Augusto 4.

Rev. Dr. Kennedy Bailie commenced the reading of a paper on "Certain Greek Inscriptions copied on the Sites of Ancient Teos and Aphrodisias in Asia Minor."

DONATIONS.

Journal of the Franklin Institute. Vols. III. and IV Third Series. Presented by the Institute.

Proceedings of the Zoological Society of London. Part 10. 1843. Presented by the Society.

Tribes and Customs of Hy-Many. By John O'Donovan, Esq. Presented by the Irish Archæological Society.

Astronomische Nachrichten. Nos. 462–477.

Annales des Sciences Physiques et Naturelles d'Agriculture et d'Industrie, publiées par la Société Royale d'Agriculture, &c. de Lyon. Tomes I. II. and III. Presented by the Society.

Second Mémoire sur les Kaolins. Par M. Brongniart. Presented by the Author.

June 26.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Present, His Excellency Earl De Grey, Lord Lieutenant, Visitor of the Academy.

Dr. Kennedy Bailie read in continuation the Account of his Researches in Ancient Teos and Aphrodisias, in Asia Minor.

Previously to entering on his selection of notices with respect to the Teian, &c. inscriptions, he thought it proper to offer a few remarks on that part of his former essay which relates to the subject of the inscriptions from Sardes and Pergamus.

The passages more particularly referred to are those in pages 132–4, and 149–50, on which certain observations were made either explanatory of, or modifying, the author's conclusions, as expressed therein. The result in the case of the Sardian titulus has been, that it must no longer be considered as referrible to the ages of Hadrian or of the Antonines, as he was at first led to suppose; and in that of the Pergamenian, that the document *may be so interpreted* as not to be in anywise connected with the question of Hadrian's adoption by Trajan.

The new readings illustrative of these points were submitted to the notice of the Academy.

The author then proceeded to a detail of his researches on the sites of the ancient Teos and the neighbouring port-town of Cherræïdæ, which is mentioned by Strabo. This last he considers as occupied by the modern village of *Sighadjék.*

The most interesting of the inscriptions which he brought from these sites is a fragment of one of an early date, at least coeval with those which Chishull has published in his celebrated work on the Antiquities of Asia, from copies made by the late Sir William Sherard in 1709 and 1716. It related, as far as can be collected from the extremely mutilated state of the monument, to a treaty of Asylumship (ἀσυλία) between the inhabitants of this district of Asia Minor and certain other States of Greek origin, amongst which there are fragments of the names of the Agrigentines, the Coans, the Polyrrhenians (of Crete), also of the people of Delphi.

This notice was concluded with a translation of the Titulus, which contained such supplementary matter as the author deemed requisite to complete the sense.

He then proceeded to notice two other inscriptions, one of which he regarded as marking the site of the Temple of Bacchus, in Teos, of which Vitruvius has made mention; and the other as a remnant of the inscribed monuments of the ancient Chalcis, which lay contiguous to Teos.

The first of these is remarkable, from its containing a notice of the election of a female of rank to serve the office of High Priestess of Asia.

The second informs us of the existence of a Gerusia, or House of Assembly for the Seniors, in the city to which it belonged. Whether this was Chalcis (as conjectured above), or Teos, is uncertain.

In proceeding to Gheyerah (the representative of Aphrodisias in Caria), the site of Tralles was noticed; as also were the Tituli, which Pococke and others have copied from the ruin at present existing in the ancient acropolis.

The Temple of Aphrodite, extensive remains of which still exist, in Aphrodisias, was then noticed; as also the probable site of the Agora. Near this the first of the Aphrodisian inscriptions was copied, which is remarkable from its containing notices of a gradation in dignity amongst the Archons of the city, as also amongst the *Neopœi*, or *Trustees of the Temple of Aphrodite*.

The inscription in honour of Constantius and one of his colleagues, over the west portal, was next explained, and reasons were assigned for supposing that the name of Julian, the Apostate, had been erased by the Christian inhabitants of the city, from this monument.

The next inscription which was noticed contains an allusion to the office of Asiarch, which led the author of the Memoir to offer some explanations in reference thereto, principally on the mode of election to, and the duties, of, that station.

The next brought under consideration was a fragment, capable of being restored so as to present the first two petitions of the Lord's Prayer; a supposition in perfect consistence with the history of the town.

Several others were also noticed; the most remarkable and interesting of which was a tomb-inscription of considerable length, copied from the eastern side of the rampart. The discussion of this led to many remarks on the mode adopted amongst the Greek colonists of Asia Minor to express degrees of descent, on the terms of their sepulchral architecture, and on the laws regulating tomb-property.

Connected with this subject was a series of observations on the office of the *Stephanephoræ*. This appears to have been partly of a civil nature, partly pontifical, in accordance with which the right of wearing diadems was granted to functionaries of this class, as to the *Flamines* amongst the Romans.

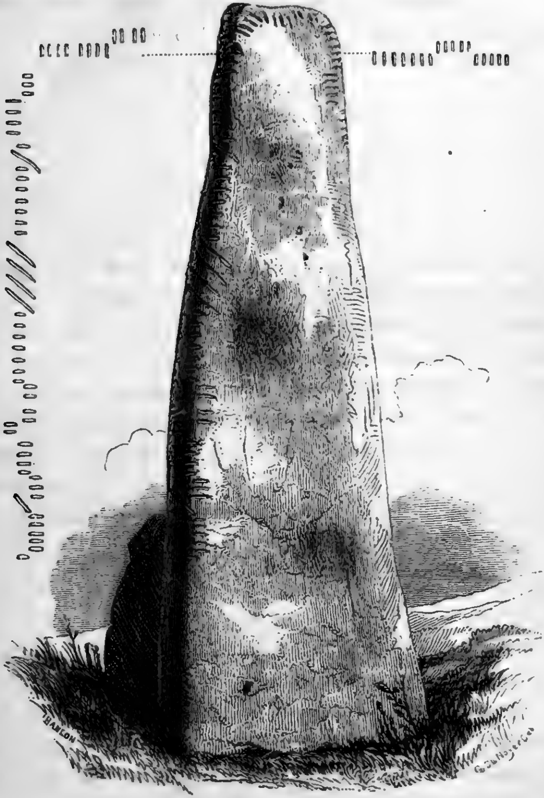
The Memoir closed with some details respecting a series of reliefs, which the author discovered on the exterior of the southern wall. These, though placed in juxta-position, did not all refer to the same subject. There are two interposed, which appear to be altogether symbolical in their meaning, or at least to possess a mythical character, and to have been intended as illustrations of some mythical circumstance.

A suggestion was offered, that perhaps it would be worthy the attention of archæologists, to adopt means to have these sculptures removed from their present position, and deposited in some museum. They appeared to the author to be curious and valuable specimens of ancient art, and are, in all probability, connected with the mythical legends of the Cretan people, with whom the early inhabitants of Aphrodisias were closely connected.

The Rev. Dr. Todd, V. P. gave an account of a Stone with an Ogham Inscription, which was found with many others in a cave at Fortwilliam, in the county of Kerry, and sent up to the Provost and Senior Fellows of Trinity College.

After having given a short account of the different kinds of Ogham spoken of by Irish grammarians, and exhibited the key usually given for reading the particular kind of Ogham to which the inscription on the stone found at Fortwilliam belongs, Dr. Todd proceeded to show the inapplicability of this key to the interpretation of the inscription. The whole subject of the Ogham inscriptions, he stated, was one which was involved in great obscurity, and although very abundant materials exist for investigating it, it has never yet been fairly examined. Several treatises on the subject are to be found in our ancient MSS., but no Irish scholar seems as yet to have had the courage to enter upon the study of them. Numerous inscriptions on stones, similar to that now exhibited to the Academy, are also to be found, particularly in the south and west of Ireland, but accurate copies of these inscriptions are no where accessible. Dr. Todd suggested this as a suitable subject for a prize, if ever the Academy should return to the former practice of offering a prize for an essay on a given subject. In this case, however, he recommended that the prize should be offered, not for the best essay or theory for the explanation of the Ogham character, but, in the first instance, for the most accurate and best authenticated collection of copies, or fac similes, of the inscriptions themselves.

The following engraving gives a correct view of the stone, which is four feet five inches high, and in its broadest part at the base four feet six and a half inches in circumference, and an exact copy of the inscription:



Mr. Griffith read a notice by Mr. Hemans, of a Dislocation in the Calp near Killester.

The President, on presenting to Dr. Kane the Cunningham Medal, awarded to him for his Researches on the Nature of Ammonia, gave an account of the progress of his discoveries.

It is now my duty to inform you, that a Cunningham Medal has been awarded by the Council to Dr. Robert Kane, for his Researches on the Nature and Constitution of the Compounds of Ammonia, published in the First Part of the Nineteenth Volume of the Transactions of this Academy. It would, indeed, have been much more satisfactory to myself, and doubtless to you also, if one of your Vice-Presidents, who is himself eminent in Chemistry, had undertaken the task which thus devolves upon me, of laying before you a sketch of the grounds of this award; but at least, my experience of your kindness encourages me to hope, that while thus called upon officially to attempt the discharge of a duty, for which I cannot pretend to possess any personal fitness, or any professional preparation, I shall meet with all that indulgence of which I feel myself to stand so much in need.

Although, in consequence of the variety of departments of thought and study which are cultivated in this Academy, and the impossibility of any one mind's fully grasping all, it is likely that many of its members are unacquainted with the details of chemistry, yet it has become matter of even popular knowledge, that in general the chemist aims to determine the constitution or composition of the bodies with which we are surrounded, by discovering the natures and proportions of their elements. Few need, for instance, to be told that water, which was once regarded as itself a simple element, and which seems to be so unlike to air, or fire, or earth, has been found to result from the intimate union of two different airs or gases, known by the names of oxygen and hydrogen, of which the one is also, under other circumstances, the chief supporter of combustion, is an ingredient of the atmosphere we breathe, and is closely connected with the continuance and healthful action of our own vital processes, by assisting to purify the blood, and to maintain the animal heat; this same gas combining also, at other times, with some metals to form rusts, with others acids, with others again alkalies and earths, entering largely into the composition of marble and of limestone, and, in short, insinuating itself, with a more than Protean ease and variety, into almost every bodily thing around us or within us; while the other gas which contributes to compose water, though endowed with quite different properties, is also extensively met with in nature, especially in organized bodies, and in particular occurs as an element in that important substance, on the confines of the mineral and organic kingdoms, to which the Researches of Doctor Kane relate; ammonia being, as all chemists admit, a compound of hydrogen and nitrogen, which last-named gas is well known as being the other chief ingredient (besides oxygen) of atmospheric air.

Again, it is generally known, to those who take an interest in physical science, as a truth which is almost the foundation of modern chemistry, that the elements of bodies of well-marked and definite constitutions, such as pure (distilled) water, or dry (anhydrous) ammonia, are combined, not in arbitrary, but in fixed and determined proportions; for example, the oxygen contained in any quantity of pure water weighs exactly, or almost exactly, eight times as much as the hydrogen contained in the same quantity, but occupies (when collected and measured) a space or volume only half as great; and the nitrogen contained in any given amount of dry ammoniacal gas, is to the hydrogen with which it is combined, by weight as 14 to 3, and by volume in the proportion, equally fixed, of 1 to 3.

Yet such results as these, respecting the constitution of compound bodies, however numerous and accurate they may be, are still not sufficient to satisfy the curiosity, or to terminate the researches of chemists. They aspire to understand, if possible, not only the *ultimate* constitution of bodies, or the elements of which they are composed, and the proportions of those elements, but also the *proximate* constitution of the same bodies, or the manner in which they arise from other intermediate and less complex compounds. Water, for instance, is believed to enter, in many cases, into composition with other bodies, *as water*, not *as* oxygen and hydrogen. Has ammonia any such component, which itself is composite? It is admitted to consist of one volume of nitrogen, combined with three of hydrogen. Can any order be discovered in this combination, any proximate constituent, any simpler and earlier product, from which the ammonia is afterwards produced? Until experiments decide, it appears not impossible, may seem even not unlikely, that nitrogen *may* combine (more intimately than by mere mixture) not only with thrice but with twice or once its own volume of hydrogen, and that thus other substances *may* be formed, from which, by the addition of new hydrogen, ammonia *may* result. It is interesting, therefore, to inquire whether either of these conceived possibilities is actually realized in nature; whether these two important gases do ever actually combine with each other in either of these two proportions. In the symbolic language of chemists, as usually written in these countries, the compound NH_3 is well known, being no other than ammonia ; but does NH* or does NH_2 exist?

An eminent French chemist, M. Dumas, in examining a substance, which he called oxamide, and which was one of the results of the action of oxalic acid on ammonia, was led to the conclusion, that the last mentioned compound of nitrogen and hydrogen, namely NH_2, does really exist in nature, and he proposed for it the name of *amide*. The same chemist considered it also to exist in the substance formed by heating potassium in ammoniacal gas ; and the same combination, amide, had been (I believe) regarded as a proximate constituent of certain other compound bodies, such as urea, sulphamide, and carbamide, before Dr. Kane's researches on the White Precipitate of Mercury. Yet it has been judged by Berzelius, that the investigations of Dr. Kane have assisted in an important degree to establish the actual existence (der wirklichen existenz) of amide, or of *amidogene* (as Kane prefers to call it, from its analogy with oxygen and cyanogen), and have thrown much light upon its chemical history and relations.

In fact, the body *oxamide*, which seems to have first led Dumas to infer the existence of amide, was one of those organic compounds, respecting which it has often been found difficult, by chemical inquirers, to pass with confidence from the *empirical* to the *rational* formula; from the knowledge of the *ultimate* elements (or of those which are at present to be viewed as such), and of the proportions in which they combine, to a satisfactory view respecting the *proximate* elements, or intermediate and less complex combi-

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* The compound NH, or as it is otherwise better written, HN, has been suspected to exist, as one of the proximate elements of melamine and of some connected bodies. See Gregory's edition of Turner's Chemistry, 1840, page 757.

nations on which the final result depends. Oxamide may be, and was considered to be, *probably* composed of amide and carbonic oxide (in the foregoing notation, $NH_2+C_2O_2$); but it was perceived to admit also* of being *possibly* compounded of nitric oxide and a certain combination of carbon and hydrogen ($NO_2+C_2H_2$); or of cyanogen and water ($C_2N+H_2O_2$). And even the amidides of potassium (KNH_2) and of sodium ($NaNH_2$), have, from the energetic affinities of those metallic bases, been thought to prove less decisively the existence of amidogene itself, than the amidide of mercury ($HgNH_2$) discovered by Dr. Kane, in his analysis of the white precipitate of the last mentioned metal. (Trans. R. I. A., vol. xviii. part iii.)

Although this precipitate had been long known, and often analyzed, erroneous views (as they are now regarded) were entertained respecting its composition, and it had, for instance, been supposed to contain oxygen, till Kane pointed out the absence of this element, and showed, with a high degree of probability, that the proximate elements were the chloride and the amidide of mercury; white precipitate being thus a chlor-amidide of that metal ($HgCl+HgNH_2$, if the Berzelian equivalent of mercury be adopted, instead of its double). Ullgren, a friend of Berzelius, obtained the chemical prize from the Swedish Academy of Sciences, for the year 1836, for a paper in which, having with great care repeated and varied the experiments, he confirmed this and other connected results of our countryman; and Berzelius himself, in his Report read to the above-mentioned Academy in 1837, on the recent progress of the Physical Sciences in Europe (to which Report allusion has been made above), expressed his opinion that these researches of Kane were among the most important of the preceding year.†

In the essay for which your Council have awarded the present

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* L'Oxamide peut donc, à volonté, être considérée comme un composé de cyanogène et d'eau, ou bien comme un composé de deutoxide d'azote et d'hydrogène bicarboné, ou bien enfin comme un composé d'oxide de carbone et d'un azoture d'hydrogène différent de l'ammoniaque.—Dumas, sur l'Oxamide, &c. Annales de Chimie et de Physique, tome xliv. page 142.

† Diese Untersuchungen von Kane gehören meiner Ansicht nach zu den wichtigeren des verflossenen Jahres.—Wöhler's German Translation of Berzelius's Report, Jahres-Bericht über die Fortschritte der physischen Wissenschaften, 17th year, page 179. (Tübingen, 1838).

prize, Dr. Kane has pursued his researches on ammonia, and has shown, with apparently a high probability, that there exist amidides (though not yet insulated) of other* metals besidesm ercury, especially of silver and copper; that is, combinations of these metals with the proximate element amide or amidogene. He has also given, in great detail, a series of analyses performed by him on a large number of compound bodies, of which some had been imperfectly examined before, while others were discovered by himself. But as it would lead into far too great length, and too minute detail, if any attempt were made at present to review these laborious processes of analytical chemistry, and as indeed they derive their chief philosophical interest from the views with which they have been associated, it may be proper to attempt no more than a very brief (I fear that it will also be a very inadequate) sketch of those views.

Dr. Kane considers that in ammonia, which, in the usual language of chemists, is said to consist of one atom of nitrogen and three atoms of hydrogen, one of these atoms of hydrogen is more loosely combined than the two others with the nitrogen, so as to be capable of a comparatively easy replacement, by many, perhaps by all, of the metals, as well as by organic radicals; the other two atoms of hydrogen being *already*, in the ammonia itself, and not merely in the products of such replacement of hydrogen by metals, combined in a particular way with the one atom of nitrogen, so as to form that substance named amide or amidogene, which was detected by Dumas (as has been mentioned) in performing the analysis of oxamide. From Dr. Kane's own study of the combinations of this substance amidogene (H_2N), with metals, he infers it to be a compound radical of feebly electro-negative energy, analogous to that important one cyanogen (C_2N), of which the discovery by Gay-Lussac has exercised so powerful an influence on modern chemistry. He considers this radical, amidogene, as existing ready formed, in combination with hydrogen, in ammonia; which latter substance is thus, according to him, to be regarded as *amidide of hydrogen;* and as, in this respect, analogous to water, and to the hydrocyanic, hydro-sulphuric, and muriatic acids, that is, to the oxide,

* Dr. Kane has since made it probable that there exist amidides of palladium and platinum also. (Phil. Trans. 1842, part ii.)

cyanide, sulphuret, and chloride of hydrogen; from all of which bodies it is possible, as from ammonia, to expel an atom of hydrogen, and to replace it by an atom of metal,—if indeed hydrogen be not (as there seems to be a tendency to believe it to be) itself of metallic nature, notwithstanding its highly rarefied form. By developing this view of the constitution and function of ammonia, Dr. Kane has offered explanations of a large number of replacements of that substance by others, some of which replacements (I believe) were known before, while many have been discovered by himself.

One of the most remarkable points in Dr. Kane's views is the way in which he considers the ordinary salts of ammonia. Many of these are known to contain an atom of water, the existence of which led to the proposition of the very remarkable theory by Berzelius, of the existence in them of a compound metal *ammonium*, which has not indeed been insulated, but has been found to form, in combination with mercury, a certain metallic amalgam. Dr. Kane looks upon these salts as double salts of hydrogen. He considers them to contain ammonia ready formed, united with a hydrated acid or with a hydrogen acid. He seeks to establish the similarity of the common ammoniacal salts to those complex metallic amidides, whose nature he has developed by analysis.

Thus, for example, the well-known body, sal-ammoniac, is, in the Berzelian view, regarded as chloride of ammonium; but, in the view put forward by Dr. Kane, it is chlor-amidide of hydrogen. The former view supposes that the ammonia robs the hydrochloric acid of its hydrogen, to form, by a combination with it, a metallic base, NH_4, with which the chlorine unites; as this last element combines with the metal sodium, in the formation of common salt. The latter view supposes that in the action between hydrochloric acid and dry ammoniacal gas, there is no separation of the chlorine from the hydrogen,—no breaking up of a previously existing union,—no overcoming of the affinity which these two elements (chlorine and hydrogen) have for each other; but an exemplification of a general tendency of chlorides, oxides, and amidides of the same or similar radicals, to unite, and form chlor-oxides, chlor-amidides, or oxamidides. Sal-ammoniac is, according to Kane, a double haloid salt; he looks upon it as being a compound exactly analogous to the white mercurial precipitate, which was first accurately analyzed by himself; the one being $HCl + HAd$ (if Ad be the symbol of amidogene), while the other is $HgCl + HgAd$, so that the mercury in the latter takes the place of the hydrogen in the former.

It was, however, in the oxysalts, such as the sulphate of ammonia, that the presence of an atom, or equivalent, of water, or at least of the elements required for the composition of such an equivalent, appears to have suggested to Berzelius the theory, that what seemed to be hydrate of ammonia ($NH_3 + HO$) was really oxide of ammonium ($NH_4 + O$). There are, undoubtedly, many temptations to adopt this view, besides the high reputation of its propounder. One is, that it assimilates the constitution of sulphate of ammonia to what seems to be regarded by the greater number of modern chemists, as the probable constitution of other sulphates, nitrates, &c., for example, the sulphate of iron. When green vitriol is to be formed by the action of sulphuric acid upon iron, it is requisite to dilute the acid with water, before the action will take place. The hydrogen of the water then bubbles off, but what becomes of the oxygen which had been combined with it? Does it combine immediately, and as it were in the first instance, with the iron, to form oxide of iron, on which the anhydrous sulphuric acid may act, to produce *sulphate of oxide* of iron, according to the view which seems, till lately, to have been adopted: or does this oxygen, from the water, combine rather with the sulphuric acid to produce a sort of oxide thereof, and does this *sulphat-oxygen* act on the pure metallic iron to form with it a *sulphat-oxide*, as many eminent chemists now appear to think? Whatever may be the final judgment of those who are entitled to form opinions on questions such as these, it cannot, I conceive, be justly said, that the questions themselves are unimportant. They touch on points connected with the philosophy of chemistry, are essentially connected with its theory, and cannot always be without an influence upon its practice.

Now according to the Berzelian view of sulphate of ammonia, that is the salt produced by the mutual action of sulphuric acid, water, and ammonia, this salt is properly a sulphat-oxide of the compound metal ammonium ($NH_4 + SO_4$), in the same way as green vitriol, on the view last mentioned, is sulphat-oxide of iron

($Fe + SO_4$), or as sulphate of potash is sulphat-oxide of potassium ($K + SO_4$), and this analogy is doubtless pleasing to contemplate.

Dr. Kane does not entirely reject this Berzelian theory of ammonium; he acknowledges that the substance NH_4, which he regards as *subamidide of hydrogen*, and compares to some suboxides, possesses metallic properties, and is a proximate constituent of certain compounds, especially of the ammoniacal amalgam; but he conceives that the evidence for the existence of ammonia itself, in many of the ammoniacal salts, is too strong to be resisted: and he looks upon the hydrated ammonia, which is found to combine with sulphuric and other oxacids, as being not, in general, oxide of ammonium, but *oxyamidide of hydrogen;* the sulphate of ammonia being thus a bibasic compound, of which one base is ammonia, while the other base is water.

Between the conflicting opinions of such men, supported each by powerful arguments and analogies,—and it will easily be conceived that in so short a sketch as this, and upon such a subject, it has been found impossible by me to mention even the names of all the eminent chemists whose experiments and writings should be studied, by persons inquiring for themselves,—not only do I not venture to express any judgment of mine, but I conceive also that your Council did not desire to express on their part any decision. To justify the present award, it was, I believe, deemed by them sufficient, that great research and great talents had been brought, in the investigations of the author to whom that award has been made, to bear on an important subject, which has derived, from those investigations, an additional degree of importance. Whatever may be the final and unappealable judgment of those persons who shall, at some future time, be competent and disposed to pronounce it, we need not fear that the honour of this Academy shall have been compromised by the recognition which the Council have thought it right on the present occasion to make, of that combination of genius and industry, which has already caused the researches of Kane to influence in no slight degree the progress of chemical science, and has won for him an European reputation.

The President then presented the Gold Medal to Dr. Kane, and the Academy adjourned for the summer.

July 31. (Extraordinary Meeting.)

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

RESOLVED,—On the recommendation of Council,—That the Treasurer be empowered to sell stock in the 3 per cent. Consols, to the amount of £300, in order to pay Mr. Gill's bill for printing Transactions to March 16, 1843, amount £264 10*s.* 4*d.*, and the rent of the Academy House to 31st July, 1843.

RESOLVED,—On the recommendation of Council,—That the Treasurer be empowered to sell such 3½ per cent. stock, being the Cunningham Fund, as shall amount to £50, towards defraying the cost of medals.

Sir William Betham presented to the Academy certain casts from the sculptures on the inside of the tower of Ardmore.

Dr. Lloyd having taken the Chair, the President gave an account of some researches in the Calculus of Probabilities.

Many questions in the mathematical theory of probabilities conduct to approximate expressions of the form

$$p = \frac{2}{\sqrt{\pi}} \int_0^t dt\ e^{-t};$$

that is,

$$p = \theta(t),$$

θ being the characteristic of a certain function which has been tabulated by Encke in a memoir on the Method of Least Squares, translated from the Berlin Ephemeris, in vol. ii. part 7 of Taylor's Scientific Memoirs; p being the probability sought, and t an auxiliary variable.

Sir William Hamilton proposes to treat the equation

$$p = \theta(t)$$

as being in all cases rigorous, by suitably determining the auxiliary variable t, which variable he proposes to call the *argument of probability*, because it is the argument with which Encke's Table should be entered, in order to obtain from that Table the value of the probability p. He shows how to improve several of Laplace's approximate expressions for the argument t, and uses in many such questions a transformation of a certain double definite integral, of the form,

$$\frac{4s^{\frac{1}{2}}}{\pi}\int_0^r dr \int_0^\infty du\, e^{-su^2}\, \mathrm{U}\cos(2s^{\frac{1}{2}} ru\mathrm{V})$$
$$= \theta(r(1+\nu_1 s^{-1}+\nu_2 s^{-2}+\ldots));$$

in which

$$\mathrm{U} = 1 + \alpha_1 u^2 + \alpha_2 u^4 + \ldots$$
$$\mathrm{V} = 1 + \beta_1 u^2 + \beta_2 u^4 + \ldots$$

while $\nu_1, \nu_2, \ldots$ depend on $\alpha_1, \ldots \beta_1, \ldots$ and on r; thus

$$\nu_1 = \tfrac{1}{2}\alpha_1 - \beta_1 r^2.$$

The function θ has the same form as before, so that if, for sufficiently large values of the quantity s (which represents, in many questions, the number of observations or events to be combined), a probability p can be expressed, exactly or nearly, by the foregoing double definite integral, then the *argument* t, of this probability p, will be expressed nearly by the formula,

$$t = r(1 + \nu_1 s^{-1} + \nu_2 s^{-2}).$$

Numerical examples were given, in which the approximations thus obtained appeared to be very close. For instance, if a common die (supposed to be perfectly fair) be thrown six times, the probability that the sum of the six numbers which turn up in these six throws shall not be less than 18, nor more than 24, is represented rigorously by the integral

$$p = \frac{2}{\pi}\int_0^{\frac{\pi}{2}} dx \frac{\sin 7x}{\sin x}\left(\frac{\sin 6x}{6\sin x}\right)^6,$$ or by the fraction $\frac{27448}{46656}$;

while the approximate formula deduced by the foregoing method gives 27449 for the numerator of this fraction, or for the product $6^6 p$; the error of the resulting probability being therefore in this case only 6^{-6}. The advantage of the method is that the quantity which has here been called the argument of probability, depends in general more simply than does the probability itself on the conditions of a question; while the introduction of this new conception and nomenclature allows some of the most important known results respecting the mean results of many observations to be enunciated in a simple and elegant manner.

DONATIONS.

Historias e Memorias da Academia Real des Sciencias de Lisboa. Tome XII. Parte 2.

Discurso lido em 22 de Janeiro de 1843 *na sessao publica da Academia Real des Sciencias de Lisboa.* Por J. J. da Costa de Macedo. Presented by the Academy.

Le Petit Agriculteur. Par N. C. Seringe. Presented by the Author.

Astronomical Observations made at the Radcliffe Observatory, Oxford, in 1840. By M. J. Johnson, Esq. Presented by the Governors.

Archives du Museum d'Histoire Naturelle. Tome III. Liv. 3, et Tome II. Liv. 4. Presented by the Museum.

Remarks on Safety Lamps. By Doctor Reid Clanny, H. M. R. I. A. Presented by the Author.

Transactions of the Royal Society of Edinburgh. Vol. XV. Part 3. Presented by the Society.

Proceedings of the National Institution for the Promotion of Science at Washington. D. C. for 1840 *and* 1842. Parts 1 and 2. Presented by Thomas Sewall, M. D., Professor of Medicine in Columbia College, U. S.

Memoirs of the Chemical Society of London for 1841–3. Vol. I. Presented by the Society.

Numismatic Chronicle. No. XXII. Presented by the Numismatic Society.

Statistical Returns of the Dublin Metropolitan Police for 1842. Presented by the Commissioners.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1843. No. 42.

November 13.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Dr. Allman drew the attention of the Academy to certain undescribed peculiarities in the anatomy of Anthocephalus, a genus of Entozoal worms. The points especially dwelt upon by Dr. Allman were the remarkably definite arrangement of the hooks with which the proboscides are furnished, and the singular apparatus destined to effect the retraction and exsertion of the latter organs. The proboscides were described as communicating each with a distinct tube, which extending through the entire length of the animal, terminates posteriorly in an oval dilatation, with thickened walls. The retraction of the proboscides consists in an inversion, by which they become invaginated in the tubular appendage. This invagination is effected by means of a muscular filament, which is attached by one extremity to the internal surface of the *cul de sac* of the proboscis, and may be thence traced through the tube as far as the oval body in which the latter terminates.

The mode by which the exsertion of the proboscides is effected would appear to be as follows:—These organs, together with their tubular prolongation through the vermicular body of the Entozoon, are filled with a transparent fluid, which during the inversion of the proboscides is expelled into the more posterior parts of the tubular prolongations, and into the oval bodies in which these terminate. Mr. Bergin had pointed out to Dr. Allman the existence of muscular fibres in the walls of the oval dilatations. The contraction, therefore, of these muscles, will cause the contained fluid to impinge upon the inverted extremity of the proboscis, which will thus be forced outwards, and the proboscis injected with the fluid. The source of this fluid would appear to be in the oval bodies themselves, whose structure is, in all probability, glandular, and which, besides possessing a contractile power, by which the contents of their cavities are expelled, would seem also to be the secerners of the fluid which plays so important a part in the protrusion of the proboscides.

The Chair having been taken *pro tem.* by the Rev. H. Lloyd, D. D., Vice-President,

The President read a paper on a new Species of Imaginary Quantities, connected with a theory of Quaternions.

It is known to all students of algebra that an imaginary equation of the form $i^2 = -1$ has been employed so as to conduct to very varied and important results. Sir Wm. Hamilton proposes to consider some of the consequences which result from the following system of imaginary equations, or equations between *a system of three different imaginary quantities:*

$$i^2 = j^2 = k^2 = -1; \tag{A}$$

$$ij = k, \quad jk = i, \quad ki = j; \tag{B}$$

$$ji = -k, \quad kj = -i, \quad ik = -j; \tag{C}$$

no linear relation between i, j, k being supposed to exist, so that the equation

$$\text{Q} = \text{Q}',$$

in which

$$\text{Q} = w + ix + jy + kz,$$
$$\text{Q}' = w' + ix' + jy' + kz',$$

and $w, x, y, z, w', x', y', z'$ are real, is equivalent to the four separate equations,

$$w = w', \quad x = x', \quad y = y', \quad z = z'.$$

Sir W. Hamilton calls an expression of the form Q a *quaternion;* and the four real quantities w, x, y, z he calls the *constituents* thereof. Quaternions are added or subtracted by adding or subtracting their constituents, so that

$$\text{Q} + \text{Q}' = w + w' + i(x + x') + j(y + y') + k(z + z').$$

Their multiplication is, in virtue of the definitions (A) (B) (C), effected by the formulæ

$$\text{QQ}' = \text{Q}'' = w'' + ix'' + jy'' + kz'',$$

$$\left.\begin{aligned} w'' &= ww' - xx' - yy' - zz', \\ x'' &= wx' + xw' + yz' - zy', \\ y'' &= wy' + yw' + zx' - xz', \\ z'' &= wz' + zw' + xy' - yx', \end{aligned}\right\} \qquad \text{(D)}$$

which give

$$w''^2 + x''^2 + y''^2 + z''^2 = (w^2 + x^2 + y^2 + z^2)(w'^2 + x'^2 + y'^2 + z'^2),$$

and therefore

$$\mu'' = \mu\mu', \qquad \text{(E)}$$

if we call the positive quantity

$$\mu = \sqrt{w^2 + x^2 + y^2 + z^2},$$

the *modulus* of the quaternion Q. The modulus of the product of any two quaternions is therefore equal to the product of the moduli. Let

$$\left.\begin{aligned} w &= \mu \cos\theta, \\ x &= \mu \sin\theta \cos\phi, \\ y &= \mu \sin\theta \sin\phi \cos\psi, \\ z &= \mu \sin\theta \sin\phi \sin\psi; \end{aligned}\right\} \qquad \text{(F)}$$

then, because the equations (D) give

$$w'w'' + x'x'' + y'y'' + z'z'' = w(w'^2 + x'^2 + y'^2 + z'^2),$$
$$ww'' + xx'' + yy'' + zz'' = w'(w^2 + x^2 + y^2 + z^2),$$

we have

$$\left.\begin{array}{l}\cos\theta''=\cos\theta\cos\theta'-\sin\theta\sin\theta'(\cos\phi\cos\phi'+\sin\phi\sin\phi'\cos(\psi-\psi')),\\ \cos\theta\ =\cos\theta'\cos\theta''+\sin\theta'\sin\theta''(\cos\phi'\cos\phi''+\sin\phi'\sin\phi''\cos(\psi'-\psi'')),\\ \cos\theta'=\cos\theta''\cos\theta+\sin\theta''\sin\theta(\cos\phi''\cos\phi+\sin\phi''\sin\phi\cos(\psi''-\psi)).\end{array}\right\}\ (\text{G})$$

Consider x, y, z as the rectangular coordinates of a point of space, and let R be the point where the radius vector of x, y, z (prolonged if necessary) intersects the spheric surface described about the origin with a radius equal to unity; call R the *representative point* of the quaternion Q, and let the polar coordinates ϕ and ψ, which determine R upon the sphere, be called the *co-latitude* and the *longitude* of the representative point R, or of the quaternion Q itself; let also the other angle θ be called the *amplitude* of the quaternion; so that a quaternion is completely determined by its modulus, amplitude, co-latitude, and longitude. Construct the representative points R$'$ and R$''$, of the other factor Q$'$, and of the product Q$''$; and complete the spherical triangle RR$'$R$''$, by drawing the arcs RR$'$, R$'$R$''$, R$''$R. Then, the equations (G) become

$$\begin{aligned}\cos\theta'' &= \cos\theta\cos\theta' - \sin\theta\ \sin\theta'\ \cos \mathrm{RR}',\\ \cos\theta &= \cos\theta'\cos\theta'' + \sin\theta'\sin\theta''\cos \mathrm{R}'\mathrm{R}'',\\ \cos\theta' &= \cos\theta''\cos\theta + \sin\theta''\sin\theta\ \cos \mathrm{R}''\mathrm{R},\end{aligned}$$

and consequently shew that the angles of the triangle RR$'$R$''$ are

$$\mathrm{R}=\theta,\quad \mathrm{R}'=\theta',\quad \mathrm{R}''=\pi-\theta''; \qquad (\text{H})$$

these angles are therefore respectively equal to the amplitudes of the factors, and the supplement (to two right angles) of the amplitude of the product. The equations (D) show, further, that the *product-point* R$''$ is to the right or left of the *multiplicand-point* R$'$, with respect to the *multiplier-point* R, according as the semiaxis of $+z$ (or its intersection with the spheric surface) is to the right or left of the semiaxis of $+y$, with respect to the semiaxis of $+x$: that is, according as the positive direction of rotation in longitude is towards the right or left. A change in the order of the two quaternion-factors would throw the product-point R″ from the right to the left, or from the left to the right of R R′.

It results from these principles, that if R R′ R″ be any spherical triangle; if, also, $\alpha\,\beta\,\gamma$ be the rectangular coordinates of R, $\alpha'\,\beta'\,\gamma'$ those of R′, and $\alpha''\ \beta''\ \gamma''$ of R″, the centre of the sphere being origin, and the radius being unity; and if the rotation round $+x$ from $+y$ to $+z$ be of the same (right-handed or left-handed) character as that round R from R′ to R″; then the following formula of multiplication, according to the rules of quaternions, will hold good:

$$\{\cos R + (i\alpha + j\beta + k\gamma)\sin R\}\ \{\cos R' + (i\alpha' + j\beta' + k\gamma')\sin R'\} \\ = -\cos R'' + (i\alpha'' + j\beta'' + k\gamma'')\sin R''. \qquad (\text{I})$$

Developing and decomposing this imaginary or symbolic formula (I), we find that it is equivalent to the system of the four following real equations, or equations between real quantities:

$$\left.\begin{aligned} -\cos R'' &= \cos R \cos R' - (\alpha\alpha' + \beta\beta' + \gamma\gamma')\sin R \sin R'; \\ \alpha''\sin R'' &= \alpha \sin R \cos R' + \alpha' \sin R' \cos R + (\beta\gamma' - \gamma\beta')\sin R \sin R'; \\ \beta''\sin R'' &= \beta \sin R \cos R' + \beta' \sin R' \cos R + (\gamma\alpha' - \alpha\gamma')\sin R \sin R'; \\ \gamma''\sin R'' &= \gamma \sin R \cos R' + \gamma' \sin R' \cos R + (\alpha\beta' - \beta\alpha')\sin R \sin R'. \end{aligned}\right\} (\text{K})$$

Of these equations (K), the first is only an expression of the well-known theorem, already employed in these remarks, which serves to connect a side of any spherical triangle with the three angles thereof. The three other equations (K) are an expression of another theorem (which possibly is new), namely, that a force $=\sin$ R″, directed from the centre of the sphere to the point R″, is statically equivalent to the system of three other forces, one directed to R, and equal to sin R cos R′, another directed to R′, and equal to sin R′ cos R, and the third equal to sin R sin R′ sin R R′, and directed towards that pole of the arc R R′, which lies at the same side of this arc as R″. It is not difficult to prove this theorem otherwise; but it may be regarded as interesting to see that the four equations (K) are included so simply in the one formula

(I) of multiplication of quaternions, and are obtained so easily by developing and decomposing that formula, according to the fundamental definitions (A) (B) (C). A new sort of algorithm, or calculus, for spherical trigonometry, appears to be thus given, or indicated. And by supposing the three corners of the spherical triangle R R′ R″ to tend indefinitely to close up in that one point which is the intersection of the spheric surface with the positive semiaxis of x, each coordinate α will tend to become $= 1$, and each β and γ to vanish, while the sum of the three angles will tend to become $= \pi$; so that the following well known and important equation in the usual calculus of imaginaries, as connected with plane trigonometry, namely,

$$(\cos \mathrm{R} + i \sin \mathrm{R})(\cos \mathrm{R}' + i \sin \mathrm{R}') = \cos(\mathrm{R} + \mathrm{R}') + i \sin(\mathrm{R} + \mathrm{R}'),$$

(in which $i^2 = -1$), is found to result, as a limiting case, from the more general formula (I).

In the ordinary theory there are only two different square roots of negative unity ($+i$ and $-i$), and they differ only in their signs. In the present theory, in order that a quaternion, $w + ix + jy + kz$, should have its square $= -1$, it is necessary and sufficient that we should have

$$w = 0, \quad x^2 + y^2 + z^2 = +1;$$

we are conducted, therefore, to the extended expression,

$$\sqrt{-1} = i \cos \phi + j \sin \phi \cos \psi + k \sin \phi \sin \psi, \qquad \text{(L)}$$

which may be called an *imaginary unit*, because its modulus is $= 1$, and its square is negative unity. To distinguish one such imaginary unit from another, we may adopt the notation,

$$i_{\mathrm{R}} = i\alpha + j\beta + k\gamma, \text{ which gives } i_{\mathrm{R}}^2 = -1, \qquad \text{(L}'\text{)}$$

R being still that point upon the spheric surface which has α, β, γ (or $\cos \phi$, $\sin \phi \cos \psi$, $\sin \phi \sin \psi$) for its rectangular coordinates; and then the formula of multiplication (I) becomes, for any spherical triangle, in which the rotation round R, from R′ to R″, is positive,

$$(\cos R + i_R \sin R)(\cos R' + i_{R'} \sin R') = -\cos R'' + i_{R''} \sin R''. \quad (\mathrm{I}')$$

If P″ be the *positive pole* of the arc RR′, or the pole to which the least rotation from R′ round R is positive, then the product of the two imaginary units in the first member of this formula (which may be any two such units), is the following:

$$i_R\, i_{R'} = -\cos RR' + i_{P''} \sin RR'; \quad (\mathrm{M})$$

we have also, for the product of the same two factors, taken in the opposite order, the expression

$$i_{R'}\, i_R = -\cos RR' - i_{P''} \sin RR', \quad (\mathrm{N})$$

which differs only in the sign of the imaginary part; and the product of these two products is unity, because, in general,

$$(w + ix + jy + kz)(w - ix - jy - kz) = w^2 + x^2 + y^2 + z^2; \quad (\mathrm{O})$$

we have, therefore,

$$i_R\, i_{R'} \cdot i_{R'}\, i_R = 1, \quad (\mathrm{P})$$

and the products $i_R i_{R'}$ and $i_{R'} i_R$ may be said to be *reciprocals* of each other.

In general, in virtue of the fundamental equations of definition, (A), (B), (C), although the *distributive* character of the multiplication of ordinary algebraic quantities (real or imaginary) extends to the operation of the same name in the theory of quaternions, so that

$$Q(Q' + Q'') = QQ' + QQ'', \&c.,$$

yet the *commutative* character is lost, and we cannot generally write for the new as for the old imaginaries,

$$QQ' = Q'Q,$$

since we have, for example, $ji = -ij$. However, in virtue of the same definitions, it will be found that another important property of the old multiplication is preserved, or extended to the new, namely, that which may be called the *associative* character of the operation, and which may have for its type the formula

$$\text{Q}.\ \text{Q}'\text{Q}''.\ \text{Q}''', \text{Q}^{IV} = \text{Q}\text{Q}'.\ \text{Q}''\text{Q}'''\text{Q}^{IV};$$

thus we have, generally,

$$\text{Q}.\ \text{Q}'\text{Q}'' = \text{Q}\text{Q}'.\ \text{Q}'', \tag{Q}$$

$$\text{Q}.\ \text{Q}'\text{Q}''\text{Q}''' = \text{Q}\text{Q}'.\ \text{Q}''\text{Q}''' = \text{Q}\text{Q}'\text{Q}''.\ \text{Q}''', \tag{Q$'$}$$

and so on for any number of factors; the notation $\text{Q}\text{Q}'\text{Q}''$ being employed to express that one determined quaternion, which, in virtue of the theorem (Q), is obtained, whether we first multiply Q'' as a multiplicand by Q' as a multiplier, and then multiply the product $\text{Q}'\text{Q}''$ as a multiplicand by Q as a multiplier; or multiply first Q' by Q, and then Q'' by $\text{Q}\text{Q}'$. With the help of this principle, we might easily prove the equation (P), by observing that its first member $= i_{\text{R}}\, i^2_{\text{R}'}\, i_{\text{R}} = -\, i^2_{\text{R}} = 1$.

In the same manner it is seen at once that

$$i_{\text{R}}\, i_{\text{R}'}\,.\, i_{\text{R}'}\, i_{\text{R}''}\,.\, i_{\text{R}''}\, i_{\text{R}'''} \ldots . \, i_{\text{R}^{(n-1)}}\, i_{\text{R}} = (-1)^n, \tag{P$'$}$$

whatever n points upon the spheric surface may be denoted by $\text{R}, \text{R}', \text{R}'', \text{R}''', \ldots \text{R}^{(n-1)}$: and by combining this principle with that expressed by (M), it is not difficult to prove that for any spherical polygon, $\text{R}\,\text{R}' \ldots \text{R}^{(n-1)}$, the following formula holds good :

$$(\cos \text{R} + i_{\text{R}} \sin \text{R})\,(\cos \text{R}' + i_{\text{R}'} \sin \text{R}')\,(\cos \text{R}'' + i_{\text{R}''} \sin \text{R}'')$$
$$\ldots (\cos \text{R}^{(n-1)} + i_{\text{R}^{(n-1)}} \sin \text{R}^{(n-1)}) = (-1)^n, \tag{R}$$

which includes the theorem (I$'$) for the case of a spherical triangle, and in which the arrangement of the n points may be supposed, for simplicity, to be such that the rotations round R from R$'$ to R$''$, round R$'$ from R$''$ to R$'''$, and so on, are all positive, and each less than two right angles, though it is easy to interpret the expression so as to include also the cases where any or all of these conditions are violated. When the polygon becomes infinitely small, and therefore plane, the imaginary units become all equal to each other, and may be denoted by the common symbol i; and the formula (R) agrees then with the known relation, that

$$\pi - \mathrm{R} + \pi - \mathrm{R}' + \pi - \mathrm{R}'' + \ldots + \pi - \mathrm{R}^{(n-1)} = 2\pi.$$

Again, let R, R′, R″ be, respectively, the representative points of any three quaternions Q, Q′, Q″, and let $\mathrm{R}_{,}$, $\mathrm{R}_{,,,}$, $\mathrm{R}_{,,}$ be the representative points of the three other quaternions, QQ′, Q′Q″, QQ′Q″, derived by multiplication from the former; then the algebraical principle expressed by the formula (Q) may be geometrically enunciated by saying that the two points $\mathrm{R}_{,}$ and $\mathrm{R}_{,,}$ are the foci of a spherical conic which touches the four sides of the spherical quadrilateral $\mathrm{R}\mathrm{R}'\mathrm{R}''\mathrm{R}_{,,,}$; and analogous theorems respecting spherical pentagons and other polygons may be deduced, by constructing similarly the formulæ (Q′), &c.

In general, a quaternion Q, like an ordinary imaginary quantity, may be put under the form,

$$\mathrm{Q} = \mu(\cos\theta + (-1)^{\frac{1}{2}}\sin\theta) = w + (-1)^{\frac{1}{2}} r, \qquad \text{(s)}$$

provided that we assign to $(-1)^{\frac{1}{2}}$, or $\sqrt{-1}$, the extended meaning (L), which involves two arbitrary angles; and the same general quaternion Q may be considered as a root of a quadratic equation, with real coefficients, namely,

$$\mathrm{Q}^2 - 2w\mathrm{Q} + \mu^2 = 0, \qquad \text{(s}'\text{)}$$

which easily conducts to the following expression for a quotient, or formula for the division of quaternions,

$$\mathrm{Q}^{-1}\mathrm{Q}'' = \frac{\mathrm{Q}''}{\mathrm{Q}} = \frac{2w - \mathrm{Q}}{\mu^2}\mathrm{Q}'', \qquad \text{(s}''\text{)}$$

if we define $\mathrm{Q}^{-1}\mathrm{Q}''$ or $\frac{\mathrm{Q}''}{\mathrm{Q}}$ to mean that quaternion Q′ which gives the product Q″, when it is multiplied as a multiplicand by Q as a multiplier. The same general formula (s″) of division may easily be deduced from the equation (O), by writing that equation as follows,

$$(w + ix + jy + kz)^{-1} = \frac{w - ix - jy - kz}{w^2 + x^2 + y^2 + z^2}; \qquad (\text{o}')$$

or it may be obtained from the four general equations of multiplication (D), by treating the four constituents of the multiplicand, namely, w', x', y', z', as the four sought quantities, while w, x, y, z, and w'', x'' y'', z'', are given; or from a construction of spherical trigonometry, on principles already laid down.

The general expression (S) for a quaternion may be raised to any power with a real exponent q, in the same manner as an ordinary imaginary expression, by treating the square root of -1 which it involves as an imaginary unit i_R having (in general) a fixed direction; raising the modulus μ to the proposed real power; and multiplying the amplitude θ, increased or diminished by any whole number of circumferences, by the exponent q: thus,

$$(\mu(\cos\theta + i_R \sin\theta))^q = \mu^q(\cos q(\theta + 2n\pi) + i_R \sin q(\theta + 2n\pi)), \quad (\text{T})$$

if q be real, and if n be any whole number. For example, a quaternion has in general two, and only two, different square roots, and they differ only in their signs, being both included in the formula,

$$(\mu(\cos\theta + i_R \sin\theta))^{\frac{1}{2}} = \mu^{\frac{1}{2}}\left(\cos\left(\frac{\theta}{2} + n\pi\right) + i_R \sin\left(\frac{\theta}{2} + n\pi\right)\right), \quad (\text{T}')$$

in which it is useless to assign to n any other values than 0 and 1; although, in the particular case where the original quaternion reduces itself to a real and negative quantity, so that $\theta = \pi$, this formula (T′) becomes

$$(-\mu)^{\frac{1}{2}} = \pm \mu^{\frac{1}{2}} i_R, \text{ or simply } (-\mu)^{\frac{1}{2}} = \mu^{\frac{1}{2}} i_R, \qquad (\text{T}'')$$

the direction of i_R remaining here entirely undetermined; a result agreeing with the expression (L) or (L′) for $\sqrt{-1}$. In like manner the quaternions, which are cube roots of unity, are included in the expression,

$$1^{\frac{1}{3}} = \cos\frac{2n\pi}{3} + i_R \sin\frac{2n\pi}{3}, \qquad (\text{T}''')$$

i_R denoting here again an imaginary unit, with a direction altogether arbitrary.

If we make, for abridgment,

$$f(Q) = 1 + \frac{Q}{1} + \frac{Q^2}{1.2} + \frac{Q^3}{1.2.3} + \&c., \qquad (U)$$

the series here indicated will be always convergent, whatever quaternion Q may be; and we can always separate its real and imaginary parts by the formula,

$$f(w + i_R r) = f(w)(\cos r + i_R \sin r); \qquad (U')$$

which gives, reciprocally, for the inverse function f^{-1}, the expression

$$f^{-1}(\mu(\cos\theta + i_R \sin\theta)) = \log\mu + i_R(\theta + 2n\pi), \qquad (U'')$$

n being any whole number, and $\log\mu$ being the natural, or Napierian, logarithm of μ, or, in other words, that real quantity, positive or negative, of which the function f is equal to the given real and positive modulus μ. And although the ordinary property of exponential functions, namely,

$$f(Q) \cdot f(Q') = f(Q + Q'),$$

does not in general hold good, in the present theory, unless the two quaternions Q and Q' be codirectional, yet we may raise the function f to any real power by the formula

$$(f(w + i_R r))^q = f(q(w + i_R \overline{r + 2n\pi})), \qquad (U''')$$

which it is natural to extend, by definition, to the case where the exponent q becomes itself a quaternion. The general equation,

$$Q_{\prime}^{q} = Q_{\prime}', \qquad (V)$$

when put under the form

$$(f(w + i_R r))^q = f(w' + i_{R'} r'), \qquad (V')$$

will then give

$$q = \frac{\{w' + i_{R'}(r' + 2n'\pi)\}\ \{w - i_R(r + 2n\pi)\}}{w^2 + (r + 2n\pi)^2}; \qquad (V'')$$

and thus the general expression for a quaternion q, which is one of the logarithms of a given quaternion Q', to a given base $Q_{\prime\prime}$, is found to involve two independent whole numbers n and n', as in the theories of Graves and Ohm, respecting the general logarithms of ordinary imaginary quantities to ordinary imaginary bases.

For other developments and applications of the new theory, it is necessary to refer to the original paper from which this abstract is taken, and which will probably appear in the twenty-first volume of the Transactions of the Academy.

November 30. (Stated Meeting.)

REV. H. LLOYD, D.D., Vice-President, in the Chair.

The Rev. Dr. Todd, V.P., presented to the Academy, in his name and that of Mr. O'Donovan, a volume containing tracings made from Irish MSS. preserved in the College of St. Isidore at Rome, by the Rev. Dr. Lyons, who had sent them from Rome, some to Mr. O'Donovan, and the remainder to Dr. Todd.

The thanks of the Academy were voted to Mr. O'Donovan and also to the Rev. Dr. Lyons, for the important service he has rendered to Irish literature, by making known the existence of these MSS.

The Rev. Dr. Todd made some remarks on the progress of the Catalogue, made by Mr. Eugene Curry, of the Irish MSS. in the Library of the Academy.

The miscellaneous character of the MSS., almost every volume of them containing tracts or poems, wholly unconnected with each other, rendered it impossible to attempt any previous classification. Mr. Curry, therefore, took the MSS. in the order in which they stood on the shelves of the Library, hoping that all the important objects of a classification might be attained by the means of proper Indexes after the work is completed.

The method pursued was to give a description of the contents of each volume, enumerating the several tracts of which it consists, describing its state of preservation, noticing, as far as possible, its defects or imperfections, and identifying, whenever it could be done, the handwriting of the scribe or scribes by whom it had been written. Particular attention has been paid to the history of every important MS.; the quotations made from it by historians or lexicographers have been verified, and, where practicable, the various hands through which it has passed, and the means by which it became the property of the Academy, have been accurately detailed and recorded.

In this way many opportunities have occurred of correcting mistakes which have been made by various writers on Irish subjects—mistakes, which must always be numerous in the history of a people, whose ancient literature is still in manuscript, and in a language which is every day becoming more obsolete and obscure. These mistakes Mr. Curry has always corrected with temper, and with due allowance for the difficulties under which the authors to be corrected must necessarily have laboured; although it must be confessed that sometimes blunders may be found of a nature well calculated to try the patience or rouse the indignation of an Irish scholar.

Another object of great importance which Mr. Curry has kept steadily in view during the progress of the Catalogue, has been the noticing of other copies of the tracts or poems described, whenever the existence of such copies was known to him: and his accurate acquaintance with the contents of the Irish MSS. of Trinity College, and those in the possession of Messrs. Hodges and Smith,* the only two great collections accessible to him for this purpose, rendered Mr. Curry peculiarly well qualified for such a task.

* Since purchased by the Academy.

In reference to the history of the MSS., of such of them, at least, as are of any high antiquity, it was of great importance to collect together the numerous memoranda, short scraps of poetry, dates, signatures, and other entries, which are frequently to be found on the margins of MSS. These are often mere scribbling, and often written from pure wantonness, or for the purpose of trying a pen; but they very frequently contain information of singular interest, shewing who were the ancient owners or possessors of the MS., and sometimes giving facts and dates of which we have no other record. A most remarkable example of the value of these apparently trifling scribblings will be found in Mr. Curry's account of the Leabhar Breac, upon whose history the most important light has been thus thrown.

The autograph volume of the Four Masters, which is one of the glories of the Academy's Library, may also be mentioned as a MS., whose history Mr. Curry's researches have greatly illustrated. By a comparison of it with the MS. (also an autograph) in the Library of Trinity College, Mr. Curry has succeeded in identifying the handwritings of its different compilers, and to assign to each the portion of these Annals which he appears to have compiled, or at least to have transcribed.

When any document occurred of peculiar interest, as an historical tale, or ancient deed, or singular narrative, Mr. Curry has very generally given an abstract of its contents. This has been sparingly done, from a wish to avoid swelling the Catalogue to too great a bulk; but it is of more importance than it might seem to be at first view, especially if the Catalogue should ever be published, as furnishing to those who are at a distance, the means of identifying the works described with MSS. in other collections.

Dr. Todd having read some extracts from Mr. Curry's Catalogue in illustration of the foregoing remarks, concluded by stating, that about five volumes still remained to be catalogued, including the important volumes, the Books of Lecan and Ballymote, whose examination would take some months, and that the Council have therefore been under the necessity of applying to the Academy for a further grant of money to enable Mr. Curry to complete the work.

It was resolved by the Academy that the sum recommended by the Council be granted for this purpose.

December 11.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Matthew Dease, Esq., William M'Doughall, Esq., Sir Montague Chapman, Bart., James H. Pickford, M. D., Edward Bewley, M.D., and James S. Eiffe, Esqrs., were elected Members of the Academy.

Professor Kane read a paper on the Chemical Composition of the plants of Flax and Hemp.

In those plants which are cultivated for the purpose of being ultimately employed as food, it is found that certain constituents are withdrawn from the soil, partly of an organic and partly of an inorganic character, which give to the plant, or to certain portions of it, the constitution that adapts it for sustaining the animal organism. Thus nitrogen, alkalies, and lastly, phosphates, &c., are found as components of plants, and the value of the crop yielded by a certain surface of ground is proportional, generally speaking, to the materials which the crop has taken up. If, therefore, wheat, or oats, or potatoes exhaust a soil, the agriculturist does not suffer thereby, for he is paid for the materials of which they have exhausted it, and when he replaces that loss of material by fresh manure he but invests a certain capital, to be delivered at a profit in the next season.

Many plants not employed as food, but ancillary to our civilization as luxuries, or as utilized in the arts, are similarly circumstanced. Thus when indigo or tobacco is grown, the object is to obtain the greatest possible development of the colouring or of the narcotic principle. For this purpose, elements are necessary of which the soil is thereby deprived, but the impoverishing of the soil is paid for, by its materials being sold as the valuable portion of the plant. In such cases, therefore, to sustain the fertility of the soil, a continued supply, from external sources, of the materials which the plants take up is required. The farmer must supply in the manure the elements which he sends to market in the grown plants.

Dr. Kane then proceeded to point out that this principle was limited as to certain classes of plants, by the fact, now clearly established by the concurrent investigations of vegetable physiologists and of chemists, that certain vegetable substances, and those of high importance to mankind, were not formed of materials abstracted from the soil, but were produced by the vital action of the plant upon the constituents of the atmosphere. This class of bodies he characterized as being constituted, generally, of carbon, united with hydrogen and oxygen in the proportions which form water. The carbonic acid of the atmosphere, with the watery vapour constantly existing in it, supplies the elements of sugar, gum, starch, and ligneous fibre, and the oxygen of the carbonic acid, evolved by the vital action of the plants, tends, as it is well known, to ameliorate the air we breathe. When, therefore, we take the sugar, or the woody fibre of a plant, we have a material, formed, as to its elements, independent of the soil. For its formation is required a plant in healthy vegetation, and for the plant to be in healthy vegetation, it may require to abstract from the soil various materials, so that the crop may actually be of a highly exhausting nature. Still those materials do not go to the sugar or to the fibre; they exist in other portions of the plant; and if the sugar or fibre be the valuable portion of the crop, as in reality usually occurs, the elements which render its production costly are rejected, and let to waste; they do not subserve any future useful purpose, although nothing should be easier than to apply them thereto.

Such is actually, according to Dr. Kane's idea, the condition of the growth of one plant of the highest importance to agricultural industry in Ireland—that of flax, and also of another, which although not now grown here, has been grown with success, and, as he conceives, might still be cultivated with considerable advantage, the hemp. In flax and hemp the valuable portion of the plant is ligneous fibre; the purer this fibre is, the more its value increases; yet the pure fibre contains no element derived from the soil. It is well known to be produced solely by the atmospherical constituents. Hence the intense exhausting nature of the flax and hemp crops, which makes them be dreaded by agriculturists, notwithstanding the high money value of the crops, arises, according to Dr. Kane, from causes of which the effects may be obviated by attention to the true conditions of the growth and composition of the plants, so that those fibre-crops, such as flax and hemp, from being the most exhausting and expensive, may be rendered the least injurious to the land, and perhaps amongst the cheapest that can be grown.

As the chemical composition of these plants had never been examined, Dr. Kane devoted himself to the determination, as well of their organic as of their inorganic constituents, and from an extensive series of analyses, of which the details are given in the memoir, arrived at the following results:

Composition of the stem of hemp, dried at 212°. F.

Carbon	39.94
Hydrogen	5.06
Oxygen	48.72
Nitrogen	1.74
Ashes	4.54
	100.00

Composition of the leaves of hemp, dried at 212°.

Carbon	40.50
Hydrogen	5.98
Nitrogen	1.82
Oxygen	29.70
Ashes	22.00
	100.00

The ashes of the hemp plant were found to consist of

Potash	7.48
Soda	.72
Lime	42.05
Magnesia	4.88
Alumina	.37
Silica	6.75
Phosphoric acid	3.22
Sulphuric acid	1.10
Chlorine	1.53
Carbonic acid	31.90
	100.00

Dressed hemp fibre was found to give but 1.4 per cent. of ashes, when dried at 212°. Its organic composition need not be given, as it is identical with that of ordinary woody fibre, which is well known. It therefore contains no nitrogen.

The characteristic constituents of the hemp plant are seen to be nitrogen and lime. In these it is peculiarly rich, and with these it is the duty of the agriculturist abundantly to supply it.

When hemp is steeped in order to separate the fibrous bark from the internal stem, it is known that the water dissolves certain substances out of the plants, and thereby acquires narcotic properties. Dr. Kane evaporated a quantity of the hemp liquor to dryness, and analyzed the extract so obtained, in order to trace what action the steeping had exerted on the plant. He found the composition of the hemp extract, dried at 212°, to be,

Carbon	28.28
Hydrogen	4.16
Nitrogen	3.28
Oxygen	15.08
Ashes	49.20
	100.00

If we exclude the ashes, the organic part consisted of

Carbon	55.66
Hydrogen	8.21
Nitrogen	6.45
Oxygen	29.68
	100.00

This composition approaches to that of the azotized animal substances, and surpasses the animal manures usually sold. The water in which hemp has been steeped contains thus most of the nitrogen of the plant, and if poured over the soil should serve efficiently to restore its fertile powers.

The ashes of the hemp extract require also to be noticed, for the plant, in steeping, gives up to the water especially its soluble constituents. The ashes of the leaves of hemp contain in 22 parts only 1.77 soluble in water, or 8.05 per cent., whilst the ashes of the hemp extract contain in 49.2 parts, 29.70 parts soluble in water, or 60.4 per cent. Thus almost all the alkaline constituents of the ashes are dissolved out by the water, whilst the earthy materials remain associated with the residual portions of the stem.

Dr. Kane next examined the stem, as it remains after treatment for the fibre, by steeping and peeling. Dried at 212° this *hemp residue* consisted of

Carbon	56.80
Hydrogen	6.48
Nitrogen	.43
Oxygen	34.52
Ashes	1.77
	100.00

The ashes contained but a trace of alkali, and it is seen that the nitrogen has almost disappeared.

From these researches it is plain that, by the quantity of nitrogen, of phosphoric acid, of potash, of magnesia, and of lime, which the hemp takes from the soil, it must be, as experience proves it, a highly exhausting crop; but as the materials so abstracted are not found in the valuable fibre, but in the residual stem, the chaff, and the steeping liquor, all these are available for the purpose of restoring to the soil what had been taken up, and in fact, if it were possible to carry on the processes of the preparation of the fibre without loss, the same nitrogen and inorganic constituents might, as it would appear from these chemical inquiries and from physiological researches, serve for any number of successive crops of hemp; the fibre alone, generated at the expense of the atmosphere, being sent out and sold, and thus the crop be absolutely deprived of all exhausting quality to the soil.

Dr. Kane's inquiries regarding the flax plant were of a precisely similar character to those described already in the case of hemp, and have led him to similar conclusions affecting the practical culture of this important plant. The general results of his analyses are as follows:

Stem of flax dried at 212°; the plant had its usual amount of leaves, but the seed vessels had not ripened.

Carbon	38.72
Hydrogen	7.33
Nitrogen	.56
Oxygen	48.39
Ashes	5.00
	100.00

There is a great difference here shewn between the composition of the plants of hemp and flax, though they resemble each other so much in their uses. The hemp contains a large amount of nitrogen, the flax very little. The hemp contains more oxygen than would form water with the hydrogen. Flax, on the contrary, contains an excess of hydrogen. The difference is also remarkable in the composition of the ashes.

The ashes of the flax plant consist of

Potash	9.78
Soda	9.82
Lime	12.33
Magnesia	7.79
Alumina	6.08
Silica	21.35
Phosphoric acid	10.84
Sulphuric acid	2.65
Chlorine	2.41
Carbonic acid	16.95
	100.00

The great quantity of lime which characterized the hemp here disappears, and the peculiar quality of the ash is the presence of soda and potash in equal quantities, much magnesia, and especially the large proportion of phosphoric acid. Dr. Kane has not met with any analysis of the ash of a plant yielding the same amount of phosphoric acid, and hence the exceedingly exhausting power of the flax crop is easily understood.

Dr. Kane notices in this ash of flax, that the potash, soda, sulphuric acid, and chlorine are in a very simple relation to each other, the numbers given above coinciding closely with those of two atoms each of sulphuric acid and chlorine, six of potash, and nine of soda. So that if (in the ash) all the soda be taken as carbonate, the potash will be divided equally among sulphuric, muriatic, and carbonic acids. Dr. Kane thinks that this simplicity is probably accidental, but suggests it for attention in subsequent analyses of flax ashes from other localities.

The steeping of flax to loosen the coat of fibrous bark is accompanied by the solution of certain constituents of the plant, as in the case of hemp. The extract of the steeping water was analyzed; it yielded, dried at 212°,

Carbon	30.69
Hydrogen	4.24
Nitrogen	2.24
Oxygen	20.82
Ashes	42.01
	100.00

The organic part of this extract consisted therefore of

Carbon	52.93
Hydrogen	7.31
Nitrogen	3.86
Oxygen	35.90
	100.00

Here, as in the case of hemp, the nitrogen of the plant is concentrated, but the total quantity of nitrogen is not half so great. In the ash of the extract, as in the case of hemp, the soluble alkaline matters also preponderate. The ashes of the plant yielded 33.90 per cent. of matters soluble in water; whilst the ashes of the flax-steep extract yield 60 per cent. of matters soluble in water. The flax-steep is therefore rich in all the materials necessary to produce a new generation of plants; and Dr. Kane stated, as a satisfactory confirmation of the views put forward in his memoir, that in many instances where agriculturists have sprinkled land with the water in which flax has been steeped, they have found it a most active manure.

After the flax fibre has been removed from the rotted stem, the residue, or chaff, was found to be composed as follows:

Carbon	50.34
Hydrogen	7.33
Nitrogen	.24
Oxygen	40.52
Ashes	1.57
	100.00

This is almost identical in composition with the residual hemp stem, and may therefore be applied to the same uses. Restored to the soil with the steep water, it should give back all that the crop of flax had taken from the grounds, and thus the valuable fibre being generated by the atmosphere, the great source of expense in the cultivation of the plant might be removed.

Dr. Kane finally placed before the Academy certain tables, in which, taking the average quantity of produce from a statute acre of fibre-crops and of food crops, and comparing, from the data supplied by the analyses of Sprengel, Boussingault, and his own, the weights of materials of which the soil is exhausted by each crop, it appeared that the fibre crops were actually more exhausting than the food crops; whilst the agriculturist profits by the materials that the food crops take out of the ground, and the substances taken up by the fibre crops from the soil are at present actually rejected as waste and valueless. Hence it is, as Dr. Kane considers, of much interest to the agricultural industry of Ireland that the views of economizing the residues of the preparation of flax and hemp, put forward in his memoir, be tested by practical men, as, if they be found correct, and that those residues may be applied with success to prepare and fit the soil for another crop, those fibrous plants will be practically deprived of their exhausting qualities, and the greatest disadvantage, under which their extensive cultivation in this country labours, may be removed.

Professor Mac Cullagh gave an account of his researches in the Theory of Surfaces of the second Order, in connexion with a former communication which he had made to the Academy on the same subject. These researches are contained in the following paper.

On the Surfaces of the Second Order.

There is hardly any geometrical theory which more requires to be studied, or which promises to reward better whatever thought may be bestowed upon it, than that of the surfaces of the second order. My attention was drawn to it, many years ago, by the consideration of mechanical and physical questions. In the dynamical problem of the Rotation of a Solid Body, and in the investigation of the properties of the Wave-Surface of Fresnel, I found, so long since as the year 1829, that the ellipsoid could be employed with very great advantage; while the discussion of these questions, but especially of the former,* suggested properties of the ellipsoid and its kindred surfaces which I might not otherwise have perceived. In this manner I was led to consider systems of confocal surfaces, and thence to notice the focal curves, which I discovered to be analogous, in the theory of the surfaces of the second order, to the foci in that of the plane conic sections. That theory now began to interest me on its own account, and, guided by analogy, I struck out the leading properties possessed by the surfaces in relation to their focal curves; but the interference of other matters prevented me from continuing the inquiry. I had done enough, however, in this and other parts of the theory, to open new views respecting

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* The Theory of Rotation, here spoken of, was completed in the year 1831; but, from causes which need not be mentioned at present, it was not published. The investigations relative to Fresnel's Wave-Surface will be found in the Transactions of the Royal Irish Academy, vol. xvi. p. 65; vol. xvii. p. 241. See also vol. xxi. p. 32, of the same Transactions.

it; and the results at which I had arrived seemed so fitted for instruction, that when I was appointed Professor of Mathematics in the University, I made them the subject of the first lectures which I gave in that capacity, in the beginning of the year 1836. Next year the heads of these lectures were communicated to this Academy, in a paper of which a very short abstract appeared in the Proceedings.* The subject soon became a favourite one among the more advanced students in the University, who are, for the most part, excellent geometers, and in the present Article very little will be found which is not well known amongst them; very little, indeed, which was not communicated to the Academy on the occasion just mentioned, or which may not be gathered, in the shape of detached questions, out of the Examination-Papers published yearly in the University Calendar. But as nothing has yet been published on the subject in a connected form, except the brief notice in the Proceedings of the Academy, and as mathematicians in other countries attach some importance to researches of this kind, and appear to be in quest of certain principles which are familiar to us here, it seems proper to collect together the chief results that have already been obtained, in order that persons wishing to pursue these speculations may be better able to judge where their inquiries should begin, and in what direction further progress is most likely to be made.

PART I.—GENERATION OF SURFACES OF THE SECOND ORDER.

§ 1. The different species of surfaces of the second order are obtained, as is usually shown in elementary treatises, by the discussion of the general equation of the second degree among three coordinates; but it is necessary that we should also be able to derive these surfaces from a common geometrical origin, if we would bring them completely within

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* Proceedings of the Royal Irish Academy, vol. i. p. 89.

the grasp of geometry. Now as the different conic sections may (with the exception of the circle) be described *in plano* by the motion of a point whose distance from a given point bears a constant ratio to its distance from a given right line,* it is natural to suppose that there must be some analogous method by which the surfaces of the second order may be generated in space. Accordingly I have sought for such a method, and I have found that (with certain analogous exceptions) every surface of the second order may be regarded as the locus of a point whose distance from a given point bears a constant ratio to its distance from a given right line, provided the latter distance be measured parallel to a given plane; this plane being, in general, oblique to the right line. The given point I call, from analogy, a *focus*, and the given right line a *directrix;* the given plane may be called a *directive plane*, and the constant ratio may be termed the *modulus*.

To find the equation of the surface so defined, let the axis of z be parallel to the directrix; let the plane of xy pass through the focus, and cut the directrix perpendicularly in Δ, the coordinates being rectangular, and their origin arbitrarily assumed in that plane; and let the axis of y be parallel to the intersection of the plane of xy with the directive plane, the angle between the two planes being denoted by ϕ. Then if we put x_1, y_1 for the coordinates of the focus, and x_2, y_2 for those of the point Δ, while the coordinates of a point S upon the surface are denoted by x, y, z, the distance of this last point from the focus will be the square root of the quantity

$$(x-x_1)^2 + (y-y_1)^2 + z^2;$$

and if a plane drawn through S, parallel to the directive plane, be conceived to cut the directrix in D, the distance SD will be the square root of the quantity

* This method of describing the conic sections is due to the Greek geometers. It is given by Pappus at the end of the Seventh Book of his *Mathematical Collections*.

$$(x-x_2)^2 \sec^2\phi + (y-y_2)^2;$$

so that, m being the modulus, the locus of the point S will be a surface of the second order, represented by the equation

$$(x-x_1)^2 + (y-y_1)^2 + z^2 = m^2\{(x-x_2)^2\sec^2\phi + (y-y_2)^2\}, \quad (1)$$

which, by making

$$\begin{array}{ll} \mathrm{A} = 1-m^2\sec^2\phi, & \mathrm{B} = 1-m^2, \\ \mathrm{G} = m^2x_2\sec^2\phi - x_1, & \mathrm{H} = m^2y_2 - y_1, \\ \mathrm{K} = m^2(x_2{}^2\sec^2\phi + y_2{}^2) - x_1{}^2 - y_1{}^2, & \end{array} \quad (2)$$

may be put under the form

$$\mathrm{A}x^2 + \mathrm{B}y^2 + z^2 + 2\mathrm{G}x + 2\mathrm{H}y = \mathrm{K}, \quad (3)$$

showing that the plane of xy is one of the principal planes of the surface, and that the planes of xz and yz are parallel to principal planes.

Before we proceed to discuss this equation, it may be well to observe that as it remains the same when ϕ is changed into $-\phi$, or into $180°-\phi$, the directive plane may have two positions equally inclined to the plane of xy, and therefore equally inclined to the directrix. Indeed it is obvious that, if through the point S we draw two planes making equal angles with the directrix, and cutting it in the points D and D′ respectively, the distances SD and SD′ will be equal. Every surface described in this way has consequently two directive planes; and as each of these planes is parallel to the axis of y, their intersection is always parallel to one of the axes of the surface. This axis may therefore be called the *directive axis*. The directive planes have a remarkable relation to the surface, as may be shown in the following manner:—

Suppose a section of the surface to be made by a plane which is parallel to one of the directive planes, and which cuts the directrix in D; then the distance of any point S of the section from the focus F will have a constant ratio to its distance SD from the point D; and, as the locus of a point whose distances from the two points F and D are in a constant ratio to each other, is a plane or a sphere, according as the ratio is one of equality or not, it follows that the section aforesaid will be a right line in the one case, and a circle in the other. Hence it appears that all *directive sections*, that is, all sections made in the surface by planes parallel to either of the directive planes, are *right lines* when the modulus is unity, and *circles* when the modulus is different from unity.

Since the equation (3) is not altered by changing the sign of ϕ, or by changing ϕ into its supplement, we may suppose this angle (when it is not zero) to be always positive and less than 90°; for the supposition $\phi = 90°$ is to be excluded, as it would make the secant of ϕ infinite, and the directive planes parallel to the directrix. In the discussion of the equation there are two leading cases to be considered, answering to two classes of surfaces. The first case, when neither A nor B vanishes, gives the ellipsoid, the two hyperboloids, and the cone; the second, when either or each of these quantities is zero, includes the two paraboloids and the different kinds of cylinders.

§ 2. *First Class of Surfaces.*—When neither A nor B vanishes, we may make both G and H vanish, by properly assuming the origin of coordinates. Supposing this done, we have

$$x_1 = m^2 x_2 \sec^2\phi, \qquad y_1 = m^2 y_2, \tag{4}$$

the equation of the surface being then

$$\text{A}x^2 + \text{B}y^2 + z^2 = \text{K}, \tag{5}$$

in which the axes of coordinates are of course the axes of the surface. When K is not zero, the surface is an ellipsoid or hyperboloid, having its centre at the origin of coordinates; when $\text{K} = 0$, the surface is a cone having its vertex at the origin.

Eliminating x_2, y_2 from the value of K, by means of the relations (4), we get

$$\text{K} = \frac{\text{A}}{1-\text{A}} x_1{}^2 + \frac{\text{B}}{1-\text{B}} y_1{}^2; \tag{6}$$

and eliminating x_1, y_1 in like manner, we get

$$\text{K} = \text{A}(1-\text{A})x_2^2 + \text{B}(1-\text{B})y_2^2; \qquad (7)$$

from which expressions it appears that, every thing else remaining, the focus and directrix may be changed without changing the surface described. For in order that the surface may remain unchanged, it is only necessary that K should remain constant, since A and B are supposed constant. This condition being fulfilled, the focus may be any point F whose coordinates x_1, y_1 satisfy the equation (6), and Δ (the foot of the directrix) may be any point whose coordinates x_2, y_2 satisfy the equation (7); it being understood, however, that when one of these points is chosen, the other is determined. The locus of F (supposing K not to vanish) is therefore an ellipse or a hyperbola,* which may be called the *focal curve*, or the *focal line;* and the locus of Δ is another ellipse or hyperbola, which may be called the *dirigent* curve or line: the centre of each curve is the centre of the surface, and its axes coincide with the axes of the surface which lie in the plane of xy. Moreover, as the quantities $1 - \text{A}$ and $1 - \text{B}$ are essentially positive, the two curves are always of the same kind, that is, both ellipses, or both hyperbolas; and when they are hyperbolas, their real axes have the same direction. The directrix, remaining always parallel to the axis of z, describes a cylinder which may be called the *dirigent cylinder*.

Since, by the relations (4), the corresponding coordinates of F and Δ have always the same sign, these points either lie within the same right angle made by the axes of x and y, or lie on the same axis, at the same side of the centre. And as these relations give

$$x_2 - x_1 = \frac{\text{A}}{1-\text{A}}x_1, \qquad y_2 - y_1 = \frac{\text{B}}{1-\text{B}}y_1, \qquad (8)$$

* In the Proceedings of the Academy, vol. i. p. 90, it was stated inadvertently that "if we confine ourselves to the central surfaces, the locus of the foci will be an ellipse."

it is easy to see that the right line ΔF is a normal to the focal curve; for the quantities $x_2 - x_1$ and $y_2 - y_1$ are proportional to the cosines of the angles which that right line makes with the axes of x and y respectively, while the values just given for these quantities are, in virtue of the equation (6), proportional to the cosines of the angles which the normal to the focal curve at the point F makes with the same axes.

It may also be shown that if the directrix prolonged through Δ intersect a directive plane in a certain point, and if a right line drawn through F, parallel to the directrix, intersect the same plane in another point, the right line joining those points will be a normal to the curve described in that plane by the first point.

§ 3. To find in what way the focal and dirigent curves are connected with the surface, let the equations (5), (6), (7) (when K does not vanish) be put under the forms

$$\frac{x^2}{\mathrm{P}} + \frac{y^2}{\mathrm{Q}} + \frac{z^2}{\mathrm{R}} = 1, \tag{9}$$

$$\frac{x_1^2}{\mathrm{P}_1} + \frac{y_1^2}{\mathrm{Q}_1} = 1, \qquad \frac{x_2^2}{\mathrm{P}_2} + \frac{y_2^2}{\mathrm{Q}_2} = 1, \tag{10}$$

so that the quantities P, Q, R may represent the squares of the semiaxes of the surface, and P_1, Q_1, P_2, Q_2 the squares of the semiaxes of the curves, these quantities being positive or negative, according as the corresponding semiaxes are real or imaginary. Then we have

$$\begin{aligned} &\mathrm{P} = \frac{\mathrm{K}}{\mathrm{A}}, \qquad \mathrm{Q} = \frac{\mathrm{K}}{\mathrm{B}}, \qquad \mathrm{R} = \mathrm{K}, \\ &\mathrm{P}_1 = \mathrm{P}(1-\mathrm{A}), \qquad \mathrm{Q}_1 = \mathrm{Q}(1-\mathrm{B}), \\ &\mathrm{P}_2 = \frac{\mathrm{P}}{1-\mathrm{A}}, \qquad \mathrm{Q}_2 = \frac{\mathrm{Q}}{1-\mathrm{B}}; \end{aligned} \tag{11}$$

whence it follows that

$$\mathrm{P}_1\mathrm{P}_2 = \mathrm{P}^2, \qquad \mathrm{Q}_1\mathrm{Q}_2 = \mathrm{Q}^2, \tag{12}$$

and also that

$$P_1 = P - R, \qquad Q_1 = Q - R. \qquad (13)$$

From equations (12) we see that P_1 and P_2 have always the same sign, as also Q_1 and Q_2; and that, neglecting signs, the semiaxes of the surface are mean proportionals between the corresponding semiaxes of the focal and dirigent curves. These curves are therefore reciprocal polars with respect to the section made in the surface by the plane of xy; and it would be easy to show that the points F and Δ are reciprocal points, or that a tangent applied at one of them to the curve which is its locus has the other for its pole.

The focal curve, when we know in which of the principal planes it lies, is determined by the conditions (13), and as it depends on the relative magnitudes of the quantities P, Q, R, it will be convenient to distinguish the axes of the surface, with relation to these magnitudes. Supposing, therefore, the quantities P, Q, R to be taken with their proper signs, as they are in the equation (9), that axis to which the greatest of them (which is always positive) refers, shall be called the *primary* axis; and that to which the quantity algebraically least has reference, shall be termed the *secondary* axis; while the quantity which has an intermediate algebraic value shall mark the *middle* or *mean* axis. Then, since both P_1 and Q_1 will be negative, if R be the greatest of the quantities aforesaid, the focal curve cannot lie in the plane of the mean and secondary axes. Its plane must therefore pass through the primary axis; it will be the plane of the primary and mean axes, if R be the least of the three quantities; but the plane of the primary and secondary axes, if R be the intermediate quantity. In the former case the curve will be an ellipse, in the latter a hyperbola; and we shall extend the name of focal curves to both the curves so determined, though it may happen that only one of them can be used in the generation of the surface by the *modular method,* as the method of which we are treating may be called, from its employment of the modulus. A focal curve which can be so used shall be distinguished as a *modular focal;* but each focal, whether modular or not, shall be supposed to have a dirigent curve and a dirigent cylinder connected with it by the relations already laid down.

Since $P_1 - Q_1 = P - Q$, the foci of a focal curve are the same as those of the principal section in the plane of which it lies, and they are therefore on the primary axis of the surface. It will sometimes contribute to brevity of expression, if we also give the name of primary to the major axis of an ellipse and to the real axis of a hyperbola. We may then say that the primary axes of the surface and of its two focal curves are coincident in direction; and that (as is evident) the foci of either curve are the extremities of the primary axis of the other.

If K be supposed to approach gradually to zero, while A and B remain constant, the focal and dirigent ellipses will gradually contract, and the focal and dirigent hyperbolas will approach to their asymptotes, which remain fixed. When K actually vanishes, the surface becomes a cone; the two ellipses are each reduced to a point coinciding with the vertex of the cone, and each hyperbola is reduced to the pair of right lines which were previously the asymptotes. The dirigent cylinder, in the one case, is narrowed into a right line; in the other case it is converted into a pair of planes, which we may call the *dirigent planes* of the cone.

§ 4. We have now to show how the different kinds of surfaces belonging to the first class are produced, according to the different values of the modulus and other constants concerned in their generation.

I. When m is less than $\cos\phi$, the quantities A, B, K, P, Q, R are all positive, and Q is intermediate in value between P and R. The surface is therefore an ellipsoid, and its mean axis is the directive. As the quantities $1 - A$ and $1 - B$ are always positive, the focal and dirigent curves are ellipses.

Here we cannot suppose K to vanish, as the surface would then be reduced to a point.

When $\phi = 0$, that is, when the directive planes coincide with each other, and therefore with a plane perpendicular to the directrix, so that SD is the shortest distance of the point S from the directrix, the surface is a spheroid produced by the revolution of an ellipse round its minor axis, and the focal and dirigent curves are circles.

II. When m is greater than unity, A and B are negative; and if K be finite, it is also negative; whence P and Q are positive, and R is negative. Also, supposing ϕ not to vanish, Q is greater than P. The surface is therefore a hyperboloid of one sheet, with its real axes in the plane of xy; and the directive axis is the primary. The focal and dirigent curves are ellipses. But when $\phi = 0$, the surface is that produced by the revolution of a hyperbola round its imaginary axis, and the focal and dirigent* are circles.

If $K = 0$, which implies, since A and B have the same sign, that x_1, y_1, x_2, y_2 are each zero, the surface is a cone having the axis of z for its internal axis; and the focal and dirigent are each reduced to a point. The focus and directrix are consequently unique; the focus can only be the vertex of the cone, the directrix can only be the internal axis; and the directrix therefore passes through the focus. The directive axis, which coincides with the axis of y, is one of the external axes; that one, namely, which is parallel to the greater axes of the elliptic sections made in the cone by planes perpendicular to its internal axis. This is on the supposition that ϕ is finite; for, when $\phi = 0$, the cone becomes one of revolution round the axis of z.

III. When m is greater than $\cos\phi$, but less than unity, we have A positive and B negative, and the species of the

* When the term *dirigent* stands alone, it is understood to mean a dirigent *line*.

surface depends on K. It is inconsistent with these conditions to suppose $\phi = 0$, and therefore the surface cannot, in this case, be one of revolution. The value of K may be supposed to be given by the formula

$$K = \frac{1 - A}{A}(x_2 - x_1)^2 + \frac{1 - B}{B}(y_2 - y_1)^2, \qquad (14)$$

which contains only the relative coordinates of the focus and the foot of the directrix, and is a consequence of the equations (6) and (8).

1°. If K is a positive quantity, the surface is a hyperboloid of one sheet, with its secondary axis in the direction of x; the primary axis, as before, is the directive, but the focal and dirigent are now hyperbolas.

2°. If K is a negative quantity, the surface is a hyperboloid of two sheets, having its primary axis coincident with that of x. The secondary axis is the directive; the focal and dirigent are hyperbolas.

3°. If $K = 0$, the surface is a cone, having the axis of x for its internal axis; the directive axis being, as before, that external axis to which the greater axes of the elliptic sections, made by planes perpendicular to the internal axis, are parallel. The axis of z is the other external axis, which may be called the *mean axis* of the cone, because it coincides with the mean axis of any hyperboloid to which the cone is asymptotic. As A and B have different signs, it is evident, from the equations (6) and (7), that the focal and dirigent are each a pair of right lines passing through the vertex, each pair making equal angles with the internal axis. Two planes, each of which is drawn through the mean axis and a dirigent line, are the dirigent planes of the cone.

The corresponding focal and dirigent lines are those which lie within the same right angle made by the internal and directive axes; and since by the equations (6) and (8) the value of K may be written

$$\kappa = x_1 (x_2 - x_1) + y_1 (y_2 - y_1), \tag{15}$$

we see that, as κ now vanishes, the right line joining corresponding points F and Δ upon these lines is perpendicular to the focal line. Of the two sides of the cone which are in the plane of xy, one lies between each focal and its dirigent; and it may be inferred from the equations, that the tangents of the angles which the internal axis makes with a focal line, with one of these sides of the cone, and with a dirigent line, are in continued proportion, the proportion being that of the cosine of ϕ to unity. And hence it follows, that these two sides of the cone, with a focal line and its dirigent, cut harmonically any right line which crosses them.

§ 5. From this discussion it appears, that the ellipsoid and the hyperboloid of two sheets can be generated modularly, each in one way only, the modular focal being the ellipse for the former, and the hyperbola for the latter; but that the hyperboloid of one sheet can be generated in two ways, each of its focals being modular, and each focal having its proper modulus. The cone also admits two modes of generation,* in one of which, however, the focus is limited to the vertex of the cone, and the directrix to its internal axis.

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* The double generation of the cone, when its vertex is the focus, may be proved synthetically by the method indicated in the Examination Papers of the year 1838, p. xlvi (published in the University Calendar for 1839). Supposing the cone to stand on a circular base (one of its directive sections), and to be circumscribed by a sphere, the right lines joining its vertex with the two points where a diameter perpendicular to the plane of the base intersects the sphere, will be its internal and mean axes. Then if P be either of these points, V the vertex, C the point where the axis PV cuts the plane of the base, and B any point in the circumference of the base, the triangles PVB and PBC will be similar, since the angles at V and B are equal, and the angle at P is common to both triangles; therefore BV will be to BC as PV to PB, that is, in a constant ratio. It is not difficult to complete the demonstration, when the focus is supposed to be any point on one of the focal lines.

But when the hyperboloid of one sheet, or the cone, is a surface of revolution, it has only one mode of modular generation. In cases of double generation, the directive planes of course remain the same, as they have a fixed relation to the surface. A modular focal, it may be observed (and the remark applies equally to surfaces of the second class), is distinguished by the circumstance that it does not intersect the surface. The only exception to this rule are the focal lines of the cone, which pass through its vertex. A focal which is not modular may be called *umbilicar*, because it intersects the surface in the umbilics; an umbilic being a point on the surface where the tangent plane is parallel to a directive plane. Thus the focal hyperbola of the ellipsoid, and the focal ellipse of the hyperboloid of two sheets, are umbilicar focals, and pass through the umbilics of these surfaces; but the hyperboloid of one sheet has no umbilics, and accordingly both its focals are modular, and neither of them intersects the surface. The umbilicar focals and dirigents have properties which shall be mentioned hereafter.

An umbilicar focal and the principal section whose plane coincides with that of the focal are curves of different kinds, the one being an ellipse when the other is a hyperbola; but a modular focal is always of the same kind with the coincident section of the surface, being an ellipse, a hyperbola, or a pair of right lines, according as the section is an ellipse, a hyperbola, or a pair of right lines; and when the section is reduced to a point, so likewise is the modular focal.

The plane of a modular focal always passes through the directive axis. When the directive axis is the primary, as in the hyperboloid of one sheet, both focals are modular. But in the ellipsoid and the hyperboloid of two sheets, where the primary axis is not directive, only one of the focals can be modular. The plane of an umbilicar focal is always perpendicular to the directive axis; and therefore, when that axis is the primary, there is no umbilicar focal.*

When the surface is doubly modular, the two moduli m, m' are connected by the relation

$$\frac{\cos^2\phi}{m^2} + \frac{\sin^2\phi}{m'^2} = 1; \qquad (16)$$

where ϕ is the angle made by a directive plane with the plane of the focal to which the modulus m belongs. One modulus is greater than unity; the other is less than unity, but greater than the cosine of the angle which the plane of the corresponding focal makes with a directive plane. In the hyperboloid of one sheet, the less modulus is that which belongs to the focal hyperbola. In the cone, the less modulus belongs to the focal lines. Of the two moduli of a cone, that which belongs to the focal lines may be termed the *linear modulus;* and the other, to which only a single focus corresponds, may be called the *singular modulus.*

§ 6. *Second Class of Surfaces.*—In this class of surfaces, one of the quantities A, B vanishes, or both of them vanish.

I. When $m = \cos\phi$, and ϕ is not zero, A vanishes, but B

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* If the first of the equations (10), when P_1 and Q_1 are both negative, be supposed to express an imaginary focal, there will, in a central surface, be three focals, two modular and one umbilicar; the two modular focals being in the principal planes which pass through the directive axis, and the umbilicar focal in the remaining principal plane. Then, when we know which of the axes is the directive axis, we know which of the three focals is imaginary, because the plane of the imaginary focal is perpendicular to the primary axis. A modular focal may be imaginary, and yet have a real modulus; this occurs in the hyperboloid of two sheets. In the ellipsoid, the imaginary focal has an imaginary modulus. In all cases the two moduli are connected by the relation (16).

It will appear hereafter, that the vertex of the cone is an umbilicar focus. The cone has therefore three focals, none of which is imaginary; but two of them are single points coinciding with the vertex.

does not; and the surface is either a paraboloid or a cylinder.

1°. If the surface is a paraboloid, we may suppose the origin of coordinates to be at its vertex, in which case both H and K vanish, and we have the relations

$$\begin{gathered} G = x_2 - x_1, \qquad y_1 = y_2 \cos^2 \phi, \\ x_2^2 + y_2^2 \cos^2 \phi - x_1^2 - y_1^2 = 0; \end{gathered} \tag{17}$$

the equation of the surface being

$$y^2 \sin^2 \phi + z^2 + 2Gx = 0, \tag{18}$$

which shews that the paraboloid is elliptic, having its axis in the direction of x, and the plane of xy for that of its greater principal section. From the relations (17) we obtain the following,

$$\begin{gathered} y_1^2 \tan^2 \phi + 2Gx_1 + G^2 = 0, \\ y_2^2 \sin^2 \phi \cos^2 \phi + 2Gx_2 - G^2 = 0; \end{gathered} \tag{19}$$

from which we see that the focal and dirigent curves are parabolas, having their axes the same as that of the surface; and their vertices equidistant from the vertex of the surface, but at opposite sides of it. The concavity of each curve is turned in the same direction as that of the section xy. The focus of the focal parabola is the focus of the section xy, and its vertex is the focus of the section xz of the surface; its parameter being the difference of the parameters of these two sections. The parameter of the section xy is a mean proportional between the parameters of the focal and dirigent parabolas.

2°. If the surface is a cylinder, we may make G and H vanish, by taking the origin on its axis. We then have

$$\begin{gathered} x_2 = x_1, \qquad y_1 = y_2 \cos^2 \phi, \\ K = y_1^2 \tan^2 \phi = y_2^2 \sin^2 \phi \cos^2 \phi; \end{gathered} \tag{20}$$

the equation of the cylinder, which is elliptic, being

$$y^2 \sin^2 \phi + z^2 = K. \tag{21}$$

Here the focal and dirigent are each a pair of right lines parallel to the axis of the cylinder, and passing through the foci and directrices of a section perpendicular to the axis. The corresponding focal and dirigent lines lie at the same side of the axis.

II. When $m = 1$, and ϕ is not zero, B vanishes, but A does not.

1°. If the surface is a paraboloid, and the origin of coordinates at its vertex, the quantities G and K vanish; same the equation of the surface becomes

$$x^2 \tan^2 \phi - z^2 = 2\mathrm{H}y, \tag{22}$$

and we have the relations

$$\begin{aligned} \mathrm{K} = y_2 - y_1, \qquad x_1 = x_2 \sec^2 \phi, \\ x_2^2 \sec^2 \phi + y_2^2 - x_1^2 - y_1^2 = 0. \end{aligned} \tag{23}$$

The paraboloid is therefore hyperbolic, its axis being that of y, which is also the directive axis; and as the tangent of ϕ may have any finite value, the plane of xy, which is that of the focal curve, may be either of the principal planes passing through the axis of the surface. The relations (23) give

$$\begin{aligned} x_1^2 \sin^2 \phi - 2\mathrm{H}y_1 - \mathrm{H}^2 = 0, \\ x_2^2 \tan^2 \phi \sec^2 \phi - 2\mathrm{H}y_2 + \mathrm{H}^2 = 0, \end{aligned} \tag{24}$$

for the equations of the focal and dirigent, which are therefore parabolas, having their axes the same as those of the surface, and their concavities turned in the same direction as that of the section xy; their vertices being equidistant from the vertex of the surface, and at opposite sides of it. The focus of the focal parabola is the focus of the section xy, and its vertex is the focus of the section yz, its parameter being the sum of the parameters of these two sections. The parameter of the section xy is a mean proportional between the parameters of the focal and dirigent parabolas.

2°. If the surface is a cylinder, and the origin on its axis, G and H vanish, and we have

$$\begin{aligned} x_1 &= x_2 \sec^2\phi, \qquad y_1 = y_2, \\ -\text{K} &= x_1^2 \sin^2\phi = x_2^2 \tan^2\phi \sec^2\phi; \end{aligned} \tag{25}$$

the equation of the cylinder, which is hyperbolic, being

$$x^2 \tan^2\phi - z^2 = -\text{K}. \tag{26}$$

The focal and dirigent are each a pair of right lines parallel to the axis of the cylinder; the corresponding lines passing through a focus and the adjacent directrix of any section perpendicular to the axis. The directive planes are parallel to the asymptotic planes of the cylinder.

In this case, if $\text{K} = 0$, the surface is reduced to two directive planes, and the focal and dirigent to the intersection of these planes.

III. When $m = 1$, and $\phi = 0$, both A and B vanish, and the surface is the parabolic cylinder. If, as is allowable, we suppose G and K to vanish, the equation of the cylinder becomes

$$z^2 + 2\text{H}y = 0, \tag{27}$$

and we have

$$\begin{aligned} \text{H} &= y_2 - y_1, \qquad x_1 = x_2, \\ x_2^2 &+ y_2^2 - x_1^2 - y_1^2 = 0; \end{aligned} \tag{28}$$

whence

$$y_1 = -\tfrac{1}{2}\text{H}, \qquad y_2 = \tfrac{1}{2}\text{H}. \tag{29}$$

The focal and dirigent are each a right line parallel to the axis of x, the former passing through the focus, the latter meeting the directrix of the parabolic section made by the plane of yz. The plane of xy is the directive plane.

§ 7. We learn from this discussion, that, among the surfaces of the second class, the hyperbolic paraboloid is the only one which admits a twofold modular generation; the modulus, however, being the same for both its focals. In the elliptic paraboloid the modular focal is restricted to the plane of that principal section which has the greater parameter; we shall therefore suppose a parabola to be described in the plane of the other principal section, according to the law of the modular focals; the law being, that the focus of the parabola shall be the focus of the principal section in the plane of which the parabola lies, and its vertex the focus of the principal section in the perpendicular plane. The parabola so described will have its concavity opposed to that of the surface; it will cut the surface in the umbilics, and will be its umbilicar focal, the only such focal to be found among the surfaces of the second class. We shall of course suppose further, that this focal has a dirigent parabola connected with it by the same law as in the other cases, the vertices of the focal and dirigent being equidistant from that of the surface and at opposite sides of it, while the parameter of the dirigent is a third proportional to the parameters of the focal and of the principal section in the plane of which the curves lie. The two focals of a paraboloid are so related, that the focus of the one is the vertex of the other. The cylinders have no other focals than those which occur above.

§ 8. In this, as in the first class of surfaces, the right line FΔ, joining a focus F with the foot of its corresponding directrix, is perpendicular to the focal line; and the focal and dirigent are reciprocal polars with respect to the section xy of the surface. These properties are easily inferred from the preceding results; but, as they are general, it may be well to prove them generally for both classes of surfaces. Supposing, therefore, the origin of coordinates to be any where in the plane of xy, and writing the equation of the surface in the form

$$(x-x_1)^2+(y-y_1)^2+z^2=\mathrm{L}(x-x_2)^2+\mathrm{M}(y-y_2)^2, \quad (30)$$

which, when identified with (3), gives the relations

$$\begin{aligned} &\mathrm{A}=1-\mathrm{L}, \qquad \mathrm{B}=1-\mathrm{M}, \\ &\mathrm{G}=\mathrm{L}x_2-x_1, \qquad \mathrm{H}=\mathrm{M}y_2-y_1, \\ &\mathrm{K}=\mathrm{L}x_2^2+\mathrm{M}y_2^2-x_1^2-y_1^2, \end{aligned} \quad (31)$$

we find, by differentiating the values of the constants G, H, and K,

$$\begin{gathered} L dx_2 = dx_1, \qquad M dy_2 = dy_1, \\ L x_2\, dx_2 + M y_2\, dy_2 - x_1\, dx_1 - y_1\, dy_1 = 0. \end{gathered} \tag{32}$$

Hence we obtain

$$(x_2 - x_1)\, dx_1 + (y_2 - y_1)\, dy_1 = 0\,; \tag{33}$$

an equation which expresses that the right line joining the points F and Δ is perpendicular to the line which is the locus of the point F.

Again, the equation of the section xy of the surface being

$$A x^2 + B y^2 + 2 G x + 2 H y = K, \tag{34}$$

the equation of the right line which is, with respect to this section, the polar of a point Δ whose coordinates are x_2, y_2, is

$$(A x_2 + G)\, x + (B y_2 + H)\, y = K - G x_2 - H y_2\,; \tag{35}$$

but the relations (31) give

$$\begin{gathered} A x_2 + G = x_2 - x_1, \qquad B y_2 + H = y_2 - y_1, \\ K - G x_2 - H y_2 = x_1(x_2 - x_1) + y_1(y_2 - y_1)\,; \end{gathered} \tag{36}$$

and hence the equation (35) becomes

$$(x_2 - x_1)(x - x_1) + (y_2 - y_1)(y - y_1) = 0, \tag{37}$$

which, as is evident from (33), is the equation of a tangent applied to the focal at the point F corresponding to Δ. This shows that the focal and dirigent are reciprocal polars with respect to the section xy, and that in this relation, as well as in the other, the points F and Δ are corresponding points.

Supposing F′ and Δ' to be two other corresponding points on the focal and dirigent, if tangents applied to the focal at F and F′ intersect each other in T, the point T will be the pole of the right line $\Delta\Delta'$ with respect to the section xy, as well as the pole of the right line FF′ with respect to the focal; and hence if any right line be drawn through T, and if P be the pole of this right line with respect to the section, and N its pole with respect to the focal, the points P and N will be on the right lines $\Delta\Delta'$ and FF' respectively. Now it is useful to observe that the distances $\Delta\Delta'$ and FF' are always similarly divided (both of them internally or both of them externally) by the points P and N, so that we have ΔP to $\Delta' P$ as FN to $F'N$. This property may be proved directly by means of the foregoing equations; or it may be regarded as a consequence of the following theorem:—If through a fixed point in the plane of two given conics having the same centre, or of two given parabolas having their axes parallel, any pair of right lines be drawn, and their poles be taken with respect to each curve, the distance between the poles relative to one curve will be in a constant ratio to the distance between the poles relative to the other curve.* In fact, the poles of the right lines TF, TF′, with respect to the focal, are F, F′; and their poles with respect to the section xy are Δ, Δ'; therefore, since the focal and the section xy may be taken for the given curves, and the point T for the fixed point, the ratio of FF' to $\Delta\Delta'$ is the same as the ratio of FN to ΔP or of $F'N$ to $\Delta' P$, and consequently the distances FF' and $\Delta\Delta'$ are similarly divided in the points N and P.

§9. In the equation (30), considered as equivalent to the equation (1), the constants L and M are both positive; but the properties which have been deduced from the former equation are independent of this circumstance, and

* There is an analogous theorem for two surfaces of the second order which have the same centre, or two paraboloids which have their axes parallel. If through a fixed right line any two planes be drawn, and their poles be taken with respect to each surface, the distance between the poles relative to the one surface will be in a constant ratio to the distance between the poles relative to the other.

equally subsist when one of these constants is supposed to be negative (for they cannot both be negative). This leads us to inquire what surfaces the equation (30) is capable of representing when the constants L and M have different signs; as also, for a given surface, what lines are traced in the plane of xy by points F and Δ, of which x_1, y_1 and x_2, y_2 are the respective coordinates. After the examples already given, this question is easily discussed, and the result is, that the only surfaces which can be so represented are the ellipsoid, the hyperboloid of two sheets, the cone, and the elliptic paraboloid—that is to say, the umbilicar surfaces together with the cone; and that, for an umbilicar surface, the locus of F is the umbilicar focal, and therefore the locus of Δ is the corresponding dirigent; while for the cone the points F and Δ are unique, coinciding with each other and with the vertex of the cone. A geometrical interpretation of this case is readily found; for as L and M have different signs, the right-hand member of the equation (30), if M be the negative quantity, is the product of two factors of the form

$$f(x - x_2) + g(y - y_2), \quad f(x - x_2) - g(y - y_2),$$

in which f and g are constant; and these factors are evidently proportional to the distances of a point whose coordinates are x, y, z, from two planes whose equations are

$$f(x - x_2) + g(y - y_2) = 0, \quad f(x - x_2) - g(y - y_2) = 0,$$

which planes always pass through a directrix, and are inclined at equal and constant angles to the axis of x or of y. Therefore, if F be the focus which belongs to this directrix, the square of the distance of F from any point of this surface is in a constant ratio to the rectangle under the distances of the latter point from the two planes. And these planes are directive planes; because, if a section parallel to one of them be made in the surface, the distance of any point of the section from the other plane will be proportional to the square of the distance of the same point from the focus; and, as the locus of a point, whose distance from a given plane is proportional to the square of its distance from a given point, is obviously a sphere, it follows that the section aforesaid is the section of a sphere, and consequently a circle; which shows that the plane to which the section is parallel is a directive plane. Thus,* the square of the distance of any point of

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* In attempting to find a geometrical generation for the surfaces of the second order, one of the first things which I thought of, before I fell upon the modular method, was to try the locus of a point such that the square of its distance from a given point should be in a constant ratio to the rectangle under its distances from two given planes; but when I saw that this locus would not represent all the species of surfaces, I laid aside the discussion of it. Some time since, however, Mr. Salmon, Fellow of Trinity College, was led independently, in studying the modular method, to consider the same locus; and he remarked to me, what I had not previously observed, that it offers a property supplementary, in a certain sense, to the modular property; that when the surface is an ellipsoid, for example, the given point or focus is on the focal hyperbola, which the modular property leaves empty. This remark of Mr. Salmon served to complete the theory of the focals, by indicating a simple geometrical relation between a non-modular focal and any point on the surface to which it belongs.

In a memoir "On a new Method of Generation and Discussion of the Surfaces of the second Order," presented by M. Amyot to the Academy of Sciences of Paris, on the 26th December, 1842, the author investigates this same locus, conceiving it to involve that property in surfaces which is analogous to the property of the focus and directrix in the conic sections; and the importance attached to the discovery of such analogous properties induced M. Cauchy to write a very detailed report on M. Amyot's memoir, accompanied with notes and additions of his own (*Comptes rendus des Séances de l'Académie des Sciences*, tom. xvi. pp. 783-828, 885-890; April, 1843); and also occasioned several discussions, principally between M. Poncelet and M. Chasles, relative to that Memoir (*Comptes rendus*, tom. xvi. pp. 829, 938, 947, 1105, 1110). But the property involved in this locus cannot be said to afford a method of generation of the surfaces of the second order, since it applies only to some of the surfaces, and gives an ambiguous result even where it does apply. It is therefore not at all analogous to the aforesaid general property of the conic sections, and moreover it was not new when M. Amyot the surface from an umbilicar focus bears a constant ratio to the rectangle under the perpendicular distances of the same

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brought it forward. Mr. Salmon had in fact proposed it for investigation to the students of the University of Dublin, at the ordinary examinations in October, 1842; and it was published, towards the end of that year, in the University Calendar for 1843, some months before the date of M. Cauchy's report, by which the contents of M. Amyot's memoir were first made known. The parallelism of the two given planes to the circular sections of the surface is also stated in the Calendar; but this remarkable relation is not noticed by M. Amyot, nor by M. Cauchy. (See the Examination Papers of the year 1842, p. xlv, quest. 17, 18; in the Calendar for 1843.) It is scarcely necessary to add, that the analogue which M. Amyot and other mathematicians have been seeking for, and which was long felt to be wanting in the theory of surfaces of the second order, is no other than the modular property of these surfaces, which appears to be not yet known abroad. M. Poncelet insists much on the importance of extending the signification of the terms *focus* and *directrix*, so as to make them applicable to surfaces; and he supposes this to have been effected, for the first time, by M. Amyot. These terms however, applied in their true general sense to surfaces, had been in use, several years before, among the mathematical students of Dublin, as may be seen by referring to the Calendar (Examination Papers of the year 1838, p. c; 1839, p. xxxi).

The locus above-mentioned, being co-extensive with the umbilicar property, does not represent any surface which can be generated by the right line, except the cone. To remedy this want of generality, M. Cauchy proposes to consider a surface of the second order as described by a point, the square of whose distance from a given point bears a constant ratio either to the rectangle under its distances from two given planes, or to the sum of the squares of these distances. This enunciation, no doubt, takes in both kinds of focals, and all the species of surfaces; but the additional conception is not of the kind required by the analogy in question, nor has it any of the characters of an elementary principle. For the given planes, according to M. Cauchy's idea, do not stand in any simple or natural relation to the surface; and besides there is no reason why, instead of the sum of the squares of the distances from the given planes, we should not take the sum after multiplying the one square by any given positive number, and the other square by another given positive number; nor is there any reason why we should not take other homogeneous functions of these distances. This conception would therefore be found of little use in geometrical applications; while the modular principle, on the contrary, by employing a simple ratio between two right lines, both of which have a natural connexion point from two directive planes drawn through the directrix corresponding to that focus; and it is easy to see that this ratio, the square root of which we shall denote by μ, is equal to L — M, or, neglecting signs, to the sum of the numerical values of L and M. Of course, if the distances from the directive planes, instead of being perpendicular, be measured parallel to any fixed right line, the ratio will still be constant, though different. For example, if the fixed right line for each plane be that which joins the corresponding umbilic with either focus of the section xy, the ratio of the square to the rectangle will be the square of the number $m \sec \phi$, where m is the modulus, and ϕ the angle which the primary axis makes with a directive plane.

When the umbilicar property is applied to the cone, the vertex of which is, as we have seen, to be regarded as an umbilicar focus, having the directive axis for its directrix, it indicates that the product of the sines of the angles which any side of the cone makes with its two directive planes is a constant quantity.

It is remarkable that the vertex of the cone affords the only instance of a focal point which is at once modular and umbilicar, as well as the only instance of a focal point which is doubly modular. This union of properties it may be conceived to owe to the circumstance that the cone is the asymptotic limit of the two kinds of hyperboloids. For if a

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with the surface, lends itself with the greatest ease to the reasonings of geometry. Indeed the whole difficulty, in extending the property of the directrix to surfaces of the second order, consisted in the discovery of such a ratio inherent in all of them; a ratio having nothing arbitrary in its nature, and for which no other of equal simplicity can be substituted.

It may be proper to mention that the term *modulus*, which I have used for the first time in the present paper, with reference to surfaces of the second order, has been borrowed from M. Cauchy, by whom it is employed, however, in a signification entirely different. Several other new terms are also now introduced, from the necessity of the case.

series of hyperboloids have the same asymptotic cone, and their primary axes be indefinitely diminished, they will approach indefinitely to the cone; and, in the limit, the focal ellipse and hyperbola of the hyperboloid of one sheet will pass into the vertex and the focal lines of the cone, thus making the vertex doubly modular, while the focal ellipse of the hyperboloid of two sheets will also be contracted into the vertex, and will make that point umbilicar.

When the two directive planes coincide, and become one directive plane, the umbilicar property is reduced to this, that the distances of any point in the surface from the point F and from the directive plane are in a constant ratio to each other; and therefore the surface becomes one of revolution round an axis passing through F at right angles to that plane, the point F being a focus of the meridional section, or the vertex if the surface be a cone. When the directive planes are supposed to be parallel, but separated by a finite interval, we get the same class of surfaces of revolution, with the addition of the surface produced by the revolution of an ellipse round its minor axis; the point F being still on the axis of revolution, but not having any fixed relation to the surface.

§ 10. If in the equation (30) we supposed the right-hand member to have an additional term containing the product of the quantities $x - x_2$ and $y - y_2$, with a constant coefficient, all the foregoing conclusions regarding the geometrical meaning of that equation would remain unchanged, because the additional term could always be taken away by assigning proper directions to the axes of x and y. If, after the removal of this term, the coefficients of the squares of the aforesaid quantities were both positive, the locus of F would be a modular focal of the surface expressed by the equation; but if one coefficient were positive and the other negative, the locus of F would be an umbilicar focal. The equation in its more general form is evidently that which we should obtain for the locus of a point S, such that the square of its distance SF from a given point F should be a given homogeneous function of the second degree of its distances from two given planes; the plane of xy being drawn through F perpendicular to the intersection of these planes, and x_2, y_2 being the coordinates of any point on this intersection, while x_1, y_1 are the coordinates of F. The point F might be any point on one of the focals of the surface described by S; the intersection of the two planes (supposing them always parallel to fixed planes) being the corresponding directrix.

These considerations may be further generalised, if we remark that the equation of any given surface of the second order may be put under the form

$$(x-x_1)^2+(y-y_1)^2+(z-z_1)^2=\text{L}(x-x_2)^2+\text{M}(y-y_2)^2+\text{N}(z-z_2)^2 \\ +\text{L}'(y-y_2)(z-z_2)+\text{M}'(x-x_2)(z-z_2)+\text{N}'(x-x_2)(y-y_2), \quad (38)$$

where L, M, N, L′, M′, N′ are constants, and x_1, y_1, z_1 are conceived to be the coordinates of a certain point F, and x_2, y_2, z_2 the coordinates of another point Δ. The constants L′, M′, N′ may, if we please, be made to vanish by changing the directions of the axes of coordinates; and when this is done, the new coordinate planes will be parallel to the principal planes of the surface. Then, by proceeding as before, it may be shown that, without changing the surface, we are at liberty, under certain conditions, to make the points F and Δ move in space. The conditions are expressed geometrically by saying that the two surfaces, upon which these points must be always found, are reciprocal polars with respect to the given surface, the points F and Δ being, in this polar relation, corresponding points; and that the surface which is the locus of F is a surface of the second order, *confocal* with the given one, it being understood that confocal surfaces are those which have the same focal lines. The surface on which Δ lies is therefore also of the second order, and the right line ΔF is a normal at F to the surface which is the locus of this point. Moreover, if through the point Δ three or more planes be drawn parallel to fixed planes, and perpendiculars be dropped upon them from any point S whose coordinates are x, y, z, the right-hand member of the equation (38) may be conceived to represent a given homogeneous function of the second degree of these perpendiculars; and the given surface may therefore be regarded as the locus of a point S, such that the square of the distance SF is always equal to that function.

§ 11. In the enumeration of the surfaces capable of being generated by the modular method, we miss the five following varieties, which are contained in the general equation of the second degree, but are excluded from that method of generation by reason of the simplicity of their forms—namely, the sphere, the right cylinder on a circular base, and the three surfaces which may be produced by the revolution of a conic section (not a circle) round its primary axis.* These three surfaces are the prolate spheroid, the hyperboloid of two sheets, and the paraboloid of revolution; and the circumstance that the foci of the generating curves are also foci of the surfaces, renders it easy to investigate their focal properties.† In point of simplicity, the excepted surfaces are to the other surfaces of the second order what the circle is to the other conic sections, the circle being, in like manner, excepted from the curves which can be generated by the analogous method *in plano;* and the geometry of the five excepted surfaces may therefore be regarded as comparatively elementary. These five surfaces

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* The case of two parallel planes is also excluded, but it is not here taken into account. The case of two parallel right lines is in like manner excluded from the corresponding generation of lines of the second order.

† A paper by M. Chasles, on these surfaces of revolution, will be found in the Memoirs of the Academy of Brussels, tom. v. (An. 1829).

were, in fact, studied by the Greek geometers,* and, along with the oblate spheroid and the cone, they make up all the surfaces of the second order with which the ancients were acquainted. Except the cone, the surfaces considered by them are all of revolution; and there is only one surface of revolution, the hyperboloid of one sheet, which was not noticed until modern times. This surface is mentioned (under the name of the hyperbolic cylindroid) by Wren,† who remarks that it can be generated by the revolution of a right line round another right line not in the same plane. As to the general conception of surfaces of the second order, the suggestion of it was reserved for the algebraic geometry of Descartes. In that geometry the curves previously known as sections of the cone are all expressed by the general equation of the second degree between two coordinates; and hence it occurred to Euler‡ about a century ago, to examine and classify the different kinds of surfaces comprised in the general equation of the second degree among three coordinates. The new and more general forms thus brought to light have since engaged a large share of the attention of geometers; but the want of some other than an algebraic principle of connexion has prevented any great progress from being made in the investigation of such of their properties as do not immediately depend on transformations of coordinates. This want the modular method of generation perfectly supplies, by evolving the different forms from a simple geometrical conception, at the same time that it brings them within the range of ideas familiar to the ancient geometry, and places their relation to the conic sections in a striking point of view.

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* The hyperboloid of two sheets, and the paraboloid of revolution, were known by the name of *conoids*. Archimedes has left a treatise on Conoids and Spheroids, as well as a treatise on the Sphere and Cylinder.

† In the Philosophical Transactions for the year 1669, p. 961.

‡ See his *Introductio in Analysin Infinitorum*, p. 373; Lausanne, 1748.

It may be well to remark that the excepted surfaces are *limits* of surfaces which can be generated modularly, as the circle is the limit of the ellipse in the analogous generation of the conic sections. Thus the sphere is the limit of an oblate spheroid, one of whose axes remains constant, while its focal circle is indefinitely diminished; and the right circular cylinder is the limit of an elliptic cylinder, whose focal lines are conceived to approach indefinitely to coincidence with each other and with the axis of the cylinder, while one of the axes of the principal elliptic section remains constant. In these cases the dirigent lines, along with the directrices, move off to infinity. The other three excepted surfaces correspond to the supposition $\phi = 90°$, which was excluded in the discussion of the general equation (1). For if we make $m \sec \phi = n$, the quantity which constitutes the right-hand member of that equation may be written

$$n^2 (x - x_2)^2 + n^2 (y - y_2)^2 \cos^2 \phi;$$

and if we suppose n to remain finite and constant, while ϕ approaches to 90°, and m indefinitely diminishes, this quantity will approach indefinitely to $n^2 (x - x_2)^2$, which will be its limiting value when $\phi = 90°$. But $x - x_2$ is the distance of the point S from a fixed plane intersecting the axis of x perpendicularly at the distance x_2 from the origin of coordinates; and therefore, in the limit, the equation expresses that the distances of any point S of the surface from the focus F and from this fixed plane, are to each other as n to unity, that is, in a constant ratio; which is a common property of the three surfaces in question. This property also belongs to the right cone, but the right cone does not rank among the excepted surfaces.

§ 12. We have seen that, when the modulus is unity, any plane parallel to either of the directive planes intersects the surface in a right line; whence it follows, that through any point on the surface of a hyperbolic paraboloid two right lines may be drawn which shall lie entirely in the surface. The plane of these right lines is of course the tangent plane at that point, and therefore every tangent plane intersects the surface in two right lines. This is otherwise evident from considering that the sections parallel to a given tangent plane are similar hyperbolas, whose centres are ranged on a diameter passing through the point of contact, and whose asymptotes, having always the same directions, are parallel to two fixed right lines which we may suppose to be drawn through that point. For as the distance between the plane of section and the tangent plane diminishes, the axes of the hyperbola diminish; and they vanish when that distance vanishes, the hyperbola being then reduced to its asymptotes. The tangent plane therefore intersects the surface in the two fixed right lines aforesaid. The same reasoning, it is manifest, will apply to any other surface of the second order, which has hyperbolic sections parallel to its tangent planes; and therefore the hyperboloid of one sheet, which is the only other such surface,* is also intersected in two right lines by any of its tangent planes. These right lines are usually called the *generatrices* of the surface.

From what has been said, it appears that the generatrices of the hyperbolic paraboloid, and the asymptotes of its sections (all its sections, except those made by planes parallel to the axis, being hyperbolas), are parallel to the directive planes. The generatrices of the hyperboloid of one sheet, and the asymptotes of its hyperbolic sections, are parallel to the sides of the asymptotic cone; because any section of the

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* The double generation of these two surfaces by the motion of a right line has been long known. It appears to have been discovered and fully discussed by some of the first pupils of the Polytechnic School of Paris. This mode of generation had, however, been remarked by Wren, with regard to the hypreboloid of revolution. It does not seem to have been observed, that the existence of rectilinear generatrices is included in the idea of hyperbolic sections parallel to a tangent plane.

hyperboloid is similar to a parallel section of the asymptotic cone, and when the latter section is a hyperbola its asymptotes are parallel to two sides of the cone.

PART II.—PROPERTIES OF SURFACES OF THE SECOND ORDER.

§ 1. In the preceding part of this paper it has been necessary to enter into details for the purpose of communicating fundamental notions clearly. In the following part, which will contain certain properties of surfaces of the second order, we shall be as brief as possible; giving demonstrations of the more elementary theorems, but confining ourselves to a short statement of the rest.

Many consequences follow from the principles already laid down.

Through any directrix of a surface of the second order let a fixed plane be drawn cutting the surface, and let S be any point of the section. If the directrix and its focus F be modular, and if a plane always parallel to the same directive plane be conceived to pass through S and to cut the directrix in D, the directive distance SD will be always parallel to a given right line, and will therefore be in a constant ratio to the perpendicular distance of S from the directrix. This perpendicular distance will consequently bear a given ratio to SF, the distance of the point S from the focus. And the same thing will be true when the directrix and focus are umbilicar, because the perpendicular distance of the point S from the directrix will be in a constant ratio to its distance from each directive plane drawn through the directrix.

The fixed plane of section will in general contain another directrix parallel to the former, and belonging to the same focal; and it is evident that the perpendicular distance of S from this other directrix will be in a given ratio to its distance SF′ from the corresponding focus F′, the ratio being the same as in the former case. Hence, according as the point S lies between the two directrices, or at the same side of both, the sum or difference of the distances SF and SF′ will be constant.

If the plane of section pass through either of the foci, as F, this focus and its directrix will manifestly be the focus and directrix of the section. In this case the plane of section will be perpendicular to the focal at F. And if the surface be a cone, the point F being anywhere on one of its focal lines, the distance of the point S from the directrix will be in a constant ratio to its perpendicular distance from the dirigent plane which contains the directrix, and therefore this perpendicular distance will be in a given ratio to the distance SF. Now calling V the vertex of the cone, and taking SV for radius, the perpendicular distance aforesaid is the sine of the angle which the side SV of the cone makes with the dirigent plane; and SF, which is perpendicular to VF, is the sine of the angle SVF. Consequently the sines of the angles which any side of a cone makes with a dirigent plane and the corresponding focal line are in a given ratio to each other.

§ 2. Conceive a surface of the second order to be intersected in two points S, S′ by a right line which cuts two parallel directrices in the points E, E′, and let F, F′ be the foci corresponding respectively to these directrices. The perpendicular distances of the points S, S′ from the first directrix and from the second are to each other as the lengths SE, S′E, SE′, S′E′ respectively, and therefore the ratios of FS to SE, of FS′ to S′E, of F′S to SE′, and of F′S′ to S′E′ are all equal.

Hence, the right line FE bisects one of the angles made by the right lines FS and FS′; and the right line F′E′ bisects one of the angles made by F′S and F′S′.

When the points S, S′ are at the same side of E, the angle supplemental to SFS′ is that which is bisected by the right line FE. Now if the point S be fixed, and S′ approach to it indefinitely, the angle SFE will approach indefinitely to a right angle. Therefore if a right line touching the surface meet a directrix in a certain point, the distance between this point and the point of contact will subtend a right angle at the focus which corresponds to the directrix. And if a cone circumscribing the surface have its vertex in a directrix, the curve of contact will be in a plane drawn through the corresponding focus at right angles to the right line which joins that focus with the vertex.

When the surface intersected by the right line SS′ is a cone, suppose this line to lie in the plane of the focus F and its directrix, that is, in the plane which is perpendicular at F to the focal line VF (the vertex of the cone being denoted, as before, by V); the angles made by the right lines FE, FS, FS′, are then the same as the angles made by planes drawn through VF and each of the right lines VE, VS, VS′; and the last three right lines are the intersections of a plane VSS′ with the dirigent plane on which the point E lies, and with the surface of the cone. Therefore if a plane passing through the vertex of a cone intersect its surface in two right lines, and one of its dirigent planes in another right line, and if a plane be drawn through each of these right lines respectively and the focal line which belongs to the dirigent plane, the last of the three planes so drawn will bisect one of the angles made by the other two. And hence, if a plane touching a cone along one of its sides intersect a dirigent plane in a certain right line, and if through this right line and the side of contact two planes be drawn intersecting each other in the focal line which corresponds to the dirigent plane, the two planes so drawn will be at right angles to each other.

Let a right line touching a surface of the second order in S meet two parallel directrices in the points E, E′, and let F, F′ be the corresponding foci. Then the triangles FSE and F′SE′ are similar, because the angles at F and F′ are right angles, and the ratio of FS to SE is the same as the ratio of F′S to SE′. Therefore the tangent EE′ makes equal angles with the right lines drawn from the point of contact S to the foci F, F′. When the surface is a cone, let the tangent be perpendicular to the side VS which passes through the point of contact; the angles FSE and F′SE′ are then the angles which the tangent plane VEE′ makes with the planes VSF and VSF′, because the right line FE is perpendicular to the plane VSF, and the right line F′E′ is perpendicular to the plane VSF′. Therefore the tangent plane of a cone makes equal angles with the planes drawn through the side of contact and each of the focal lines.

Supposing a section to be made in a surface of the second order by a plane which cuts any directrix in the point E, if the focus F belonging to this directrix be the vertex of a cone having the section for its base, the right line FE will be an axis of the cone. For if through FE any plane be drawn cutting the base of the cone in the points S, S′, one of the angles made by the sides FS, FS′ which pass through these points will always be bisected by the right line FE; and this is the characteristic property of an axis.

§ 3. Two surfaces of the second order being supposed to have the same focus, directrix, and directive planes, so that they differ only in the value of the modulus m, or of the umbilicar ratio μ (see Part I. § 9), let a right line passing through any point E of the directrix cut one surface in the points S, S′, and the other in the points S_0, S_1, and conceive right lines to be drawn from all these points to the common focus F. Since, if ratios be expressed by numbers, the ratio of FS to SE (or of FS′ to S′E) is to the ratio of FS_0 to S_0E (or of FS_1 to S_1E) as the value of m for the one surface is to its value for the other, when the focus is modular, or as the value of μ for the one surface is to its value for the other when the focus is umbilicar, the sines of the angles EFS_0 and EFS (or of the angles EFS_1 and EFS′) are in a constant proportion to each other, because these sines are proportional to those ratios. And since the right line FE bisects the angles SFS′ and S_0FS_1, both internally or both externally, in which case the angles SFS_0 and $S'FS_1$ are equal, or else one internally and the other externally in which case the angles SFS_0 and $S'FS_1$ are supplemental, it is easy to infer, from the constant ratio of the aforesaid sines, that in the first case the product, in the second case the ratio of the tangents of the halves of the angles SFS_0 and $S'FS_0$ (or of the halves of the angles SFS_1 and $S'FS_1$) is a constant quantity.

If the point S′ approximate indefinitely to S, the right line passing through these points will approach indefinitely to a tangent. Therefore when two surfaces are related as above, if a right line passing through any point E of their common directrix intersect one surface in the points S_0, S_1, and touch the other in the point S, the chord S_0S_1 will subtend a constant angle at the common focus F, and this angle will be bisected, either internally or externally, by the right line FS drawn from the focus to the point of contact. And the angle EFS being then a right angle, the cosine of the angle SFS_0 or SFS_1 will be equal to the ratio of the less value of m or μ to the greater.*

§ 4. Among the surfaces of the second order the only one which has a point upon itself for a modular focus is the cone, the vertex of which is such a focus, related either to the internal or to the mean axis as directrix. In the latter relation the vertex belongs to the series of foci which are ranged on the focal lines. To see the consequence of this, let V be the vertex of the cone, and VW its mean axis perpendicular to the plane of the focal lines. On one of the focal lines and its dirigent assume any corresponding

* See Exam. Papers, An. 1839, p. xxxi. questions 9, 10. These and some of the preceding theorems were originally stated with reference to modular foci only. They are now extended to umbilicar foci.

points F and Δ, and let ΔD be the directrix passing through Δ. Then if a directive plane, drawn through any point S of the surface, cut this directrix in D and the mean axis in W, the ratio of SF to SD will be expressed by the linear modulus, as will also the ratio of VF to WD, since V is a point of the surface, and WD is equal to the directive distance of V from ΔD. But since V is a focus to which the mean axis is directrix, the ratio of SV to SW is expressed by the same modulus. Thus the triangles SVF and SWD are similar, the sides of the one being proportional to those of the other. Therefore the angle SVF is equal to the angle SWD; that is to say, the angle which the side VS of the cone makes with the focal line VF is equal to the angle contained by two right lines WD and WS, of which one is the intersection of the directive plane with the dirigent plane VWD corresponding to VF, and the other is the intersection of the directive plane with the plane VWS passing through the mean axis and the side VS of the cone.

Hence it appears that the sum of the angles (properly reckoned) which any side of the cone makes with its two focal lines is constant. For if F′ be a point on the other focal line, and D′ the point where the directrix corresponding to F′ is intersected by the same directive plane SWD, it may be shown as above that the angle SVF′ is equal to the angle SWD′, that is, to the angle made by the right line WS with the right line WD′ in which the directive plane intersects the dirigent plane corresponding to VF′. Conceiving therefore the points F, F′, S, and with them the points D, D′, to lie all on the same side of the principal plane which is perpendicular to the internal axis, the right line WS will lie between the right lines WD and WD′, and the sum of the angles SVF and SVF′ will be equal to the angle DWD′, which is a constant angle, being contained by the right lines in which a directive plane intersects the two dirigent planes of the cone. This constant angle will be found to be equal, as it ought to be, to one of the angles made by the two sides of the cone which are in the plane of the focal lines, namely to the angle within which the internal axis lies.

If we conceive the cone to have its vertex at the centre of a sphere, and the points F, F′, S to be on the surface of this sphere, the arcs of great circles connecting the point S with each of the fixed points F, F′ will have a constant sum. The curve formed by the intersection of the sphere and the cone may therefore, from analogy, be called a *spherical ellipse*, or, more generally, a *spherical conic*, because, by removing one of its foci F, F′ to the opposite extremity of the diameter of the sphere, the difference of the arcs SF and SF′ will be constant, which shows that the spherical curve is analogous to the hyperbola as well as to the ellipse. Either of these plane curves may, in fact, be obtained as a limit of the spherical curve when the sphere is indefinitely enlarged, according as the diameter along which the enlargement takes place, and of which one extremity may be conceived to be fixed while the other recedes indefinitely, coincides with the internal or with the directive axis of the cone. The fixed extremity becomes the centre of the limiting curve, which is an ellipse in the first case, and a hyperbola in the second.

The great circle touching a spherical conic at any point makes equal angles with the two arcs of great circles which join that point with the foci, because the sum of these arcs is constant. This is identical with a property already demonstrated relative to the tangent planes of the cone. Indeed it is obvious that the properties of the cone may also be stated as properties of the spherical conic, and this is frequently the more convenient way of stating them.

§ 5. If the sides of one cone be perpendicular to the tangent planes of another, the tangent planes of the former will be perpendicular to the sides of the latter. For the plane of two sides of the first cone is perpendicular to the intersection of the two corresponding tangent planes of the second cone; and as these two sides approach indefinitely to each other, their plane approaches to a tangent plane, while the intersection of the two corresponding tangent planes of the second cone approaches indefinitely to a side of the cone. Thus any given side of the one cone corresponds to a certain side of the other; and any side of either cone is perpendicular to the plane which touches the other along the corresponding side. This reasoning applies to cones of any kind.

Two cones so related may be called *reciprocal cones.* When one is of the second order, it will be found that the other is also of the second order, and that, in their equations relative to their axes, which are obviously parallel or coincident, the coefficients of the squares of the corresponding variables are reciprocally proportional, so that the equations

$$\mathrm{P}x^2 + \mathrm{Q}y^2 + \mathrm{R}z^2 = 0, \qquad \frac{x^2}{\mathrm{P}} + \frac{y^2}{\mathrm{Q}} + \frac{z^2}{\mathrm{R}} = 0, \qquad (1)$$

express two such cones which have a common vertex. These cones have the same internal axis, but the directive axis of the one coincides with the mean axis of the other, and it may be shown from the equations that the directive planes of the one are perpendicular to the focal lines of the other. The two curves in which these cones are intersected by a sphere, having its centre at their common vertex, are reciprocal spherical conics. In general, two curves traced on the surface of a sphere may be said to be reciprocal to each other, when the cones passing through them, and having a common vertex at the centre of the sphere, are reciprocal cones. Any given point of the one curve corresponds to a certain point of the other, and the great circle which touches either curve at any point is distant by a quadrant from the corresponding point of the other curve.

By means of these relations any property of a cone of the second order, or of a spherical conic, may be made to produce a reciprocal property. Thus, we have seen that the tangent plane of a cone makes equal angles with two planes passing through the side of contact and through each of the focal lines; therefore, drawing right lines perpendicular to the planes, and planes perpendicular to the right lines here mentioned, we have, in the reciprocal cone, a side making equal angles with the right lines in which the directive planes of this cone are intersected by a plane touching it along that side. It is therefore a property of the cone, that the intersections of a tangent plane with the two directive planes make equal angles with the side of contact; a property which it is easy to prove without the aid of the reciprocal cone.

The two directive sections drawn through any point S of a given surface of the second order may, when they are circles, be made the directive sections of a cone, and this may obviously be done in two ways. Each of the two cones so determined will be touched by the plane which touches the given surface at the point S, because the right lines which are tangents to the two circular sections at that point, are tangents to each cone as well as to the given surface; therefore the side of contact of each cone bisects one of the angles made by these two tangents; and hence the two sides of contact are the principal directions in the tangent plane at the point S, that is, they are the directions of the greatest and least curvature of the given surface at that point; for these directions are parallel to the axes of a section made in the surface by a plane parallel to the tangent plane, and the axes of any section bisect the angles contained by the right lines in which the plane of section cuts the two directive planes.

§ 6. It has been shown that the sum of the angles which any side of a cone makes with its focal lines is constant. Hence we obtain the reciprocal property, that* the sum of

* This property, and that to which it is reciprocal, as well as some other properties of the cone, were, together with the idea of reciprocal cones and of

the angles (properly reckoned) which any tangent plane of a cone makes with its two directive planes is constant. This property may be otherwise proved as follows.

Through a point assumed anywhere in the side of contact, let two directive planes be drawn. As the circles in which the cone is cut by these planes have a common chord, they are circles of the same sphere; and a tangent plane applied to this sphere, at the aforesaid point, coincides with the tangent plane of the cone, because each tangent plane contains the tangents drawn to the two circles at that point. The common chord of the circles is bisected at right angles by the principal plane which is perpendicular to the directive axis, and therefore that principal plane contains the centres of the two circles and the centre of the sphere. Now the acute angle made by a tangent plane of a sphere with the plane of any small circle passing through the point of contact, is evidently half the angle subtended at the centre of the sphere by a diameter of that circle; therefore the acute angles, which the common tangent plane of the cone and of the sphere above-mentioned makes with the planes of the directive sections, are the halves of the angles subtended at the centre of the sphere by the diameters of the sections. But the diameters which lie in the principal plane already spoken of, and are terminated by two sides of the cone, are chords of the great circle in which that plane intersects the

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spherical conics, suggested by my earliest researches connected with the mechanical theory of rotation and the laws of double refraction. I was not then aware that the focal lines of the cone had been previously discovered, nor that the spherical conic had been introduced into geometry. Indeed all the properties of the cone which are given in this paper were first presented to me in my own investigations. Its double modular property, related to the vertex as focus, was one of the propositions in the theory of the rotation of a solid body, and was used in finding the position of the axis of rotation within the body at a given time. But the modular property common to all the surfaces of the second order was not discovered until some years later.

sphere; and the halves of the angles which they subtend at its centre are equal to the angles in the greater segments of which they are the chords, and consequently equal to the two adjacent acute angles of the quadrilateral which has these chords for its diagonals. Hence, as two opposite angles of the quadrilateral are together equal to two right angles, it follows that the four angles of the quadrilateral represent the four angles, the obtuse as well as the acute angles, which the tangent plane of the cone makes with the planes of the directive sections; the two angles of the quadrilateral which lie opposite to the same diagonal being equal to the acute and obtuse angles made by the tangent plane with the plane of the section of which that diagonal is the diameter.

Thus any two adjacent angles of the quadrilateral may be taken for the angles which the tangent plane of the cone makes with the directive planes. If we take the two adjacent angles which lie in the same triangle with the angle κ contained by the two sides of the cone that help to form the quadrilateral, the sum of these two angles will be equal to two right angles diminished by κ; and if we take the two remaining angles of the quadrilateral, their sum will be equal to two right angles increased by κ; both which sums are constant. But if we take either of the other pairs of adjacent angles, the difference of the pair will be constant, and equal to κ.

The same conclusion may be deduced as a property of the spherical conic. Let a great circle touching this curve be intersected in two points, one on each side of the point of contact, by the two directive circles, that is, by two great circles whose planes are directive planes of the cone which passes through the conic and has its vertex at the centre of the sphere. Since the right lines in which the tangent plane of a cone intersects the directive planes are equally inclined to the side of contact, the arc intercepted between the points where the tangent circle of the conic intersects the directive circles is bisected in the point of contact; therefore, either of the spherical triangles whose base is the tangent arc so intercepted, and whose other two sides are the directive circles, has a constant area; because, if we suppose the tangent arc to change its position through an indefinitely small angle, and to be always terminated by the directive circles, the two little triangles bounded by its two positions and by the two indefinitely small directive arcs which lie between these positions, will have their nascent ratio one of equality, so that the area of either of the spherical triangles mentioned above, will not be changed by the change in the position of its base. But in each of these triangles the angle opposite the base is constant; therefore the sum of the angles at the base is constant.

From this reasoning it appears that if a spherical triangle have a given area, and two of its sides be fixed, the third side will always touch a spherical conic having the fixed sides for its directive arcs, and will be always bisected in the point of contact.

§ 7. The intersection of any given central surface of the second order with a concentric sphere is a spherical conic, since the cone which passes through the curve of intersection and has its vertex at the common centre, is of the second order. The cylinder also, which passes through the same curve and has its side parallel to any of the arcs of the given surface, is of the second order; and the cone, the cylinder, and the given surface are *condirective*, that is, the directive planes of one of them are also the directive planes of each of the other two. This may be seen from the equations of the different surfaces; for, in general, two surfaces, whose principal planes are parallel, will be condirective, if, when their equations are expressed by coordinates perpendicular to these planes, the differences of the coefficients of the squares of the variables in the equation of the one be proportional to the corresponding differences in the equation of the other.

If any given surface of the second order be intersected by a sphere whose centre is any point in one of the principal planes, the cylinder passing through the curve of intersection, and having its side perpendicular to that principal plane, will be of the second order, and will be condirective with the given surface. This cylinder, when its side is parallel to the directive axis, is hyperbolic; otherwise it is elliptic. If a paraboloid be cut by any plane, the cylinder which passes through the curve of section and has its side parallel to the axis of the paraboloid, will be condirective with that surface; and it will be elliptic or hyperbolic, according as the paraboloid is elliptic or hyperbolic.*

If two concentric surfaces of the second order be reciprocal polars with respect to a concentric sphere, the directive axis of the one surface will coincide with the mean axis of the other, and the directive planes of the one will be perpendicular to the asymptotes of the focal hyperbola of the other. When one of the surfaces is a hyperboloid, the other is a hyperboloid of the same kind; the asymptotes of the focal hyperbola of each surface are the focal lines of its asymptotic cone; and the two asymptotic cones are reciprocal.

When any number of central surfaces of the second order are confocal, or, more generally, when their focal hyperbolas have the same asymptotes, it is obvious that their reciprocal surfaces, taken with respect to any sphere concentric with them, are all condirective.

§ 8. If a diameter of constant length, revolving within a

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* I have introduced the terms *directive* and *condirective*, as more general than the terms *cyclic* and *biconcyclic* employed by M. Chasles. The latter terms suggest the idea of circular sections, and therefore could not properly be used with reference to the hyperbolic paraboloid, or to the hyperbolic or parabolic cylinder, in each of which surfaces a directive section is a right line.

given central surface, describe a cone having its vertex at the centre, the extremities of the diameter will lie in a spherical conic. And if the cone be touched by any plane, the side of contact will evidently be normal to the section which that plane makes in the given surface, and will therefore be an axis of the section. As the axes of a section always bisect the angles made by the two right lines in which its plane intersects the directive planes of the surface, and as the cone aforesaid has the same directive planes with the given surface, it follows that the right lines in which a tangent plane of a cone cuts its directive planes are equally inclined to the side of contact; a theorem which has been already obtained in another way.

If a section be made in a given central surface by any plane passing through the centre, the cone described by a constant semidiameter equal to either semiaxis of the section will touch the plane of section; for if it could cut that plane, a semiaxis would be equal to another radius of the section. Denoting by r, r' the semiaxes of the section, conceive two cones to be described by the revolution of two constant semidiameters equal to r and r' respectively. These cones are condirective with the given surface, and have the plane of section for their common tangent plane. Supposing that surface to be expressed by the equation

$$\frac{x^2}{\mathrm{P}} + \frac{y^2}{\mathrm{Q}} + \frac{z^2}{\mathrm{R}} = 1, \qquad (2)$$

and the directive axis to be that of y, the axis of x will be the internal axis of one cone, say of that described by r, and the axis of z will be the internal axis of the other cone. Let κ be the angle made by the two sides of the first cone which lie in the plane xz, and κ' the angle made by the two sides of the second cone which lie in the same plane; the former angle being taken so as to contain the axis of x within it, and the latter so as to contain within it the axis of z.

Then, considering r, r' as radii of the section xz of the surface, we have obviously

$$\begin{aligned} \frac{1}{r^2} &= \frac{\cos^2 \frac{1}{2}\kappa}{\mathrm{P}} + \frac{\sin^2 \frac{1}{2}\kappa}{\mathrm{R}} = \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} + \frac{1}{\mathrm{R}}\right) + \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} - \frac{1}{\mathrm{R}}\right)\cos\kappa, \\ \frac{1}{r'^2} &= \frac{\cos^2 \frac{1}{2}\kappa'}{\mathrm{R}} + \frac{\sin^2 \frac{1}{2}\kappa'}{\mathrm{P}} = \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} + \frac{1}{\mathrm{R}}\right) - \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} - \frac{1}{\mathrm{R}}\right)\cos\kappa'; \end{aligned} \tag{3}$$

observing that when these formulæ give a negative value for r^2 or r'^2, in which case the surface expressed by the equation (2) must be a hyperboloid, the direction of r or r' meets, not that surface, but the surface of the conjugate hyperboloid expressed by the equation

$$\frac{x^2}{\mathrm{P}} + \frac{y^2}{\mathrm{Q}} + \frac{z^2}{\mathrm{R}} = -1. \tag{4}$$

Now calling θ and θ' the angles made by the tangent plane of the cones with the directive planes of the given surface, which are also the directive planes of each cone, the angles κ, κ' depend on the sum or difference of θ and θ'. If the latter angles be taken so that their sum may be equal to the supplement of κ, their difference will be equal to κ', and the formulæ (3) will become

$$\begin{aligned} \frac{1}{r^2} &= \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} + \frac{1}{\mathrm{R}}\right) - \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} - \frac{1}{\mathrm{R}}\right)\cos(\theta + \theta') \\ \frac{1}{r'^2} &= \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} + \frac{1}{\mathrm{R}}\right) - \tfrac{1}{2}\left(\frac{1}{\mathrm{P}} - \frac{1}{\mathrm{R}}\right)\cos(\theta - \theta'), \end{aligned} \tag{5}$$

by which the semiaxes of any central section are expressed in terms of the non-directive semiaxes of the surface, and of the angles which the plane of section makes with the directive planes.*

* See the Transactions of the Royal Irish Academy, vol. xxi., as before cited. The formulæ (5) were first given, for the case of the ellipsoid, by Fresnel, in his Theory of Double Refraction, Mémoires de l'Institut, tom. vii., p. 155.

§ 9. From the centre O of the surface expressed by equation (2) let a right line $O\Sigma$ be drawn cutting perpendicularly in Σ the plane which touches the surface at S. Let σ denote the length of the perpendicular $O\Sigma$, and α, β, γ the angles which it makes with x, y, z. Then

$$\sigma^2 = \text{P} \cos^2\alpha + \text{Q} \cos^2\beta + \text{R} \cos^2\gamma. \tag{6}$$

From this formula it is manifest, that if three planes touching the surface be at right angles to each other, the sum of the squares of their perpendicular distances from the centre will be equal to the constant quantity $\text{P} + \text{Q} + \text{R}$, and therefore the point of intersection of the planes will lie in the surface of a given sphere. If another surface represented by the equation

$$\frac{x^2}{\text{P}_0} + \frac{y^2}{\text{Q}_0} + \frac{z^2}{\text{R}_0} = 1,$$

be touched by a plane cutting $O\Sigma$ perpendicularly in Σ_0, and if σ_0 be the length of $O\Sigma_0$, then

$$\sigma_0^2 = \text{P}_0 \cos^2\alpha + \text{Q}_0 \cos^2\beta + \text{R}_0 \cos^2\gamma;$$

and therefore when the two surfaces are confocal, that is, when

$$\text{P} - \text{P}_0 = \text{Q} - \text{Q}_0 = \text{R} - \text{R}_0 = k,$$

we have $\sigma^2 - \sigma_0^2 = k$, which is a constant quantity. Hence if three confocal surfaces be touched by three rectangular planes, the sum of the squares of the perpendiculars dropped on these planes from the centre will be constant, and the locus of the intersection of the planes will be a sphere.

The focal curves of a given surface are the limits of surfaces confocal with it,* when these surfaces are conceived,

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* It was by this consideration, arising out of the theorems given in this and the next section about confocal surfaces, that I was led to perceive the nature of the focal curves, and the analogy between their points and the foci of

by the progressive diminution of their mean or secondary axes, to become flattened, and to approach more and more nearly to a plane passing through the primary axis. And it will appear hereafter, that if a *bifocal right line*, that is, a right line passing through both focal curves, be the intersection of two planes touching these curves, those two planes will be at right angles to each other. Therefore the locus of the point where a tangent plane of a given central surface is intersected perpendicularly by a bifocal right line is a sphere. The primary axis of the surface is evidently the diameter of this sphere.

Hence we conclude that the locus of the point where a tangent plane of a paraboloid is intersected perpendicularly by a bifocal right line is a plane touching the paraboloid at its vertex. For a paraboloid is the limit of a central surface whose primary axis is prolonged indefinitely in one direction, and a plane is the corresponding limit of the sphere described on that axis as diameter. As this consideration is frequently of use in deducing properties of paraboloids from those of central surfaces, it may be well to state it more particularly. It is to be observed, then, that the indefinite extension of the primary axis at one extremity may take place according to any law which leaves the other extremity always at a finite distance from a given point, and gives a finite limiting parameter to each of the principal sections of the surface which pass through that axis. The simplest supposition is, that one extremity of the axis and the adjacent foci of those two principal sections remain fixed, while the other extremity and the other foci move off, with the centre, to distances which are conceived to increase without limit. Then, at any finite distances from the fixed

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conics. And I regarded that analogy as fully established when I found (in March or April, 1832) that the normal at any point of a surface of the second order is an axis of the cone which has that point for its vertex and a focal for its base.

points, the focal curves approach indefinitely to parabolas, as do also all sections of the surface which pass through the primary axis, while the surface itself approaches indefinitely to a paraboloid; so that the limit of the central surface is a paraboloid having parabolas for its focal curves. The limit of an ellipsoid, or of a hyperboloid of two sheets, is an elliptic paraboloid, having one of its focals modular and the other umbilicar, like each of the central surfaces from which it may be derived; and the limit of a hyperboloid of one sheet is a hyperbolic paraboloid, having, like that hyberboloid, both its focals modular.

§ 10. Let the plane touching at S the surface expressed by equation (2), intersect the axis of x in the point X, and let the normal applied at S intersect the planes yz, xz, xy, in the points L, M, N respectively. Since the section made in the surface by a plane passing through OX and the point S has one of its axes in the direction of OX, it appears, by an elementary property of conics, that the rectangle under OX and the coordinate x of the point S is equal to the quantity P; but that coordinate is to LS as OΣ or σ is to OX, and therefore the rectangle under σ and LS is equal to P. Similarly the rectangle under σ and MS is equal to Q, and the rectangle under σ and NS is equal to R. Thus the parts of the normal intercepted between the point S and each of the principal planes, are to each other as the squares of the semiaxes respectively perpendicular to these planes; the square of an imaginary semiaxis being regarded as negative, and the corresponding intercept being measured from S in a direction opposite to that which corresponds to a real semiaxis.

The rectangle under σ and the part of the normal intercepted between two principal planes, is equal to the difference of the squares of the semiaxes which are perpendicular to these planes. This rectangle is therefore constant, not only for a given surface, but for all surfaces which are confocal with it.

Hence the part of the normal intercepted between two principal planes bears a given ratio to the part of it intercepted between one of these and the third principal plane, whether the normal be applied at any point of a given surface, or at any point of a surface confocal with it.

If therefore normals to a series of confocal surfaces be all parallel to a given right line, they must all lie in the same plane passing through the common centre of the surfaces, because otherwise the parts of any such normal, which are intercepted between each pair of principal planes, would not be in a constant ratio to each other.

The point S being the point at which any of these parallel normals is applied, the plane touching the surface at S is parallel to a given plane, the perpendicular OΣ dropped upon it from the centre has a given direction, the plane OSΣ is fixed, and the directions of the lines OL, OM, ON in which this plane intersects the principal planes are also fixed. And as the angle OΣS is always a right angle, and the normal at S is always parallel to OΣ, the distance SΣ bears a given ratio to each of the distances OL, OM, ON, and therefore also to each of the intercepts MN, LN, LM. Hence, since the rectangle under OΣ and any one of these intercepts is constant, the rectangle under OΣ and SΣ is constant.

Therefore if a series of confocal central surfaces be touched by parallel planes, the points of contact will all lie in one plane, and their locus, in that plane, will be an equilateral hyperbola, having its centre at the centre of the surfaces, and having one of its asymptotes perpendicular to the tangent planes. This hyperbola evidently passes through two points on each of the focal curves, namely the points where the tangent to each curve is parallel to the tangent planes.

If a series of confocal paraboloids be touched by parallel planes, it will be found that the points of contact all lie in a bifocal right line, and that the normals at these points lie in a plane parallel to the axis of the surfaces; so that the part of any normal which is intercepted by the two principal planes is constant. This theorem may be proved from the two following properties of the paraboloid:—1. A normal being applied to the surface at the point S, the segments of the normal, measured from S to the points where it intersects the planes of the two principal sections, are to each other inversely as the parameters of these sections. 2. Supposing the axis of x to be that of the surface, the difference between the coordinates x of the point S and of the point where the normal meets the plane of one of the principal sections, is equal to the semiparameter of the other principal section.

§ 11. Let a tangent plane, applied at any point S of a surface of the second order, intersect the plane of one of its focals in the right line Θ, and let P be the foot of the perpendicular dropped from S upon the latter plane. The pole of the right line Θ, with respect to the principal section lying in this plane, is the point P. Let N be its pole with respect to the focal. Then if T be any point of the right line Θ, the polar of this point with respect to the section will pass through P, and its polar with respect to the focal will pass through N; and if the former polar intersect the dirigent curve in Δ, Δ', and the latter intersect the focal in F, F′, the points F, F′ will correspond respectively to the points Δ, Δ', and the distances $\Delta\Delta'$ and FF′ will be similarly divided by the points P and N (See Part I. § 8). But since the point S is in the plane of the two directrices which pass through Δ and Δ', the lengths ΔP and Δ'P, which are the perpendicular distances of S from the directrices, are proportional to the lengths FS and F′S. Therefore FN is to F′N as FS is to F′S, and the right line NS bisects one of the angles made by the right lines FS and F′S. And as this holds wherever the point T is taken on the right line Θ, that is, in whatever direction the right line FF′ passes through the point N, it follows that the right line NS is an axis of the cone which has the point S for its vertex and the focal for its base. Further, if FF′ intersect Θ in the point Q, we have FN to F′N as FQ is to F′Q, because N is the pole of Θ with respect to the focal; therefore FQ is to F′Q as FS is to F′S, and hence the right line QS also bisects one of the angles made by FS and F′S. The right lines NS and QS are therefore at right angles to each other, and as the latter always lies in the tangent plane, the former must be perpendicular to that plane.

Consequently the normal at any point of a surface of the second order is an axis of the cone which has that point for its vertex and either of the focals for its base.

It is known that when two confocal surfaces intersect each other, they intersect everywhere at right angles; and that through any given point three surfaces may in general be described, which shall have the same focal curves. If three confocal surfaces pass through the point S, the normal to each of them at S is an axis of each of the cones which stand on the focals and have S for their common vertex. The normals to the three surfaces are therefore the three axes of each cone.

If the points at which a series of confocal surfaces are touched by parallel planes be the vertices of cones having one of the focals for their common base, each of these cones will have one of its axes perpendicular to the tangent planes. Therefore when an axis of a cone which stands on a given base is always parallel to a given right line, the locus of the vertex is an equilateral hyperbola or a right line, according as the base is a central conic or a parabola.

§ 12. A system of three confocal surfaces intersecting each other consists of an ellipsoid, a hyperboloid of one sheet, and a hyperboloid of two sheets, if the focals be central conics; but it consists of two elliptic paraboloids and a hyperbolic paraboloid, if the focals be parabolas. In the central system, the ellipsoid has the greatest primary axis, and the hyperboloid of two sheets the least; and the focal which is modular in one of these surfaces is umbilicar in the other. The asymptotic cones of the hyperboloids are confocal, the focal lines of each cone being the asymptotes of the focal hyperbola. In the system of paraboloids, the two elliptic paraboloids are distinguished by the circumstance that the modular focal of the one is the umbilicar focal of the other.

The curve in which two confocal surfaces intersect each other is a line of curvature of each, as is well known;* and a series of lines of curvature on a given surface are found by making a series of confocal surfaces intersect it.

Now if a series of the lines of curvature of a given surface be projected on one of its directive planes by right lines parallel to either of its non-directive axes, the projections will be a series of confocal conics; and when the surface is umbilicar, the foci of all these conics will be the corresponding projections of the umbilics.† When the surface is not umbilicar, its directive axis will be parallel to the primary axis of the projections.

The same line of curvature has two projections, according as it is projected by right lines parallel to the one or to the other non-directive axis. In the ellipsoid these projections are always curves of different kinds, the one being an ellipse when the other is a hyperbola; but in a hyperboloid the projections are either both ellipses or both hyperbolas. In the hyperbolic paraboloid the projections are parabolas. In the elliptic paraboloid, one of the projections is always a parabola, and the other is either an ellipse or a hyperbola.

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* See Dupin's Développements de Géométrie.

† Exam. Papers, An. 1838, p. xlvi., quest. 4; p. xcix., quest. 70.

The corresponding projections of two lines of curvature which pass through a given point of the surface, are confocal conics intersecting each other in the projection of that point, and of course intersecting at right angles.

§ 13. A *bifocal chord* is a bifocal right line terminated both ways by the surface.* In a central surface, the length of a bifocal chord is proportional to the square of the diameter which is parallel to it; the square of the diameter being equal to the rectangle under the chord and the primary axis.

More generally, if a chord of a given central surface touch two other given surfaces confocal with it, the length of the chord will be proportional to the square of the parallel diameter of the first surface, the square of the diameter being equal to the rectangle under the chord and a certain right line $2l$, determined by the formula

$$l^2 = \frac{\mathrm{PQR}}{(\mathrm{P}-\mathrm{P}')(\mathrm{P}-\mathrm{P}'')}, \tag{7}$$

wherein it is supposed that the equation (2) represents the first surface, and that P', P'' are the quantities corresponding to P in the equations of the other two surfaces.

In any surface of the second order, the lengths of two bifocal chords are proportional to the rectangles under the segments of any two intersecting chords to which they are parallel.

In the paraboloid expressed by the equation

$$\frac{y^2}{p} + \frac{z^2}{q} = x,$$

if χ be the length of a bifocal chord making the angles β and γ with the axes of y and z respectively, we have

$$\frac{1}{\chi} = \frac{\cos^2\beta}{p} + \frac{\cos^2\gamma}{q}. \tag{8}$$

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* The theorems in § 13 are now stated for the first time.

§ 14. At the point S on a given central surface expressed by the equation (2), let a tangent plane be applied, and let k, k' be the squares of the semiaxes of a central section made in the surface by a plane parallel to the tangent plane; each of the quantities k, k' being positive or negative according as the corresponding semiaxis of the section is real or imaginary, that is, according as it meets the given surface or not. Then the equations* of two other surfaces confocal with the given one, and passing through the point S, are

$$\frac{x^2}{\text{P}-k}+\frac{y^2}{\text{Q}-k}+\frac{z^2}{\text{R}-k}=1, \quad \frac{x^2}{\text{P}-k'}+\frac{y^2}{\text{Q}-k'}+\frac{z^2}{\text{R}-k'}=1. \quad (9)$$

The given surface is intersected by these two surfaces respectively in the two lines of curvature which pass through the point S; the tangent drawn to the first line of curvature at S is parallel to the second semiaxis of the section, and the tangent drawn to the second line of curvature at S is parallel to the first semiaxis of the section.

When two confocal surfaces intersect, the normal applied to one of them at any point S of the line of curvature formed by their intersection lies in the tangent plane of the other, and is parallel to an axis of any section made in the latter by a plane parallel to the tangent plane. Supposing the surfaces to be central, if two normals be applied at the point S, and a diameter of each surface be drawn parallel to the normal of the other, the two diameters so drawn will be equal and of a constant length, wherever the point S is taken on the line of curvature; the square of that length being equal to the difference of the squares of the primary axes of the surfaces, and the diameter of the surface which has the greater primary axis being real, while that of the other surface is imaginary. As the point S moves along the line of curvature, each constant diameter

* Exam. Papers, An. 1837, p. c., quests. 4, 5, 6; An. 1838, p. c., quests. 71, 72.

describes a cone condirective with the surface to which it belongs; the two cones so described are reciprocal, and the focal lines of the cone which belongs to one surface are perpendicular to the directive planes of the other surface.

When two confocal paraboloids intersect, if normals be applied to them at any point S of their intersection, and a bifocal chord of each surface be drawn parallel to the normal of the other, the two chords so drawn will be equal and of a constant length, wherever the point S is taken in the line of intersection of the surfaces; that constant length being equal to the difference between the parameters of either pair of coincident principal sections.

§ 15. The point S being the common intersection of a given system of confocal surfaces, of which the equations are

$$\frac{x^2}{\mathrm{P}}+\frac{y^2}{\mathrm{Q}}+\frac{z^2}{\mathrm{R}}=1, \qquad \frac{x^2}{\mathrm{P}'}+\frac{y^2}{\mathrm{Q}'}+\frac{z^2}{\mathrm{R}'}=1,$$
$$\frac{x^2}{\mathrm{P}''}+\frac{y^2}{\mathrm{Q}''}+\frac{z^2}{\mathrm{R}''}=1, \tag{10}$$

suppose that another surface A confocal with these, and expressed by the equation

$$\frac{x^2}{\mathrm{P}_0}+\frac{y^2}{\mathrm{Q}_0}+\frac{z^2}{\mathrm{R}_0}=1, \tag{11}$$

is circumscribed by a cone having its vertex at S. If the normals applied at S to the given surfaces, taken in the order of the equations (10), be the axes of new rectangular coordinates ξ, η, ζ, the equation of the cone, referred to these coordinates, will be*

* The equation (12) was obtained in the year 1832, and was given at my lectures in Hilary Term, 1836. The most remarkable properties of cones circumscribing confocal surfaces, are immediate consequences of this equation. That such cones, when they have a common vertex, are confocal, their focal lines being the generatrices of the hyperboloid of one sheet passing through the ver-

$$\frac{\xi^2}{\text{P} - \text{P}_0} + \frac{\eta^2}{\text{P}' - \text{P}_0} + \frac{\zeta^2}{\text{P}'' - \text{P}_0} = 0. \qquad (12)$$

The surfaces of the given system, in the order of their equations, may be supposed to be an ellipsoid, a hyperboloid of one sheet, and a hyperboloid of two sheets; the axes of x, y, z being respectively the primary, the mean, and the secondary axes of each surface. Then P is greater than P′, and P′ greater than P″.

The normals to the given surfaces are the axes of the cone expressed by the equation (12); and if the surface A be changed, but still remain confocal with the given system, it is obvious from that equation that the focal lines of the circumscribing cone will remain unchanged, since the differences of the quantities by which the squares of ξ, η, ζ are divided are independent of the surface A. As P′ is intermediate in value between P and P″, the normal to the hyperboloid of one sheet is always the mean axis of the cone; the focal lines lie in the plane $\xi\zeta$, and their equation is

$$\frac{\xi^2}{\text{P}' - \text{P}} + \frac{\zeta^2}{\text{P}' - \text{P}''} = 0, \qquad (13)$$

which shows that they are parallel to the asymptotes of a central section made in the hyperboloid of one sheet by a plane parallel to the plane $\xi\zeta$, since the quantities P′ − P and P′ − P″ are (including the proper signs) the squares of the semiaxes of the section which are parallel to ξ and ζ re-

tex, was first stated by Professor C. G. J. Jacobi, of Königsberg, in 1834. See Crelle's Journal, vol. xii., p. 137. See also the excellent work of M. Chasles, published in 1837, and entitled "Aperçu historique sur l'Origine et le Développement des Méthodes en Géométrie;" p. 387. The analogy which exists between the focals of surfaces and the foci of curves of the second order was supposed by M. Chasles to have been pointed out in that work for the first time (*Comptes rendus*, tom. xvi., pp. 833, 1106); but that analogy had been previously taught and developed in the lectures just alluded to.

spectively. The focal lines are therefore the generatrices of that hyperboloid at the point S.

When $R_0 = 0$, the equation (12) becomes

$$\frac{\xi^2}{R} + \frac{\eta^2}{R'} + \frac{\zeta^2}{R''} = 0, \tag{14}$$

which is that of the cone standing on the focal ellipse and having its vertex at S. When $Q_0 = 0$, the same equation becomes

$$\frac{\xi^2}{Q} + \frac{\eta^2}{Q'} + \frac{\zeta^2}{Q''} = 0, \tag{15}$$

which is that of the cone standing on the focal hyperbola, and having its vertex at S. The normal to the hyperboloid of one sheet at the point S is the mean axis of both cones; the normal to the ellipsoid is the internal axis of the first cone and the directive axis of the second, while the normal to the hyperboloid of two sheets is the directive axis of the first and the internal axis of the second.

The three surfaces expressed by the equations

$$\frac{\xi^2}{P} + \frac{\eta^2}{P'} + \frac{\zeta^2}{P''} = 1, \qquad \frac{\xi^2}{Q} + \frac{\eta^2}{Q'} + \frac{\zeta^2}{Q''} = 1,$$
$$\frac{\xi^2}{R} + \frac{\eta^2}{R'} + \frac{\zeta^2}{R''} = 1, \tag{16}$$

are a confocal system, having their centre at S, and being respectively an ellipsoid, a hyperboloid of one sheet, and a hyperboloid of two sheets. They intersect each other in the centre of the system expressed by the equations (10), and their normals at that point are the axes of x, y, z respectively. The relations between the two systems of surfaces are therefore perfectly reciprocal. From the equations (14) and (15) it is manifest that the asymptotic cones of the hyperboloids of one system pass through the focals of the other.

§ 16. The point S being the intersection of a given system of confocal paraboloids whose equations are

$$\frac{y^2}{p} + \frac{z^2}{q} = x + h, \qquad \frac{y^2}{p'} + \frac{z^2}{q'} = x + h',$$
$$\frac{y^2}{p''} + \frac{z^2}{q''} = x + h'', \tag{17}$$

where $p - p' = q - q' = 4(h - h')$, and $p - p'' = q - q''$ $= 4(h - h'')$; suppose that another paraboloid A confocal with these, and expressed by the equation

$$\frac{y^2}{p_0} + \frac{z^2}{q_0} = x + h_0, \tag{18}$$

is circumscribed by a cone having its vertex at S. Then if the normals applied at S to the given system of surfaces, taken in the order of their equations, be the axes of the coordinates ξ, η, ζ respectively, the equation of the circumscribing cone will be

$$\frac{\xi^2}{p - p_0} + \frac{\eta^2}{p' - p_0} + \frac{\zeta^2}{p'' - p_0} = 0; \tag{19}$$

showing that those normals are the axes of the cone, and that the focal lines of the cone are independent of the surface A, provided it be confocal with the given surfaces. If the hyperbolic paraboloid be the second surface of the given system, the parameter p' will be intermediate in value between p and p'', and the equation of the focal lines of the cone will be

$$\frac{\xi^2}{p' - p} + \frac{\zeta^2}{p' - p''} = 0, \tag{20}$$

which is the equation of a pair of right lines parallel to the asymptotes of a section made in the hyperbolic paraboloid by a plane parallel to the plane $\xi\zeta$, since the quantities $p' - p$ and $p' - p''$ are proportional to the squares of the semiaxes of the section which are parallel to ξ and ζ respectively. The focal lines are therefore the generatrices of the hyperbolic paraboloid at the point S.

Putting p_0 and q_0 alternately equal to zero in the equation (19), we get

$$\frac{\xi^2}{p} + \frac{\eta^2}{p'} + \frac{\zeta^2}{p''} = 0, \qquad \frac{\xi^2}{q} + \frac{\eta^2}{q'} + \frac{\zeta^2}{q''} = 0, \qquad (21)$$

the equations of two cones which have a common vertex at S, the first of them standing on the focal which lies in the plane xz, the second on the focal which lies in the plane xy. The mean axis of each of these cones is the normal at S to the hyperbolic paraboloid; the internal axis of either cone is the normal to the elliptic paraboloid which has the base of that cone for its modular focal.

As the cones which have a common vertex, and stand on the focals of any surface of the second order, are confocal, they intersect at right angles. Therefore when two planes passing through a bifocal right line touch the focals, these planes are at right angles to each other. And as cones which have a common vertex, and circumscribe confocal surfaces, are confocal, two such cones, when they intersect each other, intersect at right angles. Therefore when a right line touches two confocal surfaces, the tangent planes passing through this right line are at right angles to each other.

§ 17. When two surfaces are reciprocal polars* with respect to any sphere, and one of them is of the second order, the other is also of the second order. Let the surface B be reciprocal to the surface A before mentioned, with respect to a sphere of which the centre is S; and suppose R′ and R to be any corresponding points on these surfaces. Then the plane which touches the surface A at the point R, intersects the right line SR′ perpendicularly in a point K, such that the rectangle under SR′ and SK is constant, being equal to the

* Transactions of the Royal Irish Academy, vol. xvii., p. 241; Exam. Papers, An. 1841, p. cxxvi., quest. 4.

square of the radius of the sphere. Now if the point K approach indefinitely to S, the distance SR′ will increase without limit, the surface B being of course a hyperboloid; and if through S any plane be drawn touching the surface A, a right line perpendicular to this plane will evidently be parallel to a side of the asymptotic cone of the hyperboloid. The asymptotic cone of B is therefore reciprocal to the cone which, having its vertex at S, circumscribes the surface A. Hence, as the directive planes of a hyperboloid are the same as those of its asymptotic cone, it follows that the directive planes of the surface B are perpendicular to the generatrices of the hyperboloid of one sheet, or the hyperbolic paraboloid, which passes through S, and is confocal with the surface A. And this relation between two reciprocal surfaces ought to be general, whatever be the position of the point S with respect to them;* for though it has been deduced by the aid of the circumscribing cone aforesaid, it does not, in its enunciation, imply the existence of such a cone. This conclusion may be verified by investigating the equation of the surface B in terms of the coordinates ξ, η, ζ. Suppose ρ to be the radius of the sphere with respect to which the surfaces A and B are reciprocal. Then if A be a central surface expressed by the equation (11), and having ξ_0, η_0, ζ_0 for the coordinates of its centre, the surface B will be represented by the equation

$$\begin{aligned}(\mathrm{P} - \mathrm{P}_0)\,\xi^2 + (\mathrm{P}' - \mathrm{P}_0)\,\eta^2 + (\mathrm{P}'' - \mathrm{P}_0)\,\zeta^2 \\ = 2\rho^2\,(\xi_0\,\xi + \eta_0\,\eta + \zeta_0\,\zeta) - \rho^4;\end{aligned} \tag{22}$$

but if A be a paraboloid expressed by the equation (18), the equation of B will be

$$\begin{aligned}(p - p_0)\,\xi^2 + (p' - p_0)\,\eta^2 + (p'' - p_0)\,\zeta^2 \\ = 4\rho^2\,(\xi \cos\alpha + \eta \cos\beta + \zeta \cos\gamma),\end{aligned} \tag{23}$$

where α, β, γ are the angles which the axis of x makes with

* This relation was first noticed by Mr. Salmon.

the axes of ξ, η, ζ respectively. In the first case, the equation (22) shows that the directive planes of B are perpendicular to the right lines expressed by the equation (13); in the second case, the equation (23) shows that the directive planes of B are perpendicular to the right lines expressed by the equation (20).

When the surface A is a paraboloid, and the distance of the point R from its vertex is indefinitely increased, the plane touching the surface at R approaches indefinitely to parallelism with its axis, and the right line SK, perpendicular to that plane, increases without limit. Therefore the surface B passes through the point S, and is touched in that point by a plane perpendicular to the axis of A.

When the point S lies upon the surface A, the coefficient of the square of one of the variables, in the equation (22) or (23), is reduced to zero, and the surface B is a paraboloid having its axis parallel to the normal applied at S to the surface A. This also appears from considering that when S is a point of the surface A, the normal at that point is the only right line passing through S, which meets the surface B at an infinite distance.

If a series of surfaces be confocal, their reciprocal surfaces, taken with respect to any given sphere, will be condirective.

When the equations of any two condirective surfaces are expressed by coordinates perpendicular to their principal planes, the constants in the equations may be always so taken that the differences of the coefficients of the squares of the variables in one equation shall be equal to the corresponding differences in the other. Then by subtracting the one equation from the other, we get the equation of a sphere. Therefore when two condirective surfaces intersect each other, their intersection is, in general, a spherical curve. But when the surfaces are two paraboloids of the same species, their intersection is a plane curve.

§ 18. Through any point S of a given surface four bifocal right lines may in general be drawn. Supposing the surface to be central, let a plane drawn through the centre, parallel to the plane which touches the surface at S, intersect any one of these right lines. Then the distance of the point of intersection from the point S will always be equal to the primary semiaxis of the surface.*

If through any point S of a given central surface a right line be drawn touching two other given surfaces confocal with it, and if this right line be intersected by a plane drawn through the centre parallel to the plane which touches the first surface at S, the distance of the point of intersection from the point S will be constant, wherever the point S is taken on the first surface. If this constant distance be called l, and the other denominations be the same as in the formula (7), the value of l will be given by that formula.†

Professor Mac Cullagh communicated the following note relative to the comparison of arcs of curves, particularly of plane and spherical conics.

The first Lemma given in my paper on the rectification of the conic sections (Transactions of the Royal Irish Academy, vol. xvi., p. 79) is obviously true for curves described on any given surface, provided the tangents drawn to these curves be *shortest lines* on the surface. The demonstration remains exactly the same; and the Lemma, in this general form, may be stated as follows.

Understanding a tangent to be a shortest line, and supposing two given curves E and F to be described on a given

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* Exam. Papers, An. 1838, p. xlvii., quest. 9.

† In the notes to the last mentioned work of M. Chasles, on the History of Methods in Geometry, will be found many theorems relative to surfaces of the second order. Among them are some of the theorems which are given in the present paper; but it is needless to specify these, as M. Chasles's work is so well known.

surface, let tangents drawn to the first curve at two points T, t, indefinitely near each other, meet the second curve in the points P, p. Then taking a fixed point A on the curve E, if we put s to denote (according to the position of this point with respect to T) the sum (or difference) of the arc AT and the tangent TP, and $s + ds$ to denote the sum (or difference) of the arc At and the tangent tp, we shall have ds equal to the projection of the infinitesimal arc Pp upon the tangent; that is, if α be the angle which the tangent TP makes with the curve F at the point P, we shall have ds equal to Pp multiplied by the cosine of α.

Now through the points P, p conceive other tangents T′P, $t'p$ to be drawn, touching the curve E in the points T′, t'; and let s' and ds' have for these tangents the same signification which s and ds have for the former tangents. Supposing the nature of the curve F to be such that it always bisects, either internally or externally, the angle made at the point P by the tangents TP and T′P, it is evident that $ds = \pm ds'$, and therefore either $s + s'$ or $s - s'$ is a constant quantity.

A simple example of this theorem is afforded by the plane and spherical conics. If the curves E and F be two confocal conics, either plane or spherical, and tangents TP, T′P be drawn to F from any point P of E (the tangents being of course right lines when the curves are plane, and arcs of great circles when they are spherical; in both cases shortest lines) it is well known that the angle TPT′ made by the tangents is always bisected by the conic E. The angle is bisected internally or externally according as the conics intersect or not. Hence we have the two following properties* of confocal conics:—

* The first of these properties was originally given for spherical conics by the Rev. Charles Graves, Fellow of Trinity College, in the "notes and additions" to his translation of M. Chasles's Memoirs on Cones and Spherical Conics,

1. When two confocal conics do not intersect, if one of them be touched in the points T, T′ by tangents drawn from any point P of the other, the sum of the tangents TP, T′P will exceed the convex arc TT′ lying between the points of contact, by a constant quantity.

2. When two confocal conics intersect in the point A, if one of them be touched in the points T, T′ by tangents drawn from any point P of the other, the difference between the tangents TP, T′P will be equal to the difference be- the arcs AT, AT′.

These properties give the readiest and most elegant solution of problems concerning the comparison of different arcs of a plane or spherical conic. Any arc being given on a conic, we may find another arc beginning from a given point, which shall differ from the given arc by a right line if the conic be plane, or by a circular arc if the conic be spherical.

DONATIONS.

Memoires de la Société Géologique de France. Tom. 5. Parts 1, 2. Presented by the Society.

The Tenth Annual Report of the Royal Cornwall Polytechnic Society. (1842.) Parts 1 and 2. Presented by the Society.

Bulletin de l'Academie Royale de Bruxelles, from 5th of November, 1842, to 8th of July, 1843.

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p. 77 (Dublin, 1841). Mr. Graves obtained it as the reciprocal of the proposition, that when two spherical conics have the same directive circles, any tangent arc of the inner conic divides the outer one into two segments, each of which has a constant area. Both properties, with the general theorem relative to curves described on any surface and touched by shortest lines, were afterwards given in the University Calendar. See Exam. Papers, An. 1841, p. xli., quests. 3–6; An. 1842, p. lxxxiii., quests. 30–34. These two properties of conics were communicated, in October 1843, to the Academy of Sciences of Paris, by M. Chasles, who supposed them to be new. See the *Comptes rendus*, tom. xvii. p. 838.

Ordnance Survey of Tipperary, in 93 *Sheets, including Title and Index.* Presented by His Excellency the Lord Lieutenant.

Oberon's Vision in the Midsummer Night's Dream. Illustrated by the Rev. N. J. Halpin. Presented by the Author.

Oversight over det Kongelige Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider, 1 *Aaret,* 1841. By Professor Oersted. Presented by the Author.

The Numismatic Chronicle and Journal of the Numismatic Society of London for July, 1843. (*No.* 21). Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1844. No. 43.

January 8.

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

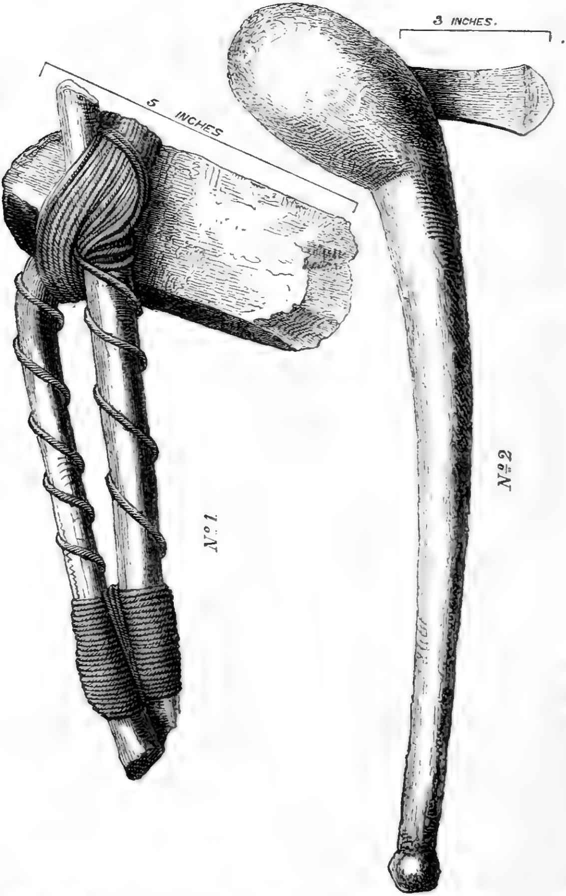
William Henry and John Neville, Esquires, were elected Members of the Academy.

The President read a letter from the Rev. James Kennedy Bailie, D.D., presenting his "Fasciculus Inscriptionum Græcarum."

The special thanks of the Academy were given to Dr. Bailie for his donation.

Robert Ball, Esq., read a notice of the Means used by the Ancients for attaching Handles to the Stone and Meta Implements called Celts.

Mr. Ball stated that many years since, the lamented Dean Dawson proposed to him to put handles to the four most remarkable forms of celts, with a view of discovering the probable manner in which these instruments were used. He accordingly did affix the handles (exhibited to the Academy), and they appeared satisfactorily to answer the question: but recent observation has convinced him that in two at least of these hypothetical mountings he was incorrect, as proved, he thought, by a stone celt mounted, which was a short time since brought from a mine in Mexico, and an iron one—a war weapon—brought a few weeks since from Little Fish Bay in Africa. As he deemed the subject one of interest to antiquarians, he described as follows the mounting of the recent implements alluded to, which, he conceived, may fairly be assumed as the manner used in olden time for celts of similar form.



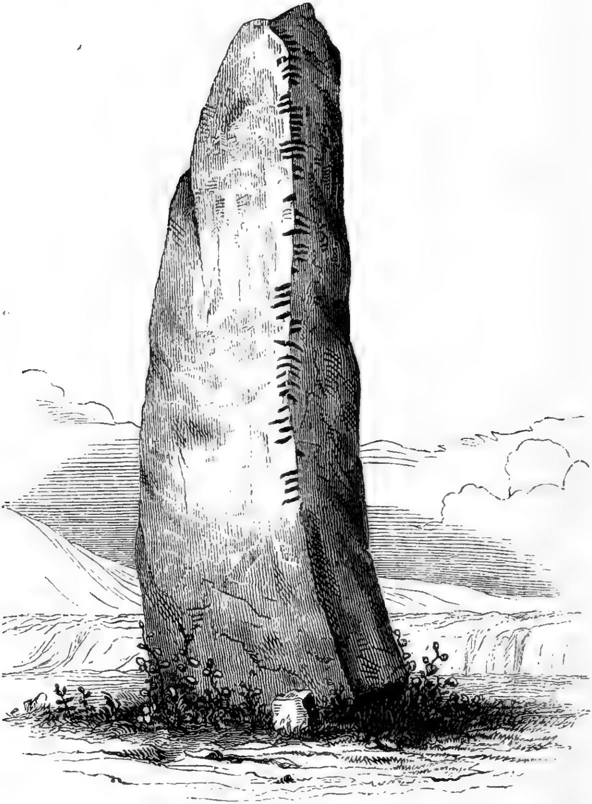
The Mexican stone celt (No. 1) (which is the property of Mrs. Lyle) was mounted by placing a slender rod at each side of it, in the direction of its length, so that the larger ends of the rods would have overlapped each other about two inches, had they not been separated by the body of the instrument; a small cord was then loosely wound round the ends of the rod and the included celt: when thus arranged, the smaller ends of the rods were brought together and tied, forming what sailors call a Spanish Windlass. The elasticity of the rods keeping a constant strain, makes a more effective handle than it would appear possible to form by ordinary tying, and with much less expense of time and trouble. The iron celt (No. 2) kindly given to Mr. Ball by Captain Adams, R.N., is fixed in the bend of a club formed like a Scotch golf stick; by this arrangement, while the iron is so fixed that a stroke serves to make it only the faster, the effectiveness of the weapon is much increased by the weight of the knob at its end. The accompanying figures illustrate the foregoing.

Mr. Ball observed that these were, he thought, proofs of the value of seeking explanation of antiquarian difficulties, by observing the analogies afforded by the less civilized portions of the human race, rather than by indulging in hypothetical fancies.

Mr. Oldham read a brief notice of a stone with Ogham characters in the County of Waterford.

The stone referred to (fig 1) is well known throughout that portion of the country, by the name of Ballyquin stone. It stands on the road to Curraghmore from Carrick-on-Suir, about three miles and a half from that town. This road is comparatively a new one, and the stone has been left standing about three feet from the ditch on the south side. It is a single block of the hard and coarse red conglomerate, so abundant in the neighbourhood, and in the adjoining range of the Commeragh mountains. In height it is eight feet, and tapers gradually but irregularly from about four feet at the base, to about one foot three inches at the top, and is about one foot or a little more in average thickness. The sides of the stone are rough, and do not exhibit any trace of chiselling or tooling, further than possibly a rude dressing with

Fig. 1.



the hammer; but along the south east corner of the stone (as it now stands), and extending from the summit to near the base, are a series of Ogham characters of peculiar interest. These have been carefully worked, the bottom of the cuts or grooves which form them being quite smooth and even, notwithstanding the very unfavourable texture of the stone, composed as it is of pebbles varying in size, composition, and hardness. Some of these markings or letters are imperfect, from injuries which the stone has received, or from wear by exposure, but the drawing (fig. 1) gives a tolerably accurate idea of its present state.

This Ogham differs in some respects from any with which Mr. Oldham was acquainted. There is no combination of more than four letters or grooves in it, and if the corner of the stone be considered the centre line, to which these letters should be referred, several of them do not come up to that line, and in one case two appear interrupted or discontinued in the centre; that is, there are portions of the cut or groove corresponding to each other at both ends, but they do not pass over the corner or central line. Mr. Oldham's object was, however, more particularly to add another to the collection of Ogham inscriptions, and thus increase the data from which some clue to these now unknown quantities might perhaps be obtained. He was the more anxious to do this, as this stone had been altogether omitted on the Ordnance Maps of the County of Waterford recently published.

This stone is mentioned by Ryland in his History of Waterford, who merely notices the existence of some defaced markings. He alludes to the occurrence of caves in the fields adjoining. Ballyquin is also the name of the townland in which the stone stands.

Mr. Oldham also presented drawings of some Oghams now in the Cork Institution, and remarked how very desirable it was that they should be published at once, the originals being so liable to injury, either from accident or design. Fig. 2, is a block of sandstone, very rough and unhewn, the surface on which the letters or marks are cut being the only flat one on the stone. It is about four feet six inches in length, of which the letters extend two feet; one foot ten inches broad at the top, and tapers rudely to the base.

Fig. 2.

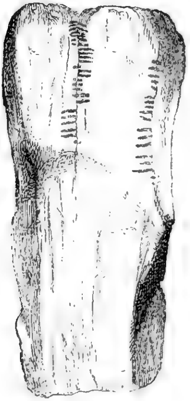


Fig. 3.

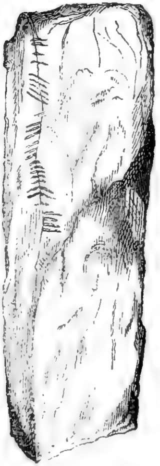


Fig. 3 was "dug out of an ancient fort or rath at Burntfort, near Mallow, in the County of Cork, on the property of H. Purcell, Esq." It is of talcose mica slate, coarse-grained; the broad face is exceedingly rough and uneven; the narrow one more smooth and regular, being the natural cleavage of the rock. It is nearly seven inches wide on the narrow side, and fifteen on the broad, and about five feet high along, being nearly a parallelogram. The cuttings are nearly similar throughout in depth and care of execution.

Fig. 4 was found at Glounaglough, parish of Aghabolloge. The entire stone is five feet seven inches long; eleven inches and a-half broad at top, and nearly nine at the bottom. It is of a clayey-slate rock. The letters do not extend further down the stone than one foot ten inches; it is nearly of the same thickness all through, forming a thin slab. On the face of the stone there are scrapings, and the lower letters are not formed by a regular groove, as the upper are, but have all the characters of such scratches as would be formed on a stone by sharpening knives or other edged tools.

Fig. 4.

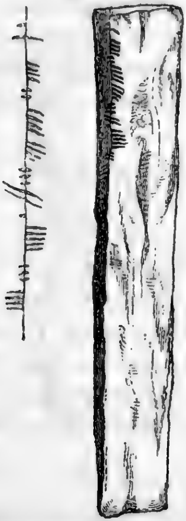


Fig 5.

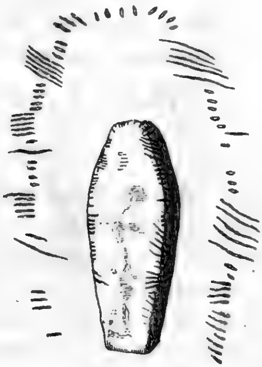


Fig. 5 is of sandstone, rudely chiselled on the faces and sides, and roughly rounded on the corners of the back, the back itself being flat. It is two feet eight inches high; eleven inches and a-half at the broadest part, and about seven inches thick. In shape it has a rude resemblance to the ordinary form of a coffin. The letters are distinct grooves, but they do not appear to be all of the same age, as some are very evidently new or recent, and, as in Fig. 3, very similar to the scratches formed by sharpening tools.

The Cork Institution is indebted to the zeal of Messrs. Windele and Abel for these valuable Ogham stones.

Dr. Apjohn read a notice, by the Rev. Thomas Knox, on Cyanogen, as a Food for Plants.

Liebig having proved in his work on Agricultural Chemistry that the nitrogenous compounds of vegetables are derived principally from the decomposition of ammonia, and that the carbon is derived from the carbonic acid of the atmosphere, it occurred to me to try (while experimenting on some manures) whether a source of each might not be found in some salt of cyanogen ($c_2 n$). This, I think, the following facts will make probable. The salt I used for this purpose was the ferro-cyanuret of potassium,

$$(K_2 Cfy = C_6 N_3 + Fe + K_2.$$

EXPERIMENTS.

A piece of grass was selected in the garden, as being as even and equal as possible, and five plots were marked out on it, side by side, each containing exactly ten square yards; they were marked out by pegs in the corners, and a line put round each while the salts were putting on, and during the cutting of the grass. They were then manured as follows, on the 17th of June last:

No. 1. Muriate of Ammonia, 3 oz.
2. Aqua Ammonia of the shops, ½ a pint; with Linseed Oil, 4 pints.
3. Nothing.
4. *Yellow Prussiate of Potash*, 3 oz. In the usual state, as sold by druggists, in crystals.
5. Phosphate of Soda, 1½ oz.
Pearl Ash, 3 oz.
Sulphate of Magnesia, 1½ oz.
Carbonate of Ammonia, 3 oz.

The salts on these two last plots were not laid on till the 26th of June, which gave them a slight disadvantage. They were all mown on the 25th of September, and weighed fresh the moment they were cut, when the weights were as follows:

No. 1.	$23\frac{3}{4}$ lbs.	when dry	$7\frac{1}{2}$ lbs.
2.	19	„	$5\frac{1}{2}$
3.	$21\frac{1}{2}$	„	$6\frac{1}{4}$
4.	$32\frac{1}{2}$	„	$9\frac{1}{2}$
5.	$28\frac{1}{2}$	„	$8\frac{3}{4}$

I cannot depend on the dry weight, nor draw any conclusions from it, though it follows nearly the same proportion as the fresh grass; the weather had been very wet, and it had been left too long exposed to it.

The great advantage of the plot manured with the prussiate of potash over the others is very remarkable; for about a month it seemed rather inferior to that manured with the muriate of ammonia; but after that time the difference became very perceptible to the eye or foot.

The final advantage of No. 4 above No. 1 is at the rate of 38 cwt. of fresh grass, or $8\frac{1}{2}$ cwt. of dry grass to the acre. The reason of this superiority cannot arise from the nitrogen alone, as the quantity of *it* in the three ounces of muriate of ammonia (applied to No. 1) actually exceeds that in the three ounces of ferro-cyanuret of potassium, in the proportion of 13 to 11. It must, therefore, be sought for in the other elements of the salt.

Supposing this salt to be absorbed by the plant, and decomposed in the same manner as the ammoniacal salts, the plant will then obtain *carbon* and *potash,* as well as the *nitrogen,* in the nascent state, which seems to be the only way in which *carbon* can be assimilated. In fact almost every element required by the plant is contained in this one compound, and obtained by one and the same decomposition.

I beg leave to lay these facts before the Academy, as they may prove interesting to those engaged in the subject of manures, and may tend to throw a little further light on the subject of the food of plants, should they be confirmed on repetition; but I fear they can be of no service to the practical agriculturist, from the high price of all the compounds of cyanogen.

Mr. George Yeates read a paper containing the results of a Meteorological Journal for the year 1843.—*See* Appendix V.

The Rev. H. Lloyd communicated a letter written many years ago to his father, the late Dr. Lloyd, Provost of Trinity College, by Mr. Mac Cullagh, who was then a Fellowship-Candidate in the College. It relates principally to a mechanical theory (that of the rotation of a solid body) which Mr. Mac Cullagh was occupied with at that period, and which he had occasion to allude to at the last meeting of the Academy. The following is an extract from the letter. The beginning and the date are wanting.

"Theorem I.—If a rigid body, not acted on by any extraneous forces, revolve round a fixed point O, and if an ellipsoid be described having its semiaxes in the direction of the principal axes passing through O, and equal to the radii of gyration round them; then a perpendicular to the invariable plane being raised from O to meet the surface of the ellipsoid in I, the line OI (which is fixed in space, as the ellipsoid revolves with the body) will be of a constant length during the motion; and a perpendicular from O upon the plane which touches the surface at I, will always be the axis of rotation, and will vary inversely as the angular velocity.

"*Corollaries.*

"1. Since every radius which is nearly equal to the greatest or least semiaxis of an ellipsoid must lie near that semiaxis, it appears that if, in the beginning of the motion, the point I be near the vertex of either of these semiaxes, it will always be near it, since OI remains constant; and therefore, by the preceding construction, the axis of rotation will always remain near the same semiaxis. Hence the rotation about the axes of greatest and least moment in any body is stable. The rotation about the axis of mean moment is unstable, because the radii of an ellipsoid, which are nearly equal to the mean semiaxis, do not all lie near that semiaxis.

"These things are evident from considering the trace of the constant line OI on the surface of the ellipsoid, and observing that, in general, its projection on the plane of the greatest and least axes is a hyperbola, and its projections on the other two planes ellipses.

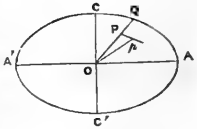
"2. But if OI be equal to the mean semiaxis b (a and c being the greatest and least) it will always intersect the body in the same plane, and the ellipsoid in a circle. For there are two circular sections through the mean axis; and therefore if the point I be at any instant in either of them, it will remain in it during the motion. It would be easy to show also, that the axis of rotation, connected with OI by the construction in the proposition, will in this case always remain in a given plane within the body.

"3. If two axes (or moments) of the ellipsoid are equal, OI will describe in the body a conical surface round the third, and the axis of rotation will always be in the same plane with OI and that third axis, and these three lines will make constant angles with each other; also the perpendicular on the tangent plane, and therefore the angular velocity, will be constant. These things are evident merely from considering that the ellipsoid becomes one of revolution.

"4. Whatever be the forces applied to the body, the varying plane of the maximum of areas and the axis of rotation are always connected by the construction in the proposition. But the angular velocity is no longer inversely as the perpendicular.

"To find the axis about which a body restrained by a fixed point O, and acted on by given forces, will begin to revolve, is usually considered a problem of great complexity. But it may be elegantly solved by means of the ellipsoid described above. Reduce the given forces to a single one through the fixed point O, and a pair; raise a perpendicular to the plane of the pair from O to meet the ellipsoid in I; a perpendicular from O to the tangent plane at I will be the initial axis of rotation.

"The construction is true whether the forces that set the body in motion be impulses or pressures. If they be impulses, and no external forces subsequently act on the body, the axis of rotation will vary its position both in the body and in space; its course in the body is determined by the preceding theorem, as well as the variation of the angular velocity. The motion of the body in space depends mainly on the two following theorems and the rectification of the ellipse.



Let the principal axes of the ellipsoid (or a, b, c) be OA, OB, OC.

"THEOREM II.—If a perpendicular IP be let fall from I on any of the principal planes (as AOC), the *areolar* velocity of P round O will be proportional to the perpendicular IP.

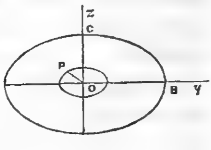
"By areolar velocity I mean the increment of the area (as POp) divided by the increment of the time when taken indefinitely small.

"Since $IP = \sqrt{(OI^2 - OP^2)}$, the position of OI, and therefore of the axis of rotation at any given time, may be determined from this theorem by the method of quadratures; and it may be reduced to the rectification of the ellipse.

"THEOREM III.—Let a plane passing through the fixed line OI and any of the principal axes (as OB), intersect the plane AOC in OQ, and the invariable plane (to which OI is perpendicular) in a straight line which may be called OR; the angular velocity of OR is inversely as the square of OQ; and hence if OR be always taken equal to OQ, the point R will describe in the invariable plane areas proportional to the times.

"Since OQ is known at any time by the preceding proposition, the position of OR at any time will be known from this by the method of quadratures. Also the inclination of the plane AOC to the invariable plane is known, since it is equal to the angle OIP. Hence the position of the body at any instant is completely determined.

"For an application of the theorems let us take the following problem:—The body revolving round a line indefinitely near the greatest or least of the principal axes, to find the time of an oscillation. By the time of an oscillation I mean that in which OI, and consequently the axis of rotation, returns to the same position within the body.



"Let the axis of rotation be indefinitely near OA. Then x, y, z being the coordinates of I, we have $x^2 + y^2 + z^2 = OI^2 = k^2$, and $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$. Therefore

$$\left(\frac{1}{b^2}-\frac{1}{a^2}\right)y^2+\left(\frac{1}{c^2}-\frac{1}{a^2}\right)z^2=1-\frac{k^2}{a^2}.$$

Hence the locus of P is an ellipse whose semiaxes a' and b' are

$$\frac{b\sqrt{(a^2-k^2)}}{\sqrt{(a^2-b^2)}} \text{ and } \frac{c\sqrt{(a^2-k^2)}}{\sqrt{(a^2-c^2)}};$$

and therefore its area

$$\pi a'b'=\frac{\pi bc\,(a^2-k^2)}{\sqrt{(a^2-b^2)(a^2-c^2)}}.$$

"But I ought to have mentioned, as part of Theorem II., the method of determining in general the areolar velocity of P. Let the angular velocity multiplied by the cosines of the angles which the axis of rotation makes with OA, OB, OC be denoted (as is usual) by p, q, r. These have constant ratios to the perpendiculars, as IP, drawn in that proposition; and in that case the areolar velocity of P is equal to $\frac{1}{2}(b^2-k^2)q$: and similarly when AOC is any of the other principal planes. Hence, in the present instance, the areolar velocity $=\frac{1}{2}(a^2-k^2)p$; and therefore the time of an oscillation

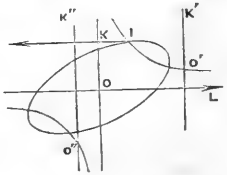
$$=\frac{2\pi bc}{p\sqrt{(a^2-b^2)(a^2-a^2)}},$$

from the above value of the area of the ellipse, and observing that, since OI is indefinitely near OA, IP and therefore p may be regarded as constant.

"If τ denote the time of one revolution of the body round its axis, then ultimately $\tau=\frac{2\pi}{p}$, and therefore the time of an oscillation is to the time of a revolution as the rectangle under the semiaxes of the section BOC is to the rectangle under the eccentricities of the other two sections. A similar theorem holds when the body revolves round a line indefinitely near the least principal axis. The times of small oscillations of different magnitudes are equal, as in the pendulum.

"Many particular consequences might be deduced from what has been said; but it will be better to mention some new theorems about moments of inertia and centrifugal forces.

" The forces resulting from the centrifugal forces of a body of any figure, revolving round an axis passing through a fixed point O, may be found elegantly by the ellipsoid of which we have already made so much use. Let a plane at right angles to the given axis OK, and cutting it in K, touch the ellipsoid in I; the centrifugal forces will be reduced to a pair whose moment is OK $\times$ KI $\times$ ω^2* (ω being the angular velocity), whose plane is OKI, and direction as marked in the figure; and a single force equal to $Mp\omega^2$, p being the distance of the centre of gravity from OK.



" If OK pass through the centre of gravity, there remains only the pair. The perpendicular OK is the radius of gyration for the axis OK. Particular consequences of these things are numerous.

" Any line, taken at random in a body, may not be a principal axis. All the principal axes parallel to a given line lie in the same plane; and the points of their lengths which must be fixed, in order that they may be principal axes, will lie in a hyperbola. Suppose in this case the point O (preceding fig.) to be the centre of gravity, and OK to be parallel to the given line, and describe through I an equilateral hyperbola whose asymptotes are OK and OL; then all the principal axes, as O′K′, O″K″, parallel to OK, lie in the plane OKI, and the points O′, O″ of their lengths, which must be fixed, are at their intersections with the hyperbola.

" By means of theorems of this nature, all of which are proved geometrically, without any calculation, I have been able to give a complete geometrical solution of the problem of the motion of a solid body not acted on by any forces. If it be acted on by given forces, the differential equations in A, B, C and p, q, r, which are given by all the writers on mechanics, are direct consequences of the first principles, without the intervention of any calculation.

* * * * * * * *

" Another thing with which I had occupied myself is the attrac-

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* Multiplied by the mass of the body, or by M.

tion of ellipsoids. Having written out a simple demonstration of a very elegant known theorem relating thereto, I shall subjoin it separately.

* * * * * * * *

"The proposition above alluded to depends on the following theorem, which may be very simply proved:—If from the extremities A, B, C of the semiaxes of an ellipsoid whose centre is O, there be drawn three parallel chords $A\alpha$, $B\beta$, $C\gamma$, meeting the surface of the ellipsoid in α, β, γ; and if a perpendicular from α on OA meet it in r, a perpendicular from β on OB meet OB in s, and a third from γ on OC meet OC in t; then will

$$\frac{Ar}{AA'} + \frac{Bs}{BB'} + \frac{Ct}{CC'} = 1.$$

AA′, BB′, CC′ are the whole axes.

"The proposition itself is this:—If the particles of a homogeneous ellipsoid attract inversely as the square of the distance, and if a, b, c be the semiaxes, and A_0, B_0, C_0 its attractions on points placed at their vertices, then will

$$\frac{A_0}{a} + \frac{B_0}{b} + \frac{C_0}{c} = 4\pi.$$

"The attractions are here, as is usual, represented by lines; the attraction of an indefinitely small part of the solid being represented by its *volume* divided by the square of its distance from the attracted point.

"The attraction being thus measured, it is evident that if from the vertex of a pyramid, whose transverse sections are indefinitely small, as a centre, with any radius, a sphere be described whose surface is penetrated by that of the pyramid, the attraction of the pyramid on a point at its vertex will be to its length, as the intercepted surface of the sphere is to the square of its radius.

"Let A, B, C be the three vertices of the axes, and from them let parallel chords $A\alpha$, $B\beta$, $C\gamma$ be drawn; from whose extremities α, β, γ let perpendiculars be let fall on the respective axes, meeting them in r, s, t; then by the preceding theorem

$$\frac{Ar}{AA'} + \frac{Bs}{BB'} + \frac{Ct}{CC'} = 1.$$

Let now two other chords be drawn from A making with $A\alpha$ very small angles, so as to form with it the edges of a very small pyramid, and let other chords parallel to them be drawn from B and C, forming also with $B\beta$ and $C\gamma$ the edges of two other small pyramids. Imagine a sphere fixed in space, from whose centre are drawn three lines parallel to the three chords drawn from A, or from B, or from C, and conceive the surface of the pyramid, of which they are the edges, to penetrate that of the sphere ; then will the attractions of the three pyramids, reduced each to the direction of the axis passing through its vertex, be to Ar, Bs, Ct as the intercepted surface of the sphere to the square of its radius ; and therefore the sum of each of those attractions, divided respectively by AA', BB', CC', will be to unity in the same ratio. Conceive pyramids thus related to be multiplied indefinitely, and the spheroid will be exhausted at once from each of the three points A, B, C, while half the surface of the sphere is exhausted by the parallels drawn from its centre. Hence it appears that the sum of the whole attractions at A, B, C, divided respectively by AA', BB', CC', is to unity as the surface of a hemisphere to the square of its radius, or as 2π to 1 ; and therefore

$$\frac{A_0}{a} + \frac{B_0}{b} + \frac{C_0}{c} = 4\pi.$$

January 22.

REV. JAMES H. TODD, D. D., Vice-President, in the Chair.

Mr. W. H. Hudson exhibited specimens of Irish books, now in the course of publication in Cork, which are lithographed. He described the advantages which that process presents over types, for composition in the Irish character.

Dr. Kane read a paper on the Chemical Composition of the different kinds of fuel found in Ireland.

Although this country is recognized as destitute of the great development of the coal strata, which has proved so important an element in the industrial progress of Great Britain, yet there are known to exist several coal districts, some bituminous and some anthracitous, as well as deposits of wood coal, which, with the great extent of turf-bog occupying the surface in many places, may be considered as stores of fuel, available and sufficient for the supply of the interior of the country for a very long time. In order, however, to be able to calculate the economic value, or calorific power of any of these Irish fuels, and so to compare them with the corresponding fuels in other countries, it was necessary to know their elementary composition; and hence, in order to lay the basis of a true estimate of the worth of our native fuels, Dr. Kane commenced the series of analyses which formed the present communication.

In order to exhibit all the relations of the composition of these fuels, that might be useful in drawing practical conclusions, Dr. Kane adopted two distinct modes of analysis: one, exhibiting the real elementary composition; the other, which he terms the practical analysis, representing the relation of the ashes, and of the fixed and volatile constituents of the fuel. He also in each case ascertained the quantity of oxygen which the fuel was capable of taking up, in order to be perfectly consumed. As the analysis of fuels is known to present some difficulty, it is necessary to mention briefly the precautions taken in order to secure accurate results.

The point first determined was in each case the quantity of ashes present. To effect this a certain weight of the fuel was burned in a current of hot air, until all traces of organic material disappeared. The residual ash was then weighed.

To conduct the determination of the carbon and the hydrogen of the fuels, the methods were varied according to the nature of the substance, with turf, lignite, and the bituminous coals. The proper weight of the material having been dried at 212° F., was in some cases mixed with chromate of lead, and the analysis conducted in the ordinary manner; in other cases, the substance was mixed with black oxide of copper, and some chlorate of potash having been placed in the end of the analysis tube, the operation was conducted in the usual way to near the termination, when the chlorate of potash being heated, a stream of oxygen gas passed through the apparatus, and burned out the last traces of the organic substances.

These two modes gave almost identical results with the same fuel, and there is no necessity for distinguishing amongst the analyses, of which the results follow, those that were done in the one way or in the other.

It was found, however, that the anthracite could not be perfectly analysed by either of these modes: the difficulty of burning away the last portions of the carbon was so great. Hence a totally different plan was adopted for that variety of fuel. An analysis tube of Bohemian glass having been taken about a foot long, the substance to be analysed was placed in a little boat of platina foil, and introduced into the tube near one end. To this end was fitted a tube containing dry chloride of calcium to collect the water; then the potash absorbing apparatus, then another potash absorbing apparatus, and finally a tube containing dry potash. These three were for the purpose of separating the carbonic acid perfectly from the excess of oxygen, and also to prevent the oxygen from carrying away any moisture from the potash liquor. The other end of the tube was connected with a gazometer full of pure oxygen gas, which, streaming over a large surface of fused chloride of calcium, was rendered perfectly dry. The apparatus being so adjusted, the analysis tube was heated to redness by charcoal, so that the oxygen gas passed through five or six inches of red hot tube before coming to the ignited anthracite. The analysis was thus conducted, as it were, with the hot blast, and the combustion was in all cases quite perfect. This kind of process would only answer with such fuels as anthracite, which contains very little hydrogen; but with those it succeeded perfectly.

Such were the means taken for the organic elementary analysis. The nitrogen was not separately determined, as the results were only required for economic calculations, and the minute trace of nitrogen does not there become important. Its weight (in all cases very small) is included in the number assigned to oxygen in the results of the analyses.

The practical analysis was conducted by very strongly igniting a weighed portion of the fuel in a platinum crucible the cover of which fitted so closely as to prevent any sensible combustion of the residual coke. The weight of ashes being known, the pure coke was then found.

The determination of the reducing power of the fuel by means of litharge, requires very considerable care in practice in order to get satisfactory results. The principal point to be attended to, is to use a roomy crucible, and to apply a quick and strong heat, so that the litharge shall at once run thin. When this is done, the results with the same fuel are very uniform, and with different fuels are fully comparable; although in no case is so much lead got as should be in theory obtained from the conversion of the carbon and hydrogen of the fuel, minus its oxygen, into carbonic acid and water. The deficiency is usually proportional to the quantity of volatile matter in the fuel, and is not in any case large, provided proper care be taken. Hence Dr. Kane considers, and the opinion is also held by Berthier, that the result is so near the truth as to be quite available as a practical and ready measure of the heating power of the fuel.

The general nature of the inquiry, and the methods employed, having been thus described, it is only necessary to add the numerical results of the analysis.

In order that the results might represent as far as practicable the average composition of the fuel, in each case rather a large mass was broken up, and its coarse powder well mixed. Some ounces of this were then reduced to impalpable powder, and from this all the portions to be operated upon were taken.

I. ANTHRACITES OF THE SOUTH OF IRELAND.

Three specimens of this kind of coal were analysed:

1, from the Rushes Colliery, Queen's County;

2, „ the Pollough Vein, Castlecomer, Co. Kilkenny;

3, „ the Sweet Vein, Kanturk, County Cork.

The anthracites have no tendency to froth or cake in cokeing. They give off little or no inflammable gas on being ignited, but usually the masses break up quite small, especially if the heat be suddenly applied. The ashes are almost always red, owing to peroxide of iron remaining after the combustion of the iron pyrites, which the anthracite generally contains.

Rushes anthracite—0.375 grammes gave:

Water	0.118
Carbonic acid	1.238
Light red ashes . . .	0.014

The Pollough anthracite. 0.364 grammes gave:

Water	0.079
Carbonic acid	1.086
Brown ashes	0.036

The Sweet Vein anthracite—0.293 grammes gave:

Water	0.098
Carbonic acid	0.928
0.305 gave . . .	0.026 ashes, white.

These coals consisted, therefore, of:

	Rushes.	Pollough.	Sweet Vein.
Carbon	90.04	81.36	86.37
Hydrogen . . .	3.50	2.41	3.71
Oxygen . . .	2.73	6.34	1.40
Ashes	3.73	9.89	8.52
	100.00	100.00	100.00

Of these coals the Sweet Vein was perfectly free from sulphur; the Rushes coal contained but a minute trace; but the Pollough coal contained a good deal, and as the sulphurous acid produced during its combustion should be absorbed by the potash, and counted as carbonic acid in the analysis, it was necessary to correct the above result by a direct determination of the sulphur. For this purpose 3.526 grammes of the coal were boiled with aqua regia, and the liquor precipitated by chloride of barium. The sulphate of barytes obtained weighed 1.589 grammes, corresponding to 45.07 per cent., containing 6.18 of sulphur.

Now, 6.18 sulphur give 12.36 sulphurous acid, and subtracting that from the carbonic acid obtained in the elementary analysis, then converting the sulphur into bisulphuret of iron, and subtracting the pyrites from the ash, there comes out, as the true composition of the Pollough coal:

Ash, free from iron . . .	2.19	
Bi-sulphuret of iron . . .	11.58	
Carbon	75.42	giving of pure anthracite 86.23.
Hydrogen	2.41	
Oxygen	8.40	
	100.00	

It is interesting to contrast the composition of the really organic part of these three varieties of coal.

	Rushes.	Pollough.	Sweet Vein.
Carbon	93.53	87.46	94.39
Hydrogen . . .	3.63	2.79	4.05
Oxygen . . .	2.84	9.75	1.56
	100.00	100.00	100.00

By the practical mode of analysis these coals were found to give, per cent.:

	Rushes.	Pollough.	Sweet Vein.
Volatile matter . .	9.85	10.40	10.35
Pure coke	86.42	79.71	81.13
Ashes	3.73	9.89	8.52
	100.00	100.00	100.00

The result of ignition with litharge was, that

One part of Rushes coal gave .	31.8	of lead.
Pollough	26.7	,,
Sweet Vein	29.0	,,

Hence they correspond respectively.

100 parts of Rushes to . .	93.5	of pure carbon.
100 ,, Pollough . .	73.5	,,
100 ,, Sweet Vein .	85.3	,,

And in average 100 parts of Irish anthracite may be considered to possess a calorific power equal to 84 parts of pure carbon.

II. COAL OF THE CONNAUGHT BASIN.

The coals examined were all from the collieries of Brahlieve mountain, forming the western division of the Lough Allen coal field. The specimens were furnished through the kindness of Colonel Jones, member of the Shannon Commission. The results were as follow :

AUGHABEHY COAL.

A rich, black coal, easily broken. Sp. gr. 1.274. When heated, it gives off a good deal of inflammable gas, and leaves a light grey, porous, coherent coke.

Its elementary analysis was effected :

0.472 grammes gave:

Carbonic acid	1.379	grammes.
Water	0.265	,,

0.921 grammes gave of white ashes, 0.099, or 10.75 per cent.

Hence it contained:

Carbon	79.69
Hydrogen	6.24
Oxygen	3.32
Ashes	10.75
	100.00

ROVER COAL.

This coal is rather brown in aspect, and splits easily into cubical fragments. On ignition it gives out gas, but does not froth. Its coke is porous, slightly coherent.

Its elementary analysis was:

3.196 grammes gave . . . 0.237 of ashes, equivalent to 7.41 per cent.

0.489 gramme gave:

Water	0.216
Carbonic acid	1.453

Hence it contained:

Carbon	81.04
Hydrogen	4.91
Oxygen	6.64
Ashes	7.41
	100.00

The practical analysis of these two coals gave the following results:

Aughabehy Coal.—13.418 grammes gave on ignition 10.340 of coke.

Rover Coal.—14.300 gave on ignition 11.770 of coke.

Hence they consisted of:

	Aughabehy.	Rover.
Volatile matter . . .	23.10 . .	17.70
Pure coke	66.15 . .	74.89
Ashes	10.75 . .	7.41
	100.00	100.00

Specimens of coal from the Celtnaveena and the Meenashama collieries were also examined in this manner, with the following results:

Celtnaveena Coal.—14.772 grammes gave by ignition 11.960 of coke.

1.091 gramme gave 0.164 of white ashes.

Meenashama Coal.—6.280 grammes gave 5.095 coke.

3.778 gave 0.742 of ashes.

Hence they consist of—

	Celtnaveena.	Meenashama.
Volatile matter	19.10	18.90
Pure coke	65.87	61.46
Ashes	15.03	19.64
	100.00	100.00

Each of these varieties of coal was examined as to the quantity of oxygen it absorbed by reducing litharge.

1 part of Aughabehy coal produced 26 parts of lead.

1 part of Rover coal produced $28\frac{1}{2}$ parts of lead.

1 part of Celtnaveena coal gave 26 of lead.

1 part Meenashama coal gave 25 of lead.

100 parts are therefore equivalent

Of Aughabehy to	77	parts of pure carbon.
Rover	84	,,
Celtnaveena	77	,,
Meenashama	73	,,

These coals are similar in appearance to the Aughabehy, but are more slaty. When ignited they give off inflammable gas, but do not froth. Their coke is dense.

It is thus seen that the Aughabehy is the most bituminous of these coals, whilst the Rover is the least so, and that in fact the latter approaches closely in its composition to the anthracite of the Munster coal field.

III. COAL ON THE TYRONE BASIN.

Of this locality two kinds of coal were examined, from opposite sides of the field, the new Drumglass Colliery, and the colliery at Coal Island.

COAL ISLAND COAL.

It is slaty in structure, dull coloured; sp. gr. 1.267. On ignition it gives off much gas, froths, and leaves a very porous coke.

2.814 gave 0.328 of ashes almost white.

8.830 grammes gave after ignition 5.390 of coke.

It hence consisted of

Volatile matter	38.96
Pure coke	49.39
Ashes	11.66
	100.00

In its elementary analysis, 0.563 gramme gave:

Water	0.297
Carbonic acid	1.426

Whence results the composition

Carbon	69.08
Hydrogen	5.86
Oxygen	13.41
Ashes	11.65
	100.00

On ignition with litharge, one part of this coal gave $26\frac{1}{2}$ of lead, hence 100 parts correspond to 78 of pure carbon.

NEW DRUMGLASS COLLIERY.

This coal is brilliant, black, friable, frequently mixed with pyrites, which oxidize on exposure to the air. Its ashes are consequently reddish. On ignition it gives off much gas, froths, and produces a light porous coke. Its practical analysis was as follows:

1.977 grammes gave of brown ash 0.342.

11.540 gave on ignition 5.920 of coke. It consisted hence of—

Volatile matter	48.70
Pure coke	34.00
Ashes	17.30
	100.00.

When ignited with litharge, one part produced 22 parts of lead. 100 parts of it are therefore equivalent to 65 parts of pure carbon.

IV. COAL OF THE ANTRIM DISTRICT.

The coal of Ballycastle is dull, black; sp. gr. 1.279. On ignition it gave out much gas, frothed, and left a porous coke. On its practical analysis it gave in 100 parts

Volatile matter	36.96
Pure coke	45.94
Ashes	17.10

One part of it produced 25 of lead, and 100 are therefore equivalent to 71½ parts of pure carbon.

V. LIGNITES OF LOUGH NEAGH.

Having thus determined the composition, and more important practical relations of the coals from the several coal districts of Ireland, Dr. Kane proceeded to examine the nature of the deposit of lignite which is found among the tertiary beds along the southern extremity of Lough Neagh. As these investigations had solely a technical object, the silicified wood of that district did not require any notice, but only such wood-coals as were capable of use as fuel, Two specimens were examined. They retained all the structure of wood, and were of a deep brown colour. When ignited they gave off gas, which burned brilliantly, and left a dense black charcoal.

On elementary analysis, they gave the following results:

No. 1.—1.887 gave 0.163 of a reddish ash containing much iron.

0.489 grammes gave:

Water	0.262
Carbonic acid	1.050

No. 2.—3.393 grammes gave of slightly reddish ashes 0.550.

0.648 gramme gave

Water	0.429
Carbonic acid	1.220

These lignites consequently consisted of

	No. 1.	No. 2.
Carbon	58.56	51.36
Hydrogen	5.95	7.35
Oxygen	26.85	25.08
Ashes	8.64	16.21
	100.00	100.00

The results of the practical analyses were as follows:

	No. 1.	No. 2.
Volatile matter	57.70	53.70
Pure charcoal	33.66	30.09
Ashes	8.64	16.21

By ignition with litharge, No. 1 gave 19½ parts of lead, and No. 2 gave 16.7 parts. They hence were equivalent in 100 parts.

No. 1.—To 58 parts of pure carbon.

No. 2.— „ 50 „

VI. TURF.

The specimens of turf were selected from Cappoge, in Kildare, and Kilbeggan, in Westmeath, on different sides of the great Bog of Allen, and from Kilbaha, in Clare. When ignited, turf gives off inflammable gas, and leaves a light, easily combustible charcoal.

The elementary analyses were as follows:

KILBEGGAN TURF.

.383 grammes gave:

Water	0.230
Carbonic acid	0.857
Ashes	0.007

KILBAHA TURF.

3.435 grammes gave 0.277 of a light reddish ash.

0.663 gramme gave:

Water	0.378
Carbonic acid	1.243

CAPPOGE TURF.

10.566 grammes gave 0.270 of ashes.

0.500 gramme gave:

Water	0.308
Carbonic acid	0.935

From these results follow the composition:

	Kilbeggan.	Kilbaha.	Cappoge.
Carbon	61.04	51.13	51.05
Hydrogen	6.67	6.33	6.85
Oxygen	30.46	34.48	39.55
Ashes	1.83	8.06	2.55
	100.00	100.90	100.0

In the practical analysis of turf it is necessary to attend to the physical constitution of the fuel, as, even with the same chemical elements, the heating power, and the proportion of fixed and volatile parts, will vary with the denseness of texture of the fuel. Important differences exist also in the characters of the turf taken at different depths below the surface of a bog. These circumstances require to be carefully attended to in practice.

When ignited, there were obtained from specimens of light surface turf:

	Cappoge.	Kilbeggan.
Volatile matter	73.63	75,50
Pure charcoal	23.82	22.67
Ashes	2.55	1.83
	100.00	100.00

and from deep-seated turf,

		Kilbaha.	Cappoge.
Volatile matter	.	72.80	70.10
Pure charcoal	.	19.14	23.66
Ashes	. . . . .	8.06	6.24
		100.00	100.00

Of these varieties of turf it was found that on ignition with litharge,

1 part	light	Cappoge turf	gave	13.0	of lead,
1	„	Kilbeggan turf	„	14.2	„
1	„	Kilbaha turf	„	13.8	„

and hence that 100 parts corresponded, of

Cappoge turf	to	37	of	pure carbon.
Kilbeggan	„	41	„	„
Kilbaha	„	40	„	„

By means of these investigations Dr. Kane trusted that the chemical nature, and economic value of the fuels of Ireland might be considered as established, and thus one step made towards a correct knowledge of the circumstances under which this country is placed as to those important materials of industry. The question as to the extent of those deposits, the real quantity of each fuel available in practice, as well as the mode in which those deposits have had their origin, pass from the domain of chemical inquiry, and hence have been left by Dr. Kane to those geological philosophers whom the Academy proudly enumerates amongst its members.

Dr. Apjohn and Mr. R. Mallet made some observations.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1844. No. 44.

February 12.

REV. JAMES H. TODD, D. D., Vice-President, in the Chair.

Henry Clare, Esq., was elected a member of the Academy, and the Rev. Charles Graves was elected a member of the Committee of Polite Literature.

Mr. Ball made a communication on a collection of the Irish names of animals, which he had been for many years collecting from ancient manuscripts, dictionaries, persons speaking the Irish language at present, &c. He stated that for one important addition he was indebted to Mr. Curry, who pointed out in a manuscript poem, said to be of the fifth century, ascribed to Caoilte, one of Finn Mac Coole's heroes, and which is certainly older than the year 1000, a portion, in which the names of one hundred animals are recorded in a list of the ransom paid for the celebrated Finn Mac Coole, when a prisoner. Some of the names mentioned have not yet been translated. Mr. Ball observed on the value of such a collection as a means of throwing light on the names of places in Ireland, and urged the interest that naturalists of other countries felt, in preserving the names by which animals were known in their native places, as a sufficient reason for desiring to preserve those of Ireland. He stated his intention of having the collection he had made properly digested and arranged by a competent person, and that he would then offer it to the Academy for publication.

Professor Mac Cullagh made some remarks, of which the following is the substance, concerning the letter communicated by Mr. Lloyd at a former meeting (see Proceedings, p. 520).

The letter read by Mr. Lloyd at a late meeting of the Academy, was written by me immediately after the examination for Fellowships, which was held in Trinity College, in the year 1831. I had been a candidate on that occasion; and Dr. Bartholomew Lloyd, to whom the letter was addressed, had been one of the examiners. The letter contains, among other things, several theorems taken from a geometrical theory of Rotation, with which I had been previously occupied. Soon after it was written, I returned to that theory, for the purpose of improving it in one part where I felt it to be defective, and where, indeed, I experienced the chief difficulty; I mean the part which relates to finding the position of the body at any given time. The method given in my letter for doing this by quadratures, had occurred to me in 1829; but I was, of course, not satisfied with it, and I had in the interval made some attempts to find a method more elegant, and, as far as possible, really geometrical. In the autumn of 1831 I succeeded completely in this, and no further additions of any consequence were made to the theory. The position of the line OI within the body, at any given time, was found by an elliptic function of the first kind, the modulus and amplitude of which are given immediately by geometrical considerations; the modulus of the function being in fact the ratio of the two moduli of the cone which that line, stationary in space, describes within the body. This result was deduced from Theorems I. and II. of the letter. The cone reciprocal to that just mentioned was used to find the position of the body in space. This reciprocal cone, carried about with the body, always touches the invariable plane; the side of contact, at any instant, being that which corresponds to OI, and which therefore lies in the plane passing through OI and the axis of rotation. The angle described in the invariable plane by the side of contact is the sum or difference of two angles, one of which is proportional to the time, and the other is the angle described by that side in the surface of the cone. As the latter angle is measured by the arc of a spherical conic, it followed, on comparing this result with the integral given by Legendre in his discussion of the question of rotation, that the arc of a spherical conic represents an elliptic function of the third kind with a circular parameter.

The curve described by the point I on the surface of the ellipsoid, is a spherical conic; and it now appears in what way the consideration of this mechanical question led to the study of the properties of cones and spherical conics. From theorems relating to centrifugal forces and principal axes of rotation, I was further led to consider systems of ellipsoids and hyperboloids having the foci of their principal sections the same; and then the focal curves presented themselves as the limits of these surfaces. The properties of the focal curves and of confocal surfaces occupied me, at intervals, in the year 1832; but in the latter part of that year my attention was diverted from these subjects, and it was not until 1834 that I began to think of writing down and publishing the results of my inquiries respecting them. In doing so, I wished to be able to assign a geometrical origin to the surfaces of the second order, the theory of these surfaces being intended to precede that of rotation; and in seeking for such an origin, I found the modular property. But not long after (in the summer of 1834) happening to look into a French scientific journal, I learned that M. Poinsot had just read to the Academy of Sciences of Paris a memoir in which he treated the question of rotation geometrically, by a method substantially the same as mine. This caused me to give up the design of writing on that subject; and, my thoughts then turning to the theory of light, the subject of surfaces of the second order was also dropped.

Another form of Theorem I. is given by the property of reciprocal ellipsoids. If a second ellipsoid be constructed, having its centre at O, and its semiaxes coincident with, and inversely proportional to those of the first, and if this ellipsoid be touched by a plane parallel to the invariable plane, it is obvious, from the relations of reciprocal ellipsoids, that the tangent plane will be fixed in space, and that the right line which joins the point of contact with the point O, will always be the axis of rotation, and will be proportional to the angular velocity. This form of the theorem, though not mentioned in the letter, was nevertheless employed in my theory of rotation. It is the form given by M. Poinsot, who uses only the second ellipsoid; and it has the advantage of determining geometrically (as M. Poinsot has remarked) the successive positions of the body in space, independently of the consideration of time; for the ellipsoid evidently *rolls* upon the fixed plane which it always touches. This advantage, however, though evident when stated, I do not recollect that I had distinctly perceived.

The theorem mentioned in my letter, for finding the moment of the centrifugal forces, is the same (making allowance for the difference of the ellipsoids) with one given by M. Poinsot, which he speaks of as " a simple and remarkable theorem, containing in itself the whole theory of the rotation of bodies;" and of which he further observes, as I have done, that " translated into analysis, it gives immediately the three elegant equations which are due to Euler, and which are usually demonstrated by long circuits of analysis." It was, in fact, from this theorem, by means of the principle of the composition and resolution of rotatory motions, that my theory, as well as that of M. Poinsot, was deduced. I may add, that I also employed M. Poinsot's beautiful theory of *couples*, which has introduced so much clearness into the fundamental doctrines of mechanics.

Mr. G. Wilkinson read a paper on the existence of the pointed arch in the early buildings of Ireland, prior to the introduction of Gothic architecture.

Mr. Petrie offered some remarks on Mr. Wilkinson's communication.

Dr. Allman noticed the occurrence in Ireland of Fredericella Sultana, and entered into certain details of its zoological and anatomical characters. This zoophyte has been very imperfectly described, and is moreover burthened with a discordant synonomy which has involved its history in no small obscurity. The difficulty which is thus necessarily connected with the attempt to determine the true Fredericella Sultana, Dr. Allman endeavoured to remove, by reducing to some sort of order the mass of synonymes in which it is involved. It would appear to be the *Tubularia Sultana* of Blumenbach, its original discoverer; the *Plumatella Gelatinosa* of Dr. Fleming; the *Plumatella Sultana* of Sir J. G. Dalyell; and the *Fredericella Sultana* of Gervais. It would appear also that the zoophyte described by Mr. Varley, in a late number of the London Physiological Journal, is the same as the present.

By some singular oversight, Dr. Fleming, in the description of his Plumatella Gelatinosa, refers to the Tubularia Gelatinosa of Pallas, described in the "Elenchus Zoophytarum." The Tubularia Gelatinosa of the Elenchus, however, is quite a different animal; it belongs to the group with crescentic disks, and is identical with the free variation of *Plumatella repens*.

The author, in entering into the details of its anatomical structure, drew attention to the high ascidiform type which it presented. He also noticed a hyaloid membrane of great tenuity which surrounds the base of the tentacular plume, and extends upwards for about the fourth of the length of the plume, being adherent to the tentacula, and constituting a kind of calyciform appendage to the base of the crown.

He mentioned the existence of this calyciform membrane in *Plumatella* and *Cristatella*, but would not speak positively as to its presence in *Alcyonella*; from *Paludicella* it is certainly absent, a fact which, along with several others, tends to approach this elegant zoophyte to the marine *Ciliobrachiates*.

Dr. Allman also alluded to a singular valve-like organ with which the mouth is furnished, exactly similar to that found in *Plumatella*, and described by the Author at the late meeting of the British Association. This organ he has also detected in *Cristatella*.

Through the external tunic of the polypidom will be found scattered, numerous silicious particles of no definite figure, and the Author considered himself justified, from the observations which he had made upon the fresh-water zoophytes, to come to the general conclusion that in the corneous polypidom of these animals, silica replaces the calcareous deposits of the marine species.

February 26.

ROBERT BALL, Esq., Treasurer, in the Chair.

The Secretary read a paper by the Rev. Dr. Hincks, "On the Defacement of Divine and Royal Names on Egyptian Monuments."

An attempt is made in this paper to specify the several occasions, on which the principal defacements of Egyptian monuments took place; mentioning the principal ones which suffered on each occasion. The occasions specified are four.

I. The dethronement or death of Q. Amuneth (*circa* 1325, B. C.), when her monuments were defaced by her brother Thothmos III. The propylon at Elassassif is the principal one defaced on this occasion.

II. The change in the religious views of Amenothph IV. (the sun-worshipper of El Tell) (*circa* 1250, B. C.), which led him to deface all the figures and titles of the God Amoun, and all names of which his name formed a part. The monuments defaced on this occasion are referred to three classes.

1. Those which were never restored, as the lesser obelisks at Karnac.

2. Those in which the sun-worshipper substituted another name for what he defaced; as in a cartouche of his own cited by M. Prisse, and in those of his supposed grandfather Amenothph III., where he substituted a repetition of the prænomen for the defaced phonetic name.

3. Those in which the names and figures that were defaced have been restored by subsequent kings. Instances of this are the Lateran Obelisk at Rome, the great obelisks at Karnac, and those cartouches in which the name of Amenothph III. appears cut over the repetition of his prænomen; the latter having been previously substituted for the original name.

III. The overthrow of the sun-worshippers and restoration of the worship of Amoun, on which occasion all the monuments of the intrusive worship were destroyed, as at Karnac, Gebel Tounh, and Ell Tell (a few years after the preceding occasion). The tomb of the king called Skhai, the father of the sun-worshipper, was violated at this time; and this was probably the occasion on which the royal name on the lion, presented by Lord Prudhoe to the British Museum, was obliterated. It was that of Amenothph IV.

IV. The hostility to the god Seth, Nahas, or Noubti, which arose in the minds of the Egyptian priests, and which led to the defacement of all monuments in which he appears as a beneficent god, and of his name when forming a part of names of kings. The time when this hostility arose, and the cause of it, are yet unexplained ; but it could not have led to this defacement sooner than 1100, B. C. This defacement is conspicuous on the statues of Menephthah III. at Turin and London, and the Flaminian Obelisk of Menephthah I. at Rome, and frequently at Karnac.

It is incidentally mentioned that Pone, or Penne, is Lower Egypt ; its extremities being mentioned in a papyrus in the British Museum in connexion with Ebo, or Elephantine, as the limits of Egypt. And the titles "King of Penne," "King of the Pure Country," which occur in the second cartouches of many Egyptian kings, are shewn to imply that the kings bearing those titles were only kings of parts of Egypt; a King of Penne, or Lower Egypt, like Horus, always implying a King of Keme, or the pure country, *i. e.* of Upper Egypt, as Skhai and Amenothph IV. were.

Mr. E. Clibborn made a communication respecting the Hycsos, or Shepherd Kings, tending to shew that they were descendants of Isaac.

March 16. (Stated Meeting.)

SIR Wm. R. HAMILTON, LL. D., President, in the Chair.

Resolved,—That the Rev. J. D'A. Sirr's collection of Irish Antiquities be purchased on the terms recommended by Council. The terms being a payment of £350, the cancelling of his arrears, and his being made a Life Member of the Academy.

The Secretary of Council read the following Report:

In presenting to the Academy the Report of Proceedings during the past year, the Council does not find it necessary to enter into much detail, as the events of that period have not been of any considerable importance or unusual character.

The Second Part of the 19th Volume of our Transactions has been published and distributed to the members of the Academy. The 20th volume, which will be altogether occupied by Mr. Petrie's Essay on the Round Towers, is still at press. The delay in its publication arises mainly from the number and importance of the artistic illustrations; and it is expected that the retarded progress of this work will be fully compensated for, in the opinion of the Academy, by its excellence, when brought out.

Several Memoirs are already prepared and printed for the 21st Volume of the Transactions, and the Proceedings of last Session, which compose Part VII., have been lately distributed to the members.

Since the date of the last Report the attention of the Council has been given to the means of providing for the exhibition and guarding of the collection of Irish Antiquities. The plans proposed for this object have been already submitted to the Academy, but are not as yet in any way carried into effect; the Council being, on the one hand, restricted by want of funds, and, on the other, as it was found that the duration of tenure of the Academy House becomes uncertain after a few years, it was thought advisable not to expend much money on alterations in the building, until some definite arrangement had been made concerning its future tenure. For this purpose the Council have been in communication with the law agents of the Academy, but no decisive result has been as yet arrived at. It is a question of great importance to the Academy, for, at present, from the want of place for exhibition, the antiquarian treasures which we possess, and to which, we trust, each year will make large additions, are practically inaccessible to the public. Some of the best evidences of the activity and utility of this Institution are hidden from the public eye, and thus the influence of the Academy, and its claims for public sympathy, are narrowed, and deprived of force.

The Donations to the Antiquarian Museum during the past year have been few in number, most probably owing to the circumstances just now described.

The work of cataloguing the Irish Manuscripts in the library of the Academy is still in progress, but is expected to be terminated in a few weeks. The time occupied in this work, and the extent, three vols. folio, to which the Catalogue has gone, will be understood when it is considered that, not merely the name, but also an abstract of the contents of each MS. are inserted in the Catalogue, which will thus in itself become a very valuable addition to our library.

About a year ago the Council received a communication from the Booksellers to the Academy, Messrs. Hodges and Smith, regarding the purchase of a collection of Irish Manuscripts in their possession. A Committee of Council, appointed for the purpose, reported that the Manuscripts were of much interest, and worth the price which Messrs. Hodges and Smith had set on them. The funds of the Academy did not, however, admit of the Council taking any direct steps for their purchase, but an application has been made, through his Excellency the Lord Lieutenant, for some assistance towards their purchase from the Government. His Excellency has expressed on this, as on all occasions, the greatest anxiety to advance the objects of the Academy, but as yet no final answer has been received from the heads of the Government in England.

The Library of the Academy has been increased during the past year, by numerous donations of scientific and literary works, for which, at the several meetings, thanks have been voted to the donors. An interchange of Transactions has been kept up with most of the eminent scientific institutions of Europe and America, there having been added during the past year:

The Academy of Sciences of Metz, the Royal Academy of Amsterdam, with whom we did not previously correspond, and the Museum du Jardin des Plantes, at Paris, the correspondence with which had been accidentally interrupted.

During the past year seventeen new members have been elected into the Academy. Their names are as follows, viz.:

George J. Allman, M.D.
Rev. Francis Crawford.
Henry Lindsay, Esq.
John M'Mullen, Esq.
Hon. and Very Rev. Henry Pakenham, Dean of St. Patrick's.
Goddard Richards, Esq.
John Wynne, Esq.
I. George Abeltshauser, A.B.
Rt. Hon. The Earl of Dunraven.
Matthew Dease, Esq.
William M'Dougall, Esq.
Sir Montague L. Chapman, Bart.
James H. Pickford, M.D.
Edward Bewley, M.D.
James S. Eiffe, Esq.
William Henry, Esq.
John Neville, Esq.

Out of our list of members we have to deplore the loss of several since the date of our last Report; most of them, certainly, persons whose energies, being devoted to other spheres, rendered their connexion with this Academy only nominal: but some, and especially one, whose connexion with us was of the closest and most endearing kind, whose scientific labours in various climates were of an extent and diversity which, while they created for him a distinguished reputation, unfortunately sapped the foundations of his health.

List of Members of the Royal Irish Academy deceased since the 16th of March, 1843.

Robert Bateson, Esq.
Thomas Coulter, M.D.
Right Hon. William Vesey Lord Fitzgerald and Vesci.
Arthur Hume, Esq.
Major-General Sir Joseph O'Halloran, K.C.B.
Rev. Thomas Prior, D.D.
Rt. Hon. John Radcliffe, LL.D.

Honorary Members deceased:

His Royal Highness the Duke of Sussex.
Professor Wallace.

Amongst the honorary members had been reckoned his Royal Highness the Duke of Sussex. His exalted rank removed him from in any way personally contributing to the advancement of knowledge, but he favoured its cultivation by his august patronage, and filled for many years the office of President of the Society of Arts, having a decided taste for practical mechanics, and leaving behind him, at his death, a very valuable and numerous collection of clocks and watches. In the year 1830 he was elected to the Presidency of the Royal Society of London, and was present at the meetings of that illustrious assemblage, whenever his health, which, unfortunately, was delicate, or the other demands upon his time, unavoidable from his exalted rank, admitted of his so doing. He was nominated an honorary member of this Academy, of course not for any special scientific merits, but that we might show some consonance of feeling with the scientific men of London who elected his Royal Highness to the most exalted scientific position of the British Empire, the chair of Newton.

Professor Wallace, of Edinburgh, was known to the mathematical world for various memoirs, into the details of which it is not necessary to enter. His works were not of a character to influence the progress of general science in any material degree, although they manifested powers of inquiry and analysis of a very creditable amount.

Of the ordinary members of the Academy whom we have lost during the past year, the Lord Fitzgerald and Vesci, the Right Hon. Judge Radcliffe, Arthur Hume, Esq., the Rev. Thomas Prior, D.D., and Major-General Sir Joseph O'Halloran, do not require special notice. They were all men publicly known, and recognized as of eminent ability in the various professional pursuits to which they had devoted themselves. Success of no ordinary kind was the result of their exertions, and has connected the names of some permanently with history. It can hence be understood that, except by a general desire to promote the objects of this Academy, by which, we trust, every member is actuated, they were not able to take any part in our proceedings.

We cannot, however, pass so briefly from the name of Robert Bateson, late M.P. for Derry. Separating himself from the whirl of merely trivial and political pursuits, to which young men of his age and station are unfortunately in this country almost exclusively devoted, he engaged in the cultivation of literature and antiquities with a zeal and ability which promised to bear the best fruit. The ancient monuments and history of his native country specially occupied his attention, but not exclusively; and whilst travelling in Palestine, for purposes of literary inquiry, amongst those scenes in which the most important acts of human history have been performed, he was seized with fever, and expired in Jerusalem.

The position which Dr. Coulter occupied in this Academy, in our University, and in science generally, rendered it the duty of the Council to prepare, with more than ordinary care, a sketch of his life and labours, such as might not be derogatory to his fame ; and, happily, the task was undertaken by one who, from long acquaintance and intimate friendship with the deceased, was enabled to speak minutely of his personal career ; and whose own extensive and profound acquaintance with almost every department of knowledge, which this Academy has had so often occasion to admire, enabled him to judge correctly of the aspects in which the labours of Doctor Coulter should be placed. The following biography of Doctor Coulter has been drawn up for this Report by the Rev. Dr. Robinson.

"It is an old saying, that science has its martyrs as well as religion ; we may add that it has its Forlorn-hope as well as war, urged to the adventure by loftier and nobler impulses, encountering in its pursuit even a greater amount of suffering and danger; but too often unnoticed and unrewarded. Its heroism is of too high an order to be appreciated by vulgar minds ; the wise and good, who alone value it, are comparatively few and powerless, and the triumphs which it achieves are not in unison with the evil tendencies and passions which unhappily predominate among mankind. Therefore it finds, in the Present, neglect, perhaps scorn or contemptuous pity of the folly which wasted on such unprofitable pursuits the powers that, if otherwise directed, might have commanded wealth, rank, and power. But the Present ere long becomes the Past ; all of its glittering array which is not based on the eternal and immutable principles of virtue and truth moulders to dust ; the stream of time in its flow washes all that is earthy from the ruin, and leaves in imperishable brightness the grains of gold and gem which it contained, the treasure of the Future. In this sacrifice of self to science, few have surpassed the associate, whose loss, during the last year, it is my painful duty to announce to you ; and a brief notice of his history may therefore be permitted.

"Thomas Coulter was born in 1793, near Dundalk. His parents died during his childhood, but the loss was in part supplied by the guardianship of a good and intelligent uncle. From an early age he was devoted to field sports, which he followed with a minute attention to the habits of his game, that belonged more to the naturalist than to the sportsman. Bees were another favourite object; and he possessed that remarkable power of handling these irritable insects with impunity, which attracted so much notice in Wildman and others. He had in after-life the same privilege as to serpents; of which some members may recollect an amusing exhibition in this room; his secret being the union of gentleness and courage.

"He was prepared for college by Dr. Neilson, the author of a well-known Irish Grammar, from whom, perhaps, he derived that intense interest in the antiquities of our native land, which characterized him to the last. One proof of it deserves to be recorded for example's sake. There stood on his property an ancient building, described in Wright's Louthiana, as a Ship Temple, which the tenant was converting into lime. The young landlord had him prosecuted and punished for the trespass, to the surprise of many who were in the practice of similar misdeeds. In the University he had the good fortune to be placed under the care of the late Dr. Lloyd, whose esteem and regard he possessed in a high degree; though the prevailing bias of his mind prevented him from equalling in mathematical attainments some of his fellow-pupils. He pursued that science only so far as it ministered to other objects. But in practical mechanics, in Chemistry, Physiology, and above all, in Entomology and Botany, he far outstripped his college contemporaries, and while yet an undergraduate, his collections of Irish insects and mosses were such as might have been owned with credit by a veteran. But his success made him only the more conscious of his deficiencies, and determined him to seek abroad the means of supplying them. Having spent one or two summers in Paris, where he made very extensive dried collections of the plants of the Jardin des Plantes, he established himself in 18—, at Geneva, where, under the auspices of De Candolle, he found all that he could desire. How well the three or four years which he spent there were employed, appears from the memoir on the Dipsaceæ, which he then published, and still more from his Herbarium, of which the European part was then formed, and compared with De Candolle's own collection; a work, which when considered as the result of almost unaided individual exertion, may well be called gigantic.* The consciousness of power excited him to enterprize, and on his return from the Continent, in 1824, he arranged an expedition to explore a considerable portion of America. His intention was to commence at Buenos Ayres, cross the great plains to Mendoza and Chili, to explore the western side of the Cordilleras, and the Lake of Titicaca; thence to California, and to return by Mexico, or by the Columbia river and Canada. For this he had actually made arrangements, and it is to be regretted that he did not execute it. He had every requisite for success among half civilized or savage races: a noble and commanding person; great stature, strength, and dexterity in the use of arms; good temper, courage, and presence of mind: a combination of qualities, which Bruce only, of modern travellers, possessed in the same degree, while he was far behind him in practical science.

"He was, however, induced to change part of his plan, and commence with Mexico, engaging as medical attendant to the establishment of the Real del Montè Mining Company for three years, during which time he hoped to complete the Mexican Flora, and afterwards to resume his original design.†

"But in that unhappy country, there was found neither probity nor peace. The English companies were regarded as legitimate objects of plunder, and several of those whom they employed retired in sickness or despair from their posts.

"Under such circumstances he felt himself called to go beyond his peculiar duty, and undertook the charge of one of the company's principal mines, the Veta Grande, though such work was entirely new

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* His Herbarium (including the Mexican and Californian plants), contains about 150,000 specimens.

† "While in Mexico he collected, at a very great expense, plants of seventy species and varieties of Cacti, and sent them to the late Provost, the Rev. Dr. Lloyd, then Bursar, to be presented to the College for their botanic garden. He sent, at the same time, a similar collection to his friend, the late Professor De Candolle, for the Geneva Botanic Garden. Many of them were then very valuable, and unknown in European collections. One of them, a fine tall-growing species, has been named *Cereus Coulteri*, and may now be seen, as well as other interesting species, in the College Botanic Garden.

to him; he, however, soon acquired the necessary knowledge, and under his management the concern became productive. This measure was fortunate for his employers, but not for himself. It distracted his attention from his primary object, detained him for more than a year in a district barren and uninteresting to the botanist, and, above all, mixed him up with the cabals and personal feelings which seem inseparable from such corporate bodies, and in which the high-minded and open-hearted always have the worst. At the close of his engagement he passed to California, where, and in Sonora, he spent four years, always actively employed on his primary objects,* and involved in spirit-stirring adventure; at times exposed to the Indian arrows, or compelled to defend his countrymen from the attacks of revolutionary patriots; exploring a burning waste of sand, when the thermometer reached 140, or nearly perishing by the bites of poisonous but almost invisible insects. At one time his metallurgic skill had acquired for him considerable wealth, which, during a botanical excursion, was plundered in some political convulsion.

"The industry and energy with which he carried on his botanical inquiries, is abundantly shewn by the fact, that the herbarium which he collected under such circumstances contains upwards of 50,000 specimens of 10,000 to 11,000 species, the far greater proportion of which was collected and preserved by himself; and that in connexion with the herbarium he had gathered specimens about the size of a 16mo. book of nearly 1,000 descriptions of woods, most, if not all of which are accompanied by dried specimens of the foliage and inflorescence

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* "One of his most interesting discoveries in California is a tall-growing pine, having cones a foot or more in length, and six inches in diameter. This has been named by the late Professor Don, at the desire of Mr. Lambert, *Pinus Coulteri*. It is quite hardy, and plants of it may now be seen in various collections in England and Ireland. It was found in the mountains of Santa Lucia, near the mission of San Antonio, in lat. 36°, within sight of the sea, and at an elevation of 3,000 or 4,000 feet above its level, growing intermixed with another fine species, Pinus Lambertiana, also introduced, and rising to the height of from 80 to 100 feet, with large permanent spreading branches, and a trunk three or four feet in diameter. There are two small plants of it in the College Botanic Garden, and the cones may be seen in the College Herbarium."

of the trees from which they were taken; the whole gathered by himself, and being, perhaps, the largest collection of this particular kind ever made by any unaided individual.

"At the end of this period he returned to Europe with an immense increase to his collection, but with a constitution irreparably injured by the hardships which he had encountered; and even at home he was destined to meet a severe loss. In the transport from London to Dublin, a case containing his botanical manuscripts, and the materials of a personal narrative, disappeared, and could never be traced; so that of the latter, nothing remains except a brief account of Upper California, published in the 5th volume of the Journal of the Geographical Society, and the former are totally lost, except some communications to De Candolle and Lambert. After this his chief anxiety was to secure the herbarium, which had cost him so much, from dispersion or neglect; and in this at least he was not disappointed. It has become the property of our University, and the task of arranging it was the employment of his few remaining years, which were devoted to that work with a concentrated energy that shewed his consciousness of his days being numbered. It was completed for the European part, and about 8,000 of the American specimens; but the remaining packages are well furnished with memoranda, so that for them also the arrangement is practicable. That the possession of this invaluable treasure must give a powerful impulse to the study of Botany among us is sufficiently obvious; but it is doubly interesting to a scientific body like this, as an evidence of the increasing importance attached to the study of Natural History in the highest and most influential quarter. That important branch of knowledge has hitherto been too much neglected in university education; but better prospects are opening; and to this the influence of one so good and highly gifted as Dr. Coulter seems mainly to have contributed. Should our hopes be realised, there is no doubt that he would have regarded it as an ample compensation for all his sufferings."

The ballot for the annual election having closed, the Scrutineers reported that the following gentlemen were elected Officers and Council for the ensuing year:

President—Sir William Rowan Hamilton, LL. D.

Treasurer—James Pim, Jun., Esq.

Secretary to the Academy—James Mac Cullagh, LL. D.

Secretary to the Council—Robert Kane, M. D.

Secretary of Foreign Correspondence—Rev. Humphrey Lloyd, D. D.

Librarian—Rev. W. H. Drummond, D. D.

Clerk and Assistant Librarian—Edward Clibborn.

Committee of Science.

Rev. Franc Sadleir, D. D., Provost of Trinity College; Rev. Humphrey Lloyd, D. D.; James Apjohn, M. D.; James Mac Cullagh, LL. D.; Robert Ball, Esq.; Robert Kane, M. D.; G. J. Allman, M. B.

Committee of Polite Literature.

His Grace the Archbishop of Dublin; Samuel Litton, M. D.; Rev. William Hamilton Drummond, D. D.; Rev. Charles Graves, A. M.; Rev. Charles W. Wall, D. D; John Anster, LL. D.; Rev. S. Butcher, A. M.

Committee of Antiquities.

George Petrie, Esq.; Rev. James H. Todd, D. D.; Henry J. Monck Mason, LL. D; Samuel Ferguson, Esq.; J. Huband Smith, A. M.; James Pim, Jun., Esq.; Captain Larcom, R. E.

The President then appointed, under his hand and seal, the following Vice-Presidents:

The Rev. James Henthorn Todd, D. D.; James Apjohn, M. D.; the Rev. Charles W. Wall, D. D.; and George Petrie, Esq.

The Auditors appointed by Council to examine the Treasurer's accounts reported as follows:

"We have examined the above Account,* with the vouchers produced, and have found it to be correct; and we find that there is a balance in bank, amounting to £203 18*s.* 3*d.*, sterling, and in the Treasurer's hands, 6*s.* 1½*d.*"

"(Signed,)

"JOSEPH CARSON.

"THOMAS A. LARCOM."

"*March* 15*th*, 1844."

"The Treasurer reports, that there is £1117 10*s.* 10*d.* in 3 per Cent. Consols, and £1643 19*s.* 6*d.* in 3½ per Cent. Stock, the latter known as the Cunningham Fund. He also reports that there are due this 16th March, 1844:

2 Entrance fees, at £5 5*s.* per				£10	10	0
6 Arrears of two years, at £4 4*s.* per				25	4	0
25 Do. one year, . £2 2*s.* per . . .				52	10	0
170 Subscriptions for the past year, now due, at £2 2*s.* per				357	0	0
Balance unappropriated in the Bank of Ireland,	£203	18	3			
Balance in Treasurer's hands, . .	0	6	1½	£204	4	4½
				£649	8	4½

"Signed for JAMES PIM, Jun., *Treasurer.*

"EDWARD CLIBBORN, *Clerk, &c.*"

April 8.

JAMES APJOHN, M. D., Vice-President, in the Chair.

The Marquis of Kildare and William Smith O'Brien, Esq., M. P., were elected Members of the Academy; and

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* Entered in Treasurer's book.

Robert Ball, Esq., was elected Treasurer of the Academy, in the room of James Pim, Jun., Esq., who resigned.

Dr. Apjohn read a paper by Mr. Thomas Knox, "On the Purification and Ventilation of Vessels from bad Air."

In reperusing lately Professor Daniell's interesting researches* "on the spontaneous evolution of sulphuretted hydrogen in the waters of the western coast of Africa and of other localities," a method occurred to me of purifying the cabins of vessels, and the sleeping apartments in houses, which would be as efficacious as Professor Daniell's, without being liable to the objection of having free chlorine always present producing its enervating effects.

The method I propose is this: to have air pumped through tubes extending from the steam engine to the cabins. The extremities of the tubes should dip into vessels containing solutions of chlorine or metallic solutions; the last solution, being of lead, would indicate when the solutions were to be renewed, by the black precipitate of sulphuret of lead. At the further end or top of the cabins there should be corresponding tubes to allow the foul air to be removed; these latter would be unnecessary when there was a fire, the draft being sufficient to remove the foul air.

As we can absorb or destroy all vapours, miasma, &c., this method would apply to all unhealthy regions of the world, and would render habitable parts of the world which at present lie deserted and waste. Sierra Leone would cease to be the grave of Europeans, and the Pontine Marshes would no longer exhibit a ghostlike peasantry.

EXPERIMENTS.

Chambers made of wood, with air-tight windows, having apertures in the sides, into which the tubes would fit, could

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* Phil. Mag., July, 1841.

be made at little expense, and sent to Sierra Leone and the Pontine Marshes; in the latter place the pumps might be worked by water conveyed from the mountains or other cheap motive power.

Dr. Apjohn read a paper "On the hygrometric Correction in barometric Formulæ for the Measurements of Heights.

If the atmosphere were of one uniform temperature throughout, destitute of moisture, or in a constant hygrometric condition, and if the intensity of gravity were also constant, it is well known that the difference of the altitude of any two points in the atmosphere would be represented correctly by the formula $\text{D} = m \times \log. \frac{p}{p'}$, m being a constant quantity, and p and p' being the respective pressures at the lower and upper stations, as measured by the barometer, or in any other way. A correction for temperature has been long applied by augmenting or diminishing the approximate height, or $m \times \log. \frac{p}{p'}$, by the amount that a column of air of this length would expand or contract if its temperature were changed from 32° to $\frac{t + \theta}{2}$, t being the temperature of the lower, and θ that of the upper extremity of the ærial column, by which the expression becomes

$$\text{D} = m \times \log. \frac{p}{p'} \times \left(1 + \frac{\frac{t+\theta}{2} - 32}{493}\right).$$

Such is, I believe, a correct account of the present form of the barometric formula, at least when we neglect the correction for variations of gravity, which is, however, in general so small as to be safely negligible. The presence of moisture in the air, or rather its varying amount, must obviously exercise some disturbing effect on this formula; but though this has been generally admitted by those who have turned their attention to the subject, I am not aware that any attempt at estimating its exact amount has been as yet made; and as the correction for moisture is frequently of considerable magnitude, and may, in my opinion, be applied with as much accuracy as that for temperature, I have taken the liberty of occupying, for a few moments, the time of the Academy with an explanation of the method which it has occurred to me to devise, and with which, from some trials I have made of it, I have every reason to be satisfied.

Let p be the pressure, and t the temperature of the air at the lower station, t'' the dew point of the air, and f'' the force of the included vapour ; and let p', θ, θ'' and F'' represent the corresponding quantities at the upper station. This being understood, a little consideration will suffice to shew that the presence of the aqueous vapour produces on the formula a twofold deranging effect. It augments the values of p and p' beyond what they would be in dry air, and it produces an alteration in the length of the column of air between the two stations additional to that which results from the difference between its mean temperature and 32°, or the freezing point. The first of these is obviated, or, in other words, the correction for it is made, by substituting for p and p' in the approximate formula, $p - f''$ and $p' - \mathrm{F}''$, by which it becomes

$$\mathrm{D} = m \times \log. \frac{p - f''}{p' - \mathrm{F}''}.$$

Having thus eliminated the effects of the tension of aqueous vapour upon the pressures, we have next to estimate the conjoint influence of it and temperature, in elongating the pillar of air between the two stations. The theory of mixed gases and vapours enables us to do this, provided we can assign proper mean values to the temperature, the pressure, and the force of vapour of the aerial column in question. The mean temperature its usually taken as $\frac{t+\theta}{2}$, and this must be very nearly its true value. For the same reason, the mean force of vapours may be set down as $\frac{f''+F''}{2}$; and let us assume the mean value belonging to the pressure as

$$\sqrt{(p-f'')\times(p'-F'')}.$$

Now a volume v of dry air at 32° under a pressure π, if raised to a temperature t'', becomes

$$v \times \frac{461+t''}{493};$$

and if saturated with vapour at this temperature, the tension of such vapour being s'', it will become

$$v \times \frac{461+t''}{493} \times \frac{\pi}{\pi - s''}.$$

This is the volume of the air when raised to t'' and saturated with vapour at this temperature; and if this volume of air have its temperature further changed, we shall say to t, then its bulk will be represented by the expression

$$v \times \frac{461+t''}{493} \times \frac{\pi}{\pi-s''} \times \frac{461 \pm t}{461+t''} = v \times \frac{461 \pm t}{493} \times \frac{\pi}{\pi-s''};$$

substituting, then, in this expression instead of v the value of the length of the column of air between the two stations supposed dry, and at 32°, viz.:

$$m \times \log.\frac{p-f''}{p'-F''},$$

and for π, t, and s'' their proper mean values as already explained, the barometric formula finally becomes

$$D = m \times \log.\frac{p-f''}{p'-F''} \times \frac{461 \pm \frac{(t+\theta)}{2}}{493} \times \frac{\sqrt{(p-f'')\times(p'-F'')}}{\sqrt{(p-f'')\times(p'-F'')} - \frac{1}{2}(f''+F'')}.$$

I may add here, that the correction for moisture is far from being insignificant in its amount, as may be seen by the following example. Let us suppose, that when the approximate height, corrected for temperature, amounts to 2700 feet (a height reached by several of our Irish mountains), the mean value of π, or the pressure to be used in the final factor of the formula, is 27.3, and of the force of vapour, 0.3 of an inch, its value when the dew point is 43.6, then the elongation of the aerial column resulting from moisture is $\frac{3}{270} = \frac{1}{90}$th of $2700 = 30$ feet. It will, of course, have been observed that the correction for aqueous vapour differs from that for temperature in the circumstance of being always positive ; and this coincides perfectly with the observation I have had frequent occasion of making, namely, that in damp states of the atmosphere heights calculated by the formulæ in general use are all appreciably less than the truth.

And here I may be permitted to observe, that the great Laplace, in discussing the barometric formula, in his "Système du Monde," has fallen into a slight oversight; for as a rude method of compensating for the effect of the aqueous vapour present in the atmosphere, he proposes, that in applying the correction for temperature the coefficient of the expansion of gases should be augmented from .00375, its value for one degree Centigrade, to .004. Now this would certainly produce the desired effect at all temperatures above 32°; but as below 32° this equation is subtractive, the augmentation of the coefficient, instead of diminishing, would increase the error. The following is the passage referred to:

"Les vapeurs aqueuses répandues dans l'atmosphère, etant moins denses que l'air, à la même pression et a la même temperature, elles diminuent la densité de l'atmosphère; et comme, tout étant égal d'ailleurs, elles sont plus abondantes dans les grandes chaleurs; on y aura égard en partie, en augmentant un peu le nombre .00375 qui exprime la dilatation de l'air pour chaque degré du thermomètre. Je trouve que l'on satisfait assez bien a l'ensemble des observations, en le portant a 0,004; on pourra donc fair usage de ce dernier nombre, du moins jusq'à ce que l'on soit parvenu par une longue suite d'observations sur l'hygromètre, à introduire cet instrument dans la mesure des hauteurs par le baromètre."*

I may in conclusion observe, that in assuming, with the view of calculating the expansion produced by moisture, that the pressure to be employed is the geometric mean of the corrected pressures given by the barometer at the two stations, I am quite aware that I am assigning to it but an approximate value. An exact expression for the pressure to be employed admits of being investigated;† but its introduction into the formula, while it would give the latter complexity of form, and thus render it less suited for practical use, would conduct to results not appreciably different from those given by the more simple methods just explained.

Mr. Clibborn presented to the Academy an ancient stone image, called in some places a Shela-na-gig; and read the following extract from a letter from Dr. Charles Halpin:

"About two years ago, as I drove past the *old grave-yard* of Lavey Church, I discovered this curious figure, laid loosely, in a half reclining position, on the top of a gate pier that had been built recently, to hang a gate upon, at the ancient entrance of the old church-yard. I believe the stones used in building those piers were taken from the ruins of

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* Systeme du Monde, p. 89.

† Let $\dfrac{\log.\frac{p}{p'}}{\mathrm{M}\left(\frac{1}{p'}-\frac{1}{p}\right)}$, M being the modulus of the common system of logarithms, $=\mathrm{P}$. Then if v be the column of dry air, and that, when saturated with moisture whose force is f, it becomes v', we will have

$$v'=v\times\frac{\mathrm{P}}{\mathrm{P}-f}.$$

For the very elegant expression for P I am indebted to my friend, Professor Renny.

the old church of Lavey (there is scarcely a trace of the old church on the site it occupied); and I think probable, that this figure was found amongst them, and laid in the position in which I found it, by the masons employed at the work. I was not aware of its real value, until apprised of it by my brother, the Rev. N. J. Halpin. He immediately recognized it as a 'Sheela-na-gig,' and the most perfect of any he had seen. I thought it my duty to protect this precious relic from the hammer.

"Lavey church lies about fifty miles north-west of Dublin, on the mail-coach road. There is a neat new church near the site of the old one."

Mr. Petrie having expressed a desire that some further information should be given about this figure, and others, of the same kind, of which, he understood, there were two in the museum of the Academy, which had belonged to the late Dean Dawson:

Mr. Clibborn explained that he had received notices or outlines of ten other figures, of the same kind, which had been found in old churches and castles, and from their position in the walls, sometimes hid in the course, and from the difference of the stone, it was probable they had been used in older buildings, so that their actual antiquity could not be determined by the age of the buildings in which they had been found. From the form of the stones on which several of these figures were carved, it was surmised that some of them had been originally used as grave-stones, and probably intended to act as charms to avert the evil eye, or its influence, from the place. These figures have a great similitude to others used elsewhere for this purpose formerly, as well as at present, by the natives of the east coast of Africa.

He also explained that, about five years ago, when, in company with several advocates of the O'Brien theory of the Round Towers of Ireland, he was led to express an opinion that, possibly, these buildings, though erected subsequently to the introduction of *nominal* Christianity into Ireland, might still have, to a certain extent, some analogies to views entertained by the African and Asiatic ascetics, and which might have been imported into Ireland by the first Christians, in the third century; who, if from Africa or Spain, may have brought with them more or less of Gnosticism (or views analogous to it), and with it notions and practices not very unlike, apparently the same originally with those, by which the author above-mentioned endeavoured to explain the nature and origin of the Round Towers. The first nominal Christians, if he had been correctly informed, who came to Ireland, were lay ascetics;* and, like the ascetics of Egypt and the East, they selected secluded valleys in the mountains, or islands in lakes, where they gave themselves up to those penitential observances calculated, according to their views, to destroy the "Hylic, or material," to humble and conquer the "psychic, or animal," and to elevate and cultivate the "pneumatic, or spiritual," principle of their natures.

It was argued that, if the tower was the residence of the Irish ascetics during their lives, it may have been considered the type of the *plus*, male, "pneumatic," or spiritual principle; and so the earth, grave, crypt, or church near it, in which were deposited the bodies, or material principles of the deceased, originally derived from mother earth, may have been considered the type of the negative female, hylic, or material principle, and have been considered analogous to Ge, or De-meter, to whom the body of the dead returned, by interment; and, hence, it was argued that, if O'Brien's theory were true in this qualified sense, it should apply to the churches or graves near the towers or residences of the ascetics, where we should find types or indications of the negative principle. Mr. R. P. Collis, who was present, im-

* See Moore's Hist. p. 221. The extract from St. Patrick's letter: "ubi nunquam pervenerat qui baptizaret, aut clericos ordinaret, aut populos consummaret."

mediately mentioned the female figure at Rochestown, and stated that he had heard of several others in the same neighbourhood, and he recommended an inquiry into the subject, which led to the discovery of several more figures of the same kind in different places.

The "hylic principle," including the materials composing the body, was little more than the *locus, where the battle of the two other principles was fought during the life of the ascetic;** and if he persevered to death in the practices prescribed for the evolution of the pneumatic principle, and lost his life in these observances, or in the fulfilment of the duties which belonged to this system, his victory over the hylic or psychic principles was complete, and he was said to have arrived at " perfect virtue," and consequently became, according to Asiatic views, an inferior, or little Bauddha, which *may, possibly*, give us an original of the name of Monasterboyse; in Irish, the monastery of *Boaithin*, or the little Bauddha. The legend of St. Colum Cille, who struck his crosier against the glass ladder, by which he went to heaven, which belongs to this place, and which strongly corroborates a Ceylonese legend, increases the suspicion, that the system which was called here Christian, originally may have been analogous to that ascetic system which existed under the same name in Egypt and the East, and was closely allied to Bauddhism, which was, and is, a system of Asceticism,† and

* This doctrine is the same, or nearly the same, as that which is called Dualism, which attributes creation and life to the action and reaction of two principles, *plus* and *minus*, or positive and negative, which were personified by the ancients under every species of antagonism. The fighting dogs and serpents of the Irish are, apparently, manifestations of it, applied specially to the daily strife, or " cross," of these two principles in the body of the ascetic.

† When O'Brien's book was written our knowledge of the Bauddist system was very limited. Now its antiquity, history, principles, and corruptions, are better understood, through the labours of Mr. Princep, Fa-hian's Travels, The Mahavansa, &c.

mixed up with more or less pure Gnosticism; for, "the greatest part of the Gnostics adopted very austere rules of life, recommended rigorous abstinence, and prescribed severe bodily mortifications, with the view of purifying and exalting the mind," like the Irish ascetics. "These tenets were *revived* in Spain, in the fourth century, by a sect called Priscillianists," where they may have been, to a certain degree, suppressed by the instrumentality of missionaries and seculars from Rome. The same system which existed in Spain previously, and which planted those views there afterwards, may have also planted them here; and the same means which suppressed them there for a time, may have here suppressed them; or there may have been, to a certain degree, for several centuries, a compromise between the advocates of both systems, and that which was finally adopted here, and called Christianity, may have, in a covert way, contained much Gnosticism, particularly that branch of it which was adopted by the ascetics, or Culdees, and small religious communities, and by whom the first towers may have been originally built.* It is a curious circumstance, not hitherto noticed by any writer on the Round Towers, that the technical term for a Bauddist monastery in the East, is a *tower;* no matter whether it be a cave in the earth, or a cabin or palace on its surface.

We may add to these notices another notion of the

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* The following extract, from the very old Irish MS. called the Speckled Book, in the Academy, will explain and confirm what I have stated concerning Irish asceticism: "When, then, said St. Bartholomew, the Son of God was born, he was tempted by the Devil, but Christ overcame, by fastings in the wilderness, him who overcame Adam, in Paradise, through gluttony; for it was meet that Christ, the son of the Virgin, should overpower him who overpowered Adam, the son of the virgin, i.e. *the son of holy earth;* for the (mother) earth of which Adam was formed was virgin, because it had not then been polluted by iron, nor by the blood of man, nor had it been opened for the interment of man in it at that time."

Gnostics, which was, "that malevolent genii presided in nature, and occasioned diseases and calamities, wars, and desolations; induced them to apply themselves to the study of magic, in order to weaken the powers, or suspend the influence, of these malignant agents." This doctrine of their's was, no doubt, extended and carried out fully in every mode and form, and led them to consider themselves, and all things living on the earth, to be under the influence and subject to the evils caused by the instrumentality of these evil genii, who, in some cases, attached themselves to individuals, who were then said to have the evil eye, or who became afflicted with what is termed "covetousness," which blasted everything which they desired, and made it unlucky; and its possessor was shunned and avoided, as he was subject to that malign influence which is technically termed the "evil eye." This influence was greatly dreaded by the living, for themselves, their children, cattle, and goods, and their houses; and in many places, even now, people put up over their doors, over their hearths, and in many other places, talismans, to give them good luck, or to take away or neutralize the evil look, which brings them bad luck, by averting the evil eye, also considered to be a distinct individuality, or genius. The term "good look," or "luck," is incorporated into the English language, though the belief of the evil eye is nearly lost in England, where it was universal. It still exists in Scotland, and we find it also in Ireland, where various methods are still practised to avert its influence from children, cattle, churns of milk, houses, &c.

One of the most efficacious is the horse shoe, which is called "the lucky horse-shoe" for this reason, and it is nailed to doors and gateways for luck, by people who have no notion that they are, probably, putting up equivalents for those hideous figures which the people call shela-na-gigs, one of which was lately discovered at Kiltynan Castle, by

Mr. Thomas Oldham, which held the lucky horse-shoe in one hand, and a cross, or dagger, in the other.

The horse-shoe, and the triangle, Δ, or ח, &c., and the trefoil, are all, apparently, emblems for the same antidote, which the evil eye abhors, and by which the mechanic's wife was not only able to identify the evil genius himself, but to eject him from her house, and save her husband's body and soul, the stake which he proposed to play for. In this country the peasantry are said to entertain similar notions of the great efficacy of the same means, which is said to be "capable of driving the Devil away," the use for which, it is surmised, these figures were intended.

Mr. William Hackett, the moment he saw a drawing of one of the figures, declared it was a "fetish;" the African name of a figure which closely resembles the shela-na-gigs, and is commonly used for the purpose of averting the evil eye, and giving good luck. On the north coast of Africa certain emblems, carved in stone, are placed over the doors for this purpose; and formerly it would appear that certain parts of animals were used instead. In Italy the peasantry, in the neighbourhood of Naples, have a complete system "of magic" for averting the evil-eye, which consists, to a great extent, of exposures and practices, which are compared to the ancient orgies, and calculated to eject or avert the evil eye, or *genius*, from a place, and drive him and his colleagues, and their influence, beyond certain limits.

These figures were, probably, intended as *fetishes*, or charms, to keep off the evil eye, or its influence; and, consequently, they are found placed over doors of churches and castles, &c. In many instances they are evidently much older, and of a totally different material and style of art, to the building in which they are found. The workmanship is quite unequal, and the style of the figures differ very much. They are not copies of a common original, but, generally, the most hideous and frightful-looking female figure which the stonecutter could devise. There is, however, in the best sculptured figures a certain expression of countenance which resembles that of death. In these the hair is very long, and there is no appearance of the tonsure, which occurs in others. The former have a strong resemblance to a Mithraic figure, published in the Archæologia, XIX. p. 74, and also to another figure, in Ingrami "Monumenti Etruschi," T. 3, Tav. XXIII. Both of these, it is thought, were also used as *fetishes*, or figures intended to drive away the evil influence, and obtain good luck instead.

The hair of some of the figures appears to be intended to represent a peculiar tonsure, and the persons of women represented are apparently attenuated by fasting and that course of life which the Gnostics and ascetics so strongly insisted on, as the means of gaining the victory over the hylic or psychic (together, the evil principle) in themselves, and what St. Bridget so ably contended for in herself, and those who placed themselves under her rules. In these almost skeleton figures we have an analogy between the *rule* of abstinence of the Gnostics, and also their notion about amulets, abraxes, fetishes, and the evil genius; and hence the probability, that the use to which they have been assigned is the correct one, independent of any other considerations which arise from the practices now said to be efficacious in Ireland, &c., in ejecting the evil genius, or averting the evil eye; and which formerly, as well as at present, were common in Africa, Italy, Spain, Ireland, &c.

With the ancient Egyptians the *crux ansata* appears to have been the great emblem of good luck, prosperity, and soforth. It appears to have been the antidote to the evil eye which we find mentioned in Prov. xxiii. 6, and xxviii. 22, and the Gnostics and early Egyptian Christians appear to have adopted it, without any alteration or change in its form from that used by the old Egyptians. The *crux ansata* appears to have been a substitute for the gesture called the *fico* of the ancient Romans and modern Neapolitans, which combined the Dualism, or positive and negative principle. It is still used, according to the Canon De Jorio, when a lay Neapolitan wishes another good luck, when he is going on an expedition, &c. And we find the *fico*, combined with other emblems into the form of the *crux ansata*, in the museum at Naples, where there are many examples analogous to many Gnostic emblems, which are well known; some of which have been published by the Rev. Dr. Walsh. One found in the baggage of Prince Charles Edward, after the battle of Culloden, has on it a woman, in a better style of art than that of the shela-na-gigs; but, probably, intended for the same purpose, "*as a charm*" to avert the evil eye, and gain the good luck instead.

The crosses which are placed round certain enclosures in Ireland, and act as *termini*, or boundary marks, had probably the same use formerly, to keep off the evil-eye and its influence from the enclosure, so that the sleep of the dead might not be disturbed; hence the request to pray for the repose of the soul of Bran, on the tombstone in the museum, and the usual "may he rest in peace"; terms calculated to neutralise the disturbing influence of the evil-eye principle. In Asia and Africa things owned by individuals are frequently *tabooed*, or marked with the cross, or circle, crescent, or both combined, which, it is believed, protects them from the evil-eye, and consequently from being coveted by people, or rendered unlucky. This practice, or the notions which caused it, appears to be almost as old as man himself, and is found incorporated into the language, and occupying a greater or less proportion of the popular belief in every country. The pattern which composes the tracery on our cross of Cong, and other old Irish shrines, reliquaries, and the tomb at Cashel, which represents an animal like a dog or serpent always worrying itself, or another creature of the same kind, may probably be a type of the doctrine of abstinence or mortification of the flesh,* which to the ascetic was his daily cross, and antidote to the hylic or evil principle, which he considered himself bound to bear, and which his master before him had borne victorious to death, and by which he became exalted to the highest rank in heaven, consistent with our extract from the Irish MS., in which we find at least one of the doctrines mentioned, which the ascetics magnified into a constant rule of life, and made it the means of conquering the evil principle in themselves, to which these figures, it is thought, may have been charms or external antidotes, like the cross and bells, &c., which they ornament, which are covered with dog and knotted serpent patterns, crossing each other continually, and supposed to be emblematic of the ascetic principle, or daily cross, and antidotes of the evil eye or principle. By this rule the stone in the museum presented by Mr. Webber, which apparently represents two dogs fighting, may have been an ingenious device to hide from common eyes, but to exhibit this principle where it would be understood, instead of a shela-na-gig of the common form, and so it may have been intended originally as a *fetish* or charm to the house or castle from whence it was removed. Besides the three figures now in the Museum, I have been informed of the existence of many

* The emblem, or device, for Christianity on the Roman medals, given by the Rev. Dr. Walsh, is analogous to the monstrous figures of the double dog and serpent patterns referred to, which, it is surmised, may be emblems of the ascetic principle. He observes: "It may be that Dioclesian wished to represent only the depraved and corrupt sectarians, of which this figure (*in his plate*) is the emblem; and that his more atrocious colleague, careless of distinction, exhibited the genius of Christianity, under any form, as equally the object of his persecution." There is a figure called the Idol, at Cashel, with fish-tail extremities, with a face like the shela-na-gig presented by Mr. Halpin. It appears to connect, or identify, the designs on the Roman medals with those Irish figures.

Shela-na-gigs in different parts of Ireland ; but have received drawings and exact descriptions of five others only.

1. The first discovered and described by Mr. R. P. Collis. It is in the gable of an old church at Rochestown, County Tipperary. This figure is called a Shela-na-gig, by the country people, and as it was the first found it has supplied the name to all the others.

2. In the church at Dowth there is a Shela-na-gig, carved in stone quite different to that which composes the walls of the church. This figure appears to have been originally a head or foot-stone of a grave. It was said to be a figure of St. Shanahan, by the person who shewed me the place. At Lusk there was a figure called the Idol, which was buried by the late Rev. Mr. Tyrrell. It appears to have been a Shela-na-gig also.

3. Found over the door of the keep of Ballinahinch Castle, near Cashel. In this figure there is an appearance of the tonsure. It was the opinion of the person who examined it, that it had been inserted in the wall, and might have been taken from the ruins of the church, which are quite near the Castle.

4. Found in the south front of Moykarkey Castle, County Tipperary. This figure has a more finished and modern air than any other of which I have drawings. The country people have a legend, and call it Cathleen Owen.* It also appears inserted into the wall, and there is a ruin of a church quite near, from whence it might have been procured, to bring ' luck about the house."

5. Found in the wall of the old church on the White Island, Lough Erne, in the demesne of Colonel Archdall. This figure occurs lying on its side, and is in the course low down near the door, and appears to have been a part of the

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* This legend may be equally authentic as that about the dog and wolf stone, presented by Mr. Webber.

materials of an older building, which were used in the building of the church now in ruins. In the same way one of the figures in the Museum, from the Dawson collection, appears to have been built into the wall of the church where it was found. Under such circumstances, the actual antiquity of these curious figures is quite problematical. The subject is a new one, and well deserving of the attention of antiquaries, to whom this notice is submitted more as a suggestion for consideration than as an opinion. The number of facts known are few, and probably it may be premature to attempt a generalization.

April 22.

SIR Wm. R. HAMILTON, LL. D., President, in the Chair.

Read,—a letter from the Secretary of the Lord Lieutenant, presenting to the Academy the stones containing the inscription from the old bridge of Athlone.

Resolved,—That the thanks of the Academy be given to His Excellency the Lord Lieutenant for his donation.

The Rev. Professor Graves read a paper on the Algebraic Geometry of Curves traced upon given Surfaces.

Let $\text{U} = \phi\,(x, y, z) = 0$ be the equation of a surface referred to ordinary rectangular coordinates. Its complete differential will be

$$\text{P}dx + \text{Q}dy + \text{R}dz = 0.$$

Making

$$\text{X} = \frac{\text{P}}{\text{R}}, \text{ and } \text{Y} = \frac{\text{Q}}{\text{R}},$$

Mr. Graves denominates X and Y the *normal coordinates* of a point on the surface. When they are known, the x, y, z of the point are determined by the three equations

$$\text{U} = 0, \frac{\text{P}}{\text{R}} = \text{X}, \text{ and } \frac{\text{Q}}{\text{R}} = \text{Y}.$$

As P, Q, R, are proportional to the cosines of the angles which the normal at the point (X, Y) makes with the axes; it is easy to shew that if we describe a sphere with its centre at the origin and radius $= 1$, X and Y will be at the same time the rectangular spherical coordinates of that point on the sphere at which the tangent plane is parallel to the plane touching the surface $\text{U}=\text{o}$ at the point (X, Y). Thus, to every point on the latter corresponds a point on the former: and a succession of points, or a line of any kind, on the surface $\text{U}=\text{o}$ is in general represented by a succession of points, or a line upon the auxiliary sphere.

As plane curves have been classed according to the degrees of the equations by which they are represented, so curves traced on any given surface may be advantageously distinguished by the degrees of the equations in X and Y which define them. For the properties of a curve, traced on the surface $\text{U}=\text{o}$, and characterized by an equation of the *n*th degree between X and Y, are, so far as we regard only the relations of normals or tangent planes along it, identically the same as those of the spherical curve which has the same equation. But the analogy between spherical and plane curves of the *n*th degree has been already established. Instead, then, of looking upon the *shortest lines* on a surface as analogous to the right line, Mr. Graves directs his attention to the line defined by the equation

$$a\text{X} + b\text{Y} + 1 = 0, \qquad \text{(A)}$$

the geometrical character of which is, that the normal at any point on it is always parallel to a fixed plane. Systems of such lines upon any surface possess, in general, those properties of right lines which have been termed *projective*.

Thus, for instance: "If four lines of the first degree, diverging from the same point on a given surface, be cut in four points, a, b, c, d, by another line of the same kind, we shall have

$$\frac{\sin[a, d] \cdot \sin[b, c]}{\sin[a, b] \cdot \sin[c, d]} = \text{a constant,"}$$

$[a, b]$ being used to denote the angle between the normals to the surface at the points a and b.

The normals along the line (A) are all parallel to the tangent plane at the point whose normal coordinates are a and b. Mr. Graves designates this point *the pole* of the line. And if a and b be connected by an equation, so that the pole describes some curve of the nth degree, the line (A) will always touch another curve to which n tangent lines of the first degree may in general be drawn from the same point. This relation between the curves being obviously reciprocal, Mr. Graves calls them *reciprocal curves*. Here is laid the foundation of a theory of polar reciprocals for curves traced upon any given surface.

Amongst other exemplifications of this method, Mr. Graves employs it to discuss the lines of greatest and least curvature on the surface of an ellipsoid. Their equation in normal coordinates is

$$\frac{a^2}{(a^2 - k^2)} \mathrm{X}^2 + \frac{b^2}{(b^2 - k^2)} \mathrm{Y}^2 + \frac{c^2}{c^2 - k^2} = 0,$$

where a^2, b^2, c^2 are the squares of the semi-axes of the ellipsoid, and k^2 is indeterminate.

Now, from the mere fact of this equation being of the second degree, it follows that the sum or difference of the angles between the tangent plane at any point on a line of curvature and two fixed planes is constant.

But further, all the spherical curves of the second degree represented by the preceding equation are *biconfocal*: and it is easy to shew that their common foci are the points on the sphere which correspond to the umbilici of the ellipsoid. Hence, the sum or difference of the angles between the tangent plane at any point on a line of curvature, and the tangent planes at two umbilici, is constant; or, as the tangent planes at the umbilici are parallel to the planes of circular section, we have the following elegant theorem:

"The sum or difference of the angles between the tangent plane at any point along a line of curvature on an ellipsoid, and the two planes of circular section, is constant."

The proposition just mentioned was, it is believed, first published by Sir William Hamilton, in the Dublin University Review, part (3); the short article which contains it being dated June, 1833. It has also been published by Dr. Joachimsthal, in a paper printed in the 26th vol. of Crelle's Journal, and dated January, 1842, where that geometer claims it as "novum neque inelegans."

The reciprocal of the line of curvature has for its equation

$$\frac{a^2-k^2}{a^2}\,\mathrm{X}^2+\frac{b^2-k^2}{b^2}\,\mathrm{Y}^2+\frac{c^2-k^2}{c^2}=0,$$

in which if we make

$$\mathrm{X}=\frac{x}{z}, \text{ and } \mathrm{Y}=\frac{y}{z},$$

we shall get the equation of the cone, whose generatrices are parallel to the normals along the reciprocal of the line of curvature, and whose vertex is at the centre of the ellipsoid. After this substitution the last equation becomes

$$x^2+y^2+z^2-k^2\left(\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}\right)=0,$$

from the form of which it is evident that the cone passes through the intersection of the given ellipsoid, and a concentric sphere having k for its radius. The properties of this cone, and its relation to the lines of curvature, were first noticed by Professor Mac Cullagh.*

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* Proceedings of the Academy, vol. ii. p. 499.

For the quadrature of areas on the surface of the ellipsoid Mr. Graves gives the following formula:

$$\text{area} = a^2b^2c^2 \iint \frac{(1 + \text{X}^2 + \text{Y}^2)^{\frac{1}{2}}\, d\text{X}\, d\text{Y}}{(c^2 + a^2\text{X}^2 + b^2\text{Y}^2)^2}.$$

The President made some observations on the communication of Professor Graves.

Mr. Clibborn read a notice of certain points in Egyptian History.

Read,—The following Report from the Council:

"That the Council do recommend to the Academy, at its next meeting, to carry into effect the following recommendations of the Committee of Antiquities, and to request a vote of the Academy of £100 for the fitting-up of the Museum.

"1. That the resolution of the Academy, of the 30th of November, 1842, for making a new Board Room in the lower part of the house, be carried into effect.

"2. That the present Board Room be converted into a Museum.

"3. That, for this purpose, two tables be provided, to stand across the new Museum, opposite the piers. The present glass cases, except that containing the Cross of Cong, to be placed on those tables, and flat glazed cases to be added; the Cross of Cong to stand on a separate pedestal between the tables, *i. e.* in the centre of the room.

"The Council having taken into consideration the best means of exhibiting the antiquarian treasures contained in the Museum of the Academy, and thus giving proper importance and utility to that department, appointed a Committee, which recommended the adoption of the resolutions of the Committee of Antiquities. These have been adopted by the Council, and are now proposed for the adoption of the Academy."

Resolved,—That this Report and Recommendation of the Council be adopted, and that £100 be placed at the disposal of the Council for the purpose specified.

DONATIONS.

Annuaire de l'Académie Royale de Bruxelles. Néuvieme Année 1843.—*Annuaire de l'Observatoire Royal de Bruxelles,* 1843. Dixiéme Année.—*Rapport sur l'Etat et les Travaux de l'Observatoire Royal,* pendant l'Année 1841 et 1842.—*Résumé des Observations magnetiques et meteorologiques faites a des Epoques determinees.* (Extrait du tome XVI. des Memoires.—*Observations des Phenomenes periodiques* (Extrait des tomes XV., XVI. des Memoires).—*Instructions pour l'Observation des Phenomenes periodiques.*—*Memoires Couronnés et Memoires des Savans Etrangers.* Publiés par l'Academie Royale. Tome XV. partie 2.—*Nouveaux Memoires de l'Academie Royale de Bruxelles.* Tome XVI. Presented by the Academy of Brussels.

Memoires de la Société Geologique de France. Tom. V. Parts 1, 2. Presented by the Society.

Memoires de l'Academie Imperiale des Sciences de St. Petersbourg. Sixth Series.—*Sciences Mathematiques et Physiques.* Tom. XIII. Livraisons 1, 2, 3.—*Sciences Politiques.* Tom. VI. Livraisons 1, 3.—*Sciences Naturelles.* Tom. V. Livraisons 1, 2.—*Recueil des Actes des Seances Publiques, tenues le* 31 *Decembre,* 1841, *et le* 30 *Decembre,* 1842.—*Memoires presentes a l'Académie.* Par divers Savans. Tom. XVI. Livraison 5. Presented by the Academy of St. Petersburgh.

Sur l'Emploi de la Boussole dans les Mines. Par A Quetelet. Presented by the Author.

Erster Zusatz, zu der Schrift Ueber den Galvanismus. Von Gustav. Crusell. Presented by the Author.

Ninth Annual Report of the Poor Law Commissioners, for 1843. Presented by the Commissioners.

Catalogue of the Museum of the School of Medicine, Park-street, Dublin. By John Houston, M.D. Presented by the Author.

Faune Ornithologique de la Sicile. Par Alfred Malherbe. Presented by the Anthor.

Annales des Sciences Physiques et Naturelles, &c. Par la Société Royale d'Agriculture, &c., de Lyon. Tom. IV. 1841. Presented by the Society.

Proceedings of the American Philosophical Society, May 25–30, 1843. Presented by the Society.

Transactions of the American Philosophical Society. Vol. VIII., new Series, Parts 2, 3. Presented by the Society.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1844. No. 45.

May 13.

SIR WM. R. HAMILTON, LL. D., President, in the Chair.

Wm. H. Harvey, M.D., was elected a Member of the Academy.

READ,—A recommendation of Council to the Academy, to open a subscription list for the fund required to complete the sum necessary for the purchase of Hodges and Smith's Irish MSS., and that the Academy be recommended to head the list by a subscription of £100.

READ,—A letter from Lord Adare to Mr. Petrie, regarding a Grant from Government to the Academy, for the said purchase; and also a letter from Sir Robert Peel to Lord Adare, in which he stated that he was "willing to recommend to the Treasury to grant £600 for the purchase of the MSS.," "on the condition that the whole collection shall be purchased, and that the sum required to complete the purchase of the whole shall be raised from other sources."

RESOLVED, on the recommendation of Council,—That the Academy do open a Subscription list for the fund above mentioned, and that it do head the list by a donation of £100.

Wm. R. Wilde, Esq., read a paper on the Pharos of Corunna.

Mr. Wilde prefaced his observations by stating that he had already published an account of this celebrated building, which is situated at the extremity of the peninsula, on which the town of Corunna stands, wherein he had cursorily mentioned, that independent of the architectural beauty of its structure, its inestimable value as a beacon to mariners crossing this portion of the Bay of Biscay, and its marking the common entrance to the harbours of Corunna and Ferrol, what added "still greater interest to it in the eye of the traveller, was the fact of its enclosing within its massive walls one of the most interesting monuments of antiquity—the Pharos of Hercules—the oldest existing specimen of this kind in Europe, and amongst the very few now anywhere to be found."*

These observations were those of an ordinary traveller, who had no particular theory to support, and no peculiar object in view, save that of eliciting truth, and recording, with fidelity, what passed under his notice. Since then Sir William Betham having, in his "Etruria Celtica," questioned some of the statements put forth in this quotation, and finding, as he states, some incongruity between the accounts given by Mr. Wilde and Laborde, appears to have come to the conclusion that the ancient Pharos is *not* included, as is stated, within the walls of the modern Tower.

Mr. Wilde went on to say, that "being about to republish the original notice of this building, and feeling somewhat piqued at the assertion of Sir William Betham, who, never having seen the locality, laboured, I conceive, under such disadvantages as hardly entitled him to criticise, although, it must be said, in the most kindly spirit, the description which I had given from a personal examination on the spot,

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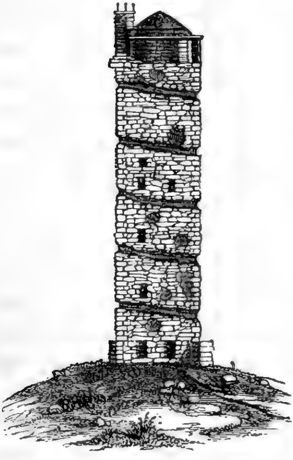
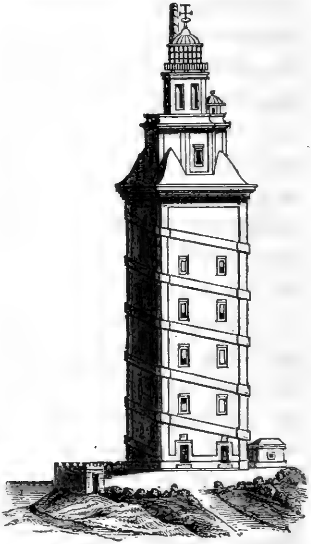
* Narrative of a Voyage to Madeira and the Mediterranean, 2 vols. 8vo. 1st edition, 1840, pp. 12–14.

I have, however, to thank him for having noticed the subject, even in the manner which he did, for it has led to the discovery of a most interesting manuscript and two drawings, the only ones, I believed, in existence, of the ancient and modern Towers, which I beg leave to lay before the Academy, and which I procured in the following manner:

"When Sir William's book appeared I wrote to the British Consul at Corunna, requesting him to procure me some information upon the subject of the 'Hercules Light,' as well as plans or drawings of the ancient and modern tower; and also to have made for me a copy of, or extracts from, any work or archive, either in manuscript or print, which might be still extant at Corunna, Betanzos, or Brigantia, or any of the towns bordering the splendid harbour of Ferrol, and where such a record would be most likely to have been preserved; at the same time, from the present unsettled state of Spain, and the various revolutions with which that unhappy country has been visited, I hoped for, more than anticipated, a favourable answer to my communication. After the lapse of a considerable length of time I have received the most confirmatory proof of my original position in these two drawings, together with the Spanish manuscript, which I now exhibit to the Academy, and which were discovered in the bureau of an old architect in Corunna. This document, entitled, '*Copia de la representacion y mas documentos que con fha de* 16 *de Marzo de* 1786, *dirigio, esta Junta de Gobierno condor Planos al Ecmo Sr. Marques de la Sonora,*' appears to be a Report presented to the Marquis De La Sonora by a Government Commission, empowered to inquire into and report upon certain improvements destined to be put in force in the harbours of Corunna and Ferrol, in 1786. In this '*Memoria Sobre la antiquedad de la Torre de Hercules,*' it is recommended to repair the ancient Tower or Pharos standing at the extremity of the peninsula, 'the only notice of which,' says the writer of this Report, 'is, that it was in existence at the beginning of the fifth century,' and was originally intended for the same purpose, namely, a signal for the ships going to England. It may be remarked, that so advantageous was the post considered, that in 1684 the Consuls of England, Holland, and Flanders, entreated of the Spanish authorities to have the building repaired, and stated that their Governments would, at their own expense, defray the cost of keeping up a light on it.





" The preceding representations faithfully exhibit the condition of the original Tower, as it stood in 1786, and also that of the present modern casing of granite with which it is surrounded.

" The wood-engraving to the left represents the original ancient Pharos, a square, hollow tower, surmounted by a rotundo, which was crowned by a large flag, bearing evident marks of the long-continued action of fire upon its surface. At each of the corners there was a small square turret; one of these is represented as still existing when this drawing was made, but evidently of a much more modern construction than the rest of the building. At foot of the drawing we find the following inscription: '*Fecit Trueva Alumnus Academiæ ex Civitate portus Brigantini, anno* 1797.'

"An external winding staircase led to the top, and permitted ingress to its internal apartments, through the small apertures still existing in the tower. A small square buttress at each corner, portions of which were in existence when this drawing was made, seems to have supported the stair or external winding passage at the angles; and the groove in the masonry still shews the position which such originally occupied. We read of a similar mode of access being employed on the exterior of the celebrated Pharos at Alexandria, probably for the purpose of carrying up the fuel, which was used to light the beacon that was placed at top.

"The mode of construction of this Tower is decidedly antique, although the general architecture and stone-work does not point out a period older than that of the Romans; and the masonry, composed of stones of comparatively small size, is cemented together by a lime-concrete, similar to that known to have been employed, if not introduced, by this people. The height of the Tower, from the base to the rotunda at the top, was 82 royal Spanish feet, and the rotundo itself was 11 more, making in all about 132 feet English. It was 31 feet broad on each side, and in the interior were two walls crossing in the centre, each 4½ feet in thickness. The Tower was divided into chambers or compartments by three stone floors, originally without any apertures in them, so that these apartments could only have been entered from without. The outer winding stair having been removed at some period long prior to the date to which we now refer, apertures were made in these stone floors, and ladders leading from one flight to another, enabled persons to ascend to the top from within. It is stated in this Spanish document that the outer staircase was pulled down to build a convent in the neighbourhood, but at what precise period history does not record. The small Towers at the top are believed to have been erected subsequent to the removal of the outer stair, perhaps in 1684, when the British, Dutch, and Flemish Consuls relighted this wide-spreading beacon.

"With regard to the precise date of its destruction, all that we can learn from Spanish authorities is, that when Molina De Malaga wrote his description of Galicia, in 1549, this staircase did not exist; for in this old poetic work we find some rhymes referring to it, thus:

'*Pues la Coruña tampoco la deso,*
Gran Puerto do numa fortuna le corre.
Y hablo de aquerte por sola una Torre
Antiquo Castillo que llaman el Vieso;
Aquerte es do dicen que estaba el eyrep,
Mas es fabuloso sabido lo que era
Estaba cereada de grand escalera
Que quien la deshiro no tubo consep.'

Of which the following exceedingly rough, but literal translation, may afford the English reader some idea:

But Corunna I do not like,
A Great Port where no fortune runs.
I speak of this only on account of a Tower,
An ancient Castle, which was called le Vieso (the old);
This is where they say lived the witch,
But it is a fabulous saying—whatever it was
Was surrounded by a large staircase,
Which whatever mounted could not find its way down.

"The origin of the original Tower, and its name, are involved in much obscurity. Galician tradition assigns it to the workmanship of Hercules himself. Some characters, scarcely legible, on one of the stones, says the writer of this

Spanish manuscript, states that it was erected in honour of some of the Cæsars. Near its base was discovered a stone bearing the following inscription: the translation of which is attended with some difficulty from defacement, as well as the number of contractions of the text. In any attempt at doing so it should be compared with the inscription at p. 593. Baron Humboldt states that Laborde, who furnished him with a copy of these lines, likewise informed him, I suppose from the inscription, that 'this Pharos was constructed by Caius Sevius Lupus, architect of the city of Aqua Flavia (Cheves), and that it was dedicated to Mars.'

MARTI.
AVG. SACR.
G. SEVIVS.
LVPVS.
ARCHITECTVS.
AF . . . . . . SIS.
LVSITANVS EXVD.

" Strabo, indeed, affirms that Galicia had been peopled by Greek colonies, and according to an extract from the Geographies of Spain, by Asclepiades, the Myrlean, an ancient tradition, stated that the companions of Hercules settled in these countries. Very few Spanish authorities mention this ancient '*Torre del Pharo*,' or, as it is sometimes called, The Iron Tower; and the appearance which it must have presented when originally built, accords precisely with the descriptions which we read of the ancient Pharos at Messina, and also that at Alexandria, around which we know there wound an external spiral staircase, so broad and so gentle in ascent that it is recorded a car and oxen could with facility pass to the top. The Spanish manuscript, which

I now lay before the Academy, refers its construction (in all likelihood) to the time of Trajan, because none of the geographers who lived before this emperor mention it, not even the accurate Mela, who alludes to other particularities on this coast. This, however, is but a negative proof; and even among later geographers the same silence is preserved. There is, however, one record extant in a stanza to be found in the old Spanish geographer Ororio, or Orosirus, who lived in the beginning of the fifth century, to this effect:

> 'Ubi Brigantia Calletce Civitas Sita
> Altissimum pharum & inter pauca
> Memorandi operis ad speculam Britanice
> Erigit . . . .'

"Here we have the first notice of one of the purposes for which this Tower was supposed to be erected, and also of the ancient tradition, existing both in this country and in Spain, of the British Isles being seen from the Pharos of Hercules. Without, however, attaching any weight to the story of our island being seen from this Tower, it may be remarked, that if the ancients sailed directly *northward* from it they would, owing to the concavity in the Bay of Biscay in which the harbour of Corunna is placed, arrive at Cape Clear, instead of Cornwall.

"The early writers upon Irish history and Irish traditions have made frequent allusions to this ancient structure, as the 'Tuir Breoghan.' It is mentioned under this head in the Leabhar Gabhaltas, or Book of the Conquests, a translation of which was made by Henry O'Hart about the year 1686, and the original, which is now in the possession of Sir William Betham, contains this notice of it: 'Then Lughaigh, the son of Ith, went to Tuir Breoghan, or Corunna, and shewed his father's dead body unto the posterity of Breoghian,' &c.; and from this Breoghain is, in all probability derived the name of Brigantia, one of the oldest cities in this part of Europe.

"Sir William Betham has, with great labour and ingenuity, searched out and recorded, in his 'Etruria Celtica,' the various Irish authorities that refer to this building, and says, that he has discovered references made to it in the Eugubian Tables, which, he believes, speak of the early navigators steering by the fire set up on the land when the ship left the coast of Spain for the Turn or Carne; and in the same passage the triple-pointed hill of Cape Ortugal, the next most prominent headland, appears to him to be referred to.

"In another place Sir William Betham says: 'The name of Corunna and the Groyne are both derived from the river upon which the town stands,—Garonne, the rough or boisterous river, as the Garonne of France.' On this passage, however, I may remark, that I cannot agree with my brother Academician, for Corunna *does not stand on any river*, and the only one in its neighbourhood, and that too at a considerable distance across the harbour, is not the Groyne or Garonne, but the Rio Burgo. The term Groyne, however, is constantly applied by the early Spanish writers to the Bay itself.

"The term Corunna, or Colonna, may have been applied in after-times by the Romans, from the circumstance of finding the Tower or Column upon this headland, in the same way that the appellation of Cape Colunna has been applied to the island in the Grecian Archipelago on which was erected the celebrated Suniam temple, the remarkable columns or pillars of which are still standing.

"Again: 'There is,' says Sir William, 'some incongruity between the accounts of Mr. Wilde and Laborde. The latter says, the lighthouse is situated "upon a very high mountain, a league from the harbour;" and Mr. Wilde has stated its position to be "about a mile to the S. W. of the town, on a rock by the water's edge." Any one, however, at all acquainted with the locality, knows that there is no such mountain in this vicinity as that described by Laborde, and the position of the Hercules Tower can easily be ascertained by those who have not seen it by referring to any of the Admiralty's charts of the coast; and, moreover, a light on "a very high mountain a league from the harbour" would be of little service for nautical purposes.'

"I find, however, on again referring to the work of Laborde, that it consists of two parts—an itinerary, or journal, which appears to have been written from personal observation, and a running comment, in the form of notes, and printed in a smaller type, on the population, commerce, administration, natural history, &c. &c. of the countries visited, and which is evidently derived from other sources, and compiled from different authorities. It happens that this latter is the part quoted by Sir William, and not the text of the Journal, where, at p. 435, speaking of the harbour, he says: 'The harbour is in the form of a crescent; at the two points are the castles of Sainte-Clare and Saint Martin, which defend it, and a little island which shelters it from the north wind. All travellers have mentioned the ancient tower which excites admiration from its height, and its strong and solid walls. The Galicians declare that it was built by Hercules, whose name it still bears; this is to attribute it to the Phœnician merchants who frequented this coast; but a Roman inscription has been found near this tower, which ascribes it to the god Mars. If it is really the work of the Phœnicians, as its antiquity and the tradition lead us to believe, this account may be reconciled by supposing that the Romans, wishing to preserve this monument, and in gratitude for their victory over the Carthaginians, who sprung from the Phœnicians, consecrated it to their tutelary deity.'

"As this was a matter of some popular interest in connexion with the antiquities and early history of this country, Mr. Wilde quoted several extracts from what Sir William

Betham has put together upon this subject, from Giolla Keavin, an Irish poet, who lived about A. D. 1072, in a poem called Reim re Riogh, or the Race of Kings—from the Annals of the Four Masters—and from the Book of Ballymote; from all which it would appear that the Irish poets and annalists were well acquainted, not only with the existence of this Tower, but with many of the ancient bardic traditions assigned to it: such as its being built as a watch-tower by Breogin, the son of Braha, who is also said to be the founder of the city of Brigantia, &c. &c.

"In the Spanish manuscript it is recorded that a stone bearing the following inscription was found built into the wall of an old house in the town of Corunna.

LVPVS CONSTRVXIT EMV
LANS MIRACVLA MEMPHIS
GRADIBVS STRAVIT YLAM.
LVSTRANS CACVMINE NAVES
XÐ ÐVÐV

"The writer of the manuscript thinks that the dilapidation of the Hercules commenced in the middle ages, when it was converted into a castle or fortress belonging to the Archbishop of Santiago; that the stones and material of the outer staircase were at this time removed, and that some trace of them may still be found in the fortifications of the old town.

"The result of the commission to which allusion was made at the commencement of this notice, was, that the Spanish Government determined to leave the ancient Pharos in existence, but to envelope it within the present modern granite building, which was commenced in 1797, and is represented in the right-hand figure of the engraving at page 586. It is a handsome square tower, built of close-grained white granite, and not only contains between its massive walls the original Pharos, but is made to resemble it as much as possible; and on its exterior a projecting band of masonry exhibits the line of the original external staircase.

"No doubt can now any longer exist with regard to the position and preservation of this most interesting remain, the Pharos of Hercules. At foot of the drawing which Mr. Wilde exhibited, the following inscription is decisive: '*Perspectiva que de muestra el estado de la terre antiqua llamada de Hercules quando de emprendio sure edificacion y revestimento de canteria por orden del Real consulado du la Coruna.*"

"To establish this fact, and to record some additional notice regarding the traditions and early history of one of the most interesting structures at present remaining in Europe, must apologize for this lengthened notice."

Col. Jones made a communication concerning the discovery in the River Shannon, of a large collection of ancient bronze and iron weapons and utensils, &c., which he presented to the Museum of the Academy, on the part of the Shannon Commission.

List of Antiquities found in the River Shannon at the undernamed places.

KEELOGUE.

150 Elfstones.
1 piece of soft Stone (petrefaction).
10 Sword and Brass Spear-heads.
8 Small Brass Spear-heads.
8 Do. Iron do.
2 Iron Sword Blades.
10 pieces of Teeth.
1 piece of Deer's Horn.

1 piece of Wood, partly petrefied.
3 Iron Battle-axes, or Tomahawks.
10 Brass do. do.
41 sundry broken Spear-heads, Spurs, Ornaments of Scabbards, Druid's Rings, &c., &c.
3 parts of a Matchlock, Barrel, and Tube.

BANAGHER.

4 Lead Moulds, one with stamp of Coins.
1 Brass Dial.
3 Brass Spear-heads.
2 Iron Spear-heads.
3 Brass Tubes or Pipes (ornaments).
1 piece of Deer's Horn.

SHANNON BRIDGE.

1 Brass Pin.

DERRYHOLMES.

1 Iron Sword-blade.

BISHOP'S ISLAND.

1 Brass Vessel.

PORTUMNA.

3 Pieces of Deer's Horn.
3 Do. of Teeth.

ATHLONE.

6 Elf-stones.
1 Two-edged Sword and Handle.
2 Spear-heads.
5 Brass Pins.
1 Tin Box containing Coins.
1 Grape Shot.
1 Corroded Padlock.
Sundry small articles, Pipes, &c. (in a small Box).

Resolved,—That the special thanks of the Academy be returned to Col. Jones and the Officers of the Shannon Commission, for the collection of Antiquities now presented.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1844. No. 46.

May 27.

SIR Wm. R. HAMILTON, LL. D., President, in the Chair.

Captain O'Connor exhibited two twisted gold rings, brought from Africa and there used as current money.

The President communicated a method of mentally approximating to the calculation of ancient eclipses, and applied it to the eclipse of the moon recorded by Tacitus as having happened soon after the death of Augustus.

Mr. J. Huband Smith drew the attention of the Academy to a report, that there was in contemplation the removal of a portion, if not the whole of the celebrated mound of New Grange, near Drogheda, to be broken up for the repair of the roads.

Resolved,—That it be referred to the Council to take steps to ascertain the truth of the report, and in the event of its proving true to take proper means to ensure the preservation of this great and important national monument.

June 10.

SIR WM. R. HAMILTON, LL. D., President, in the Chair.

Charles Hanlon, Esq., Maxwell M'Master, Esq., Thomas Oldham, Esq., Philip Read, Esq., Henry Roe, Esq., and Robert Wilson, Esq., were elected Members of the Academy.

Dr. Apjohn read an account of the constitution of Jade, and also of two ores of Manganese from the South of Cork.

Dr. Apjohn observed that these minerals had been recently analysed in his laboratory, and as the results were somewhat novel, he thought he might mention them to the Academy; his principal object being that they might appear in the Proceedings, for the information of mineralogists and chemists.

The Jade submitted to analysis was wrought into ornaments of various kinds, which were brought to Europe by Captain Baddeley, who was engaged in several of the operations of the recent Chinese war. Its colour is white, with a tinge of yellowish green. It has a splintery fracture, and is highly translucent. S.G.=2, 965. Hardness over 7, or between rock crystal and topaz. Alone before the blowpipe it glazes, but with great difficulty, on the surface.

By exposure to a strong red heat, it gives off a little water, and becomes opake. Fluxed in the usual manner with carbonate of barytes, it was found to include no alkali. Another portion of it fused with a mixture of the carbonates of potash and soda, yielded the following quantitative results:

	(1)	(2)		(3)
Silex	56.921	1.224		21.10
Alumina and trace of Oxide of Chrome	2.980	0.058		1.00
Lime	14.150	0.496	=1.572	27.10
Magnesia	22.275	1.076		
Water	1.625	0.180		3.10
Loss	2.049			
	100.000			

From the numbers in columns (2) and (3), which, calculated in the ordinary manner, represent the relative numbers of atoms of the various constituents, it is obvious that the empirical formula of this mineral is

$$21\,Si\,O_3 + Ac_2\,O_3 + 27\begin{cases}MgO\\CaO\end{cases} + 3\,HO.$$

Now, these atoms may be grouped so as to form a tersilicate of alumina, and a subsesquisilicate of lime and magnesia; so that the following may be considered as the rational formula of Chinese jade:

$$Ac_2\,O_3, 3\,Si\,O_3 + 9\left(3\begin{cases}MgO\\CaO\end{cases}, 2\,Si\,O_3\right) + 3\,HO.$$

In looking into works on mineralogy, I find that nephrite or jade has already been at least twice analysed, first, by Saussure, and secondly by Kastner; and, from the account given by Beudant, of the specimen examined by the latter, it would appear to be the Chinese variety. The result, however, obtained by these chemists are quite irreconcileable with each other, and with mine. Thus, Saussure found his specimen to contain 3 per cent. less silex than I have detected in mine, to include no magnesia, but instead thereof, the oxides of iron and manganese, and about 20 per cent. of mixed soda and potash. Kastner obtained 6 per cent. less silex, about 7 per cent. more alumina, and 8 per cent. more magnesia, but no lime. The three specimens, therefore, differ as to the nature and relative proportion of their constituents. I may add, that it is not possible to represent the composition of any two of them by the same formula; so that, admitting the correctness of the published analyses, we are entitled to conclude that minerals really different are, in works upon mineralogy, confounded together under the name of Jade or Neptrite.

Of the ores of mangeneus, the first I shall notice is a specimen of psilomelanane, the black hæmatite of the older mineralogists, which I received some months since from R. W. Townsend, Esq., and which occurs a little to the north of the village of Glandore, in a mixed schistoze and arenaceous rock, which is coloured by Mr. Griffith, as old red sandstone. S. G. $=4.071$. Hardness between fluor spar and apalite, occurs massive, but more generally in botryoidal and concretionary forms. The following are its constituents, determined by an analysis very carefully conducted:

			(1)	(2)
Silex			8.592	
Barytes			5.362	0.069
Oxide Copper			1.254	0.031
Red Oxide Mang. (Mn_3O_4)	74.574	= Deutox.	31.241	0.393
Oxygen	7.212	Perox.	50.545	1.152
Water			3.006	0.334

Confining our attention to the oxides of manganese and the water, it is obvious, from the quotients in column (2) that the composition of the ore is very accurately represented by the formula $Mn_2 O_3, HO + 3 Mn O_2$, or that it is a compound of one atom of manganite and three of pyrolusite. In the psilomelanite analysed by Turner, there were 4 atoms of sesquioxide to 15 of peroxide; in that analysed by Berthier, 3 of sesquioxide to 17 of peroxide. It is obvious, therefore, that the specimen I have examined is a new variety. But it is also peculiar in other respects. 1. It contains oxide of copper in appreciable quantity, a substance not occurring in the other psilomelanes, though it was found by Professor Davy, of the Dublin Society, to the amount of 4.5 per cent. in a Swedish ore of manganese, which he considered to be a braunite (see Journal of Geol. Society of Dublin, vol. i. part 3.) 2. The amount of barytes included by it is but about one-third of that found in the ores examined by Berthier and Turner.

As respects the manner of the existence of the barytes always found in psilomelane, and in small quantity in some of the other ores of manganese also; I may observe that it is the opinion of some high authorities in science, of M. Beudant, for instance, that *it* and the dentoxide are chemically united, the latter performing the function of an acid. If this idea be correct, it will follow that they are capable of combining in at least two widely different proportions, for the psilomelanes of Berthier and Turner will, upon this view, be represented by the formula $2\,BoO, 3\,Mn_2O_3$, and that which I have analysed by the formula $BoO, 6\,Mn_2O_3$, so that the latter contains, combined with the same quantity of barytes, four times as much sesquioxide of manganese as the former.

This Cork psilomelane is obviously a rich ore of manganese, though of course inferior to the purer forms of pyrolusite. It exists in quantity in the district which I have mentioned, and some cargoes of it have been brought into the Dublin market, but have, I am told, been objected to by the manufacturers of the bleaching salt of lime, in consequence of its excessive hardness, and the consequent difficulty of reducing it to a fine powder.

About three years ago, I received from Captain Kitto, a Cornish miner, long resident in the south of Cork, an ore of manganese, which appeared so different from those with which I was previously acquainted, that I was induced to submit it to analysis. It occurs in the locality already mentioned, at Rowry, a little to the east of Glandore, in lumps of variable size, which, when broken, exhibit, though but ill developed, the faces of crystals belonging apparently to the right prismatic system, mixed, however, here and there with what would appear to be a brown hæmatite. Some of the crystalline portion of the ore, very carefully selected, gave, upon analysis, the following constituents:

			(1)	(2)	
Silex			3.08		
Perox. Iron			34.88	0.436	20
Red Ox. Mangan.	50.67	= Sesquioxide	5.25	0.066	3
Oxygen	6.52	Peroxide	51.94	1.188	54
Water			4.85	0.539	24
			100.00		

These results do not conduct to any very probable formula. But if we suppose that what is set down as sesquioxide is really present as peroxide, a supposition which accords sufficiently well with the analysis, then the composition of this ore becomes very simple, being represented by the formula $Fr_2 O_3, HO+3 Mn O_2$, that is by one identical with that which we have found for the psilomelane, when we substitute sesquioxide of iron for the sesquioxide of manganese. I have no doubt that this represents its real constitution, so that it may be safely set down as a new and very distinct species. I may observe that this mineral answers well for yielding oxygen, but is uneconomical as a source of chlorine, in consequence of the wasteful consumption of acid, in order to the saturation of the peroxide of iron; one-half in fact of the acid is uselessly expended.

Mr. William Andrews, Secretary to the Dublin Natural History Society, read a paper upon the genera of Ferns

Trichomanes and Hymenophyllum. His remarks were chiefly directed to the species of Trichomanes discovered by him in September, 1842, in the western part of the County of Kerry, and which presented a variety of growth and state of fructification so much more developed and characteristic of the genus of that beautiful fern than had hitherto been met with in Ireland, that determined him to examine its affinities with some of the exotic ferns, particularly with those of the West India Islands.

The Trichomanes was first discovered in Britain, by Dr. Richardson, at Belbank, near Bingley, Yorkshire, a wretched specimen of which is in the Banksian Herbarium, now in the British Museum: a figure of a barren frond is given in Dill. in Raii Syn. S. p. 127, t. 3. This specimen, however, not having been found in fructification, was supposed to be identical with the Filix (Trichomanes) pyxidifera of Plumier, and was described as such by Hudson, in his Flora Anglica, p. 461: and this name it retained until its discovery, in the month of October, 1804, at Turk Waterfall, near Killarney, by Mr. Mackay, Curator of the Botanic Garden of Trinity College. Mr. Mackay obtaining this beautiful fern in fructification, forwarded specimens to Sir James Edward Smith, who at once decided its distinctness from Plumier's plant, and considered it to be a new species, which he named and figured in English botany as Hymenophyllum alatum, from its winged stipe. The distinguished Robert Brown, the first physiological botanist of the day, corrected this specific appellation to that of brevisetum (Br. in Hort. Kew. ed. 2, 5, p. 529), from the short and barely exserted state of the receptacles that the Killarney plants generally presented. Mr. E. Newman, who has devoted so much attention to the specific characteristics of the British ferns, formed the first view, that the Killarney species perfectly agreed with Willdenow's description (Sp. Plant. 5, p. 514) of the Speciosum of Teneriffe, and published it as such, in his first edition of the History of British Ferns. The specific name brevisetum, however, was still retained through the several editions of the British Flora, until the discovery by Mr. Andrews, in September, 1842, in a wild and wooded glen in the western part of the County of Kerry. The striking characters and fine state of fructification exhibited by these splendid plants, the most rare and most beautiful of British ferns, and now altogether confined to the south-western parts of Ireland, led Mr. Andrews to examine minutely, and to trace their affinities with the numerous exotic species of that beautiful genus; and from communications with Sir William J. Hooker, and to the great kindness of that most excellent botanist and encourager of science, and the reference to his very extensive fern herbarium, it was traced and detected to be the true Trichomanes radicans of Swartz, setting aside the species brevisetum of the English flora, and the Speciosum of Willdenow. Thus the mild temperature of the south-western parts of this country produced, in the utmost luxuriance of tropical growth, a plant peculiar to the West India Islands, and to the western coast of South America. To Dr. Scouler's kindness Mr. Andrews was also much indebted for specimens of Trichomanes radicans, and T. Scandens, collected by Dr. S. in Brazil, and which enabled many doubts to be cleared.

Mr. Andrews noticed a very remarkable character of fructification in the new variety from Kerry, "that the capsules formed around the base of the receptacles within the cylindrical involucres, and as the receptacles elongated and became exserted considerably beyond the involucres, the capsules continued forming in an even dense mass to the extremity of the receptacles." This is described as of rare occurrence in Trichomanes. The Trichomanes reniforme of New Zealand, and the Hymenophyllum fuciforme of Chiloe, are noticed as having the capsules external to the involucres, but their being exposed to view was supposed merely to result from the spreading and shrinking of the valves. Loxsoma appears to be the only recorded genus as possessing that peculiarity of fructification.

The specific descriptions of Trichomanes radicans and its synonyma, are fully given in part 2, p. 125, of that invaluable work, *Species Filicum*, by Sir J. W. Hooker, recently published.

Professor Allman made some observations on Mr. Andrews's paper, in corroboration of its principles.

DONATIONS.

Proceedings of the Geological Society of London. Vol. IV., Part 1. (1843). Presented by the Society.

Bulletin der Königl. Akademie der Wissenschaften zu Munchen. Nos. 1 to 55.

Abhandlungen der Philosophisch. Philologischen Classe der Königlich Bayerischen Akademie der Wissenschaften zu Munchen. Dritten Bandes dritte Abtheilung, in der Reihe der Denkschriften der XVIII. Band.

Abhandlungen der Mathematisch. Physikalischen Classe der Königlich Bayerischen Akademie der Wissenschaften zu Munchen. Dritter Band. Die Abhandlungen von den Yahren, 1837, bis 43, enthaltend. Presented by the Academy of Munich.

Versuch einer objectiven Begründung der Lehre von der Zusammensetzung der Kräfte. Von Dr. Bernard Bolzano. Presented by the Author.

Prodromus zu einer neuen, verbesserten Darstellungsweise der höhern analytischen Dynamik. Vom Grafen G. Von Buquoy, Ph. D., &c. Presented by the Author.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1844. No. 47.

June 24.

SIR WM. R. HAMILTON, LL. D., President, in the Chair.

RESOLVED, on the recommendation of Council—That the Academy do pay Mr. E. Curry £41 13*s.*, for completing the Catalogue of the Irish MSS. of the Academy, this sum including the money due to him at present.

Sir William Betham gave notice that, at the next meeting of the Academy, he would move for—

1st. A list of all papers or essays read before the Academy, in the departments of Belles Lettres and Antiquities, which were referred to Council for publication, from the 17th of March, 1828, to the 17th of March, 1844, containing the dates of such reading, the names of the authors, whether ordered by the Council for publication, and, if published in the Transactions, with the dates of the Council's order for publication.

2nd. An account of all sums of money expended for engraving copper-plates or wood-cuts, or making lithographs, to illustrate such essays or papers, which, ordered by Council to be published, have or have not yet appeared in the Transactions of the Academy.

3rd. An account of all sums of money expended on account of paper and printing of any such essay or essays, or papers, which have been commenced, and are now in progress of printing; with the amount of liability of the Academy for what has not yet been paid.

4th. A statement of the terms of any agreement or contract entered into by the Council, with the author or authors of any such paper or essay, and the sum or sums of money advanced on that account.

5th. An account of all medals and rewards adjudged by the Council, and paid to any author for papers and essays, during the said period, from the 17th of March, 1828, to the 17th of March, 1844, with the dates of such payments and delivery.

6th. An account of the debts and liabilities of the Academy at this time, and also of their available assets.

It was moved by Dr. Apjohn,—That the Secretary of Council be requested to provide the Academy, at the next meeting, with the information required in Sir William Betham's notice.

The motion, after discussion, was withdrawn.

The Rev. H. Lloyd laid upon the table of the Academy a magnetical instrument, which had been recently constructed under his direction by Mr. Jones of London, and which he proposed to denominate the "Theodolite Magnetometer."

Much attention had of late been given to the construction of small magnetical instruments, for the use of travelling observers, and many improvements in their form had been effected by Prof. Weber, Mr. Fox, and Lieut. Riddell. Prof. Lamont had also recently adopted magnets of a very small size in all the instruments employed by him in his magnetical observatory, and had stated his conviction of their superiority over the larger magnets hitherto in use. Without entering at present into the grounds of this conviction, in the unlimited form in which it had been asserted by Prof. Lamont, Mr. Lloyd said that, as respects certain instruments intended for observations of a particular kind, there seemed now to be a pretty general agreement on the subject. He had himself proposed an instrument for the determination of the changes of the Magnetic Inclination, in which the magnet was necessarily a small one; and the advantages of small magnets, in the delicate observation of the absolute Horizontal Intensity, seemed now to be fully recognized.

While engaged in considering the best form of an instrument intended for observations of the latter class, Mr. Lloyd was led to perceive, that the same apparatus might be made to serve also in the determination of the *Absolute Declination;** and, by a few slight additions in the details of its construction, in that of the *variations of the three magnetic elements*. It may likewise be employed for all the usual purposes of a *Theodolite;* and thus, with the addition of an ordinary Inclinometer, a Chronometer, and a Sextant, constitute a complete magnetical equipment for the use of the travelling observer.

The following is a brief description of the instrument.

A divided circle, similar to that of a Theodolite, is supported on a tripod base, with levelling screws. This circle is nine inches† in diameter; it is divided to 10′, and subdivided by two verniers to 10″. The upper plate of the circle has two‡ projecting arms, each carrying a pair of adjustable Y supports for the reading telescope, at a distance of six inches from the centre. The telescope rests in these supports on a tran-

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* It may be proper to observe that this arrangement had occurred to the writer before he had seen Prof. Lamont's account of his magnetical Theodolite, an instrument in which the same end is obtained, although by different means.

† A circle six inches in diameter, and read to 20″, is sufficient for all the purposes of a travelling observer.

‡ *One* is sufficient, and the instrument will be so modified in all future constructions on the same plan.

sit axis, which is rendered horizontal by the help of a riding level. The aperture of the object glass is eight-tenths of an inch; a glass scale, divided to the $\frac{1}{400}$th of an inch, is fixed in its focus; and the eye tube is made to move across the scale in a dovetail slide.

The magnets are hollow cylinders, each furnished as a collimator with an achromatic lens, and a fine line cut on glass in its focus. There are four such magnets: two of them being $3\frac{2}{3}$ inches long, and half an inch in exterior diameter, and two 3 inches long, and three-eighths of an inch in exterior diameter. The larger magnets are furnished with a Y stirrup, in which they may be inverted; the smaller magnets have the ordinary tubular stirrup, with a suspension pin and screw socket. A hollow brass cylinder, of the same dimensions as the larger magnets, and carrying a small hollow cylindrical magnet within, serves to determine the amount of torsion of the suspension thread; it is likewise fitted up as a collimator.

There are two boxes, within which the magnets are to be suspended. That belonging to the smaller magnets is a rectangular box of copper, closed by mahogany sliding sides, and having a circular aperture at each end filled with parallel glass. It is $3\frac{1}{2}$ inches long, $1\frac{1}{2}$ inches wide, and 1 inch deep, internally; and the thickness of the metal is a quarter of an inch, so that it may act powerfully as a damper. A suspension tube of glass, eight inches long, is screwed into an aperture in the top of the box; and is furnished with a graduated torsion cap at top, and a sliding suspension pin. This box is made to fit on the centre of the upper plate of the circle, and is capable of removal at pleasure. The box employed with the larger magnets is of wood, and of the same form as the copper box, but somewhat larger. It is detached from the instrument, but may rest on the same stand. A small wooden piece with a mirror serves to illuminate the magnet collimator, either from above or from the side, according as the light of day, or that of a lamp or candle, is employed.

The measuring rod employed in deflection experiments is a compound bar of gun metal, formed of two bars, the lower of which has its surface horizontal, and the upper vertical. It is three feet in length,* and is graduated on its vertical surface. It is placed upon the upper plate of the circle, beneath the box, and at right angles to its longer sides; and it is so fixed that it may be removed with ease, and replaced exactly in the same position. The support of the deflecting magnet slides upon the upper bar, and is furnished with a vernier, by means of which the distance of the two magnets may be determined with accuracy and ease.

The apparatus is furnished with two soft-iron hollow cylinders, nine inches long, and three-fourths of an inch in diameter, which fit in vertical sockets attached to the upper plate of the circle. By this addition the instrument is converted into an Induction Inclinometer, for the measurement of the changes of the Inclination. By a slight addition to the suspension apparatus, the instrument may likewise be used as a Bifilar Magnetometer, for the measurement of the changes of the Horizontal Force. These adaptations are, however, of minor importance to the travelling observer, whose main concern is with the absolute determinations; and in a fixed observatory it is essential that there should be separate instruments for the separate purposes.

The most convenient *order* of the observations to be made with this apparatus, when employed by the travelling observer, is the following.

1. Measurement of Absolute Declination.

The copper box and measuring rod being removed, one

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* For the purposes of the travelling observer, it will be more convenient that this rod should be in two pieces. Two *single* bars, placed edgewise, will suffice.

of the larger magnets is to be suspended within the wooden box, which should be placed on the same stand with the divided circle, at a distance not less than one foot from its centre. The optical axis of the telescope, and that of the magnet-collimator, are then to be brought nearly into the same right line, by an azimuth movement of the top of the stand, and by a small parallel movement of the box. The torsion of the suspension thread is then to be determined by the help of the brass cylinder, and to be removed by means of the torsion cap. The magnet being then replaced, the coinciding division of the scale is noted, with the magnet direct and inverted, and the mean of the two readings is the division corresponding to the magnetic axis. The verniers of the circle being then read, the telescope is to be turned until the division so found coincides with a fixed mark, whose azimuth is to be determined at leisure. The latter determination is made by the help of the same Theodolite, used in combination with the Chronometer or Sextant.

2. Observation of Vibration.

The upper plate of the circle is to be moved to its original position, and clamped there.

The coefficient of torsion of the suspension thread being determined, by the help of the torsion cap and glass scale, the magnet is to be set in vibration, and the time of 200 vibrations determined in the ordinary manner. The arc of vibration should be noted, by the help of the glass scale, at the commencement and end of the observation, and the temperature recorded at the same times.

3. Observation of Deflection.

The wooden box being removed, the metal box and the measuring rod are to be attached to the upper plate of the instrument. One of the smaller magnets is then to be suspended; and the larger magnet being transferred to its support upon the measuring rod, at a fixed distance, the upper plate and telescope are to be turned until the collimator line of the suspended magnet is seen to coincide with the central division of the scale of the telescope. The verniers of the circle being then read, the deflecting magnet is reversed, and the telescope is moved until there is a new coincidence. The verniers being again read, the difference of the two readings is double the angle of deflection sought. It is necessary to eliminate the changes of the Magnetic Declination, which may occur between these two readings; and for this purpose the wooden box and one of the spare magnets may be employed by a second observer. But the same elimination may be made as effectually by a single observer, by taking a series of readings with the deflecting magnet alternately in the two positions. Finally, the observation is to be repeated with the deflecting magnet at the same distance on the other side of the suspended magnet, and the mean of the two results taken as the deflection corresponding to that distance.

The quantity sought may be inferred from the angle of deflection at a *single* distance, with as much accuracy as is generally attainable in observations made in the open air, or in a tent; and, in such cases, it will generally be found more advantageous to multiply the observations at the *same* distance, in the manner already mentioned, than to repeat them at *two* or *more* distances. The distance should be about *five times* the length of the magnets.

The preceding arrangement is suggested chiefly in regard to the economy of time. But, when the observer has sufficient leisure, it is desirable that the time of observation of the two elements should be as near as possible to the epochs of their principal maxima or minima, the periodical variation being then least. For this purpose the observations should be so arranged, that the middle of the observation of Intensity may fall between 10 and 10½ A. M.; and that of the observation of Declination between 1 and 1½ P. M. In this case, then, the preceding arrangement should be nearly reversed. The observer should commence with the observation of deflection; proceed at once to the observation of vibration, determining the coefficient of torsion at the end; and, lastly, make the preliminary arrangements (of detorsion, &c.), for the determination of the Declination, deferring the observation itself until 1 P. M. If there be a second observer, he should undertake the observation of Inclination, and such sextant observations as may be required for the determination of the Latitude, the Time, or the true Meridian. The observation of Inclination should be simultaneous with that of the Horizontal Intensity; the astronomical observations may be made whenever most convenient.

The Theodolite Magnetometer may likewise be employed with advantage in a fixed observatory, especially in observations of the absolute Intensity; and it is worthy of remark, that if the *differential* instruments used in connexion with it be small ones, the circle of this instrument may be employed in their adjustments, and their construction thus reduced to the simplest possible form.

Mr. Wm. R. Wilde read a notice of the opening of some Tumuli, by Mr. Nugent, and the Rev. Dr. Todd (V. P.) on the part of Mr. Nugent, presented a stone of a peculiar form, found in one of the Tumuli described.

The thanks of the Academy were given to Mr. Nugent, for his communication and donation.

Mr. R. Mallet presented the results of his analysis of a porcelain clay, discovered some years ago by him, at Howth, and since extensively brought into use for the manufacture of crucibles.

The clay is found upon the southern side of the peninsula of Howth, which consists principally of quartz rock; it exists in large concretionary masses, or highly irregular beds, and appears to have reached its present position by the transport of water. It is found of every degree of fineness, from a coarse gritty mass of decomposing pebbles, with occasional large nodules of friable felspar, to that of an impalpable colourless clay, like that of Dorsetshire, known as pipe-clay. This is soft, sectile, adheres to the tongue, and forms a strongly adhesive and plastic mass with water, capable of being moulded upon the potter's wheel into the finest forms.

It bakes perfectly white, or occasionally of the slightest possible rosy tint of white.

Some of the masses of this mineral are strongly discoloured by iron and manganese, and imbedded in the finest parts are occasionally found a few fragments of marine shells, and bits of wood.

By washing with abundance of water, a fine quartzose sand is separable from even the finest portions of this clay. This sand is white, but water separates from it a little sand of a darker colour, like common sea sand of the Dublin coast, and a few microscopic flakes of mica.

A singular minute black worm is found in this clay, which may be worth the attention of naturalists.

The clay, as dug out, does not efferversce with acid, and is insoluble in them; it yields no soluble matter to water, and appears to contain no alkali in any specimens yet examined.

Mr. Mallet, however, has reason to think that the less fully decomposed portions of the clay may contain alkali in a soluble condition, and hence render the material valuable as a manure.

Some of the finest portion of the clay, washed from the sand, and dried at a temperature of 212° Fah., was found by Mr. Mallet to have the following composition. The analysis having been conducted in the usual way, and with the usual precautions, it does not seem necessary to detail its steps :

Silica, ...	67.96
Alumina, ...	23.20
Lime, ...	3.23
Magnesia, ...	0.63
Oxide of Iron, ...	1.19
Water, ...	2.80
	99.01

As no washing completely removes the presence of sand from this clay, which always feels gritty to a glass rod, and as it contains comminuted mica, it could not be expected that its analysis should present a precisely mineralogical result.

From the close analogy, however, which the above figures present to the composition of various felspathic rocks, as analysed by Beudant, Berthier, &c., there can be little doubt but that the geothetic origin of this clay is the decomposition of felspar, or other allied granitic minerals. In fact the results approximate to the formula (taking the iron and magnesia together).

$$(Al_4 + Si_{15} + Ca + Mg + FeO) + HO,$$

or,

$$3(Al + Si_3) + (Ca + Si_3) + ((Mg + FeO) + Si_3) + HO.$$

This clay is of very great economic value, and capable of being used for the manufacture of the finer descriptions of pottery or even of porcelain; it has, however, hitherto only been brought into use for the manufacture of crucibles, by Mr. Mallet.

The President read a paper on an improvement in the double achromatic object glass.

DONATIONS.

Life of W. V. Morrison, Esq., M.R.I.A. By John Morrison, Esq. Presented by the Author.

Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königl. Preuss. Akadémie der Wissenschaften zu Berlin, 1842-1843.

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin (1841). Presented by the Academy.

Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen. Erster Band. Von den Jahren 1838-1841. Presented by the Society.

Almanach der Königlichen Bayerischen Akademie der Wissenschaften zu München (1843). Presented by the Academy.

Leitfaden zur Nordischen Alterthumskunde herausgegeben von der Königlichen Gesellschaft für Nordische Alterthumskunde (1837).

Die Königliche Gesellschaft für Nordische Alterthumskunde zu Kopenhagen (Jan. 27, 1842).

Memoires de la Société Royale des Antiquaires du Nord 1840-1843. Presented by the Society.

Fasciculus Inscriptionum Græcarum. Edidit Jacobus Kennedy Bailie, S.T.P. Presented by the Author.

Proceedings of the Chemical Society of London. Part 6. Presented by the Society.

Journal of the Statistical Society of London. Presented by the Society.

Literarische Sympathien oder industrielle Buchmacherei. By Dr. J. G. Flügel. Presented by the Author.

Bjorgynjar Hatfskinn. Presented by Dr. Robt. Graves, M.R.I.A.

The Numismatic Chronicle for April, 1844. Presented by the Numismatic Society.

Journal of the Franklin Institute. 5th Volume, 3rd Series. Presented by the Institute.

An Olla Podrida, or Scraps Numismatic, Antiquarian, *and Literary.* By Richard Sainthill. Presented by the Author.

Journal of the Geological Society of Dublin. Vol. III. Part 1, No. 2. Presented by the Society.

Sixteen Specimens of Chinese Cash. Presented by Robert Mallet, Esq.

Archives du Museum d'Histoire Naturelle. Tome III. Livraison 4. Presented by the Directors.

Memorie dell I. R. Istituto Lombardo di Scienze lettere ed Arti. Vol. I. Presented by the Institute.

Edinburgh Astronomical Observations. Vol. V., 1839. Presented by the Royal Astronomical Society.

Greenwich Magnetical and Meteorological Observations, 1840-1841. Presented by the Royal Astronomical Society.

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Barlow, Wm. Thos., Esq., .	1	0	0
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Butler, Rev. Wm. Archer,	1	0	0
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Hewson, John, Esq.,	1	0	0
* Hill, William, Esq.,	1	0	0
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* Houston, John, Esq., M. D.,	1	0	0
Hunt, Percival, Esq., M. D.,	1	0	0
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Hutton, Henry, Esq.,	1	0	0
Hutton, Rev. Joseph,	1	0	0
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Johns, Alexander, Esq.,	1	0	0
Johnson, Edmund, Esq.,	1	0	0
Johnston, Rev. Richard,	1	0	0
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* King, Hon. James,	5	0	0
Kemmis, Henry, Esq.,	5	0	0
* Knox, G. James, Esq.,	5	0	0
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Kane, William, Esq.,	1	0	0
* Kelly, T. F., Esq.,	1	0	0
* Kelly, D. H. Esq.,	1	0	0
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	614	11	0

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* Mollan, John, Esq., M. D.	3	0	0
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Purser, John, Esq., . . .	2	0	0
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Patterson, R., Esq., . .	1	0	0
Pepper, Colonel, ...	1	0	0
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	849	17	0

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Porter, Charles, LL. D., .	1	0	0
* Porter, Rev. Thomas, D.D.,	1	0	0
* Rosse, William Earl of .	10	0	0
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Rossmore, W. Wm. Lord, .	2	0	0
Reid, Alexander, Esq., .	2	0	0
* Reid, Rev. James, ...	1	1	0
* Radcliffe, Rt. Hon. John, LL. D., ...	1	0	0
Ray, T. M., Esq., . . .	1	0	0
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.. Roberts, Wm. B. C., Esq.,	1	0	0
* Roberts, W., Esq., F.T.C.D.,	1	0	0
Roe, George, Esq., . . .	1	0	0
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* Smith, Joseph H., Esq., .	3	3	0
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* Sedgwick, Professor, (Cambridge), ...	3	0	0
* Smith, Aquilla, Esq., M.D.	3	0	0
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Scully, Joseph, Esq., . .	1	0	0
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Shirley, E. P. Esq., M. P.,	1	0	0
Shortall, Lieut. Gen., . .	1	0	0
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* Smith, Rev. G. S., . . .	1	0	0
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	963	4	0

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Stokes, J., Esq., ...	1	0	0
Stokes, Miss, ...	1	0	0
Stubber, R. H. Esq., . .	1	0	0
Stopford, Captain, . . .	0	10	0
Templetown, John Henry Lord, ...	10	0	0
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Tomb, George, Esq., . .	2	0	0
* Thompson, J., Esq., . .	1	1	0
* Thompson, David P., Esq.,	1	0	0
Thompson, J., Esq., LL.D., Glasgow, ...	1	0	0
* Thompson, Thomas, M. D., Glasgow, ...	1	0	0
Thompson, Wm., Esq., .	1	0	0
Tickell, Edward, Esq., .	1	0	0
* Tighe, Robert, Esq., . .	1	0	0
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* Wilson, Thomas, Esq., .	5	0	0
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* Wilkinson, George, Esq., .	2	2	0
Wilson, L. P., Esq., Lond.,	2	2	0
* Westenra, Hon. H. R., M.P.,	2	0	0
* Walker, R. Chambers, Esq.,	2	0	0
* Webber, Chas. T., Esq., .	2	0	0
Wybrants, Robert, Esq., .	2	0	0
Wood, Thomas, Esq., M.D.,	1	1	0
West, Henry, Esq., . . .	1	1	0
* Wall, Rev. Rd. H., D.D.,	1	0	0
* Wallace, W. B., Jun., Esq.,	1	0	0
* Wallace, R. A., Esq., . .	1	0	0
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Wright, Edward, Esq., .	1	0	0
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Webb, P. R., Esq., . . .	0	10	0
Wood, William C., Esq., .	0	5	0
* Young, John T., Esq., .	1	0	0
Allen, Edward, Esq., . .	1	0	0
	1051	8	0

ADDITIONAL SUBSCRIPTIONS.

	£	s.	d.
Brought forward,	1051	8	0
Baker, A. W., Esq., . .	3	5	0
Benn, Edward, Esq., . .	1	0	0
Graham, F. R., Esq., . .	0	10	0
Griffith, Henry, Esq.,. .	2	0	0
Henn, Thomas R., Esq., .	1	0	0
Hughes, W. J., Esq., . .	1	0	0
Knox, R. J., Esq.,. . .	0	10	0
	£1060	13	0

	£	s.	d.
Brought forward,	1060	13	0
Knox, E. C., Esq., . . .	0	10	0
M'Master, Maxwell, Esq.,	1	0	0
Otway, C. G., Esq., . .	1	0	0
Pope, J. W., Esq., . . .	0	5	0
Ray, T. M. Esq., collected by	2	0	0
Reade, W. M., Esq., . .	2	0	0
Sharp, Richard Esq., . .	0	5	0
Total collected,	£1067	13	0

No. II.

ACCOUNT

OF THE

ROYAL IRISH ACADEMY,

FROM 1ST APRIL, 1841, TO 31ST MARCH, 1842.

THE CHARGE.

	£	s.	d.	£	s.	d.	£	s.	d.
Balance in favour of the Public. as per last Audit, ...				. . . . .			59	1	4
Parliamentary Grant for 1841, ...				300	0	0			
Quarterly Warrants from Treasury, . . .				146	17	8			
Total from Treasury, . . .							446	17	8
THREE PER CENT. CONSOLS SOLD.									
1841.	£	s.	d.						
June 8, 9, £55 18*s.* 8*d.* at 88¼ ⅌,	49	7	3						
Interest, 154 days,	0	14	3						
	50	1	6						
Brokerage, ...	0	1	6						
1841.				50	0	0			
July, 20, 21, £238 11*s.* 6*d.* at 89⅝,	213	16	6						
Interest, 16 days,	0	6	3						
	214	2	9						
Brokerage, ...	0	6	0						
1842.				213	16	9			
Feb. 9, 10, £300 at 88¾, . . .	266	5	0						
Interest, 36 days,	0	17	9						
	267	2	9						
Brokerage, ...	0	7	6						
				266	15	3			
Total proceeds Consols sold, . . .							530	12	0
							1036	11	0

	£	s.	d.	£	s.	d.
Brought forward, . . .	. .	. .	.	1036	11	0
Interest on Stock:						
(£ s. d.)						
Half year's, on 1553 10 11, $3\frac{1}{2}$ per cents.,	27	3	9			
Ditto ,, 1581 4 1, $3\frac{1}{2}$,, .	27	13	5			
Ditto ,, 1525 2 9, 3 ,, .	22	17	6			
Ditto ,, 1286 11 3, 3 ,, .	19	6	0			
Total Interest on Stock, .				97	0	8
Publications and Books sold:						
Boone, Messrs., balance of their account to 4th January, 1842, ...	31	12	0			
Clibborn, E., for Scientific Memoirs, to 16th June, 1841, ...	1	19	0			
Ditto, ditto, 6th Nov. 1841,	0	15	0			
Ditto, Transactions and Proceedings, 16th June, 1841, ...	1	5	0			
Ditto, ditto, 28th Nov. 1841,	2	0	0			
Ditto, Wolf's Letter, ditto, ...	0	8	0			
Total Publications sold, . .				37	19	0
One year's rent of stable, to Nov. 1, 1841,	. .	. .	.	21	0	0
Life Compositions:						
Thomas Wilson, Esq., ...	21	0	0			
W. Phibbs, Esq., ...	21	0	0			
Earl of Ross, ...	21	0	0			
B. Botfield, Esq., ...	21	0	0			
James Thompson, Esq., ...	21	0	0			
A. Clendinning, Esq., ...	21	0	0			
Rev. M. M'Kay, ...	18	18	0			
G. S. Gough, Esq., ...	18	18	0			
J. T. Mackay, Esq. (having subscribed twenty years), ...	6	6	0			
Total Life Composition, . .				170	2	0
Entrance Fees:						
William Monsell, Esq., ...	5	5	0			
R. Tighe, Esq., ...	5	5	0			
W. E. Hudson, Esq., ...	5	5	0			
G. F. Fitzgibbon, Esq., ...	5	5	0			
William Phibbs, Esq., ...	5	5	0			
Rev. J. Reid, ...	5	5	0			
W. Lee, Esq., ...	5	5	0			
R. Jones, Esq., ...	5	5	0			
Thomas Wilson, Esq., ...	5	5	0			
W. T. Mulvany, Esq., ...	5	5	0			
	52	10	0	1362	12	8

	£	s.	d.	£	s.	d.
Brought forward,	52	10	0	1362	12	8
O. Sproule, Esq.,	5	5	0			
James Patten, M.D.,	5	5	0			
J. G. Jellett, Esq.,	5	5	0			
J. Banks, M.D.,	5	5	0			
W. Andrews, Esq.	5	5	0			
John Burrowes, Esq.,	5	5	0			
F. Churchill, M.D.,	5	5	0			
Alexander Ferrier, Jun., Esq.,	5	5	0			
William Hogan, Esq.,	5	5	0			
W. J. Hughes, Esq.,	5	5	0			
Rev. Samuel Butcher,	5	5	0			
W. Grimshaw, M.D.,	5	5	0			
Durham Dunlop, Esq.,	5	5	0			
Alexander Clendinning, Esq.,	5	5	0			
William Roberts, Esq.,	5	5	0			
Robert Bateson, Esq.,	5	5	0			
Rev. Reginald Courtenay,	5	5	0			
Captain Stirling,	5	5	0			
Rev. R. Chatto,	5	5	0			
Joseph Nelson, Esq.,	5	5	0			
Rev. Thomas Stack,	5	5	0			
Total Entrance Fees,				162	15	0
ANNUAL SUBSCRIPTIONS AND ARREARS:						
M. Longfield, Esq.,	4	4	0			
Wm. Stokes, M.D.,	4	4	0			
W. R. Wilde, Esq.,	4	4	0			
Earl of Ross,	4	4	0			
J. Kingsley, Esq.,	4	4	0			
John Davidson, Esq.,	2	2	0			
Rev. M. M'Key,	2	2	0			
William Hill, Esq.,	2	2	0			
A. Smith, M.D.,	2	2	0			
Sampson Carter, Esq.,	2	2	0			
Rev. C. Otway,	2	2	0			
W. Edington, Esq.,	2	2	0			
E. Hutton, M.D.,	2	2	0			
Bishop of Meath,	2	2	0			
M. M. O'Grady, M.D.,	2	2	0			
Sir R. Morrison,	2	2	0			
J. Mollen, M.D.,	2	2	0			
Charles W. Hamilton, Esq.,	2	2	0			
Hon. James King,	2	2	0			
John Ball, Esq.,	2	2	0			
G. S. Gough, Esq.,	2	2	0			
W. Hemans, Esq.,	2	2	0			
	56	14	0	1525	7	8

	£	s.	d.	£	s.	d.
Brought forward, . . .	56	14	0	1525	7	8
F. W. Conway, Esq., ...	2	2	0			
W. T. Mac Cullagh, Esq., ...	2	2	0			
G. D. La Touche, Esq., ...	2	2	0			
Lord Chief Baron, ...	2	2	0			
Right Hon. the Lord Mayor, ...	2	2	0			
C. E. H. Orpen, M.D., ...	2	2	0			
W.B.Wallace, Jun., Esq., ...	2	2	0			
George Carr, Esq., ...	2	2	0			
Rev. F. C. Logan, ...	2	2	0			
General O'Halloran, ...	2	2	0			
R. Dickenson, Esq., ...	2	2	0			
Charles Vignoles, Esq., C.E., ...	2	2	0			
D. Aher, Esq., ...	2	2	0			
Archbishop of Dublin, ...	2	2	0			
Rev. J. D. Sirr, ...	2	2	0			
G. A. Kennedy, M.D., ...	2	2	0			
R. A. Wallace, Esq., ...	2	2	0			
Thomas F. Kelly, Esq., ...	2	2	0			
W. Longfield, Esq., ...	2	2	0			
G. Wilkinson, Esq., ...	2	2	0			
Sir Philip Crampton, Bart., ...	2	2	0			
Thomas Newenham, Esq., ...	2	2	0			
Thomas E. Beatty, M.D., ...	2	2	0			
Jacob Owen, Esq., ...	2	2	0			
R. C. Walker, Esq., ...	2	2	0			
Sir Lucius O'Brien, Bart., ...	2	2	0			
W. T. Lloyd, Esq., ...	2	2	0			
M. O'Conor, Esq., ...	2	2	0			
J. Hart, M.D., ...	2	2	0			
R. Mallet, Esq., ...	2	2	0			
George M'Dowell, Esq., ...	2	2	0			
Professor Davy, ...	2	2	0			
Rev. James Wills, ...	2	2	0			
J. T. Young, Esq., ...	2	2	0			
J. Anster, LL.D., ...	2	2	0			
J. H. Smith, Esq., ...	2	2	0			
F. Barker, M.D., ...	2	2	0			
R. Reid, M.D., ...	2	2	0			
G. Levinge, Esq., ...	2	2	0			
Thomas Grubb, Esq., ...	2	2	0			
J. S. Cooper, Esq., ...	2	2	0			
Rev. E. Marks, D.D., ...	2	2	0			
James Pim, Jun., Esq., ...	2	2	0			
R. W. Smith, Esq., ...	2	2	0			
J. Osborn, M.D., ...	2	2	0			
R. Adams, Esq., ...	2	2	0			
	153	6	0	1525	7	8

	£	s.	d.	£	s.	d.
Brought forward, . . .	153	6	0	1525	7	8
Hon. Judge Crampton, ...	2	2	0			
James Apjohn, M.D., ...	2	2	0			
W. Murray, Esq., ...	2	2	0			
Rev. Charles Vignoles, D.D., ...	2	2	0			
W. F. Montgomery, M.D., ...	2	2	0			
R. J. Kane, Esq., ...	2	2	0			
A. Lyle, Esq., ...	2	2	0			
J. Finlay, LL.D., ...	2	2	0			
Sir Edward Borough, Bart., ...	2	2	0			
A. Jacob, M.D., ...	2	2	0			
Charles Doyne, Esq., 1840, ...	2	2	0			
Ditto, 1841, ...	2	2	0			
E. J. Cooper, Esq., ...	2	2	0			
E. Cane, Esq., ...	2	2	0			
G. Cash, Esq., ...	2	2	0			
W. Barker, M.D., ...	2	2	0			
Eliott Warburton, Esq., ...	2	2	0			
Rev. R. Knox, ...	2	2	0			
Robert J. Graves, M.D., ...	2	2	0			
Edward S. Clarke, Esq., ...	2	2	0			
J. D'Alton, Esq., ...	2	2	0			
P. D. Hardy, Esq., ...	2	2	0			
Rev. James Gregory, ...	2	2	0			
William Gregory, M.D., ...	2	2	0			
Abraham Palmer, Esq., 1840, ...	2	2	0			
Ditto, 1841, ...	2	2	0			
Archdeacon Disney, 1840, ...	2	2	0			
Ditto, 1841, ...	2	2	0			
W. Farran, Esq., ...	2	2	0			
James O'Grady, LL.D., ...	2	2	0			
A. E. Gayner, Esq., ...	2	2	0			
S. Ferguson, Esq., ...	2	2	0			
Rev. R. V. Dixon, Esq., ...	2	2	0			
F. W. Burton, Esq., ...	2	2	0			
H. Watson, Esq., 1841, ...	2	2	0			
James Whiteside, Esq., 1841, ...	2	2	0			
H. H. Joy, Esq., 1841, ...	2	2	0			
W. Armstrong, Esq., 1841, ...	2	2	0			
G. G. Otway, Esq., 1841, ...	2	2	0			
P. M. Murphy, Esq., 1841, ...	2	2	0			
W. T. Kent, Esq., 1841, ...	2	2	0			
E. Hutton, M.D., 1842, ...	2	2	0			
C. T. Webber, Esq., 1842, ...	2	2	0			
A. Abell, Esq., 1841, ...	2	2	0			
Rev. James Carson, 1840, ...	2	2	0			
Total Annual Subscription and Arrears,				247	16	0
THE TOTAL CHARGE, . . .	. . .	.	£	1773	3	8

THE DISCHARGE.

	£	s.	d.	£	s.	d.	£	s.	d.
ANTIQUITIES PURCHASED AND REPAIRED.									
Geraghty, for silver ornaments, 3rd May, 1841, ...	0	7	6						
Bambery, for gold torque, 7th June, 1841, . , ...	50	0	0						
Peters, for repairs of do., 10th do.,	1	0	0						
Smith, for fragment of gold, 12th do..	1	0	0						
Donegan, for fragments of do., 20th July, 1841, ...	6	10	0						
Topham, for gold fibula, 4th Nov. 1841, ...	13	0	0						
Do., do., 18th Jan. 1842,	12	12	0						
Geeren, for gold collar, 3rd Feb. 1842, ...	17	2	0						
				101	11	6			
Hogarth, unrolling papyrus, ...				12	0	0			
Total Antiquities purchased and repaired,							113	11	6
BOOKS, PRINTING, STATIONERY, &c.									
Allen, J.W., lithography, to 19th July, 1841,				5	0	0			
Branston, F. W., wood engravings for Proceedings, 23rd March, 1841, ...				8	7	0			
Ditto, ditto, 1st October, 1841,				1	8	0			
Du Noyer, G., for drawing on wood-block, 5th March, 1841, ...				1	0	0			
Duncan, J., engraving bells, 12th Feb. 1841,				44	2	0			
Graisberry and Co., printing, balance of account, 31st Dec. 1839, ...				150	0	0			
Ditto, ditto, 29th March, 1841,				282	19	1			
Hope, stationery, 16th Dec. 1841, ...				4	6	4			
Healy, ditto, 26th Jan. 1842, ...				0	16	0			
Hodges and Smith, books, &c., 31st Dec. 1840,				37	16	4			
Ditto, ditto, 2nd Dec. 1841,				29	18	11			
Kirkwood, engraving, on account, 26th April, 1841, ...				11	0	6			
Ditto, ditto, in full, 13th July, 1841,				20	0	0			
Ditto, ditto, 15th Jan. 1842, . . .				33	10	0			
Morrison, ditto, 13th May, 1841, . . .				1	0	0			
Mullen, bookbinding, 3rd Jan. 1842, . . .				84	14	4			
				715	18	6	113	11	6

	£	s.	d.	£	s.	d.
Brought forward, . . .	715	18	6	113	11	6
Oriental Translation Fund Subscription, 1st Jan. 1841, ...	10	10	0			
Pettigrew and Oulton, Directory, 28th Jan. 1841, ...	0	12	6			
Ponsonby, stationery, 28th Dec. 1841, . .	0	2	6			
Taylor, Messrs., Scientific Memoirs, 16th March, 1841, ...	6	0	0			
Ditto, ditto, 20th Sept. 1841,	6	0	0			
Yeates, letter balance, 27th Jan. 1840, . .	0	9	0			
Total Books, Printing, Stationery, &c.,				739	12	6
Coals, Candles, Oil, &c.						
Allen, William, oil, to 26th June, 1841, . .	6	14	11			
Ditto, ditto, 6th Jan. 1842, . . .	4	15	0			
Daly, John, bogwood, 24th Feb. 1842, . .	0	15	0			
Kenny, M., for coal, 14th Dec. 1841, . . .	10	0	0			
Rathborne, for candles, 8th Feb. 1841, . .	2	12	6			
Total Coals, Candles, Oil, &c., . .				24	17	5
Contingencies, &c.						
Clibborn, E., incidentals, to 26th June, 1841,	2	7	0			
Ditto, ditto, 25th Sept. 1841,	1	14	10			
Ditto, ditto, 31st Dec. 1841, .	4	9	2			
Ditto, ditto, 9th March, 1842,	1	8	7			
Hodges and Smith, engrossing Address, 18th Jan. 1841, ...	1	15	0			
Johnston and Co., advertising, 1st Jan. 1841,	6	9	0			
Ditto, ditto, 8th Dec. 1841,	0	13	6			
Mallet, Robert, postage, 10th Jan. 1842, .	0	6	0			
Nash, P., carriage to Park, 13th Nov. 1841, .	0	10	6			
Roberton, J. D., carriage of parcels, 15th May, 1841, ...	4	15	0			
Smith, J. H., expenses to Drogheda, 18th Jan. 1842, ...	7	12	7			
Williams, Thos., and Co., carriage of books, &c., 4th June, 1841, ...	2	7	5			
Treasurers for stamps, &c., 7th Feb. 1842, .	0	17	9			
Ditto, ditto, ...	0	0	9			
Total Contingencies, . . .				35	0	8
Repairs of House, Furniture, &c.						
Acheson, Joseph, drugget, &c., to 3rd Nov. 1840, ...	1	17	4			
Ditto, repairs, 22nd Oct. 1841,	0	6	0			
	2	3	4	913	2	1

	£	s.	d.	£	s.	d.
Brought forward, . . .	2	3	4	913	2	1
Blackwall and Co., lamps and repairs, 30th Nov. 1840, ...	3	6	4			
Brown, John, cleaning windows, 2nd June, 1841, ...	1	10	0			
Ditto, repairs, 2nd Dec. 1841,	2	2	0			
Casey, P., repairs, locks, &c., 14th Sept. 1841,	0	6	6			
Ditto, ditto, 31st Dec. 1841,	1	9	6			
Clibborn, E., for sundries used in cleaning house, &c., for year ending 16th July, 1841,	10	0	0			
Edmonston and Co., sundries, 1st June, 1840,	0	9	0			
Flinn, R., cleaning ash-pit, &c., 7th August, 1841, ...	0	4	0			
Hughes, H., a hemp mat, 2nd Sept. 1841, .	0	4	0			
Kane, M., washing down house, 3rd Nov. 1841, ...	0	12	0			
Kane, C., washing rollers, &c., 1st June, 1841,	0	12	0			
Ditto, ditto covers, 29th Nov. 1841, .	0	6	0			
Keough, F., beating carpets, &c., 4th Sept. 1841, ...	0	5	0			
Mullen, Wm., cleaning chimneys, 9th June, 1841, ...	0	19	6			
Ditto, repairs of ditto, 17th July, 1841,	4	12	6			
Nannetti, G., plaster casts, &c., 11th May, 1841, ... , ...	11	9	0			
Perry and Co., furniture, &c., 11th Nov. 1841,	5	5	2			
Surman, G., repairs, &c., 14th Nov. 1841, .	24	19	6			
Travell, G., matting and repairs, 3rd Nov. 1841, ...	1	1	0			
Walker, Wm., repairs, stove, &c., 26th Oct. 1841, ...	0	14	7			
Total Repairs of House, Furniture, &c.,				72	11	6

RENT, TAXES, AND INSURANCE.

	£	s.	d.	£	s.	d.
H. Truel, one year's rent, to 1st Feb. 1842, .	104	9	0			
Grand Jury cess, one year, Michaelmas, 1841,	7	3	9			
Wide street tax, ditto, ditto, 1841,	1	17	6			
Police tax, ditto, ditto, 1841,	4	7	6			
Pipe-water, ditto, 1st June, 1841,	1	7	8			
Ministers' money, ditto, Michaelmas, 1841,	2	15	5			
Parish cess, ditto, ditto, 1841,	2	0	0			
Paving and lighting, ditto, 5th Jan. 1842, .	12	8	9			
Watering street, ditto, ditto, 1841, .	0	9	9			
Insurance at Globe, £5 6*s*. 3*d*. / Ditto, National, 5 6 3 . . .	10	12	6			
Total Rent, Taxes, and Insurance,				147	11	10
				1133	5	5

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward, . . .				. .	. .	. .	1133	5	5
SALARIES, SERVANTS' WAGES, &c.									
Clibborn, Edward, salary for three quarters of a year, as assistant librarian and clerk, to 16th Dec. 1841, ...				90	0	0			
Hamilton, William., salary and allowances as porter, from 27th Mar. 1841, to 12th Mar. 1842,									
viz., 26th June, 1841, . . .	8	2	6						
Ditto, ...	0	8	8						
25th Sept. 1841, . . .	8	2	6						
Ditto, ...	0	8	8						
31st Dec. 1841, . . .	8	11	2						
12th March, 1842, . .	7	4	10						
Christmas allowances, 27th Dec. 1841, . . .	2	2	0						
Livery cloth from Andrews, 15th Dec. 1841,	4	5	0						
Ditto, making, Dunn, 17th Jan. 1842, ...	2	0	5½						
Ditto, buttons, Woodhouse, 18th Dec. 1841,	0	16	6						
Barragon coat, Simpson, 17th Feb. 1842, . .	1	0	0						
Hat, Wright and Oxley, 17th June, 1840, . .	0	16	0						
Ditto, ditto, 21st Dec. 1841, ...	0	16	0						
Aprons, St. Peter's Repository, 31st Dec. 1841,	0	3	10						
				44	18	1½			
Kane, B., as extra porter at Meetings, 28th June, 1841, ...				1	1	0			
Ditto, ditto, 28th Feb. 1842,				1	4	6			
Orpen, Dr. Thomas H., salary as Treasurer, for eight months and two weeks, to 30th Nov. 1841, ...				14	16	1			
Ditto, commission as Treasurer, on £320 5*s.* at 5 per cent., ...				16	0	3			
Smith, Dr. A., salary as Treasurer, from 30th Nov. 1841, to 16th March, 1842, . . .				6	3	11			
Wisehart, James, salary as clerk at Meetings, from 12th April, 1841, to 28th February, 1842, ...				3	5	0			
Total Salaries, Servants' Wages, &c.,							177	8	10½
							1310	14	3½

	£	s.	d.	£	s.	d.
Brought forward, . . .	. . . . .			1310	14	3½
Three and a half per Cent. Government Stock purchased.						
£ 27 s. 13 d. 2 cost	27	3	9			
28 0 8 "	27	13	5			
£55 13 10 — Total cost of Three and a half per Cent. purchased, ...				54	17	2
Three per Cent. Consols purchased.						
£ 61 s. 15 d. 8 cost	55	13	0			
46 12 7 "	42	0	0			
40 18 3 "	36	15	0			
17 10 0 "	15	15	0			
23 8 10 "	21	0	0			
21 4 3 "	18	18	0			
21 2 4 "	18	18	0			
£232 11 11 — Total cost of Three per Cent. Consols purchased, ...				208	19	0
The total Discharge, . . .	. . . . .			1574	10	5½
Balance in favour of the Public, . .	. . . . .			198	13	2½
The Charge as above, ...	. . . . .			1773	3	8

State of the Balance.

		£	s.	d.
1842. 31st March.	In Bank of Ireland, ...	190	17	1
	In Treasurer's hands, as per this Account,	7	16	1½
	Balance as above, ...	£198	13	2½

The Treasurer reports, that there is to the credit of the Academy in the Bank of Ireland, £1052 6*s.* 8*d.* in Three per Cent. Consols, and £1609 4*s.* 9*d.* in Three and a half per Cent. Government Stock, the latter known as the Cunningham Fund.

(Signed), James Pim, Jun., *Treasurer.*

31*st March,* 1843.

No. III.

ACCOUNT

OF THE

ROYAL IRISH ACADEMY,

FROM 1st APRIL, 1842, TO 31st MARCH, 1843.

THE CHARGE.

	£	s.	d.	£	s.	d.
Balance in favour of the Public, as corrected by the Commissioners (£198 13s. $2\frac{1}{2}$d., less 3s. 10d.), ...	. . . . .			198	9	$4\frac{1}{2}$
Parliamentary Grant for 1842 (paid 16th March, 1843), ...	300	0	0			
Quarterly Warrants from Treasury, . . .	146	17	8			
Total from Treasury, . . .				446	17	8
INTEREST ON STOCK:						
£ s. d.						
Half year's on 1609 4 5, $3\frac{1}{2}$ per Cents.,	28	2	0			
Ditto, „ 1636 18 5, $3\frac{1}{2}$ „ .	28	11	5			
Ditto, „ 1052 6 8, 3 „ .	15	14	5			
Ditto, „ 1069 0 6, 3 „ .	15	19	6			
Total Interest on Stock (exclusive of brokerage 5s. 3d.), .				88	7	4
PUBLICATIONS AND BOOKS SOLD:						
Boone, Messrs., balance of their account to 2nd January, 1843, ...	. . . . .			8	17	4
One year's rent of Stable, to Nov. 1, 1842,	. . . . .			21	0	0
LIFE COMPOSITIONS:						
Henry Hutton, Esq., ...	21	0	0			
Robert Bateson, Esq., ...	21	0	0			
W. V. Drury, Esq., ...	15	15	0			
Stewart Blacker, Esq., ...	21	0	0			
H. L. Renny, Esq., ...	21	0	0			
Total Life Compositions, . .				99	15	0
				863	6	$8\frac{1}{2}$

		£	s.	d.	£	s.	d.
Brought forward,		.	.	.	863	6	8½
Entrance Fees.							
John Toleken, M.D.,	1842,	5	5	0			
Robert Law, M.D.,	,,	5	5	0			
Rev. R. Butler,	,,	5	5	0			
W. Blacker, Esq.,	,,	5	5	0			
B. J. Chapman, Esq.,	,,	5	5	0			
Sir Thomas Staples, Bart.,	,,	5	5	0			
Arthur Kane, Esq.,	,,	5	5	0			
F. M. Jennings, Esq.,	,,	5	5	0			
Rev. James Booth,	,,	5	5	0			
Thomas Hodder, Esq., R.N.,	1843,	5	5	0			
Henry Hutton, Esq.,	,,	5	5	0			
Hon. Frederick Ponsonby,	,,	5	5	0			
Thomas Cather, Esq.,	,,	5	5	0			
W. V. Drury, M.D.,	,,	5	5	0			
R. L. Ogilby, Esq.,	,,	5	5	0			
G. Salmon, Esq.,	,,	5	5	0			
W. R. Gore, M.D.,	,,	5	5	0			
Stewart Blacker, Esq.,	,,	5	5	0			
R. Cully, Esq.,	,,	5	5	0			
H. L. Renny, Esq.,	,,	5	5	0			
James Magee, Esq.,	,,	5	5	0			
Total Entrance Fees,					110	5	0
Annual Subscriptions and Arrears.							
Hugh Ferguson, M.D., due March 16,	1842,	2	2	0			
J. Davidson, Jun., Esq., ,,	,,	2	2	0			
G. Downes, Esq., ,,	,,	2	2	0			
M. Barrington, Esq., ,,	1841,	2	2	0			
S. Hardy, Esq., ,,	,,	2	2	0			
J. F. Lynch, Esq. ,,	,,	2	2	0			
John Mollan, M.D., ,,	1842,	2	2	0			
W. Drennan, Esq., ,,	,,	2	2	0			
Archdeacon Disney, ,,	,,	2	2	0			
W. F. Conway, Esq., ,,	,,	2	2	0			
G. D. La Touche, Esq., ,,	,,	2	2	0			
E. Davy, Esq., ,,	,,	2	2	0			
G. A. Frazer, Esq., ,,	,,	2	2	0			
Sir L. O'Brien, Bart., ,,	,,	2	2	0			
E. Cane, Esq., ,,	,,	2	2	0			
James Apjohn, Esq., ,,	,,	2	2	0			
R. Tighe, Esq., ,,	,,	2	2	0			
W. Edington, Esq., ,,	,,	2	2	0			
William Hill, Esq., ,,	,,	2	2	0			
A. Smith, M.D., ,,	,,	2	2	0			
		42	0	0	973	11	8½

		£	s.	d.	£	s.	d.
Brought forward, . . .		42	0	0	973	11	8½
W. Monsell, Esq., .	due March 16, 1842.	2	2	0			
W. B. Wallace, Esq., . . .	,, ,,	2	2	0			
R. Jones, Esq., ...	,, ,,	2	2	0			
John Hamilton, Esq., . . .	,, ,,	2	2	0			
William Gregory, Esq., . .	,, ,,	2	2	0			
G. Wilkinson, Esq., ...	,, ,,	2	2	0			
G. W. Hemans, Esq., . . .	,, ,,	2	2	0			
M. M. O'Grady, Esq., . . .	,, ,,	2	2	0			
William Murray, Esq., . .	,, ,,	2	2	0			
Hon. James King, ...	,, ,,	2	2	0			
Gerald Fitzgibbon, Esq., .	,, ,,	2	2	0			
Rev. James Reid, ...	,, ,,	2	2	0			
George Carr, Esq., ...	,, ,,	2	2	0			
Rev. H. F. C. Logan, ...	,, ,,	2	2	0			
Charles Vignoles, Esq., . .	,, ,,	2	2	0			
John Hart, Esq., ...	,, ,,	2	2	0			
Sir William Betham, ...	,, ,,	2	2	0			
Chichester Bolton, Esq., .	,, ,,	2	2	0			
Godfrey Levinge, Esq., . .	,, ,,	2	2	0			
C. E. H. Orpen, M. D., . .	,, ,,	2	2	0			
E. J. Cooper, Esq., ...	,, ,,	2	2	0			
S. Carter, Esq., ...	,, ,,	2	2	0			
M. Longfield, Esq., ...	,, ,,	2	2	0			
Sir J. K. James, Bart., . . .	,, ,,	2	2	0			
Hon. P. C. Crampton, . . .	,, ,,	2	2	0			
Rev. James Wills, ...	,, ,,	2	2	0			
Charles W. Hamilton, Esq.,	,, ,,	2	2	0			
His Grace the Abp. of Dublin,	,, ,,	2	2	0			
Thomas F. Kelly, Esq., . . .	,, ,,	2	2	0			
James Patten, M. D., ...	,, ,,	2	2	0			
W. T. Mulvany, Esq., . . .	,, ,,	2	2	0			
O. Sproul, Esq., ...	,, ,,	2	2	0			
Rev. John West, D. D., . . .	,, ,,	2	2	0			
Thomas Newenham, Esq., .	,, ,,	2	2	0			
R. Dickinson, Esq., ...	,, ,,	2	2	0			
R. Kane, M. D., ...	,, ,,	2	2	0			
Hon. M. Brady (Lord Chief Baron),	,,	2	2	0			
Rev. W. Lee, ...	,, ,,	2	2	0			
R. Reid, M. D.	,, ,,	2	2	0			
R. A. Wallace, Esq., ...	,, ,,	2	2	0			
Sir E. Borough, Bart., . . .	,, ,,	2	2	0			
W. T. Lloyd, Esq., ...	,, ,,	2	2	0			
Thomas Fortescue, Esq., . .	,, ,,	2	2	0			
R. Adams, Esq., ...	,, ,,	2	2	0			
J. H. Smith, Esq., ...	,, ,,	2	2	0			
Jacob Owen, Esq., ...	,, ,,	2	2	0			
		138	12	0	973	11	8½

	£	s.	d.	£	s.	d.
Brought forward, . . .	138	12	0	973	11	8½
M. Barrington, Esq., due March 16, 1842,	2	2	0			
J. Finlay, LL.D., ... „ „	2	2	0			
A. Palmer, Esq., ... „ „	2	2	0			
James Pim, Jun., Esq., . . „ „	2	2	0			
Mathew O'Conor, Esq., . . „ „	2	2	0			
Arthur Jacob, M. D., . . „ „	2	2	0			
W. Barker, M. D., ... „ „	2	2	0			
F. Barker, M. D., ... „ „	2	2	0			
Thomas E. Beatty, M. D., . „ „	2	2	0			
Rev. Dr. Vignoles, ... „ „	2	2	0			
Simeon Hardy, Esq., ... „ „	2	2	0			
J. Osborne, M. D., ... „ „	2	2	0			
J. H. Jellett, Esq., ... „ „	2	2	0			
R. W. Smith, Esq., ... „ „	2	2	0			
T. Grubb, Esq., ... „ „	2	2	0			
H. H. Joy, Esq., ... „ „	2	2	0			
J. Anster, LL.D., ... „ „	2	2	0			
F. W. Burton, Esq., ... „ „	2	2	0			
J. W. Young, Esq., ... „ „	2	2	0			
George M'Dowell, Esq., . . „ „	2	2	0			
William Stokes. M. D., . . „ „	2	2	0			
R. Mallet, Esq., ... „ „	2	2	0			
John Ball, Esq., ... „ „	2	2	0			
W. F. Montgomery, M.D., . „ „	2	2	0			
G. A. Kennedy, M. D., . . „ „	2	2	0			
W. T. Kent, Esq., ... „ „	2	2	0			
Acheson Lyle, Esq., ... „ „	2	2	0			
J. S. Cooper, Esq., ... „ „	2	2	0			
General O'Halloran, ... „ „	2	2	0			
A. E. Gayer, LL.D., ... „ „	2	2	0			
R. E. Walker, Esq., ... „ „	2	2	0			
W. R. Wilde, Esq., ... „ „	2	2	0			
Rev. Dr. Marks, ... „ „	2	2	0			
Elliott Warburton, Esq., . „ „	2	2	0			
H. Coulson Beauchamp, M. D. „ „	2	2	0			
William Farran, Esq. . . . „ „	2	2	0			
James Whiteside, Esq., . . „ „	2	2	0			
P. M. Murphy, Esq., ... „ „	2	2	0			
S. Ferguson, Esq., ... „ „	2	2	0			
B. J. Chapman, Esq., . . . „ 1843,	2	2	0			
Charles Doyne, Esq., . . . „ 1842,	2	2	0			
Sir R. Morrisson, ... „ „	2	2	0			
W. E. Hudson, Esq., ... „ „	2	2	0			
Ditto. ditto. . . . „ 1843,	2	2	0			
Robert Graves, M. D., . . . „ 1842,	2	2	0			
Very Rev. Dean Gregory, . . „ „	2	2	0			
	235	4	0	973	11	8½

		£	s.	d.	£	s.	d.
Brought forward, . . .		235	4	0	973	11	8½
P. D. Hardy, Esq., . due March 16,	1842,	2	2	0			
C. G. Otway, Esq., ... ,,	,,	2	2	0			
J. O'Grady. LL.D., ... ,,	,,	2	2	0			
John Dalton, Esq., ... ,,	,,	2	2	0			
G. Cash, Esq., ... ,,	,,	2	2	0			
John Burrowes, Esq., ... ,,	1843,	2	2	0			
John Hamilton, Esq., . . . ,,	,,	2	2	0			
Frederick Darley, Esq., . . . ,,	1841,	2	2	0			
Ditto, ... ,,	1842,	2	2	0			
H. Ferguson, M. D., ... ,,	1843,	2	2	0			
George Downes, Esq., . . . ,,	,,	2	2	0			
Sir P. Crampton, Bart., . . . ,,	1842,	2	2	0			
William Murray, Esq., . . . ,,	1843,	2	2	0			
A. B. Cane, Esq., ... ,,	,,	2	2	0			
John Davidson, Esq., . . . ,,	,,	2	2	0			
Rev. S. Butcher, ... ,,	,,	2	2	0			
Durham Dunlop, ... ,,	,,	2	2	0			
E. S. Clarke, Esq., ... ,,	1842,	2	2	0			
W. T. Mac Cullagh, Esq., . . ,,	,,	2	2	0			
Ditto, ... ,,	1843,	2	2	0			
W. Edington, Esq., ... ,,	,,	2	2	0			
R. Kane, M. D., ... ,,	,,	2	2	0			
C. Bolton, Esq., ... ,,	,,	2	2	0			
Dr. O'Grady, ... ,,	,,	2	2	0			
Captain Sterling, ... ,,	,,	2	2	0			
Sir E. Borough, Bart., . . . ,,	,,	2	2	0			
Thomas Fortescue, Esq., . . . ,,	,,	2	2	0			
E. Hutton, M. D., ... ,,	,,	2	2	0			
G. Carr, Esq., ... ,,	,,	2	2	0			
Total Annual Subscriptions and Arrears,					296	2	0
THE TOTAL CHARGE, . . .		. . . .		. £	1269	13	8½

THE DISCHARGE.

Antiquities purchased and repaired.	£	s.	d.	£	s.	d.
Broderick, for two gold fragments, 17th Nov. 1842, ...	1	0	0			
Donegan, for gold cup, 15th Feb. 1843, . .	4	4	0			
Edwards, for warrant, 30th May, 1842, . .	1	12	6			
Maguire, for silver pin, 8th April, 1842, .	8	2	2			
J. H. Smith, for seal, 31st March, 1842, . .	0	5	0			
Underwood, for silver seal, 2nd April, 1842,	2	0	0			
Ditto, tracery, 28th May, 1842, .	0	5	0			
Ditto, crozier, 15th Nov. 1842, .	2	0	0			
Ditto, silver relic, 14th Sept. 1842,	1	0	0			
Total Antiquities purchased and repaired,				20	8	8
Books, Printing, Stationary, &c.						
Allen, engraving, to 27th July, 1842, . . .	2	9	0			
Ditto, lithography, 2nd Feb., 1243, . . .	6	19	6			
Betham, Sir W., for Dunop's Book, 4th July, 1842, ...	1	10	0			
Camden Society, subscription to, 27th July, 1842, ...	3	0	0			
Curry, Catalogue of Manuscripts, 16th Jan. 1843, ...	14	0	0			
Ditto, ditto, 6th March, 1843,	12	19	0			
Du Noyer, lithographs, to 5th Oct. 1842, .	2	10	0			
Hanlon, wood-cuts, 1st Aug., 1842, . . .	1	12	0			
Hely, envelopes, 22nd October, 1842, . .	1	2	0			
Johnston and Co., advertisements, 26th July, 1842, ...	2	2	0			
Taylor, R. and J. E., twenty Scientific Memoirs, Part 10, 2nd May, 1842, ...	6	0	0			
Total Books, Printing, Stationary, &c.,				54	3	6
Coals, Candles, Oil, &c.						
Allen, William, oil, to 9th Dec., 1842, . .	8	0	0			
Kenny, M., coke and coal, to 9th April, 1842,	3	18	0			
Ditto, coal, to 26th Jan., 1843, . . .	3	15	0			
Rathborne, candles, to 16th March, 1842, .	6	5	2			
Wilson, T. P., coals, to 5th August, 1842, .	17	0	0			
Total Coals, Candles, Oil, &c., . .				38	18	2
				113	10	4

	£	s.	d.	£	s.	d.
Brought forward, . . .	.	. .	. .	113	10	4
Contingencies, &c.						
Clibborn, E., incidentals to May, 1842, . .	3	19	8			
Ditto, ditto, 29th July, 1842,	1	10	3			
Ditto, ditto, 21st Nov. 1842,	2	3	0			
Ditto, ditto, 5th Jan. 1843, .	2	5	7			
Ditto, ditto, 6th March, 1843,	1	0	8			
Post Office orders, 1st August, 1842, . . .	0	1	0			
Robertson, carriage of parcels, 29th July, 1842, ...	0	13	6			
Rorke, for stamps, 1st Oct. 1842, ...	7	5	0			
Stamp on treasury warrant, 16th March, 1843, ...	0	5	0			
Total Contingencies, &c., . .				19	3	8
Repairs of House, &c.						
Brown, J., cleaning windows to 2nd June, 1842, ...	1	13	6			
Ditto, ditto, to 2nd Dec., 1842,	1	10	0			
Casey, S., iron works, &c., 16th July, 1842,	1	4	0			
Clibborn, E., sundries used in cleaning house, &c., 16th July, 1842, ...	5	0	0			
Ditto, ditto, to 16th Jan., 1843,	5	0	0			
Flinn, B., cleaning ash pit, 10th May, 1842,	0	4	0			
Mullen, W., sweeping chimneys, 3rd May, 1842, ...	0	17	0			
Ditto, ditto, 14th July, 1842,	0	5	0			
Ditto, ditto, 2nd Nov., 1842,	0	10	0			
Total Repairs of House, &c., .				16	3	6
Repairs of Furniture, &c.						
Barrington, F., iron door, to 1st Aug., 1842,	4	15	6			
Ditto, repairs on safe, 14th Dec., 1842,	0	8	6			
Blackwell and O'Brien, repairs of lamps, globes, &c., 12th Nov., 1842, ...	2	11	0			
Duffy, J., boards, to 25th Dec., 1842, . .	1	7	0			
Ditto, frame and glass, 14th Feb., 1843,	0	12	0			
Kane, C., washing rollers, 2nd July, 1842,	0	12	0			
Kane, B., beating carpets, 21st July, 1842, .	0	7	6			
Littledale, J., iron chest, 4th July, 1842, .	5	10	0			
Yeates, G., scales and letter stamp, 25th Nov., 1842, ...	1	14	0			
Total Repairs of Furniture, &c.,				17	17	6
				166	15	0

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward, . . .				. . . . .			166	15	0
Rent, Taxes, Insurance, &c.									
Truell, R. H., half-year's rent, to 1st Aug., 1842, ...	52	4	6						
Ditto, ditto, 1st Feb., 1843,	52	4	6						
				104	9	0			
Grand Jury cess, half-year, Easter, 1842, ...	4	1	3						
Ditto, ditto, Michaelmas, 1842,	3	15	0						
				7	16	3			
Wide street tax, Easter, 1842, ...				0	18	9			
Police tax, 25th March, 1842, .	2	3	9						
Ditto, 29th Sept., 1842, . .	2	3	9						
				4	7	6			
Pipe water, 24th June, 1842, ...				1	7	8			
Ministers' money, 29th Sept., 1842, . . .				2	15	5			
Parish cess, 29th Sept., 1842, ...				2	0	0			
Paving and lighting, 5th Jan., 1843, . . .				12	8	9			
Watering street, ... 1842, . . .				0	9	9			
Poor rate, 24th March, 1842, . .	2	10	0						
Ditto, 10th Nov. 1842, ...	2	10	0						
				5	0	0			
Insurance at Globe, ...	5	13	6						
Ditto, National, ...	2	15	4						
Ditto, ditto, ...	5	13	6						
Ditto, ditto, ...	4	2	6						
				18	4	10			
Total Rent, Taxes, Insurance,							159	17	11
Salaries, Servants' Wages, &c.									
Clibborn, Edward, salary for one year and a quarter as assistant librarian and clerk, to 16th March, 1843, ...				150	0	0			
Hamilton, William, salary and allowances as porter, from March 12th to March 26th, 1842, . . .	1	6	4						
to June 25th, 1842, . . .	8	11	0						
to Sept. 24th, 1842, . .	8	11	2						
to Dec. 31st, 1842, . .	9	5	4						
to March 11th, 1843, . .	6	11	8						
Christmas allowances, Dec. 25th, 1842, ...	2	2	0						
				36	6	8			
				186	6	8			
							326	12	11

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward, ...				186	6	8	326	12	11
Smith, John, assistant porter, from 18th June to 18th July, 1842,	1	2	6						
to 30th July, 1842,	0	10	0						
				1	12	6			
Kane, Bernard, extra evening porter, from 16th March, 1842, to 27th June, 1842, .				1	4	6			
Corcoran, messenger, to 15th March, 1842, .				0	5	0			
Sinton, T., assistant clerk, to 24th Dec. 1842,				4	0	0			
Wisehart, James, salary as clerk at meetings, to 23rd May, 1842,	1	5	0						
to 10th Jan., 1843,	1	10	0						
to 27th Feb., 1843,	0	15	0						
				3	10	0			
Kane Robert, M.D., Secretary of Council, to 16th March, 1843, ...				21	0	0			
Pim, James, Jun., Treasurer, to 16th March, 1843, ...				21	0	0			
Mac Cullagh, James, Esq., Secretary of Council, to 16th March, 1842, ...	21	0	0						
Ditto, of Academy, 16th March, 1843, ...	21	0	0						
				42	0	0			
Drummond, Rev. W. H., Librarian, to 16th March, 1842, . . .	21	0	0						
Ditto, ditto, 1843, . . .	21	0	0						
				42	0	0			
Singer, Rev. J. H., Secretary to Academy, to 16th March, 1842, ...				21	0	0			
Total Salaries, Servants' Wages, &c.,							343	18	8

Three and a half per Cent. Government Stock purchased.

£	s.	d.			£	s.	d.	£	s.	d.
27	13	8	cost	. . . .	28	2	0			
28	5	9	„	. . . .	28	11	5			
£55	19	5		Total cost of Three and a half per Cent. purchased, ...				56	13	5
								727	5	0

	£ s. d.	£ s. d.
Brought forward, . . .	. . . . .	727 5 0
THREE PER CENT. CONSOLS PURCHASED.		
£ s. d.		
16 13 10 cost	15 15 5	
16 16 7 "	15 19 6	
309 0 7 "	300 0 0	
£342 11 0 Total cost of Three per Cent. Consols purchased, ...		331 14 11
THE TOTAL DISCHARGE, . .	. . . . . £	1058 19 11
Balance in favour of the Public .	. . . . .	210 13 $9\frac{1}{2}$
The Charge as above, (p. xxi.) . .	. . . . . £	1269 13 $8\frac{1}{2}$

STATE OF THE BALANCE.

1843.		£	s.	d.
31st March,	In the Bank of Ireland, ...	208	6	10
	In Treasurer's hands, as per this Account,	2	6	$11\frac{1}{2}$
	Balance as above, . . .	£210	13	$9\frac{1}{2}$

The Treasurer reports, that there is to the credit of the Academy in the Bank of Ireland, £1394 17*s.* 8*d.* in Three per Cent. Consols, and £1665 4*s.* 2*d.* in Three and a half per Cent. Government Stock, the latter known as the Cunningham Fund.

(Signed,) JAMES PIM, JUN.,
Treasurer.

31*st March*, 1843.

No. IV.

ACCOUNT

OF THE

ROYAL IRISH ACADEMY,

FROM 1st APRIL, 1843, TO 31st MARCH, 1844.

THE CHARGE.

	£	s.	d.	£	s.	d.
Balance in favour of the Public, as per last Audit, ...	.	.	.	210	13	9$\frac{1}{2}$
Parliamentary Grant for 1843 (paid Jan. 4, 1844), ...	300	0	0			
Quarterly Warrants from Treasury, . . .	146	17	8			
Total from Treasury, . . .				446	17	8
THREE PER CENT. CONSOLS SOLD:						
1843, August 12, 14, £300, at 94$\frac{1}{8}$ $\frac{1}{4}$ per,	282	11	3			
Interest 40 days, ...	0	19	8			
	283	10	11			
Brokerage, ...	0	7	6			
Total Proceeds Consols sold,				283	3	5
OLD 3$\frac{1}{2}$ PER CENT. STOCK SOLD:						
1843, August 12, 14, £50, at 101$\frac{5}{8}$ per, .	50	16	3			
Interest 40 days, ...	0	3	10			
	51	0	1			
Brokerage, ...	0	1	3			
Total Proceeds old 3$\frac{1}{2}$ per cent. Stock sold, . . .				50	18	10
INTEREST ON STOCK:						
£ s. d.						
Half year's on 1665 4 2, 3$\frac{1}{2}$ per Cents.,	29	1	4			
Ditto, ,, 1643 19 6, 3$\frac{1}{2}$,, .	28	13	11			
Ditto, ,, 1394 17 8, 3 ,, . .	20	17	3			
Ditto, ,, 1117 1 10, 3 ,, . .	16	13	10			
Total Interest on Stock (exclusive of brokerage, 5*s.* 6*d.*,)				95	6	4
				1087	0	0$\frac{1}{2}$

	£	s.	d.	£	s.	d.
Brought forward, . . .	. . . . .			1087	0	0½
PUBLICATIONS AND BOOKS SOLD:						
Boone, Messrs., balance of their account to 31st December, 1843, ...	. . . . .			14	6	3
ONE YEAR'S RENT OF STABLE to Nov. 1, 1843,	. . . . .			21	0	0
LIFE COMPOSITIONS:						
J. Pickford, M. D., ...	. . . . .			15	15	0
ENTRANCE FEES:						
Hon. and Very Rev. the Dean of St. Patrick's, ... 1843,	5	5	0			
Goddard Richards, Esq., ... ,,	5	5	0			
Rev. F. Crawford, ... ,,	5	5	0			
J. Wynne, Esq., ... ,,	5	5	0			
J. George Abeltshauser, Esq., . . . ,,	5	5	0			
G. J. Allman, M. D., ... ,,	5	5	0			
H. L. Lindsay, Esq., ... ,,	5	5	0			
Rev. John Homan, ... ,,	5	5	0			
John M'Mullen, Esq., ... ,,	5	5	0			
Matthew Dease, Esq., ... ,,	5	5	0			
J. Pickford, M. D., ... ,,	5	5	0			
Sir M. Chapman, Bart., ... ,,	5	5	0			
E. Bewley, M. D., ... ,,	5	5	0			
J. Neville, Esq., ... ,,	5	5	0			
Henry Clare, Esq., ... ,,	5	5	0			
William Henry, Esq., ... ,,	5	5	0			
William M'Dougall, Esq., ... ,,	5	5	0			
Total Entrance Fees, . . .				89	5	0
ANNUAL SUBSCRIPTIONS AND ARREARS:						
W. Andrews, Esq., due March 16, 1843,	2	2	0			
C. T. Webber, Esq., . . . ,, ,,	2	2	0			
The Archbishop of Dublin, ,, ,,	2	2	0			
William Hill, Esq., ... ,, ,,	2	2	0			
Sir Thomas Staples, Bart., ,, ,,	2	2	0			
F. M. Jennings, Esq., . . ,, ,,	2	2	0			
James Pim, Jun., Esq., . ,, ,,	2	2	0			
Rev. William Lee, ... ,, ,,	2	2	0			
William Gregory, M. D., . ,, ,,	2	2	0			
W. Longfield, Esq., ... ,, ,,	2	2	0			
Rev. R. V. Dixon, ... ,, 1842,	2	2	0			
Ditto, ... ,, 1843,	2	2	0			
Rev. Richard Butler, . . ,, ,,	2	2	0			
J. Nelson, Esq., ... ,, ,,	2	2	0			
G. D. La Touche, Esq., . ,, ,,	2	2	0			
	31	10	0	1227	6	3½

		£	s.	d.	£	s.	d.
Brought forward, . . .		31	10	0	1227	6	3½
J. T. Banks, M. D., due March 16,	1843,	2	2	0			
A. Smith, M.D., ... „	„	2	2	0			
Thomas Newenham, Esq., . „	„	2	2	0			
F. W. Conway, Esq., . . „	„	2	2	0			
W. Blacker, Esq., ... „	„	2	2	0			
Sir J. K. James, Bart., . . „	„	2	2	0			
Jacob Owen, Esq., ... „	„	2	2	0			
Sir W. Betham, Knt., . . „	„	2	2	0			
William Hogan, Esq., . . „	„	2	2	0			
W. Drennan, Esq., ... „	„	2	2	0			
Hon. Justice Crampton, LL.D.,	„	2	2	0			
G. Fitzgibbon, Esq., . . „	„	2	2	0			
Rev. James Wills, ... „	„	2	2	0			
W. B. Wallace, Esq., . . „	„	2	2	0			
W. T. Mulvany, Esq., . . „	„	2	2	0			
F. Churchill, M.D., . . . „	„	2	2	0			
A. Ferrier, Esq., ... „	„	2	2	0			
J. S. Cooper, Esq., . . . „	„	2	2	0			
John Mollon, M.D., . . . „	„	2	2	0			
F. W. Burton, Esq., . . „	„	2	2	0			
W. T. Lloyd, Esq., ... „	„	2	2	0			
G. Wilkinson, Esq., . . . „	„	2	2	0			
J. Wynne, Esq., ... „	1844,	2	2	0			
Thomas F. Kelly, LL.D., . „	1843,	2	2	0			
Sir L. O'Brien, Bart., . . „	„	2	2	0			
Charles Vignoles, Esq., . „	„	2	2	0			
Edward Cane, Esq., . . . „	„	2	2	0			
G. W. Hemans, Esq., . . „	„	2	2	0			
John Finlay, LL.D., . . . „	„	2	2	0			
Charles Doyne, Esq., . . „	„	2	2	0			
Rev. Thomas Stack, . . . „	„	2	2	0			
R. A. Wallace, Esq., . . „	„	2	2	0			
Thomas Grubb, Esq., . . „	„	2	2	0			
Rev. R. Chatto, ... „	„	2	2	0			
Rev. James Reid, ... „	„	2	2	0			
John Toleken, M.D., . . . „	„	2	2	0			
James Patten, M.D., . . . „	„	2	2	0			
Right Hon. Chief Baron, . „	„	2	2	0			
Edmund Davy, Esq., . . . „	„	2	2	0			
C. W. Hamilton, Esq., . . „	„	2	2	0			
J. H. Jellett, Esq., ... „	„	2	2	0			
James Apjohn, M.D., . . . „	„	2	2	0			
E. J. Cooper, Esq., ... „	„	2	2	0			
R. Adams, Esq., ... „	„	2	2	0			
C. E. H. Orpen, M.D., . . „	„	2	2	0			
		126	0	0	1227	6	3½

		£	s.	d.	£	s.	d.
Brought forward, . . .		126	0	0	1227	6	3½
Hon. James King, due March 16,	1843,	2	2	0			
M. Longfield, LL. D., . . ,,	,,	2	2	0			
Rev. H. F. C. Logan, D. D., ,,	,,	2	2	0			
J. Osborne, M. D., ... ,,	,,	2	2	0			
J. Huband Smith, Esq., . ,,	,,	2	2	0			
G. A. Frazer, Esq., ... ,,	,,	2	2	0			
Abraham Abell, Esq., . . ,,	1842,	2	2	0			
Ditto, ... ,,	1843,	2	2	0			
William Barker, M. D., . ,,	,,	2	2	0			
Robert Tighe, Esq., . . . ,,	,,	2	2	0			
R. Law, M. D., ... ,,	,,	2	2	0			
Rev. John West, D. D., . ,,	,,	2	2	0			
R. Graves, M. D., ... ,,	,,	2	2	0			
John Ball, Esq., ... ,,	,,	2	2	0			
T. E. Beatty, M. D., ... ,,	,,	2	2	0			
H. C. Beauchamp, M. D., . ,,	,,	2	2	0			
R. C. Walker, Esq., ... ,,	,,	2	2	0			
W. Monsell, Esq., ... ,,	,,	2	2	0			
William Stokes, M. D., . . ,,	,,	2	2	0			
J. T. Young, Esq., ... ,,	,,	2	2	0			
R. Reid, M. D., ... ,,	,,	2	2	0			
Rev. Matthew Horgan, . . ,,	1841,	2	2	0			
Oliver Sproul, Esq., . . . ,,	1843,	2	2	0			
Arthur Jacob, M. D., . . ,,	,,	2	2	0			
J. F. Lynch, Esq., ... ,,	1842,	2	2	0			
R. W. Smith, Esq., ... ,,	1843,	2	2	0			
Wrigley Grimshaw, M. D., ,,	,,	2	2	0			
John Hart, M. D., ... ,,	,,	2	2	0			
M. Barrington, Esq., . . . ,,	,,	2	2	0			
H. H. Joy, Esq., ... ,,	,,	2	2	0			
J. Anster, LL. D., ... ,,	,,	2	2	0			
W. R. Wilde, Esq., ... ,,	,,	2	2	0			
W. T. Kent, Esq., ... ,,	,,	2	2	0			
R. Dickinson, Esq., ... ,,	,,	2	2	0			
R. Mallet, Esq., ... ,,	,,	2	2	0			
S. Carter, Esq., ... ,,	,,	2	2	0			
M. O'Conor, Esq., ... ,,	,,	2	2	0			
W. F. Montgomery, M. D., ,,	,,	2	2	0			
G. M'Dowell, Esq., ... ,,	,,	2	2	0			
Ditto, ... ,,	1844,	2	2	0			
Rev. Edward Marks, D. D., ,,	1843,	2	2	0			
G. A. Kennedy, M. D., . . ,,	,,	2	2	0			
A. Lyle, Esq., ... ,,	,,	2	2	0			
F. Churchill, M. D., . . . ,,	1844,	2	2	0			
B. J. Chapman, Esq., . . . ,,	,,	2	2	0			
		220	10	0	1227	6	3½

	£	s.	d.	£	s.	d.
Brought forward, . . .	220	10	0	1227	6	3½
William Farran, Esq., due March 16, 1843,	2	2	0			
E. S. Clarke, Esq., ... ,, ,,	2	2	0			
John Dalton, Esq., ... ,, ,,	2	2	0			
Total Annual Subscriptions and Arrears,				226	16	0
THE TOTAL CHARGE, . . .	. . . .		£	1454	2	3½

THE DISCHARGE.

Antiquities purchased and repaired.	£ s. d.	£ s. d.
Armstrong, Robert, drawing of the Magrath tomb, 18th October, 1844, ...	1 1 0	
Davis, E., great seal of George I., Nov. 13th, 1843, ...	0 5 0	
Donegan, John, for antique gold ornament, Feb. 19th, 1844, ...	13 16 0	
Gerin, Michael, a bronze antiquity, to June 3rd, 1843, ...	1 15 0	
Glennon, Richard, spear, Oct. 12th, 1843,	0 7 0	
Reilly, Peter, shoes, &c. to May 20th, 1843,	0 10 0	
Ditto, a brass vessel, June 13th, 1843,	2 10 0	
Ditto, sundries, Oct. 11th, 1843,	0 8 0	
Sharkey, William, gold cinerary boxes and fibulæ, ...	15 10 0	
Underwood, J., for bell, to August 11th, 1843, ...	0 5 0	
Ditto, celt, Oct. 10th, 1843,	0 4 0	
Ditto, dirk, Nov. 3rd, 1843,	0 10 0	
Total Antiquities purchased and repaired,		37 1 0
Books, Printing, Stationery, &c.		
Allen, J. W., Lithography, &c., to July 4th, 1843, ...	15 17 9	
Curry, Eugene, Catalogue of Manuscripts, to April 7th, 1843, ...	11 4 0	
Ditto, ditto, June, 5th, 1843,	12 12 0	
Ditto, ditto, July 17th, 1843,	12 12 0	
Ditto, ditto, Nov. 6th, 1843,	33 12 0	
Ditto, ditto, Nov. 13th, 1843,	2 2 0	
Ditto, ditto, from 11th Dec., 1843, to Feb, 19th, 1844, ...	21 0 0	
Dalton, John, for book on Drogheda, to Dec. 21st, 1843, ...	1 4 0	
Gill, M. H., printing Proceedings and Circulars, Dec. 31st, 1842, ...	53 0 10	
Ditto, ditto, Transactions, March 16th, 1843, ...	264 10 4	
	427 14 11	37 1 0

	£	s.	d.	£	s.	d.
Brought forward, . . .	427	14	11	37	1	0
Hanlon, George, for woodcut of ogham stone to Nov. 18th, 1843, ...	3	0	0			
Hodges and Smith, books, &c., to June, 1843, ...	49	9	7			
Johnson and Co., advertising Transactions, to June 30th, 1843, ...	25	16	6			
Kirkwood, John, printing and engraving, March, 24th, 1843, ...	10	8	9			
Mullen, G., book binding, to March 20th, 1843, ...	32	3	11			
Ditto, ditto, June 30th, 1843,	58	1	6			
Ditto, ditto, Jan. 31st, 1844,	16	6	9			
Oriental Translation Fund, subscription for 1842 and 1843, ...	21	0	0			
Perry and Co., paper, to June 28th, 1843,	2	0	6			
Plunket, James, 24 sheets of drawings for Catalogue of Antiquities, to Dec. 24th, 1843, ...	19	10	0			
Reilly, John, four volumes of the Transactions, Feb. 5th, 1844, ...	1	0	0			
Taylor, R. and J. E., twenty Scientific Memoirs, Part II., to Jan. 31st, 1843, . .	6	0	0			
Total Books, Printing, Stationery, &c.,				672	12	5
Coals, Candles, Oil, &c.						
Kenny, M., for stove coals, to July 20th, 1843,	1	5	0			
Rathborne, J. & H., for candles, to May 27th, 1843, ...	6	17	11			
Todhunter, J., coals, to March 30th, 1843,	0	19	6			
Total Coals, Candles, Oil, &c.,				9	2	5
Contingencies, &c.						
Carriage of parcels, to Nov. 28th, 1843, .	1	15	10			
Clibborn, E., incidentals, to April 3rd, 1843, ...	0	18	4			
Ditto, per treasurer, ...	0	6	4			
Clifford, for gum, to Oct. 23rd, 1843, . .	0	3	10			
Declaration in Court of Exchequer, and car hire, to Dec. 6th, 1843, ...	0	2	6			
Elliot, carriage of parcels, to May 29th, 1843,	0	5	0			
Fannin, ditto, May 22nd, 1843,	0	3	0			
Ditto, ditto, Jan. 22nd, 1844,	0	1	0			
Ditto, ditto, ditto, . .	0	0	10			
Maguire, twine, June 16th, 1843, . . .	0	1	0			
	3	17	8	718	15	10

	£	s.	d.	£	s.	d.
Brought forward, . . .	3	17	8	718	15	10
Pamplin, William, carriage of parcels, June 26th, 1843, ...	0	1	6			
Patten, J., ditto, Dec. 27th, 1843, .	0	1	0			
Postages, to June 23rd, 1843, ...	10	10	8			
Ditto, Dec. 31st, 1843, ...	1	6	10			
Ditto, ditto, ...	0	0	5			
Postage stamps, to March 25th, 1843, . .	1	0	0			
Power of attorney to Boyle and Co., to sell Stock, ...	1	0	0			
Stamp on Government Grant, paid Jan. 4th, 1844, ...	0	5	0			
Subscription to Mr. Ryland, to reimburse his expenses in carrying the Act of 6 & 7 Victoria, ...	10	10	0			
Total Contingencies, &c. . .				28	13	1

Repairs of House, &c.

	£	s.	d.	£	s.	d.
Brown, J., cleaning windows, to June 2nd, 1843, ...	1	10	0			
Ditto, glazing ditto, Feb. 3rd, 1843, .	0	7	0			
Clibborn, Edward, sundries used in cleaning house, to July 16th, 1843, ...	5	0	0			
Mullen, Wm., sweeping chimneys, to May 17th, 1843, ...	0	11	6			
Total Repairs of House, &c.				7	8	6

Repairs of Furniture, &c.

	£	s.	d.	£	s.	d.
Allen, E., towels, to April 28th, 1843, . .	1	19	11			
Casey, Paul, repairing locks, to March 20th, 1843, ...	0	5	4			
Duffy, John, altering table, to March 10th, 1843, ...	1	4	0			
Edmundson and Co., for lamps, &c., to March 11th, 1843, ...	3	12	9			
Kane, B., removing and cleaning carpet, July 1st, 1843, ...	0	7	6			
Perry and Co., locks, to July 6th, 1842, .	0	18	10			
Ditto, ditto, June 28th, 1843,	1	2	4			
Sharp and Co., repairs of clocks, &c., March 7th, 1843, ...	0	15	6			
Surnam, George, repairs, to April 1st, 1843,	7	17	6			
Total Repairs of Furniture, &c.,				18	3	8
				773	1	1

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward, . . .				. . . . .			773	1	1
Rent, Taxes, Insurance, &c.									
Borough rate, made 30th Sept. 1842, . .				1	10	0			
Boyle and Co., allowance for poor rate paid by them on stable, to Nov. 1st, 1843, . .				1	6	3			
Grand Jury cess, half year, Easter, 1843, .				3	15	0			
Insurance at Globe, Dec. 25th, 1844,	5	13	6						
Ditto, National, Dec. 26th, 1844,	5	13	6						
Ditto, ditto, Dec. 25th, 1844,	4	2	6						
				15	9	6			
Ministers' money, to Sept. 29th, 1843, . .				2	15	5			
Parish cess, to Sept. 29th, 1843, ...				1	17	6			
Pipe water, to June 24th, 1843, ...				1	7	8			
Police tax, to March, 25th, 1843,	2	3	9						
Ditto, to Sept. 29th, 1843,	1	17	6						
				4	1	3			
Truell, R. H., half year's rent, to Aug. 1st, 1843, ...	52	4	6						
Ditto, ditto, Feb. 1st, 1844,	52	4	6						
				104	9	0			
Wide street tax, Easter, 1843, ...				1	17	6			
Total Rent, Taxes, Insurance,							138	9	1
Salaries, Servants' Wages, &c.									
Clibborn, Edward, for one year's salary as Assistant Librarian and Clerk, to March 16th, 1844, ...				120	0	0			
Conroy, P., delivering notices, to June 8th, 1843, ...				0	1	6			
Drummond, Rev. W. H., Librarian, year's salary, to 16th March, 1844, ...				21	0	0			
Hamilton, Wm., wages and allowance as porter, to April 29th, 1843, ...	4	12	2						
Ditto, to July 15th, 1843, . .	6	11	8						
Ditto, to Nov. 18th, 1843, . .	11	17	0						
Ditto, Christmas allowances, to Dec. 25th, 1843, ...	2	2	0						
Ditto, wages and allowance, Jan. 15th, 1844, ...	5	5	4						
Ditto, ditto, Feb. 19th, 1844,	3	5	10						
				33	14	0			
				174	15	6			
							911	10	2

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward, . . .				174	15	6	911	10	2
Kane, Bernard, extra evening porter, April 3rd, 1843, ...	1	8	0						
Ditto, ditto, June 26th, 1843,	1	1	0						
Ditto, ditto, Feb. 29th, 1844, ...	1	1	0						
				3	10	0			
Kane, Robert, M. D., Secretary of Council, year's salary, to March 16th, 1844, . .				21	0	0			
Lockett, J., for porter's clothes, to March 29th, 1843, ...	3	19	8						
Ditto, jacket, Aug. 10th,	0	18	0						
				4	17	8			
Mac Cullagh, J., Secretary of Academy, year's salary, to March 16th, 1844, . .				21	0	0			
Pim, J. jun., Esq., Treasurer, year's salary, to March, 16th, 1844, ...				21	0	0			
Singleton, J., for porter's hat, to April 26th, 1843, ...				0	16	0			
Sinton, Thomas, Assistant Clerk, $2\frac{1}{2}$ weeks, to March 25th, 1843,	2	10	0						
Ditto, 4 weeks, June 13th, 1843,	4	0	0						
Ditto, 3 weeks, Dec., 14th, 1843,	3	0	0						
				9	10	0			
Smith, John, assistant porter from March 17th to April 20th, 1843, ...	1	3	6						
Ditto, to June, 3rd, 1843, .	1	4	6						
Ditto, from July 29th to Jan. 9th, 1844, ...	1	0	0						
Ditto, from Jan. 29th to Feb. 13th, 1844, ...	0	10	0						
				3	18	0			
Wiseheart, J., clerk at Meetings, to April 25th, 1843, ...	0	15	0						
Ditto, June 13th, 1843, . .	0	15	0						
Ditto, from 14th Nov., 1843, to Jan. 8th, 1844, ...	0	10	0						
Ditto, from 22nd Jan. to Feb. 12th, 1844, ...	0	5	0						
				2	5	0			
Total Salaries, Servants' Wages, &c.,							262	12	2
							1174	2	4

	£ s. d.	£ s. d.
Brought forward, . . .	. . . . .	1174 2 4
Three and a half per Cent. Government Stock purchased.		
£ s. d. 28 15 4 cost	. . . . .	29 1 4
Three per Cent. Consols purchased.		
£ s. d. 22 4 2 cost	. . . . .	20 17 3
Cunningham Fund.		
West and Son, gold medal, to June 24th, 1843, ...	. . . . .	19 15 10
The total Discharge, . . .	. . . . .	1243 16 9
Balance in favour of the Public, . .	. . . . .	210 5 6½
The Charge as above, ...	. . . . .	1454 2 3½

State of the Balance.

1843.		£ s. d.
31st March.	In Bank of Ireland, ...	209 6 3
	In Treasurer's hands, as per this Account,	0 19 3½
	Balance as above, . .	£210 5 6½

The Treasurer reports, that there is to the credit of the Academy in the Bank of Ireland, £1117 1*s.* 10*d.* in Three per Cent. Consols, and £1643 19*s.* 6*d.* in Three and a half per Cent. Government Stock, the latter known as the Cunningham Fund.

(Signed), Robert Ball,
Treasurer.

31*st March*, 1844.

No. V.

METEOROLOGICAL JOURNAL

COMMENCING

1ST JANUARY, 1843, AND ENDING 31ST DECEMBER, 1843,

BY

GEORGE YEATES.

THE accompanying paper is a Meteorological Journal, shewing the maximum and minimum points the Thermometer indicated, the Height of the Barometer, and the Amount of Rain.

The first column gives the thermometric results; the second gives the barometric pressure, in inches and thousands of an inch; the third gives the amount of rain that has fallen, in thousands of an inch. These observations have been made as nearly as possible to 10 o'clock, A. M., each day throughout the past year. They are tabulated each month, so as to shew the quantity of rain that has fallen during that period. Twelve months are then made up, which shews the year's rain to be 23.440 inches.

It may not be out of place to mention the description of instruments which were made use of on the occasion.

The temperature was observed with a pair of Dr. Rutherford's self-registering thermometers. The barometer is similar to one first made by me for Dr. Apjohn, and under his directions; it is a very simple instrument, and extremely convenient for daily or rapid observations; there is no floating gauge used, nor is it necessary to make any observation at the cistern; the fluctuations in the height here are nearly all avoided, by very much increasing the area of the cistern over that of the tube; in this instance it is as 1 to 500, the diameter of the tube being $\frac{3}{10}$; it is graduated to the five-hundredth of an inch, and reads as 1000. From this arrangement it is evident that any deviation produced in the surface of the cistern, from the rise or falling of the mercury in the tube, will be inappreciable, and does not amount to the errors of observation. The rain-gauge is also similar to one which I made for Dr. Apjohn at the same period. In superficial area it measures 1000 inches; the rain is collected in a vessel which is graduated into cubic inches, consequently, when one inch by measure is indicated by the graduations, it denotes that $\frac{1''}{1000}$ of an inch of rain has fallen on the surface above, and as the receiver is graduated into cubic inches all the way, it gives at once the decimal, until you come to 1000 cubic inches, which is equivalent to 1 inch of rain: this gauge admits of the most simple verification.

JANUARY.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	52°	33°	30.350	. . .	S. W.
2	40	34	30.150	. . .	S. W. by S.
3	43	32	30.	. . .	N. W. by W.
4	46	29	29.950	.151	N. W.
5	40	35	30.104	.080	N. W. by W.
6	47	35	30.150	.030	W.
7	48	39	29.820	.009	W.
8	44	32	29.260	.150	W.
9	41	30	29.470	.050	S. W.
10	44	32	29.100	.200	W. S. W.
11	36	29	29.010	.075	W.
12	36	29	29.016	1.050	W.
13	38	31	28.100	.385	S. W.
14	37	30	28.726	.080	N. W.
15	35	26	28.950	. . .	N. E.
16	37	26	29.850	.100	N. E.
17	44	30	30.100	.030	N. W.
18	48	42	30.314	. . .	W.
19	49	42	30.400	. . .	W.
20	48	41	30.120	. . .	N. W.
21	46	38	29.500	. . .	N. W.
22	48	42	29.755	. . .	S. W.
23	49	40	29.580	.004	S. W.
24	49	44	29.610	.100	S.
25	49	41	29.960	. . .	S. W.
26	49	46	30.050	.035	S. W.
27	52	46	29.864	. . .	W. by S.
28	53	49	29.770	.025	W.
29	52	44	29.850	·035	W. by S.
30	53	46	29.750	. . .	S. W.
31	48	48	29.550	. . .	W.

FEBRUARY.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	49°	39	29.650	.060	W. by S.
2	47	36	29.600	.095	W.
3	41	35	29.300	.130	N. W.
4	40	25	30.000	.003	N. by W.
5	39	32	29.970	.008	N. W.
6	40	33	30.150	. . .	N. by W.
7	43	33	30.200	.040	N. E.
8	43	40	30.154	. . .	N. E.
9	43	38	30.162	. . .	N. E.
10	42	35	30.146	.008	E. N. E.
11	40	35	30.140	.006	E.
12	40	34	30.170	.020	E.
13	42	36	30.120	. . .	E.
14	40	33	29.860	. . .	E. N. E.
15	35	24	29.530	. . .	N. E.
16	32	21	29.284	. . .	N. E.
17	36	25	29.596	. . .	N. N. E.
18	39	30	29.636	. . .	E. by N.
19	40	32	29.446	.020	E.
20	40	34	29.224	.675	S. E.
21	45	37	29.252	.145	S. E.
22	47	39	29.348	.090	E.
23	42	38	29.440	.210	E.
24	45	40	29.610	.115	E. S. E.
25	47	41	29.716	. . .	E. S. E.
26	41	35	29.700	. . .	E.
27	39	35	28.371	. . .	E.
28	41	35	29.420	.010	E.

MARCH.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	43°	34°	29.350	.100	E.
2	45	28	30.070	. . .	E.
3	44	32	30.216	. . .	N. W.
4	42	27	30.468	. . .	E. by N.
5	39	33	29.970	.008	E.
6	41	32	30.150	. . .	. . . .
7	42	33	30.200	. . .	. . . .
8	43	30	30.150	. . .	. . . .
9	43	39	30.160	. . .	. . . .
10	42	35	30.140	.060	. . . .
11	42	35	30.140	.040	. . . .
12	55	44	29.793	·025	S. E.
13	54	38	29.650	. . .	N. W.
14	47	39	29.518	.430	N. E.
15	46	38	29.900	.070	E.
16	48	39	29.826	. . .	E.
17	57	40	29.620	. . .	N . E.
18	56	41	29.892	. . .	E.
19	54	42	29.846	.055	N. E.
20	53	41	29.480	. . .	E.
21	55	46	29.250	.085	E.
22	59	46	29.200	.160	N. E.
23	59	45	29.410	.380	E. by N.
24	55	46	29.562	.100	S. E.
25	52	45	29.850	.130	S. E.
26	53	39	29.900	. . .	E.
27	53	38	29.750	. . .	E.
28	53	37	29.328	. . .	. . . .
29	53	37	29.976	. . .	. . . .
30	52	39	29.478	. . .	. . . .
31	57	45	29.320	. . .	. . . .

APRIL.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	59°	47°	29.250	.015	S. E.
2	58	46	29.350	.145	W.
3	62	44	29.700	.030	
4	58	40	29.200	.130	W.
5	58	47	29.300	.002	W. by S.
6	64	47	29.600	.006	W.
7	56	46	29.320	.465	S. W.
8	61	42	29.500	.100	W.
9	59	42	29.774	.090	W.
10	46	32	30.040	.002	N. W.
11	49	33	30.150	.090	N. W.
12	50	33	30.050	. . .	N. W.
13	54	32	30.076	. . .	N.
14	53	40	29.950	.010	N. W.
15	61	42	29.500	.100	N. E.
16	54	44	29.950	. . .	N. W.
17	67	40	30.050	. . .	N. E.
18	62	44	30.050	. . .	E.
19	64	48	29.900	. . .	E. by N.
20	67	48	29.650	.020	E.
21	65	46	29.750	.055	N. W.
22	54	44	29.760	.025	W.
23	55	40	30.010	.020	W.
24	62	42	29.970	.350	N. E.
25	53	46	29.620	.270	W. by N.
26	53	35	29.600	.155	N. by W.
27	58	36	29.850	.195	W. by S.
28	58	41	29.650	.340	W. by S.
29	55	42	29.720	.030	E. by N.
30	63	43	30.020	. . .	E. by N.

MAY.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	66°	43°	30.250	. . . .	E. by N.
2	67	47	30.250	. . .	N. E.
3	69	44	29.960	.020	E.
4	63	42	29.700	.060	W.
5	64	37	20.578	. . .	W.
6	60	38	29.600	. . .	N. W.
7	58	41	29.600	.016	E.
8	59	42	29.716	.002	N. E.
9	62	42	29.950	. . .	N. E.
10	67	46	30.150	. . .	N. E.
11	62	45	30.150	. .	N. E.
12	64	50	39.250	.140	S. by E.
13	62	50	29.826	.205	S.
14	67	43	29.750	. . .	E. by N.
15	64	49	29.500	. . .	E. by S.
16	67	49	29.600	. . .	E. by S.
17	54	47	29.800	.200	E. by N.
18	60	44	30.050	.180	E.
19	66	46	19.968	.080	N.
20	64	45	29.620	.900	N. E.
21	51	46	09.560	1.320	E. by N.
22	55	47	29.700	.130	E.
23	59	47	29.722	.026	E. by N.
24	62	43	29.570	.120	E. by N.
25	60	44	29.964	.645	E. N. E.
26	63	50	29.550	.205	S.
27	60	48	29.530	. . .	W.
28	60	48	29.750	.140	E. by N.
29	62	45	30.050	.115	E. by N.
30	63	46	30.016	. . .	W.
31	62	50	29.800	.140	W.

JUNE.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	65°	54°	29.468	.300	E.
2	63	52	29.270	.268	S. W.
3	62	50	29.370	.024	N. W.
4	53	45	29.700	.240	W.
5	54	44	29.814	.590	W.
6	54	42	30.038	.035	N. W.
7	59	46	29.600	.015	W.
8	59	49	28.900	.125	W.
9	61	49	29.400	.080	N. W.
10	62	48	29.944	. . .	
11	63	49	30.210	. . .	N. W.
12	63	45	30.200	. . .	N. E.
13	71	50	30.128	. . .	
14	70	49	30.050	.360	E. by N.
15	65	53	30.050	.240	E.
16	65	53	30.114	. . .	E.
17	72	51	30.150	. . .	E.
18	70	53	30.128	. . .	E.
19	80	57	30.050	. . .	N. E.
20	72	51	30.250	. . .	N. E.
21	74	55	30.150	. . .	W.
22	65	55	30.150	. . .	N.
23	69	49	30.150	. . .	E.
24	74	52	30.130	. . .	W.
25	80	56	30.074	. . .	S. E.
26	74	52	30.300	. . .	S. E.
27	75	50	29.900	. . .	N. E.
28	78	55	29.850	. . .	W.
29	77	50	29.950	. . .	W.
30	65	52	29.950	. . .	S. W.

JULY.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	68°	55°	30.000	. . .	S. W.
2	72	56	29.864	.080	W. by S.
3	73	57	29.850	. . .	E.
4	74	54	30.000	. . .	E.
5	74	53	29.700	.120	W.
6	63	52	29.720	.110	S. E.
7	70	53	29.760	.020	S. E.
8	70	54	29.050	.020	W.
9	63	51	30.150	. . .	N.
10	71	54	30.250	. . .	N. E.
11	69	49	30.564	. . .	N. W.
12	71	53	30.250	.120	W.
13	67	56	30.200	.380	W.
14	68	53	30.200	.105	W.
15	65	58	30.140	. . .	W.
16	70	53	30.250	. . .	W.
17	71	58	30.250	.012	W.
18	76	58	29.950	.106	S. W.
19	74	54	29.850	. . .	N. W.
20	79	50	29.800	. . .	W.
21	65	53	29.800	. . .	W.
22	65	55	29.760	. . .	S. W.
23	66	50	29.750	.020	N. W.
24	69	48	30.160	. . .	N. W.
25	69	54	30.250	. . .	S. W.
26	72	61	30.250	.060	W. by S.
27	72	54	30.150	.030	N. W.
28	67	53	30.006	.115	W. by S.
29	66	55	29.634	.315	W. by S.
30	68	52	29.700	.050	N. W.
31	68	52	30.000	.110	N. W.

AUGUST.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	66°	57°	29.900	. . .	S. W.
2	70	56	29.500	.220	W.
3	70	54	29.420	.170	S. W.
4	68	53	29.560	.280	W.
5	64	51	30.000	.080	W.
6	75	54	30.100	.018	W.
7	74	62	30.150	. . .	S. W.
8	70	54	30.200	.110	S. by W.
9	73	50	30.250	. . .	W.
10	74	55	30.324	. . .	S. W.
11	77	55	30.350	. . .	S. by E.
12	73	55	30.270	. . .	E.
13	73	55	30.250	. . .	S. E.
14	73	54	30.050	. . .	E.
15	67	57	30.000	.040	E.
16	65	57	30.108	. . .	N. E.
17	74	54	30.200	. . .	E.
18	78	57	30.200	. . .	S. E.
19	78	56	29.950	. . .	E. by S.
20	78	57	29.908	.060	N. E.
21	71	54	29.600	. . .	N. E.
22	74	44	29.370	.195	S. W.
23	73	45	29.750	. . .	S.
24	71	56	29.700	.175	S. W.
25	70	56	29.850	.090	S. W.
26	71	58	29.750	. . .	S.
27	71	54	30.660	. . .	S.
28	72	56	29.700	.030	S. E.
29	71	54	30.078	.073	N. W.
30	70	50	30.200	. . .	N. E.
31	73	52	30.200	. . .	S. W.

SEPTEMBER.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	72°	48°	30.250	. . .	E.
2	72	68	30.410	. . .	E.
3	74	61	30.300	. . .	S. E.
4	74	51	30.500	. . .	N. E.
5	73	48	30.500	. . .	S.
6	74	49	30.370	. . .	W.
7	76	50	30.300	. . .	W.
8	80	56	30.272	. . .	E.
9	76	58	30.200	. . .	E.
10	75	59	30.000	.010	E.
11	67	53	29.950	.270	S. E.
12	70	46	30.400	. . .	S. W.
13	72	51	30.220	. . .	E.
14	66	50	29.958	. . .	N. E.
15	66	57	29.850	.065	W.
16	65	57	30.000	. . .	W.
17	64	57	30.150	. . .	E.
18	68	55	30.100	. . .	N. E.
19	70	55	30.300	.035	E.
20	69	53	30.150	. . .	S.
21	69	58	30.300	. . .	N. E.
22	67	56	30.522	. . .	W. by S.
23	64	45	30.624	. . .	N.
24	61	53	30.600	. . .	W.
25	62	48	30.450	. . .	N. W.
26	60	46	30.300	. . .	N. W.
27	57	41	29.900	. . .	N. W.
28	54	35	30.000	.007	W.
29	54	45	30.100	. . .	W.
30	62	48	29.950	.250	W.

OCTOBER.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	63°	56°	30.050	. . .	W.
2	64	51	30.150	.240	W.
3	61	49	30.100	.004	W.
4	62	53	30.200	.010	W.
5	69	52	29.950	. . .	W. by S.
6	68	57	29.500	.060	W. by S.
7	70	57	29.500	.025	N. W.
8	64	61	29.850	.510	N.
9	66	44	29.520	.145	W.
10	58	40	29.870	.025	S. W.
11	56	46	29.760	.330	W.
12	54	38	29.410	.250	N. W.
13	50	37	29.690	.040	S. W.
14	50	32	29.810	.008	N. W.
15	49	33	29.870	. . .	W. by N.
16	49	33	29.750	. . .	N. W.
17	46	30	29.664	.005	N. W.
18	46	35	29.618	.140	W.
19	45	30	30.122	. . .	W. by N.
20	66	30	30.412	. . .	W.
21	52	40	30.050	.130	W.
22	55	44	29.810	.025	S. W.
23	58	46	30.050	. . .	W.
24	55	48	29.600	.060	S. W.
25	54	37	29.430	.600	W.
26	47	34	29.610	. . .	W. by N.
27	47	31	29.400	. . .	E.
28	46	31	29.460	.420	W.
29	46	31	29.500	. . .	W. by S.
30	44	32	29.400	.075	W.
31	44	30	29.550	.200	W.

NOVEMBER.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	45°	33°	29.650	.025	W.
2	48	31	29.800	. . .	S. E.
3	52	42	29.400	.005	E.
4	55	43	29.500	.035	S. W.
5	54	35	30.030	.150	W.
6	57	43	29.820	.090	W. by S.
7	55	45	29.700	.095	W.
8	50	37	29.716	. . .	N. W.
9	43	32	29.916	.004	N. W.
10	49	41	29.400	.030	W.
11	52	44	30.050	.007	N. W.
12	49	44	30.120	. . .	S. W.
13	48	37	30.250	.008	S. W.
14	45	35	30.320	. . .	S. S. W.
15	44	31	30.150	.005	S. W.
16	44	35	30.150	.170	S. W.
17	50	40	29.600	.009	W. S. W.
18	48	37	29.330	.005	W. S. W.
19	44	34	29.460	.118	S. W.
20	48	34	29.580	.204	S. W.
21	50	42	29.350	.446	S. by W.
22	54	40	29.350	.634	W. by N.
23	40	38	29.490	. . .	W.
24	46	34	29.470	. . .	W. by N.
25	44	32	29.450	.130	E. by N.
26	53	42	29.300	.185	S. W.
27	54	48	29.450	.070	S. W.
28	51	44	30.100	. . .	S. W.
29	54	39	30.450	. . .	W. by S.
30	52	39	30.100	. . .	W.

DECEMBER.

	Thermometer.		Barometer.	Rain.	Wind.
	Max.	Min.			
1	51°	39°	30.120	. . .	W.
2	50	39	30.170	.004	W.
3	51	44	30.350	.004	S. W.
4	52	43	30.270	.003	S. W.
5	52	45	29.900	. . .	W. by S.
6	51	41	30.350	.040	W. by S.
7	53	43	30.100	.012	W. by S.
8	53	44	30.300	.012	W.
9	49	45	30.296	. . .	W.
10	52	46	30.150	. . .	W.
11	49	36	30.100	.002	S. E.
12	50	45	30.350	.050	E. by S.
13	50	43	30.320	.003	W. by S.
14	51	45	30.430	. . .	S. W.
15	57	47	30.350	. . .	S. by W.
16	50	48	30.450	. . .	W. by S.
17	54	45	30.460	.004	S. W.
18	50	43	30.450	. . .	W. by S.
19	49	44	30.300	. . .	S. W.
20	52	46	30.150	. . .	S. W.
21	53	41	30.300	. . .	E. by N.
22	55	42	30.300	. . .	E. by N.
23	54	45	30.250	. . .	S. by W.
24	57	53	30.400	.004	S. W.
25	56	48	30.310	. . .	E.
26	51	41	30.350	. . .	N. W.
27	50	42	30.424	. . .	W. S. W.
28	51	47	30.460	. . .	S. E.
29	50	46	30.350	. . .	W. S. W.
30	46	44	30.150	. . .	W. S. W.
31	50	43	30.100	. . .	W. S. W.

GENERAL RESULTS.

	Amount of Rain. Inches.	Mean Temp.
January,	2.589	42°
February,	1.635	34
March,	1.643	38
April,	2.643	$41\frac{1}{3}$
May,	4.644	$61\frac{1}{2}$
June,	2.778	$67\frac{1}{4}$
July,	1.773	68
August,	1.541	70
September,	.637	67
October,	1.912	56
November,	1.998	49
December,	.138	51
	23.440	

BAROMETER.

Greatest pressure, August 27,	30.660
Lowest point, January 13,	28.100

THERMOMETER.

Maximum, September 8,	80°
Minimum, February 16,	21

2, *Grafton-street.*

THE

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MARCH 16, 1843.

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of Copper and Tin.

1	12	13	14
No of Experiment.	Order of Fusibility.	Characteristic Properties, in Working, &c.	Relation to Cast Iron, in Presence of a Solvent, i. e. Sea Water.
Table No. I.—Copper and Zinc.			
1	15	Well known.	All these alloys increase the corrosion of cast iron in sea water, when in their presence.
2	14	Similar &c., Several of these are malleable at high temperatures.	
3	13		
4	12		
5	11		
6	10		
7	9	Bath Metal.	
8	8	Dutch Brass.	
9	7	Rolled Sheet Brass.	
10	6	British Brass.	
11	6	German Brass.	
12	6	,, Brass, Watchmakers.	
13	5	Very Brittle, Too hard to file or turn, lustre nearly equal to Speculum Metal.	All these alloys decrease the corrosion of cast iron in sea water, when in presence.
14	5	Very Brittle,	
15	5	Very Brittle,	
16	5	Brittle,	
17	5	Brittle,	
18	5	Very Brittle,	
19	5	Barely malleable.	
20	4	Brittle.	
21	3	White Button Metal.	
22	2	Brittle.	
23	1	Brittle, well known.	
Table II.—Copper and Tin.			
1	16	Well known.	Every alloy of Cu. + Sn. increases the corrosive action of sea water on cast iron, in their presence; the maximum increase is due to tin.
2	15	Gun Metal, &c.	
3	14	Gun Metal, &c.	
4	13	Gun Metal and Bronze.	
5	12	Hard Mill Brasses, &c.	
6	11	Brittle, All these alloys found occasionally in bells, with mixtures, of Zn. and Pb.	
7	10	Brittle,	
8	9	Crumbles,	
9	8	Crumbles,	
10	7	Brittle,	
11	6	Small bells, Brittle.	
12	5	,, Brittle.	
13	4	Speculum Metal of authors.	
14	3	,, Files, tough.	
15	2	,, Files, soft and tough.	
16	1	Well known.	

Abbre
E. Earthy. e Fibrous, C. Conchoidal, V.C. Vitreo-Conchoidal, V. Vitreous,
The m
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The at
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The ul
before disru iven are those which each prism just sustained for a few seconds
The co
by oxidatio rnwall. They were alloyed in a peculiar apparatus, to avoid loss
No sim
Zn. as is kn rd fusible metal, generally Cu. + Zn. + Pb.; or Cu. + Sn. +

TABLES Nos. I. AND II.,

Showing the Chemical and Physical Properties of the Atomic Alloys of Copper and Zinc, and of Copper and Tin.

TABLE No. I.—Copper and Zinc.

1	2		3		4	5	6	7	8	9	10	11	12	13	14
No. of Experiment.	Chemical Constitution. ε −	ε +	Composition by Weight per cent. ε −	ε +	Atomic Weight. H = 1	Specific Gravity.	Colour.	Fracture.	Ultimate Cohesion, per Square Inch. Tons.	Order of Ductility.	Order of Malleability, at 60° Fahrenheit.	Order of Hardness, &c.	Order of Fusibility.	Characteristic Properties, in Working, &c.	Relation to Cast Iron, in Presence of a Solvent, i. e. Sea Water.
1	Cu. +		100·00 +	0	31·6	8·667	Tile Red,	E.	24·6	8	1	22	15	Well known.	All these alloys increase the corrosion of cast iron in sea water, when in their presence.
2	10 Cu. +	Zn.	90·72 +	9·28	348·3	8·605	Reddish Yellow, 1	C.C.	12·1	6	13	21	14	Similar &c., Several of these are malleable at high temperatures.	
3	9 Cu. +	Zn.	89·80 +	10·20	316·7	8·607	Reddish Yellow, 2	F.C.	11·5	4	11	20	13		
4	8 Cu. +	Zn.	88·60 +	11·40	285·1	8·633	Reddish Yellow, 3	F.C.	12·8	2	10	19	12		
5	7 Cu. +	Zn.	87·30 +	12·70	253·4	8·587	Reddish Yellow, 4	F.C.	13·2	9	9	18	11		
6	6 Cu. +	Zn.	85·40 +	14·60	221·9	8·591	Yellowish Red, 3	F.F.	14·1	5	8	17	10		
7	5 Cu. +	Zn.	83·02 +	16·98	190·3	8·415	Yellowish Red, 2	F.C.	13·7	11	2	16	9	Bath Metal.	
8	4 Cu. +	Zn.	79·65 +	20·35	158·7	8·448	Yellowish Red, 1	F.C.	14·7	7	3	15	8	Dutch Brass.	
9	3 Cu. +	Zn.	74·58 +	25·42	127·1	8·397	Pale Yellow,	F.C.	13·1	10	4	14	7	Rolled Sheet Brass.	
10	2 Cu. +	Zn.	66·18 +	33·82	95·5	8·299	Full Yellow, 1	F.C.	12·5	3	6	13	6	British Brass.	
11	Cu. +	Zn.	49·47 +	50·53	63·9	8·230	Full Yellow, 2	C.C.	9·2	12	5	12	6	German Brass.	
12	Cu. +	2 Zn.	32·85 +	67·15	96·2	8·283	Deep Yellow,	C.C.	19·3	1	7	10	6	,, Brass, Watchmakers.	
13	8 Cu. +	17 Zn.	31·52 +	68·48	801·9	7·721	Silver White, 1	C.	2·1	0	22	5	5	Very Brittle, Too hard to file or turn, lustre nearly equal to Speculum Metal.	All these alloys decrease the corrosion of cast iron in sea water, when in presence.
14	8 Cu. +	18 Zn.	30·30 +	69·70	834·2	7·836	Silver White, 2	V.C.	2·2	0	23	6	5	Very Brittle,	
15	8 Cu. +	19 Zn.	29·17 +	70·83	866·5	8·019	Silver Grey, 3	C.	0·7	0	21	7	5	Very Brittle,	
16	8 Cu. +	20 Zn.	28·12 +	71·88	898·8	7·603	Ash Grey, 3	V.	3·2	0	19	3	5	Brittle,	
17	8 Cu. +	21 Zn.	27·10 +	72·90	931·1	8·058	Silver Grey, 2	C.	0·9	0	18	9	5	Brittle,	
18	8 Cu. +	22 Zn.	26·24 +	73·76	963·4	7·882	Silver Grey, 1	C.	0·8	0	20	8	5	Very Brittle,	
19	8 Cu. +	23 Zn.	25·39 +	74·61	995·7	7·443	Ash Grey, 4	F.C.	5·9	0	15	1	5	Barely malleable.	
20	Cu. +	3 Zn.	24·50 +	75·50	128·5	7·449	Ash Grey, 1	F.C.	3·1	0	16	2	4	Brittle.	
21	Cu. +	4 Zn.	19·65 +	80·35	160·8	7·371	Ash Grey, 2	F.C.	1·9	0	14	4	3	White Button Metal.	
22	Cu. +	5 Zn.	16·36 +	83·64	193·1	6·605	Very Dark Grey	F.C.	1·8	0	17	11	2	Brittle.	
23	+	Zn.	0 +	100·00	32·3	6·895	Bluish Grey,	T.C.	15·2	13	12	23	1	Brittle, well known.	

TABLE II.—Copper and Tin.

1	2		3		4	5	6	7	8	9	10	11	12	13	14
1	Cu. +	Sn.	100·00 +	0	31·6	8·667	Tile Red,	E.	24·6	1	2	10	16	Well known.	Every alloy of Cu. + Sn. increases the corrosive action of sea water on cast iron, in their presence; the maximum increase is due to tin.
2	10 Cu. +	Sn.	84·29 +	15·71	374·9	8·561	Reddish Yellow, 1	F.C.	16·1	2	6	8	15	Gun Metal, &c.	
3	9 Cu. +	Sn.	82·81 +	17·19	343·3	8·462	Reddish Yellow, 2	F.C.	15·2	3	7	5	14	Gun Metal, &c.	
4	8 Cu. +	Sn.	81·10 +	18·90	311·7	8·459	Yellowish Red, 2	F.C.	17·7	4	10	4	13	Gun Metal and Bronze.	
5	7 Cu. +	Sn.	78·97 +	21·03	280·1	8·728	Yellowish Red, 1	V.C.	13·6	5	11	3	12	Hard Mill Brasses, &c.	
6	6 Cu. +	Sn.	76·29 +	23·71	248·5	8·750	Bluish Red, 1	V.	9·7	0	12	2	11	Brittle, All these alloys found occasionally in bells, with mixtures, of Zn. and Pb.	
7	5 Cu. +	Sn.	72·80 +	27·20	216·9	8·575	Bluish Red, 2	C.	4·9	0	13	1	10	Brittle,	
8	4 Cu. +	Sn.	68·21 +	31·79	185·3	8·400	Ash Grey,	C.	0·7	0	14	6	9	Crumbles,	
9	3 Cu. +	Sn.	61·69 +	38·31	153·7	8·539	Dark Grey,	T.C.	0·5	0	16	7	8	Crumbles,	
10	2 Cu. +	Sn.	51·75 +	48·25	122·1	8·416	Greyish White, 1	V.C.	1·7	0	15	9	7	Brittle,	
11	Cu. +	Sn.	34·92 +	65·08	90·5	8·056	Whiter still, 2	T.C.	1·4	0	9	11	6	Small bells, Brittle.	
12	Cu. +	2 Sn.	21·15 +	78·85	149·4	7·387	Whiter still, 3	C.C	3·9	0	8	12	5	,, Brittle.	
13	Cu. +	3 Sn.	15·17 +	84·83	208·3	7·447	Whiter still, 4	C.C.	3·1	0	5	13	4	Speculum Metal of authors.	
14	Cu. +	4 Sn.	11·82 +	88·18	267·2	7·472	Whiter still, 5	C.C.	3·1	8	4	14	3	,, Files, tough.	
15	Cu. +	5 Sn.	9·68 +	90·32	326·1	7·442	Whiter still, 6	E.	2·5	6	3	15	2	,, Files, soft and tough.	
16	+	Sn.	0 +	100·00	58·9	7·291	White, 7	F.	2·7	7	1	16	1	Well known.	

Abbreviations used in Column 7th to denote character of fracture:—F.C. Fine Crystalline, C.C Coarse Crystalline, T.C. Tabular Crystalline, F.F Fine Fibrous, C Conchoidal, V.C Vitreo-Conchoidal, V. Vitreous, E. Earthy.

The maxima of ductility, malleability, hardness, and fusibility, are = 1.

The numbers in Column 6th denote intensity of shade of the same colour.

The atomic weights are those of the hydrogen scale.

The specific gravities were determined by the method indicated in Report "On Action of Air and Water on Iron." Trans. Brit. Ass. vol. vii. p. 283

The ultimate cohesion was determined on prisms of 0·25 of an inch square, without having been hammered or compressed after being cast The weights given are those which each prism just sustained for a few seconds before disruption.

The copper used in these alloys was granulated, and of the finest "tough pitch;" the zinc was Mossleman's, from Belgium; and the tin "grain tin," from Cornwall They were alloyed in a peculiar apparatus, to avoid loss by oxidation, and the resulting alloy verified by analysis.

No simple binary alloy of Cu. + Zn. or of Cu. + Sn. works as pleasantly in turning, planing, or filing, as if combined with a very small proportion of a third fusible metal, generally Cu. + Zn. + Pb.; or Cu. + Sn. + Zn. as is known to workers in metals.

ANATOMY OF PALUDICELLA ARTICULATA