PROCEEDINGS

OF THE

LITERARY AND PHILOSOPHICAL SOCIETY

OF

MANCHESTER.

VOL. II.

SESSIONS 1860—61 AND 1861—62.

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NOTE.

The object which the Society have in view in publishing their Proceedings, is to give an immediate and succinct account of the scientific and other business transacted at their meetings to the members and the general public. The various communications are supplied by the authors themselves, who are alone responsible for the facts and reasonings contained therein.

PROCEEDINGS
OF
THE LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 2nd, 1860.

Dr. JOULE, President, in the Chair.

The PRESIDENT brought under the notice of the meeting a sheet of copper, upon which, whilst under magnetic influence, iron had been deposited electrolytically. The experiment was made by Mr. F. H. Hobler, of London, as follows:—The plate of copper, forming the bottom of a shallow vessel filled with a saturated solution of sulphate of iron, was placed on the poles of a powerful horse-shoe magnet, fixed vertically with its poles uppermost. An iron wire, dipping into the solution, was placed in connection with the positive electrode of a Daniell's cell, of one pint capacity, the copper plate being connected with the negative electrode. The deposited iron exhibited the lines of magnetic force in the same manner as in the case of iron filings scattered on a sheet of paper placed over a magnet. When Mr. Hobler substituted a plate of tinned iron for the copper, he observed indications, though very faint ones, of the same phenomenon. On using a saturated solution of sulphate of copper, Mr. Hobler observed that the deposit was even throughout, and that no specific position of the axes of the crystals of copper could be detected, although they invariably formed on the outside of the two poles. Mr. Hobler, in discussing the phenomenon, inquires whether it is produced by the action of the magnet upon the solution in direction of the lines of force, or whether the iron is formed in the solution immediately above the copper plate, and then attracted by the magnet into the direction of the lines of force. The former suggestion appears to him to be inconsistent with our present knowledge of the influence of

magnetism on chemical action; the latter, with the theory of electro-deposition, which supposes the coating to be formed on the plate and not *deposited*, strictly speaking, thereon.

The President exhibited a slip of paper which he had received from Professor Thomson. On the paper was printed by photography the line indicating the various changes of atmospheric electricity, which took place at the observatory of Kew during twelve successive hours. Much interest was excited by witnessing one of the first fruits of Professor Thomson's beautiful instrument. The paper indicated a series of very rapid oscillations, about one per minute, of the intensity of atmospheric electrical force.

Mr. Henry Bowman presented the following statement of observations on the temperature of the six summer months ending September 30th, 1860, taken by a self-registering thermometer at Victoria Park, Manchester:—

	Maximum.	Minimum.	Range.	Mean.	Mean of 47 years, 1794 to 1840, inclusive. (1)	Mean of 1860 above that of same period.	Mean of 1860 below that of same period.	Number of corresponding months in same period, with means as low as in 1860.
1860.								
April	64·4	27·7	36·7	43·6	47·1	...	3·5	6
May	77·2	31·3	45·9	54.0	53·2	0·8	...	29
June.....	72·4	39·6	32·8	55·8	58·2	...	2·4	10
July	78·0	40·2	37·8	58·5	60·8	...	2.3	12
August.....	71·2	42·0	29·2	56·0	60·4	...	4.4	1 (2)
September	66·2	31·5	34·7	51·9	56·3	...	4·4	2 (3)
The 6 months together ...	78·0	27·7	50·3	53·3	56·0	...	2·7	...
12months ending Sept. 30, 1860.	78·0	9·5	68·5	46·4	48·8	...	2·4	4 (4)

The maximum temperature in the 12 months was 78° on July 9th.

The minimum temperature in the 12 months was 9°·5 on December 19th.

([1]) From Tables by Dr. Dalton, Society's Memoirs, Vol. III. (new series), p. 494, and Vol VI., p. 572.

([2]) The mean of August, 1799, was 55°·0.

([3]) The mean of September, 1803, was 51°·7; 1807, 50°.1.

([4]) The mean of the year 1795 was 46°·4; of 1799, 44°·6; of 1814, 45°·4; and of 1815, 46°·2.

Mr. Atkinson stated that during the months of June and August, he had observed the extraordinary rain-fall of 13 inches at Thelwell. The fall in July was not considerable.

Mr. Dyer having stated that on the morning of August 11th, a very loud explosion was heard in the neighbourhood of Blackfriars, London, the sky being clear at the time, a conversation took place on the subject of fire-balls and meteorites, in the course of which Mr. Ekman stated that during a most violent thunderstorm, passing over a tract of land intersected by a rapid stream, he had distinctly seen fire-balls, the diameter of which he estimated at 2ft., projected from the clouds down into the water. The distance of the point where he stood, from the point at which the balls struck the water, could not have been more than 150 to 200 yards. The phenomenon was witnessed in Sweden many years ago.

Mr. Wild exhibited the universal or alphabet telegraph of Professor Wheatstone, and pointed out the successive improvements which had resulted in this admirable invention.

A Paper, by Arthur Cayley, F.R.S., &c., Hon. Mem., was read by the Rev. T. P. Kirkman, entitled, "On the Δ faced Polyacrons, in reference to the Problem of the Enumeration of Polyhedra."

"The problem of the enumeration of the polyhedra is one of extreme difficulty, and I am not aware that it has been discussed elsewhere than in Mr. Kirkman's valuable series of papers on this subject in the Memoirs of this Society, and in the Philosophical Transactions. A case of the general problem is that of the enumeration of the polyhedra with trihedral summits; and Mr. Kirkman, in the earliest of his papers, viz., that 'On the Representation and Enumeration of Polyhedra' (Mem. Vol. XII., pp. 47, 70, 1855), has in fact, by an examination of the particular case, accomplished the enumeration of the octahedra with trihedral summits.

"It is intended, in the present paper, to give a method for the derivation of the triangular-faced polyaerons of a given number of summits from those of the next inferior number of summits, and to exemplify it by finding, in an orderly manner, the triangular-faced polyaerons up to the octaerons; thus, as regards the examples, stopping at the same point as Mr. Kirkman; for although perfectly practicable, it would be very tedious, and there would be no commensurate advantage to carry them further."

At this, the first Meeting of the Session, a large number of books, chiefly Transactions of learned Societies abroad, were laid on the table. The CHAIRMAN congratulated the Society on the rapid increase of its Library, which was mainly owing to the great ability and zeal of Mr. Ekman, the Honorary Librarian.

Quarterly Meeting, October 16th, 1860.

Dr. R. Angus Smith, Vice-President, in the Chair.

The Chairman gave a short account of his examination of coal pyrites for arsenic. He stated that although the knowledge of the existence of arsenic in the iron pyrites found in coal may not be considered perfectly novel, it certainly does not seem to be known that arsenic is so widely disseminated as to form an ordinary constituent of the coals burnt in our towns, and chemists of celebrity have held it—and now hold it—to be absent there. He had examined fifteen specimens of coals in Lancashire, and found arsenic in thirteen. He had also found it in a few others; but Mr. Binney having promised a collection, properly arranged, the examination will then be made more complete. Mr. Dugald Campbell had also lately found arsenic in coal pyrites. The Chairman added, that this had a very direct bearing on our sanitary knowledge, as we must now be obliged to add arsenic to the number of impurities in the atmosphere of our large towns. It is true that he had not actually obtained it from the atmosphere, but when the pyrites is burnt the arsenic burns and is carried off along with the sulphur. One or two coal brasses (as they are called) contained copper, a metal that is also to some extent volatilized, as may be readily observed wherever copper soldering takes place. Although an extremely small amount of copper is carried up from furnaces, it is not well entirely to ignore it. The amount of arsenic, however, is probably not without considerable influence, and we may probably learn the reason why some towns seem less affected than others by the burning of coals, by examining the amount of arsenic burnt as well as sulphur.

Mr. SPENCE said that he could confirm the remarks concerning the existence of arsenic in coals, as he had burnt coal pyrites for many years, and had always found a very decided amount of arsenic in the sulphuric acid made from it.

Mr. RANSOME called attention to the peculiar symptoms described by Berzelius, as produced by selenium; and he considered that some similar symptoms were produced in a manner which might be explained if selenium were found in coals.

A Paper was read by WILLIAM ROBERTS, M.D., entitled, "On the Estimation of Sugar in Diabetic Urine by the Loss of Density after Fermentation." When a diabetic urine is fermented with yeast, its specific gravity previously ranging from 1030 to 1050 falls to 1009 or 1002, or even below 1000. This result is mostly due to the destruction of the sugar it contained, but partly also to the generation of alcohol and its presence in the fermented product.

As the diminution of density must be proportional to the quantity of sugar broken up by the ferment, the amount of loss evidently supplies a means of calculating how much sugar any urine contains—always provided that the remaining ingredients of the urine continue unchanged, or become changed in some uniform ratio.

To ascertain the relation between the density lost on fermentation, and the sugar destroyed, experiments were made on the urine of diabetic patients on the following plan :—

1. The amount of sugar per 100 parts was ascertained by the volumetrical method, with Fehling's test solution.

2. The density of the urine was taken.

3. Three or four ounces were then placed in a 12oz. phial, with a drachm or two of German yeast, and having lightly covered the bottle it was set aside to ferment.

4. In about twenty-four hours the fermentation was finished

and the froth dissipated. The density was then taken a second time, and the loss calculated.

Operating in this way on a specimen of diabetic urine sp. gr. 1038·60, the following results were obtained:—

Sugar, per 100 parts, by the volumetrical method, 7·69.

Density before fermentation at 60° or D = 1038·60.

Density after fermentation at 60° or D′ = 1005·92.

Density lost, or D — D′ = 32·68.

The relation, therefore, between the density lost and the percentage of sugar, in this instance, was as 32·68 to 7·69, or as 1 to 0·235. By numerous trials with diabetic urines, of different strength, it was found that the most correct proportion was as 1 to 0·230. The corresponding formula, therefore, was:—

Sugar, per 100 parts, or $S = (D - D') \times 0{\cdot}23$.

The accuracy of this method was further tested by operating on diabetic urine diluted with known volumes of water or non-saccharine urine, and on solutions of loaf sugar in water and in healthy urine.

This method of estimating sugar is especially applicable to medical practice, and the following simple and most convenient rule expresses the result of the analysis:—

Each degree of 'density lost' indicates one grain of sugar per fluid ounce of urine.

PHYSICAL AND MATHEMATICAL SECTION.

October 11th, 1860.

Some conversation took place respecting recent storms, and the bearing of the new weather tables, given in the *Times*, on their theory, as Mr. Baxendell remarked that

according to these observations the wind did not blow from the areas of greater pressure.

Mr. Baxendell called attention to certain phenomena of solar spots recently observed by him, and stated that in cases in which projections of the penumbra into the nucleus occurred, the penumbra is generally increased in breadth in that part of its circumference, and it often happens that striations observed in the penumbra are curved, and terminate in the points of projection into the nucleus.

A Paper was read by Thomas Carrick, "On the Atomic Constitution of Water and Ice."

After briefly alluding to the nature of his own views on the ultimate atomic constitution of terrestrial matter, and its relations to cosmical force, the Author—guided by considerations derived therefrom—proceeded to discuss the question of the relative specific gravities of water and ice, and arrived at a specific gravity for ice differing by only $\frac{1}{8\,6\,5}$th part, from the most recent and correct results of experiments.

The prominent characteristics of water and ice were also shown to be the natural result of the disposition and relations of the ultimate atoms.

MICROSCOPICAL SECTION.

September 17th, 1860.

A specimen of envelopes was exhibited by the Secretary, such as were proposed to be sent to captains of vessels, in which to preserve soundings they obtain in different parts of the world, for this Section. The envelopes were much approved of, and were thought likely to be productive of future interest to the Section, and to microscopists in general.

Mr. LATHAM referred to Mr. Hepworth's method of mounting insects in Canada balsam, and described his own experience of the same. Mr. Latham spoke in very favourable terms of the facility with which slides can be washed off and finished. He found that the balsam should be as thick as possible, almost even to dryness; then dissolved in chloroform, to a consistence only thin enough to flow easily under the thin glass; the object having previously been mounted by Mr. Hepworth's process, under thin glass tied on with thread, exhausted of air, and saturated with turpentine. After heating over a spirit-lamp the balsam sets hard almost as soon as cool, when the slide, after cleaning with alcohol, is ready for the cabinet. Mr. Latham exhibited several slides thus mounted, with specimens of the gizard of a cricket, saw fly, entire system of the silk-worm trachea, ichneumon fly, spiracle of the silk-worm, goldfish scale, leaf of wheat showing spiral vessels.

Mr. LYNDE exhibited a fine plumatella living on the shell of a large lymnea or water-snail.

Mr. MOSLEY exhibited specimens of hydra and other aquatic objects.

October 15th, 1860.

A Circular was read, addressed to captains of vessels, with a request that they will preserve the produce of the soundings they make when abroad, in the envelopes sent therewith.— A Letter was read from Mr. Hayman, of Liverpool, to the effect that circulars and envelopes have been supplied to the captains of eight steamers belonging to Messrs. John Bibby and Sons, in the Mediterranean trade; three of Messrs. Mac Iver's steamers, plying between Liverpool and New

York; to the steamer "Armenian;" for Madeira, Sierra Leone, Calabar, &c.; to the "Marco Polo," and two other vessels to Melbourne; as well as to vessels which have gone to Woosung in China, Bombay, Alexandria, &c., &c.

The CHAIRMAN made some observations in praise of the plan, which he had no doubt would be productive of advantage and add to the interest of the meetings of the Section.

It was suggested by Mr. BROTHERS that a special subject, previously fixed upon, should be discussed at each meeting: the suggestion was at once adopted. The subject for discussion at the next meeting will be, "Upon the Best Method of Preparing and Mounting Diatoms, &c., obtained from Soundings and other Sources." It is requested that the Members of the Section will meanwhile obtain and communicate all the information they can on the subject

Mr. LYNDE exhibited a specimen of a small insect allied to the Podura, which he found leaping about on the surface of the water in his aquarium. Mr. Lynde had never seen a description of such an insect, nor was it known to any of the Members of the Section present.

Mr. BROTHERS exhibited the hydra viridis, &c.

A few specimens and parts of flowers obtained at the Botanical Gardens, were exhibited by the SECRETARY. In the tank of the Victoria Regia, little minute animal life could be discovered during a short visit. A specimen of Cetochilus was shown which was found there, as also a few diatoms not fully examined.

Ordinary Meeting, October 30th, 1860.

Dr. J. P. Joule, President, in the Chair.

A Paper was read by Dr. H. E. Roscoe, entitled, "On the Alleged Practice of Arsenic Eating in Styria."

Professor Roscoe being anxious to obtain further definite information respecting the extraordinary statements of Von Tschudi, quoted by Johnston in his "Chemistry of Common Life," that persons in Styria are in the habit of regularly taking doses of arsenious acid, varying in quantity from 2 to 5 grains daily, was supplied through the kindness of his friend Professor Pebal, of Lemberg, with a series of letters written by seventeen medical men of Styria, to the government medical inspector at Grätz, concerning the alleged practice. After reviewing the opinions of Dr. Taylor, Mr. Kesteven, and Mr. Heisch, upon the subject, and having mentioned the results and conclusions arrived at by those who had previously interested themselves with the subject, Mr. Roscoe stated that all the letters received from the medical men in Styria agree in acknowledging the general prevalence of a belief that certain persons are in the habit of continually taking arsenic in quantities usually supposed sufficient to produce death. Many of the reporting medical men had no experience of the practice; others describe certain cases of arsenic eating which have not come under their personal notice, but which they have been told of by trustworthy people whose names are given; whilst others, again, report

upon cases which they themselves have observed. Professor Roscoe proceeded to bring forward, in the first place, evidence bearing upon the question,—Is or is not arsenious acid, or arsenic in any other form, well known to, and distributed amongst the people of Styria? He said that he had received 6 grms. of a white substance forwarded by Professor Gottlieb, in Grätz, accompanied by a certificate from the district judge of Knittelfeld, in Styria, stating that this substance was brought to him by a peasant woman who told him that she had seen her farm-labourer eating it, and that she gave it up to justice to put a stop to so evil a practice. An accurate chemical analysis showed that the substance was pure arsenious acid. Extracts from many of the reports of the medical men were then read, all stating that arsenious acid, called "Hidrach" by the Styrian peasants, is well known and widely distributed in that country. The second question to which Mr. Roscoe sought to obtain an answer was, whether arsenic is or is not regularly taken by persons in Styria in quantities usually supposed to produce immediate death? The most narrowly examined, and therefore the most interesting case of arsenic eating is one recorded by Dr. Schäfer. In presence of Dr. Knappe, of Oberzehring, a man thirty years of age and in robust health, eat, on the 22nd February, 1860, a piece of arsenious acid weighing $4\frac{1}{2}$ grains; and, on the 23rd, another piece weighing $5\frac{1}{2}$ grains. His urine was carefully examined and shown to contain arsenic; on the 24th he went away in his usual health. He informed Dr. Knappe that he was in the habit of taking the above quantities three or four times each week. A number of other cases, witnessed by the medical men themselves, of persons eating

arsenic, were then detailed. Dr. Holler, of Hartberg, says that he and other persons, named in his report, guarantee that they are together acquainted with forty persons who eat arsenic; and Dr. Forcher, of Grätz gives a list of eleven people in his neighbourhood who indulge in the practice. Professor Roscoe did not think it necessary to translate the reports *in extenso;* he gave extracts containing the portions immediately bearing upon the two questions at issue, and deposited authentic copies of the original reports with the Society, for the purpose of reference. He concluded that decisive evidence had, in his opinion, been brought forward, not only to prove that arsenic is well known and widely distributed in Styria, but that it is likewise regularly eaten, for what purpose he did not at the moment investigate, in quantities usually considered sufficient to produce immediate death.

In the course of the conversation, after the Paper was read, Dr. Clay mentioned instances in which large quantities of arsenic had been prescribed for various diseases, with benefit. It was a valuable medicine, but if taken for other purposes it would produce most pernicious effects. It was a practice in some parts of the country to give it to horses to improve the sleekness of their coats.

Mr. Ransome confirmed the observation of Dr. Clay, and stated that he had long ago drawn the attention of the Society to the fact that sulphuric acid manufactured from arsenical pyrites contained arsenic, and that this acid being employed in the manufacture of various articles used as medicine, and even as food, these likewise contained the poisonous ingredient. He had found it even in flowers of sulphur.

Mr. Pochin and Mr. Hunt remarked that the effects of breathing the vapour of arsenious acid produced in the smelting of ores were not so injurious as might be expected; occasionally, however, the workmen had to be taken off the particular work for a short time, until the poisonous effect which manifested itself by eruptions on the face had disappeared.

Ordinary Meeting, November 13th, 1860.

Dr. FAIRBAIRN, F.R.S., &c., Vice-President, in the Chair.

The CHAIRMAN made some obvervations respecting experiments conducted in the Dukinfield Coal Pit, for the purpose of determining the rate of increase of temperature below the earth's surface. He stated that from these experiments a mean increase of one degree Fahrenheit for every seventy-one feet had been arrived at; and he promised on a future occasion to communicate the details of the determinations.

A Paper was read by Mr. BAXENDELL, F.R.A.S., entitled, "On a System of Periodic Disturbances of Atmospheric Pressure in Europe and Northern Asia."

Whilst engaged some time ago in an investigation of the phenomena of the general disturbances of the atmosphere, the Author had been led to conclude that moderately accurate determinations of the sums of the oscillations of the barometer, for given periods, at different places on the surface of the earth, would afford valuable information respecting the nature of these disturbances, and, at the same time, throw additional light upon the causes by which they are produced. Determinations of the *statical* element of mean pressure are obviously of very limited use in an inquiry of this kind; but notwithstanding the importance of the subject, meteorologists have hitherto generally neglected to ascertain, even approximately, the values of the *dynamical* element as represented by the sums of the oscillations of the mercurial column. In none of the many volumes of observations which issue from the public observatories of this country and the continent has the Author yet seen any attempt made to deduce the values of this element.

Accurate absolute values of the barometric dynamical element can, of course, be obtained for those places only where hourly observations are made; but as it appeared to the Author that good comparative values would be quite sufficient for the general purposes of his inquiry, he decided to confine his attention, in the first instance, to oscillations derived from observations made once a day only. By this plan the regular diurnal oscillations are completely eliminated; the results are adapted for very fair comparison with each other; and a greater number of sets of observations become available for the purposes of the inquiry. This method has accordingly been employed in the discussion of a very considerable number of observations made at various places in Europe and Asia, and a table is given showing the mean monthly and annual sums of the oscillations of the barometer at seven stations in Europe and six in Asia as derived from observations extending over periods varying from six to fifteen years. It is, however, remarked, with reference to the results given for Greenwich, that as the individual observations of each day at Greenwich are not given in the published volumes, these results are derived from the daily means, and not from single daily observations, as in all the other cases. Diagrams of the curves laid down from the numbers in this table accompany the Paper. All these curves show a principal minimum in one of the three summer months, June, July, or August; and in many of them there is a second minimum in one of the two winter months, January or February. With respect to the two maxima which occur between these minima, it is shown that the interval between their summits gradually increases as we advance from the eastern to the western stations. Thus, at Nertchinsk (51° 19′ N., 119° 36′ E.), the first maximum occurs in the middle of April and the second in the second week of November, the interval being nearly *seven* months; at Barnaoul (53° 20′ N., 83° 57′ E.) the first maximum takes place in the middle of March and the second in the middle of Novem-

ber, the interval being *eight* months; at Catherinbourg (56° 49′ N., 60° 35′ E.) the first maximum occurs in the second week of March and the second about the second week of December, the interval being nine months; at Tiflis (40° 42′ N., 44° 50′ E.) and at Lougan (48° 35′ N., 39° 20′ E.) the interval is also about *nine* months; at Stockholm, and also at Milan, the first maximum occurs in the middle of February and the second in the middle of December, the interval being *ten* months; but in the British Islands there is only one principal maximum, which occurs about the second week of January and which appears to be formed by the union of the first maximum of one year with the second maximum of the year preceding, the interval between the two maxima being *twelve* months. It is evident, therefore, that these maxima move across the two continents in opposite directions, the course of the first being from West to East and that of the second from East to West.

As the apparently compound maximum of January is not greater than either of the separate maxima, the Author considers it very probable that both maxima are produced by the same disturbing cause, such disturbing cause taking its rise in Eastern Asia in the month of November, and gradually moving westward until it arrives in the British Islands in January; then reversing its course, it returns with a diminished velocity to the region of its origin, where it arrives in the month of April, and afterwards rapidly disappears under the influence of an increasing temperature, to re-appear later in the year on the return of a low temperature.

As the times of first appearance and of final disappearance of the disturbing cause in Eastern and Central Asia, correspond very nearly with the times of the breaking up of the monsoons in the China Sea and Indian Ocean, it is considered very probable that the two systems of phenomena are directly connected with and dependent upon each other.

Attention is drawn to a very decided convexity of nearly

all the curves in the month of October, indicating the operation of a secondary disturbing cause acting during that month over the whole breadth of the two continents.

In concluding, the Author remarks that the first application of the method he has employed appears to be due to Dr. Dalton, and that the only other application of it which he has yet met with is in Mr. Broun's very able discussion of the Makerstoun observations.

At the conclusion of the Paper, Mr. Robt. Worthington expressed the high opinion which he entertained of the importance and value of the observations brought forward by Mr. Baxendell, as forming a new step in the method of discussion of the disturbances of atmospheric pressure in which a definite mode of measurement was adopted. He knew, from his own experience, how laborious such an investigation was, involving as it did, many scores of thousands of numerical operations. It was important to understand that the observations used by Mr. Baxendell were those published by some recognised meteorological institution.

The Chairman remarked that the Paper just read afforded striking proof of the great value of the Society's library of reference, which was fast becoming one of the most complete in the country. Without the help of the library the collection and arrangement of all these observations would have been impossible; and he strongly urged the members to assist in rendering more effective so important a part of the Institution.

Ordinary Meeting, November 27th, 1860.

Dr. J. P. JOULE, President, in the Chair.

A Paper by Thomas Moffat, M.D., F.G.S., F.R.A.S., "On the prevalence of certain forms of disease in connection with Hail and Snow Showers, and the Electric condition of the Atmosphere," was communicated by Mr. BINNEY.

In 1852, while deducing results from the meteorological observations of the two previous years, the Author observed that an intimate connexion existed between falls of snow and hail and diseases of the nervous centres, such as apoplexy, epilepsy, paralysis, and vertigo; and the results of eight more years bear out the truth of the observation.

A table formed from two hundred and thirty-six cases of the above diseases, and upwards of one thousand observations of the electrometer, is given, showing the per centage of hail and snow showers, the cases of diseases of the nervous centres, and the times that the air was positive and negative with each wind. From this table it appears that with the wind from the N., N.E., E., and S.E. points, which the Author calls the *snow* points, the per centage of hail and snow showers is 23·2; of cases of apoplexy, &c., 36·7; of positive electricity, 27·0; and of negative electricity, 34·1; while with the wind from the *hail* points, S., S.W., W., and N.W., the per centages are respectively 76·6, 65·7, 72·6, and 67·5, thus showing that the number of cases of disease increases with the frequency of hail and snow showers and the consequently

increased frequency of the alternations of positive and negative electricity.

All observers agree that the air is negative on the approach of great storms, and negative or alternately negative and positive in unsettled weather, and the Author remarks that such storms are almost invariably accompanied by convulsive diseases, or diseases of the nervous centres in some form; and in support of his statement he quotes many cases from his notes of the storms of the last twelve months, but more particularly the succession of gales which occurred from the 21st to the 30th of October, 1859 (in one of which the "Royal Charter" was lost), the gales of the 25th, 26th, and 27th of May last, which were accompanied with frequent hail showers; and those of the 24th of August and four following days. Other forms of disease accompany such atmospheric conditions, such as premature uterine action, epistaxis, and diarrhœa, with vomiting and cramps; and cases of this class are quoted by the Author from his notes; and he remarks that it would then appear that negative electricity plays an important part in the above atmospheric conditions and morbid actions. After describing the electrical phenomena of continued heavy rains, and of thunder storms and heavy showers of hail and snow, the Author observes that as the electrical tension of the clouds which produce these storms and showers is always strong, it must have a coercive force upon all bodies at the earth's surface; and that as, according to our notions of electrical action, the moment the influence of the *inducing* body is removed, a re-arrangement of the electricities in the *induced* body takes place, we cannot well avoid the conclusion that during the period of induction, and

when the re-arrangement—the rebound—the *back stroke* occurs, some important action must take place in the organic forces, such as the nervous and the muscular. Cases are quoted in illustration, and the Author then remarks that from long series of observations it would appear that there is an intimate connexion between hail and snow showers, stormy weather, atmospheric electricity, and certain forms of disease; and he ventures to add that hail and snow are formed under the influence of opposite electrical conditions, and concludes by suggesting the means of putting this opinion to the test of experiment.

MICROSCOPICAL SECTION.

November 19th, 1860.

A Letter was read from Mr. R. D. Darbishire, relative to the deposits from the raised sea bottom found at Capell Backen, Uddevalla, near Gottenburg, in Sweden. He observes that "the hill side from a height of about fifty feet above the level of the sea to that of about two hundred and thirty feet, consists of layers of fossil shells, varying from ten to thirty feet thick, alternating with beds of more or less coarse gravel and clayey sand." Mr. Darbishire contributed, for the use of the Members, a parcel of washings from shells, and a box containing dry sieved soil for microscopical examination.

A Letter was read from Mr. John Hepworth, of Crofts Bank, describing his method of washing and mounting calcareous and silicious shells, dry and in balsam. Mr. Hepworth also presented to the Members of the Section, for mounting, a piece of injected kidney.

A Paper by Mr. J. B. Dancer, F.R.A.S., was read, "On cleaning and preparing diatoms obtained from soundings and other sources."

The SECRETARY exhibited a portion of sea weed from the Gulf Stream, in which were found a few diatoms, remains of entomostraca, &c., contributed by Mr. A. da S. Lima, of London.

Ordinary Meeting, December 11th, 1860.

Dr. J. P. Joule, President, in the Chair.

Dr. Fairbairn brought before the meeting four specimens of Submarine Telegraphic Cable, as constructed by Messrs. Hall and Wells. This cable has a copper wire insulated by india rubber in the centre for the transmission of the electric current. Outside of this are twenty longitudinal strands of hemp steeped in pitch and cork dust, and eight steel wires braided together with twenty-four strands of hemp saturated with Stockholm tar. The specific gravity of the cable in sea water is 1.4 and its weight in air 0.82 ton per mile. The length that would break with its own weight when suspended in sea water is 10,810 fathoms; its tensile strength being 2.875 tons. Dr. Fairbairn presented an account of experiments which had been made on the elongation of a sample of the cable twenty feet long by the application of different tensile forces. With a force of 4,480 lbs. there was an elongation of half-an-inch, and after the weight had been removed the cable was found to be permanently stretched $\frac{3}{16}$ths of an inch. With a force of 6,440 lbs. the cable broke after having stretched $1\frac{1}{16}$ inches.

Professor Roscoe explained the recent discoveries by Bunsen and Kirchoff of the lines in the spectrum produced by various substances when ignited in the flame of a laboratory lamp. He exhibited beautiful chromo-lithographic drawings of the spectra produced by lithia and various other earths and alkalis. Lithia, which had formerly been supposed to be a very rare earth, was by this means proved to be one of those most extensively distributed. Professor Roscoe stated that Bunsen had, by this new and most delicate system of analysis, been led to the discovery of a new metal which was present in a mineral spring in so small a quantity that twenty tons had to be boiled down to obtain 250 grains of the metal.

A Paper was read by the Rev. W. N. Molesworth, M.A., entitled, "On the Origin of Species."

The Author of the Paper stated that he was neither the advocate nor the antagonist of Mr. Darwen's theory; but that he wished to point out the futility of some of the arguments which had been made use of against it, to suggest some additions which he thought necessary to give it completeness, and to ask for it that it should be considered in that spirit of philosophical calmness with which it had been proposed by its Author.

After giving a brief sketch of Mr. Darwen's theory, for the purpose of keeping its more salient points before the minds of the audience, and to enable them to follow the remarks he was about to make on it, he pointed out the difficulties which had given rise to it, and the classes of facts which it aimed at explaining. He showed that, regarded as a scientific hypothesis, it possessed a value which was altogether independent of its truth or erroneousness, and that the discussion of it would in all probability lead to important scientific results, whatever might be the ultimate fate of the hypothesis itself. He then proceeded to consider some of the objections which had been made to it; but the greater part of the Paper was devoted to the purpose of pointing out, at considerable length, the influence which changes in the conditions of existence must have in producing variation. He dwelt on the distinction between variability and a tendency to variation, showing the former to be a quality inherent in the organised being, and the latter to be generally a consequence of changes in its conditions of existence; and he quoted some passages from Darwen's work to show that in this respect the theory was defective and required further elaboration. He concluded by expressing his entire approval of the rule of the Society which prohibited the consideration of the theological bearings of the question, a rule which he regarded not merely as a regulation of wise expediency, but as the embodiment of a great principle,

namely, that the intrusion of Scriptural considerations into a scientific discussion is as theologically wrong as it is scientifically mischievous—that it is our duty to investigate the Creator's works with the utmost freedom in every direction, without entertaining the slightest dread that our inquiries can ever prejudice the moral and religious truths that are contained in His word. He reminded the Society that truth can never injure truth, but only error; and that we might, on this subject, use the words which Galileo employed in replying to objections precisely similar in their principle to some of those which Mr. Darwen's theory has encountered. "Quin ipsa philosophia, talibus disputationibus non nisi beneficium recipit. Nam si vera proponit homo ingeniosus veritatisque amans nova ad eam accepio fiet; sin falsa, refutatione eorum priores tanto magis stabilientur."—*Galilæi syst. cosm.*, p. 42.

An interesting discussion took place, in which Dr. Fairbairn, Dr. Clay, Mr. Binney, Mr. Atkinson, Mr. Francis, Mr. Hull, and others took part.

Mr. Hull, F.G.S., reviewed the geological evidence bearing on the "Development" theory, arriving at the conclusion that on geological grounds that theory was altogether untenable. At the same time, as far as regards the permanency of varieties, and their consequent establishment as species, the doctrine of Mr. Darwen appeared sound up to a certain point. The distribution of the Brachiopoda, and some other forms, appeared to be capable of explanation on these grounds, but Mr. Hull contended that it was impossible to account for the first appearance of numerous highly organized groups of animals on the hypothesis of natural selection, or any similar theory of development.

PHYSICAL AND MATHEMATICAL SECTION.

November 8th, 1860.

Mr. Baxendell was elected a Vice-President of the Section, in place of the late Mr. Long.

Mr. Baxendell read a Paper, "On a System of Periodic Disturbances of Atmospheric Pressure in Europe and Northern Asia."

[This Paper was afterwards read at the Ordinary Meeting of the Society, on the 13th November.]—See Proceedings No 5.]

December 6th, 1860.

Mr. George Mosley was elected Treasurer of the Section, in place of Mr. Baxendell.

Mr. Atkinson read a Paper, entitled "Remarks on Abnormal Disturbances of the Barometrical Column at certain Seasons of the Year."

Mr. Atkinson considers that all the movements in the atmosphere of our earth, which have received the designation of *irregular*, are caused by the reflected or radiated heat of the sun, and take place at a very moderate elevation, say within five or six miles of the general surface level;—and that these apparently irregular movements or shiftings from place to place of lighter and heavier air, causing oscillations in the barometric column, are mainly if not wholly due to irregularities of the earth's surface. Had our earth been a globe possessing a smooth surface of uniform texture and properties, it seems clear that the atmosphere would have been acted

upon by the reflected and radiated heat of the sun, in a manner so much in accordance with a uniform sequence of physica effects, that the periodic movements of the gases composing it would have been as regular as the planetary motions themselves. In the northern parts of our hemisphere, it appears by Mr. Baxendell's valuable paper, read before the General Meeting of this Society on the 13th ult., that the barometric oscillations are least in amount when the sun is on or near the equator. This fact points to the inference that if the plane of the earth's orbit had coincided with the plane of its equator the disturbance of the barometric column would have been comparatively small and nearly uniform throughout the year. The coincidence of these two planes not existing, it is found, that as the sun retreats from the equator towards the southern tropic, the sum of the oscillations of the mercury gradually increases for a considerable time, and then rapidly mounts up so fast as to form a prominence in Mr. Baxendell's curves resembling a mountain peak. This peak or summit of the "dynamical curve" occurs above different points of its axis—that is, at different periods of time—according to some peculiarity in the position—different from the latitude or the longitude—of the locality from which the data for constructing the curves were derived.

Speaking of the northern hemisphere, as the sun withdraws southward from the equator, less or greater portions of the northern part of the terraqueous surface becomes cooled down gradually to the freezing point, according to various peculiarities of substance, elevation above the sea-level, proximity to the open ocean, or to far-inland mountain ranges, and to other analogous causes. In similar latitudes, from the varying conditions just mentioned, there will exist, side by side, spots differing, or having a tendency to differ, very much in temperature, and where consequently currents of different density—set in motion by the constant struggle going on in the air to attain a state of equilibrium—will cause frequent

fluctuations in the barometer. These disturbing causes will, in any region, be much increased at the setting in of winter and the commencement of hard frost; for at this crisis a large amount of latent heat will be liberated and will contribute its influence to disturb the equilibrium of the air. A similar crisis will occur at the end of winter on the breaking up of the frost, and will necessarily be attended with similar results. As the times of these *crises* appear to correspond in a remarkable manner with the times of maximum disturbance of the barometrical column, it seems but fair to infer that a relation exists between the causes here stated to be in operation, at the critical periods just named, and the periodical disturbance of the mercury in the barometer indicated by Mr. Baxendell's "dynamical curves." The correctness of this inference, or the contrary, can only be established by future observation of phenomena, and the collection of facts, many of them of a kind seldom thought of hitherto as constituting elements for the solution of problems in meteorology.

Ordinary Meeting, December 26th, 1860.

Dr. R. Angus Smith, Vice-President, in the Chair.

Ordinary Meeting, January 8th, 1861.

E. W. Binney, F.R.S., F.G.S., &c., Vice-President, in the Chair.

Mr. Ransome exhibited and explained the means of obtaining a photograph, which, although appearing a confused series of light and shade, yet, when reflected from a polished cylinder, was a beautiful picture.

Dr. Crace Calvert brought under the notice of the Society an interesting communication made to him by Professor Arnaudon, of Turin, to the effect that oxalate of ammonia completely modifies the action of yellow prussiate of potash when mixed in solution with a salt of peroxide of iron. Thus, if oxalate of ammonia be added to this metallic salt, it will give no prussian blue when a solution of yellow prussiate of potash is added; but on the addition of an acid, prussian blue is immediately produced. The knowledge of this fact may be interesting to calico printers, as it will give them the means of easily producing prussian blue on their fabrics. To attain this desirable end, the printer will simply have to pad his fabric through a mixture of persalt of iron and oxalate of ammonia, dry, and print an acid where he wishes to produce the blue.

After Dr. Calvert had made a few more remarks on this subject, he stated that he had lately examined several varieties

of snuffs, which he had found to be more or less impregnated with lead compounds, especially the black rappee, and he found on further investigation that the presence of lead was due to the corrosive action of the snuff upon the lead foil used for packing it. He also stated that it was his intention to examine several other substances usually packed in lead foils, and that he would lay the results of his observations before the Society, as he thought it highly desirable to make the public aware of such sources of injury and to induce manufacturers to adopt means to avoid inflicting this serious evil on their consumers.

Dr. Calvert concluded by stating that he had been engaged for the last few months in investigating the action of the Manchester Waterworks water on various kinds of leaden pipes, and that he was arriving at such results as would show the necessity for serious consideration on the part of the inhabitants of this city with respect to the evils arising from the introduction of the water into their dwellings through leaden pipes.

Being requested by the Chairman to give his opinion, Dr. Angus Smith said that he had never found any Manchester water which had passed through lead pipes to be entirely free from lead. At the same time, the quantity is in almost all cases so small that, as far as we know, it can produce no bad effects, and is practically equal to nothing. There is, however, a great difficulty in knowing what is hurtful; medical men had not settled the point. Persons said to be suffering from lead paralysis were known to have taken water with as little as one-hundredth of a grain of oxide of lead per gallon, whereas it was considered generally not to

be hurtful until it contained one-fortieth of a grain. We have little idea of the extreme susceptibility of some persons, and it is better to avoid lead as much as possible. Short lead pipes may be used without fear in Manchester, especially if the water which has stood over night be thrown away. Long lead pipes should be avoided, and lead cisterns are extremely dangerous, especially with soft waters, including Manchester water. (Here, instances were given.) Soft water dissolves lead more readily than many hard waters, and if the hardness be due only to the earthy carbonates, the lead becomes coated instead of being dissolved. But if the hardness be due to chlorides or nitrates, the water dissolves lead much more rapidly than pure water (referring to what he had written on this). He gave an instance of water from a cesspool obtaining, by oxidation of its impurities in a porous soil, much nitric acid, which, along with the chlorides always found in such cases, caused the adjacent water, when drawn up by a lead pump, to have a very strong taste of lead salts. It is remarkable that this water was drunk for some years, but ultimately caused the death of two or three persons. It is a mistake to suppose that pure water dissolves lead more than all impure waters. Some very pure natural waters dissolve lead simply because they contain chlorides, although in small quantities. Such waters sometimes come from clay slates and similar formations. As to peaty water, it was of two kinds, occasionally acid, with some action on lead, but in most cases alkaline, the peaty matter not dissolving lead. Some lead pipes were more easily affected than other. Dr. Smith gave an instance of a lead pipe, nearly an inch in thickness, with holes pierced through the sides in various places by the action of the water; others are much more equally corroded. He had spent

a long time in obtaining a suitable coating for lead to protect the water from its action, and had not quite succeeded; but he had given his results to a friend, who had gone further, and, having obtained great success, patented the process. However, he was told that no one would buy lead pipes of the kind, as they cost half a crown per cwt. more than the ordinary ones. People complain of evils which they refuse to escape from. It is, however, better to avoid lead than to avoid pure water because of its action on lead.

A Paper was read by Mr. Edward Hull, F.G.S., on the nature and objects of Geological Surveys, with special reference to the progress of the geological survey of Lancashire and Cheshire.

After describing the various sources, both natural and artificial, on which the geological surveyor depends for his conclusions, and according to which he is enabled to trace the boundaries of the formations, the author went on to observe that, so generally is the value of such surveys recognised, that the governments of nearly all the most civilised nations had undertaken their support. Amongst others, France, Belgium, Germany, Russia, the States of North America, the British Colonies, as Canada, New Columbia, India, Australia, and New Zealand.

The Author then explained some details regarding the maps of Lancashire so far as they had been completed by the Geological Survey of Great Britain. Specimens of these maps, both of the one-inch and six-inch scales, were exhibited to the Society in the course of the evening.

MICROSCOPICAL SECTION.

December 17th, 1860.

Letters were read from Sir Leopold Mc. Clintock, Mr. J. W. Read, of the Admiralty, and Dr. Wallich, who accompanied the former in the *Bull Dog*, in the late expedition to the North Seas. Dr. Wallich kindly presented to the Section a few copies of his pamphlet on "Life in the Deep Sea," now circulating amongst the members.

A Letter was also read from Captain M. F. Maury, of the U.S. Navy, promising to supply envelopes for soundings amongst the sperm whalers and other vessels trading to the Pacific Ocean, &c.

Specimens of incrustations from the boilers of the steamer *Edinburgh*, trading from Glasgow and Liverpool to New York; from the steamer *Rhone*, from Liverpool to Venice, Trieste, &c.; and from the steamer *Minho*, from Liverpool to Lisbon and Oporto, were received from Mr. W. A. Hayman, of Liverpool. The incrustations are as hard as marble, breaking with a crystalline fracture, and showing, by different coloured strata, the crust obtained from harbours and from the open sea. Mr. Dale stated that the component parts of the incrustations are sulphates of lime, magnesia, &c.; he recommended maceration in bicarbonate of ammonia to obtain calcareous shells, and in weak acids or muriate of barytes to obtain silicious shells. Various members took specimens for examination.

A Letter was read from Captain Andersen, of the Cunard steamer *Canada*, from Liverpool to New York, accompanying specimens of the soundings taken during his last voyage across the Atlantic. Captain Andersen was kind enough to send the soundings by post from Queenstown, by which means they arrived just before the meeting.

Mr. W. H. Heys, of Hazel Grove, exhibited his newly invented Kaloscope, by means of which he obtains refracted and reflected light of different colours at the same time upon objects under the microscope, producing beautiful effects in some cases.

Quarterly Meeting, January 22nd, 1861.

Dr. J. P. Joule, President, in the Chair.

The following gentlemen were duly elected as Honorary Members:—Wilhelm Haidinger, Director General of the I. R. Geological Institute, Vienna, and Professor James Joseph Sylvester, M.A., F.R.S.

As Corresponding Members:—Professor George Buckland, of University College, Toronto, and Professor Joseph Henry, Secretary of the Smithsonian Institute.

As Ordinary Members:—William Henry Fisher, Rev. Thomas Buckley, M.A., Simon Pincoffs, Rev. G. H. Greville Anson, M.A., Professor R. B. Clifton, B.A., John Shae Perring, William Radford, Thomas Alcock, M.D., Charles O'Neill, George Parr, jun., John Curtis, James Bottomley, and Francis Preston.

The new rules were submitted by the Council.

It was moved by Mr. Binney, seconded by Mr. Maclure, and resolved—"That the rules proposed by the Council be adopted in place of those hitherto in force."

MICROSCOPICAL SECTION.

January 21st, 1861.

Letters were read by the Secretary from Professor Huxley and from Mr. W. K. Parker, respecting soundings.

Mr. Heys, of Hazel Grove, read a Paper "On the Kaloscope," his newly invented instrument for the use of coloured light in the examination of objects under the microscope. This the Author effects by two sets of four discs each of differently coloured glass, $2\frac{1}{2}$ inches in diameter, mounted on a stand 12 inches high, one set of which is placed between the light and the bull's eye condenser, and the other between the light and the mirror, underneath the stage, each disc having an independent motion, so that the light can be transmitted through one or more of both sets at the same time; when the object appears of the colours refracted and reflected through the discs.

One of the important uses of the instrument is the protection of the eye from injury occasioned by the use of common artificial light.

Many objects which do not polarise, by the kaloscope are made to disclose the beauties of polarised light; for instance, the anthers of the mallow, with their pollen, when viewed by means of red light below the stage, and at the same time green light (the complementary colour) through the condenser, appear of a beautiful green colour on a red or crimson ground.

The Author observes that some objects, viewed by means of the kaloscope, appear in such relief that they might be supposed to be seen through a stereoscope; these are anthers, jointed hairs, oil-glands, and vegetable sections in general. The calyx of the moss-rose is alluded to, under ordinary illumination, as a mere entanglement of fibres with dark beads; but by this method it is transformed into a stereoscopic branch, with glittering glands at its extremities.

Sections of wood, spines of echini, &c., will be found as beautiful as with the polariscope; but, by another arrangement, details are brought out not observable with the latter instrument. A black surface being placed below the stage, coloured light is thrown very obliquely from the mirror, and

the complementary colour through the condenser; hairs on the edges of leaves, petals, and filiments of stamens, &c., then appear illuminated by the light of the condenser of one colour, and fringed with the opposite colour on an intensely black ground. The Author gives a list of the botanical names of objects advantageously illuminated by this method. A single coloured disc may be also used to advantage with white light from the bull's eye lens. Details of structure are observable by means of this instrument, which the Author observed are inconspicuous without its aid, and thinks that its efficacy in connexion with such a variety of purposes, cannot fail to render it of value to the scientific observer.

The reading of the Paper gave much satisfaction to the members of the Section, and it was resolved to communicate the same to the Society, with a recommendation that it should be printed *in extenso* in its Memoirs.

The Secretary read a Paper, "On Preparing Objects found in Soundings," and described Mr. Dale's process for disposing of the tallow by means of highly rectified benzole, which is most effectual. The benzole (called benzine by French chemists), being recovered, to be used again as fast as required for a dozen filters, each with its specimen in process at the same time, with only trifling loss from evaporation.

This Paper, and one by Mr. Dancer, on the same subject, were ordered to be printed by the Section, for circulation amongst its members.

Mr. Brothers presented to the Section a very old microscope, date unknown; he also exhibited the actinophris eichornii, melicerta, sea weed with lipraria, &c.

Mr. Hardman, of Davyhulme, presented three mounted specimens of the wire worm, and a number of dissecting needles for the use of the members; he also exhibited a

mounted fly, one of the Panorpidæ, which he states feeds upon leaf-rolling caterpillars. The proboscis and feet of the insect are peculiarly adapted for dragging its victims from their concealment and holding them whilst extracting their juices; the feet being provided with combs similar to those of the spider.

Mr. R. D. Darbyshire presented a quantity of mud, &c., from the washings of shells from the raised sea bottoms at Uddevalla in Sweden.

Mr. Dancer exhibited a new 3-inch object glass, with a large and flat field of view; also specimens of gold quartz from Wales large curculia, and other objects.

Mr. Whalley exhibited some specimens of injections obtained from Germany, which were considered the best yet exhibited.

Mr. Latham exhibited various specimens of sand and mud from the East Indies, portions of which were distributed amongst the members.

Ordinary Meeting, February 5th, 1861.

J. C. Dyer, Esq., Vice-President, in the Chair.

Mr. John Curtis communicated his observations of the fall of rain in the years 1860, 1859, and 1858, and compared them with Dr. Dalton's average for 47 years, and with the mean of the last 72 and 75 years. The following is a summary of the results:—

Average from 1794 to 1860	35·46	inches.
,, from 1786 to 1857	36·398	,,
,, from 1786 to 1860	36·274	,,
Dalton's from 1794 to 1840	35·523	,,
In 1858	30·53	,,
,, 1859	33·09	,,
,, 1860	36·24	,,

Comparing the last year with 1859 it was found that

The number of rainy days	in 1860 were	28 days above that in	1859.
The amount of evaporation	,, was	0·92 inches below	,,
The mean temperature	,, was	3·13 degrees below	,,
The highest temperature in shade	,, was	9·7 degrees below	,,
The lowest temperature in shade	,, was	19·9 degrees below	,,
The highest temperature in sun	,, was	6·0 degrees below	,,
The lowest temperature on grass	,, was	19·9 degrees below	,,
The mean of barometer	,, was	0·031 inches below	,,
The number of days of snow	,, were	8 more than	,,

Dr. Crace Calvert stated that in consequence of having found lead in snuff packed in leaden cases, he had examined tea, chicory, &c., but without discovering lead in them, which he attributed to the protection afforded, in some instances, by the interposition of paper between the article and the leaden case, and in others to the absence of sufficient moisture to promote chemical action.

One of the medals struck on the occasion of the coronation of the present King and Queen of Sweden, presented to the Society by the University of Christiana, excited much admiration on account of the excellence of medallurgy it displayed.

A Paper "On the Kaloscope," by Mr. W. H. Heys, was read by Mr. GEORGE MOSLEY.—This Paper was communicated by the Microscopical Section, and an abstract will be found in the Proceedings, No. 8, under that head.

PHYSICAL AND MATHEMATICAL SECTION.

January 31st, 1861.

Mr. MOSLEY read from the *Gibraltar Chronicle* of the 8th instant, an abstract of meteorological observations taken at the Royal Engineers' Observatory, Gibraltar, during the year 1860. From the results given it appeared that while the weather in England during the last Summer and Autumn had been unseasonably cold and wet, at Gibraltar, on the contrary, it had been remarkably warm and dry. During the six months from the 30th of April to the 1st November, the fall of rain at Gibraltar had been only 1·237 inches, whilst at Manchester, according to Mr. Vernon's returns, it had been 21·858 inches. It was also remarkable that the maximum degree of humidity of the air at Gibraltar, as determined in the usual way by the wet and dry bulb thermometers, occurred on the 30th of September during the long period of drought. The average fall of rain at Gibraltar, from eight years' observations, is 41·2 inches, but during 1860 the amount collected in a gauge on the ground was only 34·874 inches, and in a gauge 25 feet above the ground 32·358 inches. The mean pressure of the atmosphere for the year, at 50 feet

above mean water level, was 30·001 inches; the mean temperature, 64°·9; and the mean dew point computed was 57°·4.

Mr. Baxendell communicated the following table of the fall of rain at the Flosh, Cleater, near Whitehaven, during the last three years, drawn up from observations made by Thomas Ainsworth, Esq., a Corresponding Member of the Society:—

	1858.	1859.	1860.
January	3·495	5·415	7·672
February	0·465	4·477	2·647
March	3·665	4·507	5·030
April	2·575	4·017	2·527
May	3·855	0·400	3·660
June	2·235	2·585	4·622
July	4·000	2·937	2·222
August	3 157	6·332	6·650
September	5·667	6·247	2·030
October	6·610	4·325	9·122
November	1·400	4·737	2·012
December	4·665	4·120	5·610
Total	41·789	50·099	53·804

Mr. Baxendell, referring to a letter by Dr. Wolf, of Zurich, inserted in No. 1,289 of the "Astronomische Nachrichten," on the variations in the frequency of the solar spots, exhibited a diagram showing such frequency by the relative lengths of ordinates laid off from a line representing the time. Treating Dr. Wolf's data by the method of least squares, Mr. Baxendell had deduced a mean period of 11·086 years, the mean epoch of minimum frequency being 1732·96.

Mr. T. Heelis read a Paper "On Meteorological Observations, and Observations of the Temperature of the Atlantic Ocean, made on runs from Liverpool to Gibraltar, and from Gibraltar to Liverpool, in September, 1860."

This Paper was considered by the Section worthy of being printed in the Memoirs, and will be read at an Ordinary Meeting of the Society.

In the course of a discussion which ensued on the red color of the sky, often observed as an indication of approaching bad weather, Mr. BINNEY mentioned that Mr. Dancer had shown him an aurora borealis of a pale greenish white color, which, when observed through glass upon which moisture had been deposited, appeared red.

Mr. BAXENDELL mentioned that several fogs, especially those which had occurred in the early part of the present winter, had been observed by him to be luminous, and that Mr. Crosse, the electrician, had found many fogs to be highly electrical.

Ordinary Meeting, February 19th, 1861.

Dr. J. P. Joule, President, in the Chair.

A Paper was read by J. C. Dyer, Esq., entitled, "Brief Notes on the Freezing, Thawing, and Evaporation of Water, and on the Condensation of Steam, with a View to Enquire into the Cause of those Changes."

In these Notes the Author merely aimed to place before the Society the apparent agency of *heat*, in the changes that water undergoes in passing alternately from one to the other of its conditions of *ice*, *water*, and *steam*, and *vice versâ;* and that these mutations are *caused*, by the taking up and giving out of heat, in its sensible or latent state, by the transitions reciprocally from one to the other of those states. The actual amount of the thermometric heat so passing from the latent to the sensible state was given, as taken from the common tables. On referring to the *two* ancient theories of heat, the one defining it to be, "a material element, *sui generis*, and pervading matter," &c.; the other holding it to be "no other than the motions, mechanically excited in the minute particles of bodies," &c.—it was contended that, by this latter or the "force heat theory," the melting of *ice* by the *action* of the sun's rays could not be explained, since it is not by their *force*, but by the matter of heat that enters and becomes *latent* in the water. The Author then submitted that the *only solution*, hitherto offered of the *absorption* of sensible heat, in water and steam, as latent in these, and the re-appearance of the same *measure* of heat, in a sensible state, by the acts of condensation and freezing, is to be found in the application of Dr. Black's "Latent Heat Theory." Considering the *force heat theory*, as directly conflicting with that of *latent heat;* they cannot both be sustained, and as the latter stands in elementary works as an established law in physics, and as it affords a clear explanation of the aqueous changes adduced; it seems incumbent on those who

deny the entity of *heat*, to account for the alternate exhibition and extinction of the thermometric heat, that *is*, in fact, evolved and absorbed by those mutations of water.

The Author again referring to the long standing controvercies concerning the essential nature of heat, stated that more than *one hundred* works have been published on the subject during the last 200 years, and yet no conclusion has been arrived at, as to the soundness of either of the original theories above cited, nor have any *discoveries* been made that explain the *agency* of heat, in the mutations of water, since the days of Bacon and Boyle, with the sole exception of those of Dr. Black, which appear to *prove* its latent state in bodies. And since we have no *settled doctrine* as to its essence, we must allow that the subject is of philosophical interest, and especially this branch of it concerning *latent heat*, in defence of which these notes are offered.

The PRESIDENT said that some very interesting experiments made by Mr. Dyer, many years ago, were in favor of the dynamical theory of heat, which he believed to be fully able to explain the phenomena ascribed by Black to "latent heat."

A Paper was read by Dr. R. ANGUS SMITH, "On the Production and Prevention of Malaria."

The Author did not pretend to enter on the whole subject, but to give a few observations which he considered fitted for its illustration.—Malaria has unquestionably been proved to be caused by the decomposition of organised bodies. If so, it must exist to some extent everywhere. By the mode of testing the air invented by the Author, every place tried at home and abroad was found to have some oxidizable matter in it, although in some this was extremely small. In such cases the matter was probably oxidized to a state in which it would be innocuous. This oxidizable matter no doubt rises, in a great measure, from vegetation. Vegetation does not merely grow; it dies. This death may be caused by

various circumstances, but two conditions are remarkable, one where the agents are animals, and the other where the agents are chemical. Animal life may act in various amounts on vegetation in the soil, from the large vermin to the microscopic classes. These do not prevent chemical action, on the contrary, it is probable that they further it exceedingly. Decomposition goes on in the soil at various rates, and in various ways. In a rich, highly-manured soil kept warm, the soil will be found alkaline. Soils generally are acid. The Author had shown in a Paper, read in 1847, that in an alkaline, peaty district, cold weather produced acidity in a few days. It would appear as if the acids of the mould (so elaborately described by Mulder) were incapable of further decomposition in the cold, and were thus retained and increased. Our great struggle with the soil is to produce alkalinity, or at least to diminish acidity, and where most acids exist we use most lime. Where most alkali exists there is a greater facility for the escape of vapours, such as we suppose to be hurtful. So far as the vapours of putrid substances have been examined by the Author, they have shown indications of containing substances composed somewhat like protein, at least the carbon and nitrogen have had relations to each other similar, or nearly identical with those found in protein, and formed the mass of the substance.

The extreme condition of putrescence may be very readily produced in a soil by artificial means; the use of a little ammonia, for example, more than vegetation will bear. The substances putrefy until the whole becomes fœtid in the highest degree. We have then a soil rich in organic matter and undrained. It is a swamp of the worst form if the soil be not very poor; worse, perhaps, than was ever seen in nature. Such a soil would bring death everywhere. *It is artificial malaria.* We can, then, produce malaria from the soil by fostering some of its tendencies; and we see by the rapid acidification of soil, in colder weather, why malaria is diminished by a lower temperature.

As we can imitate malaria of some kinds, so can we also imitate the methods by which nature prevents it. The warm alkaline soil, moistened, and washed with air and water, becomes acid, it sends forth less volatile matter—decomposition is stopped to a great extent, the matter is preserved. Cold prevents the action, drainage assists oxidation by a more active state of soil. By these modes, and others, the soil is disinfected by nature, when these do not act sufficiently we may use disinfecting agents. By their means decomposition may be interrupted without fear of diminishing the power of the plant to take up food. By the use of disinfecting agents, Mr. Mc. Dougall had been able to feed sheep and cattle, and retain them in health, on meadows constantly wet by irrigation with liquid manure. The disinfectant used is from the products of the distillation of tar, the amount required is small. Animal life is rapidly destroyed by it, and chemical decomposition is staid. All climates can furnish this, where coal lies or where trees grow.

It would be possible to irrigate great districts at an extremely small expense. The result would be as certain on a large scale as on a small one; and it is probable that, in some cases, one or two applications would be sufficient, for a long period at least. By the new state of things, destructive insects would also be destroyed. Although, according to Dr. Mc. Culloch, there are many parts of our own islands infected by malaria, most, if not all, can be cured by good attention to well-known agricultural maxims. This new method is especially applicable to other countries, and to more violent stages of the disease. The Author hopes to have it tried on extensive districts in Italy. The method arose out of an advice everywhere neglected, but still cherished as true, to disinfect whole cities by beginning with the sewers, the origin and reservoir of all the mischief.

The Author believes that he has shewn that decomposition, to a most pernicious extent, is possible in soils, that this is not a mere opinion, but a fact readily demonstrated; but that

decomposition may be arrested artificially to the preservation of health without the destruction of vegetation, and that in these facts we have not only a surer basis in our reasonings on the origin of malaria, but an almost certain process for its ultimate and total extermination.

SECTION FOR STATISTICS AND SOCIOLOGY.

March 27th, 1860.

A Paper, "On Scientific Philanthropy, or the Best Means of Promoting Social Reform," by Mr. Thomas Ballantyne, communicated by Dr. R. A. Smith, was read.

This great problem may be thus briefly stated. A fearful amount of moral and physical wretchedness exists in Manchester and the neighbourhood; is there wisdom and energy enough among the wealthy and intelligent classes of this city to remove or greatly mitigate that wretchedness; and if there is, how can we best organize these two elements of power in the most efficient manner? The great point is to combine ardent philanthropy, which gives strength of will, to scientific knowledge, which gives practical insight as to the best mode of working. Before we can hope to see a healthy and vigorous movement for the social improvement of Manchester, we must bring the science of our most intelligent reformers into harmony with the warm-hearted sympathy of our self-devoted philanthropists.

Mr. Ballantyne was of opinion that it was the peculiar province of a Society, such as this, to illustrate the best means of treating this most desirable object.

October 24th, 1860.

Dr. R. Angus Smith, F.R.S., read a Paper entitled, "Some Thoughts on the Relation of Work and Workers."

He said the want of attachment to its leaders was not found

in history to be the vice of the English nation. Independence was united to attachment, preventing them from separating without good cause. In conducting the struggle of industry, many of the captains of industry had their commissions only by purchase, not by merit. They had not learned their trade. There were, in reality, no institutions where the thorough knowledge could be gained. Such institutions as taught portions of it were not attended. Badly educated masters belong to the dangerous classes. The best men rise, because talent is always before capital. Take capital to a place and it will be lost without talent; take talent and it will make capital.

As to the men they have a right to unite; who will help them if they never call out? Pity it is that strikes represent the ignorance of the workmen; the best men are busy raising their condition, not striking. The men generally, like many of the masters, refuse to learn. They ought to combine, not to fight, but to make themselves better workmen. It is amazing how difficult it is to get good workmen. If masters united with their best men, all might assist each other, and where there is success this is really done.

The only way that workmen can rise is by intelligence; just as it is by intelligence only that the master can maintain his position. Some of the best masters are men who have accumulated property by intelligence and industry.

Intelligence in workmen causes a rise in wages, entirely irrespective of supply and demand. Instances were given in which there is a constant and established habit of looking to the condition of the employed and to what he might be supposed to expect. Supply and demand are generally used as gross words that skim over great difficulties. They have been treated as merely physical, but when moral considerations enter, supply and demand alter their conditions, and the physical laws must give way, because there are moral feelings in men stronger than their love of gain.

The common notion of supply and demand relates to a certain familar condition of things. But law changes as society changes; new beings demand new rights; new conditions also bring new laws. For example, our most rigorous laws relate to property. We believe that every man has a right to what he has obtained honestly; but in 1846 Ireland was in want, and suddenly we found that eight millions of our money did not belong to us, but was the property of Ireland by a higher law than that of the police. Character always controls, sometimes despotically rules, both supply and demand.

January 15th, 1861.

Mr. David Chadwick, F.S.S., read a Paper, "On the Equitable Adjustment of Property and Income Tax, and the Extent to which it is Practicable to Apply such Tax."

After briefly referring to the subject of taxation generally, the mode of raising it, and the purposes to which it was applied, and to the opinions of Adam Smith, John Stuart Mill, Mc. Culloch, Ricardo, and others, it was held that the best description of the principle on which all taxes should be levied was the definition of Adam Smith:—"That all persons should contribute to the taxes of a country in proportion to their ability."

"That all taxes should be clearly defined, certain in amount, and payable in a manner most convenient to the payer."

On the general question of the advantages of direct and indirect taxation, it was held that, *direct taxation* enabled each person to know the exact amount of his individual contribution, and would therefore afford him the best means of judging of the necessity and justice of the national expenditure. It was collected at a very small expense—the total charge not exceeding $1\frac{1}{2}$ per cent.

Indirect taxation (by customs and excise duties) was frequently oppressive and unjust in its operation, it occasioned vexatious delays in the transaction of business, adulterations, and frauds. The cost of collection was from 6 to 10 per cent; and it was estimated that, in addition to the duties levied in many cases, the loss to merchants and traders by extra trouble, warehousing, waiting, and other impediments and restrictions, involved an additional loss of from 5 to 20 per cent on the amount of duty.

Mr. Chadwick proposed to carry out the principle recognised in Mr. Pitt's first income tax, and in Mr. James Wilson's scheme, by assessing the tax on a graduated scale as follows:—

1st. To make the tax at one uniform rate on the capitalized value of all incomes.

2nd. To classify the various sources of income according to their general average market value.

3rd. To assess the tax by a rate on such capitalized value, instead of the present mode of assessing it on the annual income.

4th. To apply, as far as practicable, the principle of the government legacy duty tables to all fixed incomes.

5th. That the tax (on the repeal of the excise and customs duties) should be applied to all incomes above £50 a year, and stopped by the employers out of the wages and salaries of all persons in their service.

6th. That in lieu of the present income tax commissioners, there shall be in every surveyor's district, or union of districts, a paid board of three assessors, two elected by the inhabitants (in the first instance, by those on the list of parliamentary electors, and subsequently by those paying the income tax), and one by the government, with power of appeal to the judges, in like manner as the present appeals on assessed taxes.

PROPOSED NEW INCOME AND PROPERTY TAX.

Estimated uniform rate of one halfpenny in the pound on the capitalized value of all incomes :—

CLASS.	Income per Year.	No. of Years Value.	Capitalized Value.	Income and Property Tax, at One Halfpenny in the Pound on Capitalized Value.		
	£.		£.	£.	s.	d.
Labourers and Workmen	50	6	300	0	12	6
Clerk	100	6	600	1	5	0
Ditto	300	6	1,800	3	15	0
Salesman	500	6	3,000	6	5	0
Attorney	600	7	4,200	8	15	0
Surgeon	600	7	4,200	8	15	0
Shopkeeper	400	8	3,200	6	13	4
Manufacturer	1,000	10	10,000	20	16	8
Merchant	1,000	10	10,000	20	16	8
Owner of House Property.....	1,000	15	15,000	31	5	0
,, Railway Stock or Mortgage	1,000	25	25,000	52	1	8
,, Land—Farms	1,000	30	30,000	62	10	0
,, Government Consols	1,000	30	30,000	62	10	0
,, Annuity for Life ...	1,000	15	15,000	31	5	0
,, Church Living for Life	1,000	12	12,000	25	0	
,, Army or Navy Appointment	1,000	10	10,000	20	16	8
,, Civil or Military Pension	1,000	8	8,000	16	13	4

Mr. Chadwick proposed to apply this scheme by imposing a tax sufficient to raise twenty millions, and to repeal the following existing duties, and impose only a nominal duty, as in the case of corn.

Customs Duty on Tea—producing	.....	£ 5,300,000
Ditto Sugar— ditto	.....	6,000,000
Ditto Coffee— ditto	.....	500,000
Ditto Other Articles ditto	.....	1,800,000
Excise Duty—Paper	.....	1,100,000
Fire Duty	.....	1,800,000
		£16,500,000
Amount of Income Tax for 1858, at 6d.	...	6,600,000
Total Taxes to be Repealed	.....	£23,100,000

NEW TAXES.

Property and Income Tax.....		£20,000,000
Estimated saving of the cost of collection of Customs Duties and Charges	£1,800,000	
Estimated produce of new nominal duties—same as corn for purposes of registration...	1,300,000	
		3,100,000
		£23,100,000

By this scheme the excessive duties on all articles of necessity would be removed, and the only other duties remaining would be on spirits, wine, tobacco, malt, and hops,—corn (1s.), the stamp duties, licenses, assessed taxes, &c., which, according to Mr. Newmarch's schedule, would produce the remaining forty millions.

MICROSCOPICAL SECTION.

February 18th, 1861.

Letters were read from Captain Andersen, R.M.S. "Canada," and from Dr. Wallich, respecting the pamphlet on "Life in the Deep Seas."

Mr. SIDEBOTHAM described his experience in mounting desmidiæ, and the difficulty he found in discovering a suitable medium for their preservation. He had tried syrup, Goadby's fluid, and a number of other chemical preparations, but the specimens, in course of time, were spoiled from one cause or other; the fluid which has best withstood the effects of time is simple distilled water; the cells being made of gold size and Japan black. Mr. Sidebotham exhibited desmidiæ, mounted in distilled water, in the years 1842 to 1846, in which the chlorophyll is comparatively little altered.

Professor WILLIAMSON observed that Dr. Carpenter had mounted starfishes in glycerine, and had found the colours were well preserved. He himself had used a mixture of glycerine and distilled water for volvox, and had found it to answer well.

Mr. SIDEBOTHAM also exhibited specimens of Diatomaceæ, mounted in 1844. The specimens (Isthmia enervis, Biddulphia, &c.) were obtained fresh, immersed in spirits of wine to absorb the water, and mounted in balsam; the green colour of the cell contents is yet perfectly preserved.

Professor WILLIAMSON exhibited some scales of fish, prepared by Dr. Kölliker, of Warzburg, containing remarkable examples of fusiform lacunæ. He also pointed out how these and other similar discoveries, to which he referred, confirmed

his previous conclusions in the Philosophical Transactions, viz., that fusiform lacunæ were not characteristic of reptilian bones, as some had supposed, but that they existed in many fishes; he especially referred to the salmonidæ as presenting this oblong form of bone corpuscule.

Mr. Brothers exhibited a modification of the kaloscope, and objects to illustrate the same.

Soundings were received from the steamers "Canada," from New York; "Armenian," coast of Africa; "Tagus," from Lisbon; and from several vessels of war, from different parts of the world, which were duly acknowledged. Incrustations from the boilers of several sea-going steamers were also presented by Mr. W. A. Hayman, of Liverpool.

Ordinary Meeting, March 5th, 1861.

Dr. JOULE, President, in the Chair.

Mr. JOSEPH SIDEBOTHAM read a Paper "On the Structure of the Luminous Envelope of the Sun," being a communication to him from James Nasmyth, Esq., of Penshurst.

Mr. Nasmyth has made the discovery, that the entire surface of the sun is composed of objects of the shape of a willow leaf; these objects average about 1,000 miles in length, and 100 in breadth, and cross each other in all directions, forming a network; the thickness of this does not appear to be very great, as through the interstices the dark or penumbral stratum is seen, and it is this which gives to the sun that peculiar mottled appearance so familiar to observers. These willow leaf-shaped objects are best seen at the edges of a solar 'spot where they appear luminous, on a dark ground, and also compose the bridges which are formed across a spot' when it is mending up; the only approach to symmetrical arrangement is in the filaments bordering the spot, and those composing the penumbra, which appears to be a true secondary stratum of the sun's luminous atmosphere; here these bodies show a tendency to a radial arrangement. Although carefully watched for, no trace of a spiral or vortical arrangement has been observed in these filaments; thus setting aside the likelihood of any whirlwind-like action being an agent in the formation of the spots, as has been conjectured to be the case. The writer does not feel warranted at present in hazarding any conjectures as to the nature and functions of these remarkable willow leaf-shaped objects, but intends pursuing the investigation of the subject this summer, and hopes to lay the results before the British Association during their meeting in this city. The Paper was illustrated by three beautiful drawings. No. 1 represented one of the willow leaf-shaped objects; No. 2 the luminous surface of the sun as being entirely

composed of these objects; and No. 3, a large drawing of a solar spot as seen on the 20th of July, 1860, exhibiting the surface of the sun composed of these objects, as also the penumbra and the bridges across the dark portion of the spot in which the exact shapes of these objects were to be seen most clearly.

Mr. Sidebotham stated that the image of the sun was examined by Mr. Nasmyth with a mirror of plane glass, set at an angle of 45 degrees; nearly the whole of the light and heat of the sun passed through the glass, and the rays used were those only reflected from its surface.

Mr. Charles O'Neill read a Paper "On Changes of Density which take place in Rolled Copper by Hammering and Annealing."

The results of his experiments proved that the best commercial rolled copper actually lost density by hammering instead of gaining as might have been anticipated. In the first series of experiments, ten pieces of copper were cut from a sheet of the thickness of $\frac{3}{16}$ inch, the pieces weighed from 250 to 320 grains each, their mean density was 8·879. The pieces were then separately subjected to the action of a powerful compressing machine, acting on the principle of the *genou*, about fifty blows being given. The density of these hammered pieces showed a mean of 8·855, being a loss of 0·024. The same pieces were annealed by being placed in red hot sand, and cooled slowly; when cleared from adhering oxide, the mean density was found to be 8·884, being an increase of 0·029 on the hammered pieces, and 0·005 on the original pieces. A second series of experiments, made with very great care, corroborated the first in the main points. The pieces were from another and better sheet of copper; ten pieces, weighing each from 420 to 520 grains, showed a mean density of 8·898, being hammered by the same machine; their mean density became 8·878, showing a loss of 0·020 by

hammering; upon annealing in a charcoal fire, the mean density of five out of the ten pieces was 8·896, showing a gain of 0·018 upon the hammered pieces, and a loss of 0·002 upon the original. A third series of experiments upon the change of density in a bar of copper by successive hammerings showed a loss of density from 8·885 to 8·867.

The Author considered there was a connexion between these phenomena and the heat disengaged in the hammering of the copper; he conceived it possible that the expanded state of the copper while heated by hammering was retained, and that the effect of annealing might be to allow the molecules or particles to recover the state in which they were in before being disturbed by the heat produced in hammering.

PHYSICAL AND MATHEMATICAL SECTION.

February 28th, 1861.

Mr. G. V. Vernon, F.R.A.S., read a Paper, "On the Irregular Oscillations of the Barometer at Manchester."

This Paper is an addition to one upon the same subject brought before the Society by Mr. Baxendell, F.R.A.S.

The tables appended to it give the total amount and number of the barometer oscillations at eight a.m., for each month from 1849 to 1860, inclusive; the mean daily amount; the monthly fall of rain, and its difference from the average of twelve years, and Dr. Dalton's forty-seven years' average. For the month of August, the Author was indebted to the kindness of Mr. John Curtis, in supplying him with barometer observations, which were deficient in his own register.

The maximum amount of oscillation takes place in January, and the minimum in July, to which may be added a second maximum appearing to take place in October. The mean total amount of oscillation for the year is 61·410 inches, and

the total number 175·5. It appears that a fall of rain, in excess of the average, is generally accompanied by an increase in the amount of oscillation. In the months of February, April, May, June, July, October, and December, a temperature below the mean for the month appears to increase the amount of oscillation; whilst in the remaining months of January, March, August, September, and November, the opposite appears to hold good. A number of oscillations above the average appears to be accompanied by a greater fall of rain than that accompanying a number of oscillations below the average, in the months of January, February, March, June, October, November, and December. In the remaining months of April, May, July, and September, a number of oscillations above the average appears to be accompanied by a diminished fall of rain.

If the month of June is regarded as abnormal (which is probable, as I have no observations for this month in 1851, 1857, 1859, and 1860), we appear to have two distinct laws, one of which holds good in the winter months, and the other its direct converse in the summer months. Taking the entire year, these two laws appear very nearly to balance one another.

Mr. Baxendell, F.R.A.S., read a Paper "On the Irregular Oscillations of the Barometer at Lisbon."

In this Paper the Author gives the results derived from a valuable series of barometrical observations made at Lisbon during the twelve years 1849-60, by John Martin, M.D., and kindly presented by him to the Section through Mr. Mosley. These observations were made daily at 9h. a.m., the barometer being permanently fixed at about fifty feet above the mean level of the Tagus, and the readings uniformly reduced to the temperature of 32° Fahrenheit.

From the tables which accompany the Paper it appears that at Lisbon the maximum amount of oscillation occurs in

January, and the minimum in July, precisely as in the British Islands, and therefore agreeing with the law of disturbance announced by the Author in a former Paper. There is a small maximum in March, and a rather sudden and considerable increase of disturbance in October. The mean annual amount of oscillation is 31·686 inches, and the mean annual number of oscillations 156·9. The mean range and mean duration of oscillation are both greatest in the winter, and least in the summer months. The greatest range occurs in January, but the greatest duration of oscillation is in November. It is remarkable, too, that the range is also greater in November than in any other month except January. These results for November are probably due to the great barometric wave which Mr. Birt some years ago pointed out as frequently occurring on or about this month.

In England the mean duration of oscillation is greater in the summer than in the winter half of the year, and, assuming that the breadth of a barometric wave is some function of the time taken to complete an oscillation, it follows that at Lisbon the areas of disturbance or breadths of the barometric waves are greatest in the winter and least in the summer months, whilst in England, on the contrary, they are greatest in the summer and least in the winter months. It seems probable, therefore, that at some intermediate latitude they are the same in both halves of the year, and this latitude may possibly be the nodal line separating a zone of high barometer from one of low barometer.

Comparing the six years of greatest amount of oscillation with the six years of least amount, it is shown that in years when the total amount of oscillation is above the average, the distribution of the increase in the different months is by no means in the proportion of the numbers representing the mean daily range of oscillation. The increase is much greater in the winter than in the summer months, but in April and September there is a diminution instead of an increase in the

amount of oscillation. The total increase for the six winter months is 20·84 inches against 4·06 inches for the six summer months, while the total amounts of disturbance for the respective periods are in the ratio of 126·13 to 76·44. The Author adds, that the ratio of the amounts of increase in the winter and summer halves of the year appears to increase rapidly with increase of latitude; thus at Lisbon it is as 5 to 1; at Brussels as 6 to 1; and at Stockholm as $8\frac{1}{2}$ to 1.

Mr. Atkinson exhibited a Chart, showing at one view the barometric oscillations during the present month of February, as observed by him at Thelwall, and also the strength of the wind, corresponding to each observed altitude of the barometer.

Mr. Mosley read an extract from the *Gibraltar Chronicle*, of the 11th February, 1861, giving details of a violent gale experienced at that place, and on the coast of Morocco, on the 9th of February. The barometer fell to 29·261, and it oscillated violently during the gale, the mercury being jerked up and down more than ·100 inch. The range of the barometer between the 26th January and 10th February, was 1·240 inches, the range for the whole year 1860 having been only ·865. The range for twenty-four hours, commencing 9th February, at 8h. a.m., was ·625 inch. The storm appears to have been a cyclone moving on a southerly course. It was encountered off the coast of Morocco, by the steamer *Egyptian*, veering from S.E. by S.S.W. to N.W. It was met with by the *Indus* mail steamer between Lisbon and Cape St. Vincent, on Saturday, the 9th February, and blew a hurricane from N. and N.E. It did not reach the coast of Morocco until eight o'clock on the following morning. As the occurrence of a cyclone on the Portuguese coast, moving in a southerly direction, is unprecedented, this gale will be further investigated.

Ordinary Meeting, April 2nd, 1861.

J. P. Joule, LL.D., President, in the Chair.

Mr. John Parry and Mr. Thomas Carrick were appointed Auditors of the Treasurer's accounts for the present Session.

M. Durand Fardel, M.D., was elected a Corresponding Member.

Messrs. Henry Brogden, John Thomas Hobson, Ph.D., William Alexander Cunningham, and George Robert Haywood, were elected Ordinary Members.

Mr. T. T. Wilkinson, F.R.A.S., exhibited an Amulet, which, having been worn by an African chief who was captured in war about a century ago, had been recently examined, when it was found that the centre boss of about an inch and a half diameter contained an Arabic manuscript, the translation of which, kindly undertaken by Professor Theodores, is as follows:—

"In the name of God, the Merciful, the Compassionate; may God favor our master Mohammad! With God (is) a protection from Satan, the accursed; with the perfect words of God a protection from evil for all that He has created, planted, and raised; with God (is) protection from the evil eye, and the evil mouth, and the evil foe, and the evil enmity, and the evil neighbour, and the evil neighbourhood, and the agitations of the night, and the agitations of the day, all of them, O Lord of Worlds! God! No God (exists) but He! The Living, the Everlasting! Neither sleep overtakes Him, nor slumber; His (is) what is in heaven and on earth; which of these can intercede with Him, unless by leave from Him? He knows what is before them, and what behind them; but they comprehend nothing of His knowledge, except in so far as He pleases. He extended His throne over the heavens and the earth, and on Him weighs not the watchfulness over them;

for He is the High, the Mighty One! No compulsion (let there be) in religion! Since the right is distinct enough from the wrong; surely he that denies Tagoot (the idol) and believes in Allah, has indeed laid hold on a firm handle, not subject to being broken; yea, God hears and knows! * But He that fears, on the part of the testator, an error, and thus settles among them (the heirs) is not guilty; for God is forgiving, merciful. Then your hearts hardened, and were afterwards like stones, and even harder: for among stones there are some from which rivers flow; and some burst asunder so that water trickles from them; and some of them fall down from the fear of God; now God is not unmindful of what you are doing.

"Or like him that came upon a city ruined to its foundation; he said: 'Now, will God revive it after its death?' Then God caused him to be dead for a hundred years; then He raised him again, and said: 'How long didst thou continue so?' he replied: 'I continued so for a day, or a part of a day.' He said: 'No! thou didst continue so for a hundred years; look but at thy food and thy drink, they are not yet decayed! look but at thy ass; whereby we will make of thee a sign unto men; now look at its bones, how we awake them, and cover them with flesh!' Now, when this became clear to him, he said: 'I know that God is all-powerful! It is all the same, whether any one of you secret his words, or proclaim them; whether he conceal himself in night, or rove about in daylight: there are for him attendant angels, before him and behind him, and they watch over him by the behest of God; verily, God changes not towards a people, unless they have changed what is in their souls; but when God has decreed evil upon a people, there is none to avert it from them, and besides Him, there is for them no protector. * It is He that shows you the lightning, for fear and for hope, and that piles up the pregnant clouds. Yea, the thunder celebrates His

The places marked thus (*) are conjectural (the text being imperfect), as suggested by the context, which is a quotation from the Kuran.

praise and the angels, through fear of Him! He sends the thunderbolts to strike therewith whomever He pleases, even while they are disputing concerning God; indeed, He is of immense power! His name is Cayeeala Tacamamu Daburim Buaburim Jawburim Masseeyayaramu. O God! in Salvation; if it is the will of God."

Mr. WILKINSON also laid before the meeting the following Geometrical Theorems.

If from the angular points of any triangle, A B C, lines be drawn making the same constant angles with the adjacent sides, *four* triangles, $A_1B_1C_1$, $A_2B_2C_2$, $A_3B_3C_3$, $A_4B_4C_4$, will be formed which possess the following properties: —

1. The triangles $A_1B_1C_1$, $A_2B_2C_2$, $A_3B_3C_3$, $A_4B_4C_4$, are all similar amongst themselves and to the triangle A B C.

2. If circles be described about the triangles A_2C A, B_2A B, C_2B C, they will all pass through a common point P.

3. Circles described about the triangles A_3B A, B_3C B, C_3A C, will all intersect in another common point P.

4. If O_1, O_2, O_3, be the centres of the circles in (2); and O_4, O_5, O_6, the centres of those in (3); then the triangles $O_1O_2O_3$, $O_4O_5O_6$ are similar to each other and to the original triangle A B C.

5. The triangles $O_1O_2O_3$, $O_4O_5O_6$, are *coaxial*, since their vertices lie two and two on the radials O O_1, O O_2, O O_3; they are therefore also *copolar*, or the intersections of their opposite sides range in the same straight line.

6. The triangle $O_1O_2O_3$ = the triangle $O_4O_5O_6$; for $16\ A\,B\,C \times O_1O_2O_3 = 16\ A\,B\,C \times O_4O_5O_6 = a^2b^2 + a^2c^2 + b^2c^2$.

7. If r_1, r_2, r_3; r_4, r_5, r_6, be the radii of the circles in (2) and (3) respectively, and R = the radius of the circle circumscribing A B C; then $R^3 = r_1r_2r_3 = r_4r_5r_6$.

8. Let *f*, *g*, *h*, be the intersections of A C_3, C A_2; A B_3, A B_2; C B_3, B C_2; then the lines A *h*, B *f*, C *g*, will all intersect in the same point P_2.

9. The products of the alternate sides of the circumscribed hexagon are equal, viz: $A f \; B g \; C h = A g \; B h \; C f$.

10. The properties in (8) and (9) hold good in the more general case; that is, when the angles $A\,C\,A_2 = B\,C\,B_3$; $C\,A\,C_3 = B\,A\,B_2$; $A\,B\,A_3 = C\,B\,C_2$; and these angles may be taken either *internally* or *externally* with respect to the original triangle A B C.

Many other relations might be deduced from the appropriate diagrams; but the preceding appear to be the most important.

A Paper was read by W. Fairbairn, LL.D., &c., "On the Temperature of the Earth's Crust, as exhibited by Thermometrical Observations obtained during the sinking of the Deep Mine at Dukinfield."

During the prosecution of researches on the conductivity and fusion of various substances, an opportunity occurred of ascertaining by direct experiments, under favourable circumstances, the increase of temperature in the crust of the earth. This was obtained by means of thermometers placed in bore-holes, at various depths, during the sinking of one of the deepest mines in England, namely, the coal mine belonging to F. D. Astley, Esq., at Dukinfield, which has been sunk to a depth of 700 yards.

The increase of temperature in descending, shown by these observations, is irregular; nor is this to be wondered at, if we consider the difficulties of the enquiry and the sources of error in assuming the temperature in a single bore-hole, as the mean temperature of the stratum. At the same time it is not probable that the temperature in the mine-shaft influenced the results. The rate of increase has been shown in previous experiments to be directly as the depth, and this is confirmed by these experiments. The amount of increase is from 51° F. to $57\frac{3}{4}°$, as the depth increases from $5\frac{2}{3}$ to 231 yards, or 1° in 99 feet; but, in this case, the higher temperature is not very

accurately determined. From 231 to 685 yards, the temperature increases from $57\frac{3}{4}°$ F. to $75\frac{1}{2}°$. This is a mean increase of 1° in 76·8 feet, which does not widely differ from the results of other observers. Walferdin and Arago found an increase of 1° in 59 feet; at Rehme, in an Artesian well 760 yards deep, the increase was 1° in 54·7 feet; De La Rive and Marcet found an increase of 1° in 51 feet, at Geneva. Other experiments have given 1° in 71 feet. The observations are affected by the varying conductivity of the rocks, and by the percolation of water. The Author has exhibited upon a diagram, in which the ordinates are depths, and the abscissæ temperatures, the results obtained, between the depths of 231 and 717 yards. The strata of the mine are also shown in section. Additional to these, the Author gives a Table of similar results in another pit at the same colliery, taken between the depths of $167\frac{1}{2}$ and 467 yards, and showing an increase of temperature of 1° in 106 feet of descent.

Assuming as an hypothesis, that the law thus found for a depth of 790 yards, continues to operate at greater depths, we arrive at the conclusion that at $2\frac{1}{2}$ miles from the surface, a temperature of 212° would be reached, and at forty miles a temperature of 3,000°, which we may suppose sufficient to melt the hardest rocks. The Author then discusses the effect of pressure and increased conductivity of the rocks in modifying this result. If the fusing point increased 1°·3 F. for every 500 lbs. pressure, as is the case with wax, spermaceti, &c., the depth would be increased from 40 to 65 miles before the fluid nucleus would be reached; but as the same increase is not observed with tin and barytes, the influence of pressure on the thickness of the crust cannot yet be determined. Again, Mr. Hopkins has shown that the conductivity of the dense igneous rocks is twice as great as that of the superficial sedimentary deposits of clay, sand, chalk, &c. And these close grained igneous rocks are those which we believe must most resemble the strata at great depths. Now, if the conductivity of the

lower rocks be twice as great as that of the strata in which the observations were made, correcting our former estimate, we should probably have to descend 80 or 100 miles, instead of 40, to reach a temperature of 3,000°, besides the further increase due to the influence of pressure on the fusing point. On entirely independent data, Mr. Hopkins has been led to conclude that the minimum thickness of the crust does not fall short of 800 miles, in which case the superficial temperature of the crust would have to be accounted for from some other cause than an internal fluid nucleus.

A Paper was read by J. C. Dyer, Esq., Vice-President, entitled "Brief Notes on the Nature and Action of Steam in relation to Boiler Explosions."

He stated that several essays had lately appeared on boiler explosions, wherein discordant theories and opinions are offered on the action of steam in some anomalous cases of explosion, and which may justify the bringing before the Society a few established facts and principles relating to the subject, in the hope of arriving at more settled views concerning causes and effects in such cases than appear to prevail at present among our most distinguished engineers. The Author objected to the appeals made to Dr. Dalton's theory of atoms for explaining the nature of steam as an elastic force mechanically employed, since the law of definite proportions of Dalton had no reference to elastic *vapours* except as to the constituents of the *liquors* whence they arise. He then cited the fact that water, like steam, is an elastic body, and the pressure would therefore be of the same nature and force above and below the water line in a boiler; but that explosions from fractures above or below that line would have different effects, owing to the amount of expansion of water and steam being so widely different when issuing from similar apertures and under the same pressure. Many obscure cases of explosion would be explained by the more or less rapid generation of steam issuing under those circumstances, as set forth in the Paper. That free *space*, when suddenly and amply afforded, is to highly heated *water*,

under great pressure, nearly the same as *fire* is to *gunpowder*. And this will account for the most destructive cases of boiler explosions; whilst those of a more harmless nature show that the fractures were small at first, and then gradually extended.

He also objected to the term "superheated steam," as being inapplicable to it in any state; because, when steam is in contact with water, it will be of the same temperature as the water; and if heated apart from water, the same laws of expansion by heat apply to steam as to air, and neither can be "superheated," though made very hot.

Again, steam can never be "mixed up with the water" in a boiler when both are under the same statical pressure, and the steam formed will rise into the chamber, so that the water will always be in contact with the boiler except when steam is drawn off. Still, in rapid escapes, it may drive out water and become entangled therewith, as in many explosions.

It having been shown that most, if not all, explosions are occasioned by simple steam pressure, acting on the weakest parts at first, and thence extending more or less rapidly, it would seem needless to seek for any other cause or force to account for them; yet, in some cases, the effects appear to imply a more sudden and violent action, like that of explosive compounds. In such instances, may they not arise from the actual decomposition of the water by heat alone? Although we have high authority (cited) against this, yet the Author held it rash to conclude that water could not be resolved into its constituent gases by direct action of heat from the boiler upon water pressed into contact with the metal plates. It has been proved, long since, that by heat, in the most intense form known to us -- that of electricity — water is decomposed and *both* of its constituent gases are liberated. Therefore, since no evidence has been adduced to show that this does not take place in any water when so confined and heated, the affirmative may at least be possible, and seems probable, in some instances, as before named.

However, he held it desirable that the question should, if possible, be set at rest by experiment; and to this end a method was suggested for putting the matter to a direct test;

but he might not be able to make the experiment himself, and hoped it might be done by some one more competent to the task.

SECTION FOR STATISTICS AND SOCIOLOGY.

March 12th, 1861.

A Paper was read by Mr. Thos. R. Wilkinson, furnishing statistics connected with the sale of beer and spirituous liquors, with a view to enquire whether such sale had any effect on the criminal returns, and how far the legislature would be justified in a further interferenee with it.

The number of licensed victuallers in the United Kingdom in 1860, was 107,024, and the number of beer sellers, 45,198.

The licensed victuallers represent interests which directly concern £50,000,000. worth of property, and maintain 1,000,000 of people.

The revenue derived from beer and spirits in the year 1832, was £15,000,000., or 29·41 per cent. of the whole revenue. In 1858, this revenue amounted to £21,000,000., or 31·34 per cent. of the whole revenue. The increase of this revenue had been 40 per cent., whilst the inerease of the population was 25 per cent.

In 1831, the amount derived from licenses for the sale of

	£.		£.
Beer amounted to ...	273,871	And the year 1859 to...	384,178
Spirits ,, ...	395,697	,, ,, ...	563,400
Wine ,, ...	73,026	,, ,, ...	88,238
	£742,594		£1,035,816

An increase of 39·62 per cent.

An Act for closing public houses, from Saturday night at Twelve o'clock, until One o'clock on Sunday, came into operation in 1847-8.

For eight years *before* the passing of that Act, the annual average number of persons taken into custody by the Manchester police was 10,658, whilst after the Act was passed the annual average was only 5,371.

MICROSCOPICAL SECTION.

18th March, 1861.

A communication from Captain ANDERSON, R.M.S. *Canada*, written at sea on his homeward voyage, excited considerable interest. He states that Dr. Wallich's pamphlet would be communicated to the Boston Society of Natural History by Professor Agassiz, who was particularly interested in the Ophiocoma found at so great a depth. The Professor is now engaged in preparing a work upon the natural history of that class of echinoderms, which he has studied for many years, and claims to have the finest collection of those animals in existence, made on the coasts from Greenland and Labrador to Mexico and round Cape Horn to California. Since the publication, in 1848, of the "Principles of Zoology," by Agassiz and Gould (a copy of which is presented to the Section), the Professor has ascertained that the system of tubes and water pores, described at page 123, exists in all animals which much vary their depths of water in the sea, and in the herring they may be seen with the naked eye along the side of the neck.

With reference to the removal of tallow from soundings, Dr. Hayes, the Assayist for the State of Massachusets, stated to Captain Anderson that heated turpentine, poured amongst the soundings, will remove all the tallow with it through filtering paper; the operation should be twice repeated, and the residue finally washed with sulphuric ether.

Dr. J. BACON presented a copy of his Report upon the Chemical Composition and Microscopical Characters of the Pearl, said to have been formed in the interior of a cocoa nut at Singapore, in the possession of Frederick Bush, Esq., and exhibited by Dr. Winslow.*

Captain Anderson, in a very able manner, gives the outline of a plan which has occurred to him for rendering available t

* Page 290, vol. vii., Proceedings of the Boston Society of Natural His for 1860.

science the services of commanders of merchant vessels and seamen generally, in collecting specimens of natural history and information in natural science, whether in zoology, ethnology, botany, or meteorology, for which they have such facilities in all parts of the world, for the use of those scientific institutions which may desire to join in it, and also with a view to elevate the mercantile marine of England in the social scale by stimulating a taste for such knowledge amongst seafaring men. The consent and co-operation of shipowners will of course be necessary, and Captain Anderson seeks the additional influence of merchants and scientific bodies. The subject met with the unanimous approval of the members present; and it was resolved that the portion of Captain Anderson's letter relating to it should be published at the expense of the Section, for the purpose of eliciting opinions upon the feasibility of the scheme and upon the best practical method of carrying it into execution.

Commander M. F. Maury, U.S. navy, forwarded copy of a letter from Lieutenant John M. Brooke, the inventor of the Detaching Deep Sea Sounding Apparatus, and enclosing for the Section a number of soundings from the North Pacific Ocean, which were obtained with small twine and spherical weights of about 70lbs., which were detached upon contact, and left at the bottom of the ocean; Lieutenant Brooke observes, that "Nine consecutive casts (soundings), varying from 2,000 to 2,900 fathoms, were made with the same piece of twine and detaching apparatus, which last weighed less than 1lb." *As the specific gravity of a wet flax line is nearly that of water, a line that can be pulled down by a weight, may be pulled up by hand, provided the weight be detached at the bottom.* One of the specimens obtained in 3,030 fathoms, nearly three and a half miles, is the greatest depth from which material has yet been brought up from the ocean bed. Lieutenant Brooke sent also a few specimens obtained by soundings in shallow waters, on the east coast of Niphon, Japan, by him during his boat voyage from Simoda to Hallodadi in 1855, under the orders of Commander Rodgers, U.S. navy.

Mr. Binney described to the Section the appearance of certain nodules found in the middle of a seam of coal, in the lower part of the Lancashire coalfield, which contain fossil wood associated with marine shells. Specimens of the former were exhibited to the members, the most perfect of which was that of Sagenaria, the old Lepidodendron elegans, in transverse, parallel, and tangential sections. The marine shells associated with the fossils belong to the genera Aviculopecken, Orthoceras, Nautilus, &c.

Mr. Brothers exhibited a Section of Pearl, Isthmia nervosa, infusoria, &c.

Mr. Whalley exhibited living Diatomaceæ from Southport.

PHYSICAL AND MATHEMATICAL SECTION.

Annual Meeting, March 28th, 1861.

Mr. E. W. Binney, F.R.S., F.G.S., &c., in the Chair.

Professor Clifton, of Owens College, was elected a member of the Section.

The following gentlemen were elected Officers of the Section for the ensuing year:—

President, Mr. Robert Worthington, F.R.A.S.

Vice-Presidents, { Mr. Baxendell, F.R.A.S., / Mr. Binney, F.R.S., F.G.S.

Treasurer, Mr. George Mosley.

Secretary, Mr. Thomas Heelis, F.R.A.S.

A Paper was communicated by Mr. Atkinson, from T. T. Wilkinson, Esq., F.R.A.S., of Burnley, entitled, "Geometrical Theorems relating to the Triangle and its Inscribed and Escribed Circles."

Many curious properties of these two figures have been taken notice of by mathematicians, but the following theorems Mr. Wilkinson looks upon as new.

1. Let A B C be any triangle, O $O_1 O_2 O_3$ be the centres of its inscribed and escribed circles respectively; then the twelve circles described about the component triangles of the complete quadrilaterals O $O_2 O_1 O_3$, O_1O $O_3 O_2$, O $O_1 O_3 O_2$, will pass, four and four, through A B C respectively.

2. The centres of the twelve circles which circumscribe the component triangles of the three preceding quadrilaterals, lie, two and two, in six points which are in the same circumference A B C; and the lines O O_9, O_6O_8, O_5O_7, are each diameters of this circle, and intersect at its centre.

3. If perpendiculars be let fall from any angle of a triangle upon its internal and external bisectors of the other two angles, the four points of intersection, in each case, will range in a straight line.

4. If A *m* and A *n* be two of these perpendiculars, the diagonals of the rectangle A *m* B *n* bisect each other, and consequently, the straight lines in theorem 3 pass through the bisections of the sides A B, A C, B C, respectively, thus forming a triangle *r s t* equal to one-fourth of A B C.

5. If from any point in the directrix of an ellipse there be drawn two tangents to the curve, and if these be produced to cut the auxiliary circle upon the major axis in X and Y, then if X Y be joined, the line X Y will pass through the centre O of the ellipse.

6. Conversely; if from the extremities of any diameter of the auxiliary circle on the major axis there be drawn tangents to the ellipse, they will intersect on the directrix.

The demonstration of some of these theorems is easy, and of an elementary character; that of others depends upon considerations which have been advanced by the Author in some of his papers that have appeared in the *Ladies' and Gentlemen's Diary*.

Mr. G. V. Vernon, F.R.A.S., produced Manuscript Copies of thirteen years Barometrical Observations made at Greenwich, which had been kindly communicated by the Astronomer Royal, showing the observations once a day for every day instead of the daily means, and presented such series to the Section, for which present he received its thanks.

Resolved, that the Secretary be requested to prepare and issue a circular, applying for copies of Logs and Meteorological Observations made at sea, and especially on board the various mail steamers.

Ordinary Meeting, April 16, 1861.

Dr. J. P. Joule, President, in the Chair.

A letter having been read from Dr. Schunck, tendering his resignation of office as Secretary of the Society, it was unanimously resolved, "That the Society desire to express their regret at the resignation by Dr. Schunck of the office of Secretary, and to offer to him their cordial thanks for the valuable and efficient services which he has rendered to the Society during the six years he has held the office."

Mr. E. W. Binney exhibited to the meeting two specimens of peat obtained by himself from the low mosses adjoining the sea near Southport. One was a dull brown substance, having an imperfect conchoidal fracture, and which burnt and smelt like Derbyshire bitumen. This he called blazing peat. The other was of a bright black colour, with a perfect conconchoidal fracture, which looked like pitch and emitted scarcely any flame whilst burning. This he called non-blazing peat. He said that bitumens and coals were generally supposed to have been formed under an elevated temperature, something analogous to the production of tar and pitch by the distillation of wood in close vessels at a high temperature. Now, the specimens exhibited showed that vegetable matter could be converted in a peat bog into an inflammable bitumen in the one case, and, in the other, into a bright substance resembling anthracite coal, thus showing that high temperature was not absolutely requisite for the production of either bitumens or coals from ligneous fibre.

A Paper was read by the Rev. T. P. Kirkman, M.A., F.R.S., entitled, "Theorems on Groups."

The following theorems form part of a Memoir presented to the Imperial Aeademy of Paris, in competition for their prize medal which was offered in 1858, to be awarded in 1860. The subject proposed is—

"Quels peuvent être les nombres de valeurs des fonetions bièn définies qui contiennent un nombre donné de lettres, et eomment peut on former les fonetions pour lesquelles il existe un nombre donné de valeurs?"

No prize has been awarded, and the report of the Referees gives no details of the Memoirs presented. *Comptes Rendus, Mar.*, 1861.

The Memoir which I had the honour to present to the Aeademy contains numerous results, which I believe to be new, and whieh at least are so far important that they are contributions, I hope, useful and pregnant, to a direct answer to the prize question.

I may be permitted to mention what appears to me to be more or less important, as well as new, in my results.

1. The enumeration of groups of forms already known, but not enumerated.

2. The definition and enumeration of large classes of groups which were before, so far as I ean learn, unknown.

3. The diseovery of the third and prineipal speeies of substitutions in grouped groups.

4. The determination of the number of *equivalent m-valued functions* that ean be eonstrueted on a given group; *i.e.*, of functions of the same degree, of whieh none is among the m values of another.

The mathematician will remark that there is a little eonfusion of ideas in the writings of the most recent Freneh investigators, about the relation of groups and funetions.

I cannot find that either Cauchy or any of his followers have ever suspected that on the group

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

can be constructed any grouped group of six except this,

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

It is laid down in one of the last French contributions to this theory (vide pages 22, 32 of "Thèses présentées à la faculté des Sciences à Paris, &c.," Paris, Mallet Bachelier, 1860), as a point apparently too plain to require demonstration, that there are in a grouped group two species of substitutions, "*deux espèces de substitutions, bien distinctes;*"

1. those whereby the elementary groups simply change places among each other;

2. substitutions whereby, the elementary groups being undisturbed, displacements of letters are effected exclusively in their interior.

The truth is, that there is a third species of substitutions which occurs in grouped groups more frequently than the other two, whereby both the elementary groups are permuted and also displacements of letters take place in their interior.

For example, there exist the three following groups constructed like the preceding on the partition

$$N=6=2\cdot 3=A\alpha.$$

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

in which there are substitutions of the third species.

In the theorem H which follows, I have exactly enumerated a very large and well defined family of grouped groups, of which only a small portion had been before detected, without attempt at enumeration.

When the exponents in the denominator of the derivant Q are all unity, the groups contain only substitutions of the two first species: in other cases there are substitutions of the third species also.

I hope that my theorems on the connection between groups and the functions constructible on them, will be deemed of some importance.

I remember well the embarrassment I felt in asking myself the simple questions; 1st. What is the group to which the 3-valued function $ab+cd$ belongs? 2nd. What is the general theory of the connection between the group and the function?

I know not where an answer can be found to these inquiries, except in my own Memoir.

The most important addition that has been made in France to our knowledge of this subject since the days of Cauchy, is a Memoir in Liouville's Journal, January, 1860.

And I beg here to express my admiration of the demonstration there given of the existence of functions of p^n variables, which have

$$1\cdot2\cdot3\cdots(p^n-2)$$

values, whenever p is a prime number.

It appears to me that the use there made of the impossible subindices invented by Galois, is a very high analytical achievment.

I had succeeded in both finding and completely enumerating these groups for $n=1$, before I had the pleasure of reading the demonstration of the more general theorem.

Proof of the confusion of ideas that has reigned may be found in the Paper referred to in the "Journal of Liouville." The corollary at page 20 is not demonstrated, neither is the enunciation true; and there appears to be an oversight all

through of this principle, that in order to prove that a function has K values, it is not enough to show that it is invariable for a certain number of substitutions. It is required also that it shall be proved to be variable for all other substitutions.

There is an infinite number of functions which answer the definition of M. Mathieu, and are invariable for the substitutions which he considers, which yet have not the required number of values.

This question of groups, contrary to the *very frequent* custom of the Academy for a length of years, has been withdrawn from competition, after being proposed once only, viz., for 1860. I can only say that I regret this, and I wish that the Academy had given one chance more to the improved notation which they have done me the honour to commend.

It is to be hoped that a question which has been long under consideration, with no great result, and which, in my humble opinion, has somewhat been retarded by the too great generality of Cauchy's notation of substitutions, may soon receive a satisfactory solution.

The numerals in what follows refer to the articles of my memoir, which has been so peacefully buried, I hope alive, though without name or record, in the "*dark unfathomed caves*" of waste paper in the French Institute.

Theorems on Groups.

"Def. Let A_p A_q A_r be any arrangements of the same N elements 1 2 3 . . N.

The operation :—

$$\frac{A_q}{A_r} A_p = A_t$$

executes on A_p the substitution $\frac{A_q}{A_r}$, by putting for the element a in A_p, that which stands over a in the substitution. The result is the permutation A_t, or, what is the same thing, the product of the two substitutions, $\frac{A_q}{A_r}$ $\frac{A_p}{(1)}$, in that order, where

(1) denotes the natural order of the elements, is the substitution $\frac{A_t}{(1)}$."

"Def. A system of R arrangements of N elements

$$(1)\ A_1\ A_2 \cdots A_{k-1}$$

is a *group* of k substitutions.

$$\frac{(1)}{(1)}, \frac{A_1}{(1)}, \frac{A_2}{(1)}, \ldots$$

if both the products $A\ A_n$ and $A_n\ A_m$ are substitutions of the group, $A_m\ A_n$ being any pair of the group."

"Def. Let G be any group of k substitutions made with N elements not containing the substitution P. The product

$$G\,P = (1 + A_1 + A_2 + \cdots + A_{k-1})\,P.$$

is a vertieal eolumn of k permutations—

$$\begin{matrix} P \\ A_1\ P \\ A_2\ P \\ \vdots \end{matrix}$$

which differs from G written in a vertical eolumn only in the horizontal order of entire vertical rows of elements,

GP is the derangement of G by P."

Theo. "The derangement (GP) of G by P is the derangement of G by $A_m P$, A being any substitution of G."

G has $\frac{\pi N}{K}$ different derangements; $(\pi N = 1\ 2\ 3 \cdots N)$.

Def. "The produet PG of the same P and G *is the derived of G by P.*"

Theo. "The derived (P G) of G by P is the derived of G by $(P\ A_m)$."

G has $\frac{\pi N}{k}$ different derived groups (PG.)

Let $P^{-1} = \frac{(1)}{P}$;

Def. The groups G and PGP^{-1} are *equivalent groups* containing (1), if they be not the same group $(1\ A_1\ A_2 \cdots A_{k-1})$.

Def. If PG and GP are the same group of permutations, PG is a derived derangement of G.

(8) Theo. A. The $\frac{\pi N}{k}$ derived groups of G (including G), are derangements of the groups G $G_1 G_2 \cdots G_L$ equivalent to G; and there are among these derived groups neither more nor fewer derangements of G than of any group equivalent to G.

(9) Cor. If the number of groups equivalent to G is $\frac{\pi N}{k}$, G has has no derived derangement, except itself; and every derangement of G is a group of permutations different from every derived of G. The same thing is true of the derangements and derived groups of every equivalent of G.

If the number of groups equivalent to G be fewer than that of its derived groups, we know that G has derived derangements.

If M be the number of groups equivalent to G, $\frac{\pi N}{k M}$ is the number of derived derangements of each (G^1) of these equivalents (including (G^1) in this number), which are found among G and its derived groups.

Each of the equivalent groups G $G_1 \ldots G_L$ forms with its derived derangements a different group (containing (1)) of $\frac{\pi N}{M}$ substitutions.

I believe that this theorem A (8) and the corollary (9) that follow it, are among the *faits nouveaux* of my Memoir. They lead directly to all the enumerations and extensions following.

(10) Theorem B. The number of different groups of the order N (1, A, A^2, .. A^{N-1}) made with N elements, which are N powers of one substitution, is $\frac{\pi\,(N-1)}{R_N}$, R_N being the number of integers less than N and prime to it, unity included.

I believe that this enumeration, though I think it a little surprising, is new.

(11) Theorem C. Let $N = Aa + Bb + Cc + \ldots + Jj$,

$A \nearrow B$, $B \nearrow C$, $\ldots F \nearrow J$; $a, b, c, \ldots j$ being any integers $\nearrow 0$, and let K be the least common multiple of $ABC \ldots J$.

The number of different equivalent groups, each being K powers of a substitution having a circular factors of the order A (*i.e.* of A elemnts), b circular factors of the order B $\ldots$ j circular factors of the order J, is

$$W = \frac{\pi N}{R_K \, \pi a \cdot \pi b \cdots \pi j \cdot A^a \cdot B^b \cdots J^j},$$

where R_K is the number of integers less than K and prime to it, including unity.

I believe that this enumeration also is a *fait nouveau*: and it is fundamental.

(16) Theorem D. If there be, among the $R_N - 1$ integers less than N and prime to it, a prime root of the congruence

$$x^r - 1 \equiv 0 \pmod{N},$$

where $r \equiv R_N$,

we can form with N elements $\frac{\pi(N-1)}{R_N}$ equivalent groups $(1 \; A_1 \; A_2 \ldots)$ each of Nr substitutions, among which will be found the N powers of a substitution of the order N.

And if there are m prime roots of this congruence of which none is comprised among the powers of another, according to this modulus, we can form $m \cdot \frac{\pi(N-1)}{R_N}$ different equivalent groups of the same description.

(18) Cor. With the N elements we can form $\frac{\pi(N-1)}{R_N}$ equivalent groups of 2 N substitutions, each comprising N powers of one substitution, and N square roots of unity.

I believe that this theorem D, and the corollary, present what is new.

(35) Theo. E. If N—1 be any prime number, we can form π (N—3) equivalent groups, each of N · (N—1) (N—2) substitutions.

The *enumeration* of these groups is, as I believe, new.

(46) Theo. F. If N > 5, it is impossible to construct a group of N · (N—1) (N—2) (N—3) substitutions, which contain N powers of one substitution.

(53) *Groups of the form G+RG, R G being composed of square roots of unity,*

Theo. G. Let

$$N=Aa+Bb+Cc+\cdots+Jj$$

when A$\nearrow$2; A$\nearrow$B$\nearrow$ . . $\nearrow$J, and where one at least of $a\ b\cdots j$ is $\nearrow$1.

Let K be the least common multiple of A B C · · J, and let R_K be the number of integers (unity included) less than K, and prime to it.

There are

$$\frac{\pi N}{R_K\ K\ \pi a\cdot\pi b\cdot\cdots\pi j}$$

equivalent groups of 2 K substitutions of the form G+R G, where G is the group of K powers of a substitution having a factors of the order A, b of the order B, etc.; and where RG is composed of K square roots of unity. I believe that this is new.

For example, take the partition

$$6=3\cdot2=Au.$$

There are 20 groups G by theor. C; and 60 groups G+RG by theor. G. Let G be

1 2 3 4 5 6

4 6 1 3 2 5

3 5 4 1 6 2

We have the three equivalent groups

1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
4 6 1 3 2 5	4 6 1 3 2 5	4 6 1 3 2 5
3 5 4 1 6 2	3 5 4 1 6 2	3 5 4 1 6 2
1 2 4 3 6 5	1 5 4 3 2 6	1 6 4 3 5 2
3 5 1 4 2 6	3 6 1 4 5 2	3 2 1 4 6 5
4 6 3 1 5 2	4 2 3 1 6 5	4 5 3 1 2 6
H	H_1	H_2

These are equivalent groups, for we have

$$H_1 = 1\ 6\ 4\ 3\ 5\ 2\ H\ 1\ 6\ 4\ 3\ 5\ 2 = P\ H\ P^{-1}$$
$$H_2 = 1\ 5\ 4\ 3\ 2\ 6\ H\ 1\ 5\ 4\ 3\ 2\ 6 = P_1\ H\ P_1^{-1}.$$

Grouped Groups.

Def. A principal substitution P of a group G has the form

$$f\,P = Aa + Bb + Cc + \ldots Jj,$$
$$A \succ B \succ \ldots \succ J,$$

which means that P has a circular factors of the order A, b of the order B, etc. Every other substitution Q of the group has the form

$$f\,Q = A_1 a_1 + B_1 b_1 + \ldots + J_1 j_1,$$

such that the first of the differenees

$$A - A_1,\ a - a_1,\ B - B_1,\ b - b_1, \ldots$$

whieh is not zero, is positive. If they be all zero, Q is also a prineipal substitution.

66. Theo. H. Let any partition of N be

$$N = Aa + Bb + Cc + \ldots + Jj,$$
$$A \succ B \succ C \ldots \succ J \succ 1.$$

K being the least eommon multiple of A B C . . J, and such that one at least of $a\ b\ \ldots j$ is $\succ 1$.

Let G be any one of the W groups of K powers of a substitution construetible on this partition of N, by Theorem C.

$$\text{Let } p_1 p_2 \ldots p_a,\ q_{a+1}\ q_{a+2} \ldots q_{a+b}\ r_{a+b+1}\ r_{a+b+2} \ldots r_{a+b+c} \text{ etc.}$$

be the circular faetors of G of the orders A B C . . etc.

Let p_r^i be the i^{th} eyclical permutation of p_r.

Let w equivalent groups be constructible of l substitutions made with $a + b + c + \ldots j$ elements, of which the a elements are consecutive in unity, the b elements consecutive, the c elements consecutive, &c.; and such groups (g) that every circular factor in them made of the a elements is a divisor of A, every circular factor made out of the b elements is a divisor of B, &c.; and also such groups (g) that every vertical row is composed only of the a, or only of the b, &c. elements. Any one (g^1) of these groups (g) begins by the power of a *principal substitution* (P^1), whose form is, by hypothesis,

$$\begin{aligned} f P^1 = {} & A_1 a_1 + A_2 a_2 + A_3 a_3 + \cdot\cdot && (= a) \\ & + B_1 b_1 + B_2 b_2 + B_3 b_3 + \cdot\cdot && (= + b) \\ & + C_1 c_1 + C_2 c_2 + C_3 c_3 + \cdot\cdot && (= + c) \\ & + \\ & \vdots \\ & + J_1 j_1 + J_2 j_2 + J_3 j_3 + \cdot\cdot && (= + j) \end{aligned}$$

this being the partition of $a + b + \ldots + j$, in which the equivalent groups (g) are formed either by theo. C or by any of those which follow.

Let M be the least common multiple of the integers—

$$\frac{A}{A_1}, \quad \frac{A}{A_2}\ \frac{A}{A_3}\ \cdots\ \frac{B}{B_1}\ \frac{B}{B_2}\ \cdots\ \frac{C}{C_1}\ \frac{C}{C_2}\ \cdots\cdot$$

whose denominators are the orders of the circular factors of the complete group (g^1), being A_c of the a elements, B_c of the b elements, &c.

Let the substitution Q following be formed:—

$$Q = \frac{\overset{A\ B\ C}{p_\alpha\ p_\beta\ p_\gamma\ \cdots\ p_\theta}\ \overset{H\ E}{q_\eta\ \cdots\cdot}\ \overset{L}{r_\epsilon\ \cdots\cdot}}{p_1\ p_2^m\ p_3^n\ \cdots\ p_a\ \ q_{a+1}^n\ q_{a+2}^e\ \cdots\ q_{a+b}\ r_{a+b+1}^t\ \cdots}$$

when ($\alpha\ \beta\ \gamma\ \cdots\ \theta\ \eta\ \cdots\cdot\ \epsilon\ \cdots$. is) every one in turn of the l—1 substitutions of the group (g^1), $\alpha\ \beta\ \gamma\ \cdots\ \theta$, being the a elements, $\eta\ \cdots\cdot$ being the b elements, $\epsilon\ \cdots$ being the c elements, &c.; and where the terms of the numerator are those of the denominator in different order, so that $B = n$ if $\beta = 3$, &c.

and where the exponents of the factors p_r are anything we please $\angle$ A + 1, the exponents of the factors q_r are anything we please, $\angle$ B + 1, &c., and where the same system of exponents is employed in the denominator through all the l—1 substitutions Q to be formed.

The l—1 derived groups Q_1G, Q_2G, Q_3G,..... form with G a grouped group of Kl substitutions, and the number of such grouped groups constructible on the given partition of N is

$$S=\frac{R_K M\, W w\,(A^{a-\frac{a}{1}-\frac{a}{2}-\cdots}\times B^{b-\frac{b}{1}-\frac{b}{2}-\cdots}\times\ldots\times J^{j-\frac{j}{1}-\frac{j}{2}-\cdots})}{K\,(\lambda K+(l-\lambda)R_K)}$$

where λ is the number of the principal substitutions of the group g, when their form is

$$\begin{aligned} &A\,a_1 && (=a)\\ +&B\,b_1 && (=+b)\\ +&\cdot\cdot && \vdots\\ +&J\,j_1 && (+j); \end{aligned}$$

and where $\lambda=0$ in every other case R_k is here the number of integers less than K and prime to it, unity included.

The number of principal substitutions in each of the S grouped groups is

$$\lambda K+(l-\lambda)R_K$$

The elementary groups (ρ) of these grouped groups are groups of K substitutions; and each group (ρ) is composed of a vertical column of $\frac{K}{A}$ square groups of powers of a substitution of A elements, or of a column of $\frac{K}{B}$ square groups of powers of substitutions of B elements, &c.

These grouped groups, whose elements (ρ) are made up of groups of A powers, or of B powers, are grouped groups of the first class.

(70) In theorem H we have restricted the auxiliary groups g of the order l to such as have no circular factors, formed with the a elements, whose order does not divide A, etc. By this limitation we have exactly enumerated a definite and large class of equivalent grouped groups.

But, if this limitation be removed, the constructed group of Kl substitutions is still a grouped group. But it is not easy to give the exact enumeration without repetition of the constructions, when g may be any group of l, made with the $a+b+\cdot+j$ elements. Every group of the order Kl so formed by any group g, whatever be the order of its circular factors, is a grouped group, whatever be the system of exponents that we employ in the denominators of $Q_1 Q_2 Q_3 \cdots$

(83) *Grouped groups of a higher class, of which the elementary groups are of the order* Kr, *comprising* $r-1$ *derived derangements of groups of* K *powers of a substitution.* We first enunciate generalisations of theorems D and G.

Theorem J. Let

$$N = Aa + Bb + Cc + \cdots + Jj;$$

$A \nearrow 2$; $A \nearrow B \nearrow C \nearrow \cdot \nearrow J$; $a, b, c, \cdots j$ being any numbers, and K being the least common multiple of A B C $\cdots$ J.

Let λ be the number of primitive roots of the congruence

$$x^r \equiv 1 \pmod{M} \quad (r \nearrow 2),$$

of which no one is comprised among the powers of another, M being any one of the numbers A B C $\cdot$ J, these λ roots being such as are at the same time primitive or non-primitive roots of the congruences

$$x^r \equiv 1 \pmod{X}$$

where X is each one in turn of A B C $\cdots$ J.

We can construct, R_k being the number of integers (unity included) less than K and prime to it,

$$\Upsilon = \frac{\lambda \pi (N)}{R_K \pi a \pi b \pi c \cdots A^a B^b C^c \cdots J^j}$$

different groups each of Kr substitutions, all of the form

$$G + \Theta_1 G + \Theta_2 G + \cdots + \Theta_{r-1} G,$$

where G is a group of the order K, and Θ_1 Θ_2 are derivants given in terms of one of the λ primitive roots. This theorem J is, as I believe, a *fait nouveau.*

(84.) Theorem K.

Let $N = A\,a + B\,b + C\,c + \ldots + J\,j$,

$A \nearrow B \nearrow C \nearrow \ldots \nearrow J$; K being the least common multiple of A B C . . J, and $a\ b\ c\ \ldots\ j$ being any numbers.

Let $E \prec K$ be any one of the numbers A B C . . J; and let E—1 be a primitive root of the congruence

$$x^r \equiv 1 \pmod{M}.$$

M being any one of the uumbers A B C . . J; and such a root that it is also a root, primitive, or not, of the congruence

$$x^r \equiv 1 \pmod{X},$$

X being one each in turn of the numbers A B C . . . J.

We can form by the aid of this root E—1, on the given partition of N, R_K being as in theorem J,

$$\frac{E^e\ \pi N}{R_k\ \pi a \cdot \pi b \cdot \cdots \pi j\ A^a\ B^b \cdots J^j} = V_N$$

equivalent groups of Kr substitutions, e being the multiplier of E in the partition (Aa + Bb + . .) of N. These groups are all of the form

$$G + \Theta_1 G + \Theta_2 G + \ldots + \Theta_{v-1} G,$$

when G is any one of the W groups of theorem C.

For example, let

$$N = 26 = 10 \cdot 1 + 8 \cdot 2 + 4 \cdot 2 \qquad (K = 40).$$

We have the primitive root 4—1 of the congruence

$$x^4 \equiv 1 \pmod{10} \quad (E = 4 \cdot 2)$$

which is also a root of the congruences

$$x^4 \equiv 1 \pmod{8} \text{ and}$$
$$x^4 \equiv 1 \pmod{4}.$$

One of the $W = \dfrac{\pi.(26)}{R_{40}(\pi.2)^{\cdot 2} 10^{\cdot 8^{\cdot 2}} 4^2}$ groups G of theo. C is

$$\begin{array}{llllllllll|llllllllll|l}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 0 & a & b & c & d & e & f & g & h & i & j & k & l & m & n & p & q & =G \\
2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 0 & 1 & b & c & d & e & f & g & h & a & j & k & l & i & n & p & q & m & \\
3 & 4 & 5 & 6 & 7 & 8 & 9 & 0 & 1 & 2 & c & d & e & f & g & h & a & b & k & l & i & j & p & q & m & n & \\
4 & 5 & 6 & 7 & 8 & 9 & 0 & 1 & 2 & 3 & d & e & f & g & h & a & b & c & l & i & j & k & q & m & n & p &
\end{array}$$

. . . .

of 40 substitutions (1 A A^2 . . . A^{39}.)

We have the derived groups

3 6 9 2 5 8 1 4 7 0 $c f a d g b e h j i l k q p n m$ $=\Theta_1 G$
6 9 2 5 8 1 4 7 0 3 $f a d g b e h c i l k j p n m q$
9 2 5 8 1 4 7 0 3 6 $a d g b e h c f l k j i n m q p$
.
.
.
.
.
9 8 7 6 5 4 3 2 1 0 $a b c d e f g h i j k l m n p q$ $=\Theta_2 G$
8 7 6 5 4 3 2 1 0 9 $b c d e f g h a j k l i n p q m$
7 6 5 4 3 2 1 0 9 8 $c d e f g h a b k l i j p q m n$
.
.
.
.
.
7 4 1 8 5 2 9 6 3 0 $c f a d g b e h j i l k q p m n$ $=\Theta_3 G.$
4 1 8 5 2 9 6 3 0 7 $f a d g b e h c i l k j p m n q$
1 8 5 2 9 6 3 0 7 4 $a d g b e h c f l k j i m n q p$
.
.
.
.
.

which form with the group G a group of 160 substitutions. We can form 4^2 different such groups on this group G, with this root 3.

I believe that this theor. K is new.

(89) Theor. L.

Let J be any group of Kr substitutions formed with N elements on the partition

$$N = Aa + Bb + \cdots + Jj,$$

being composed of any a equivalent groups, the same or different, formed each with A elements, of any b equivalent groups formed each with B elements, etc.; these equivalent

groups being all, either with or without repetition of their substitutions, of the order Kr.

Let F be any group (1 B_1 B_2 $\cdots$) of l substitutions formed with

$$a+b+c+\cdots+j$$

elements, in which the first a vertical rows contain only the a elements, the b following vertical rows contain only the b elements, etc.

Every pair of groups JF gives a grouped group of Krl substitutions, of which the elementary groups are the above-named equivalent groups of Kr substitutions.

The equivalent groups of Kr substitutions which compose J, may be any of the groups enumerated in the preceding theorems.

It is difficult to determine how many of these groups of Krl substitutions can be presented as grouped groups of Kl substitutions of theor. H. But there is an enormous number of them which cannot be so presented.

For example, take

$$N=9=3\cdot 3=Aa.$$

We have the group J of Kr=6 substitutions,

1	2	3	4	5	6	7	8	9	= J
2	3	1	5	6	4	8	9	7	
3	1	2	6	4	5	9	7	8	
2	1	3	5	4	6	8	7	9	
3	2	1	6	5	4	9	8	7	
1	3	2	4	6	5	7	9	8	

We can take for the auxiliary group either

F =	1	2	3	or	F_1=1	2	3		
	2	3	1			2	3	1	
	3	1	2			3	1	2	
						1	3	2	
						3	2	1	
						2	1	3	

By the first we can add to J

4 5 6 7 8 9 1 2 3 $= Q_1 J$
5 6 4 8 9 7 2 3 1
6 4 5 9 7 8 3 1 2
5 4 6 8 7 9 2 1 3
6 5 4 9 8 7 3 2 1
4 6 5 7 9 8 1 3 2

and 7 8 9 1 2 3 4 5 6 $= Q_2 J$
8 9 7 2 3 1 4 5 6
9 7 8 3 1 2 5 6 4
8 7 9 2 1 3 5 4 6
9 8 7 3 2 1 6 5 4
7 9 8 1 3 2 4 6 5

forming a group $J + Q_1 J + Q_2 J$ of $18 = 3 \cdot 2 \cdot 3 = Krl$ substitutions.

By the latter we can add farther,

1 2 3 7 8 9 4 5 6 $= Q_3 J$
2 3 1 8 9 7 5 6 4
3 1 2 9 7 8 6 4 5
2 1 3 8 7 9 5 4 6
3 2 1 9 8 6 6 5 4
1 3 2 7 9 8 4 6 5

and 7 8 9 4 5 6 1 2 3 $= Q_4 J$
8 9 7 5 6 4 2 3 1
9 7 8 6 4 5 3 1 2
8 7 9 5 4 6 2 1 3
9 8 7 6 5 4 3 2 1
7 9 8 4 6 5 1 3 2

and 4 5 6 1 2 3 7 8 9 $= Q_5 J$
5 6 4 2 3 1 8 9 7
6 4 5 3 1 2 9 7 8
5 4 6 2 1 3 8 7 9
6 5 4 3 2 1 9 8 7
4 6 5 1 3 2 7 9 8

thus completing a grouped group of $3 \cdot 2 \cdot 6 = Krl$ substitutions.

Neither the group of 18 nor that of 36 can be presented as a grouped group of K*l* substitutions of theorem H, like the following of $Kl = 6 \cdot 3$ substitutions.

1 2 3 4 5 6 7 8 9	7 8 9 1 2 3 4 5 6	7 8 9 4 5 6 1 2 3
2 3 1 5 6 4 8 9 7	8 9 7 2 3 1 5 6 4	8 9 7 5 6 4 2 3 1
3 1 2 6 4 5 9 7 8	9 7 8 3 1 2 6 4 6	9 7 8 3 1 2 6 4 5
4 5 6 7 8 9 1 2 3	1 2 3 7 8 9 4 5 6	4 5 6 1 2 3 7 8 9
5 6 4 8 9 7 2 3 1	2 3 1 8 9 7 5 6 4	5 6 4 2 3 1 8 9 7
6 4 5 9 7 8 3 1 2	3 1 2 9 7 8 6 4 5	6 4 5 3 1 2 9 7 8

Woven Groups.

(95) "Let N = A + B.

Let G be any group of L substitutions, formed with A elements, and G^1, be any group of L^1 substitutions formed with B elements following the A in unity. We can always form a woven group of LL^1 substitutions. There is nothing to prevent G and G^1 being themselves woven groups.

e. g. the two woven groups:—

1 2 3 4 5	and	6 7 8 9
2 3 1 4 5		7 6 8 9
3 1 2 4 5		6 7 9 8
1 2 3 5 4		7 6 9 8
2 3 1 5 4		
3 1 2 5 4		

will form a woven group of 24 substitutions."

Woven Grouped Groups.

(96) The grouped group $J+Q_1 J+Q_2 J$ of (89) of $3 \cdot 2 \cdot 3 = krl$ substitutions can become a woven grouped group of $6^3 \cdot 3 = 648$ substitutions. For J can be woven into a group of 6^3, thus:

1 2 3 4 5 6 7 8 9	1 2 3 5 4 6 7 8 9	
1 2 3 4 5 6 8 9 7	1 2 3 5 4 6 8 9 7	
1 2 3 4 5 6 9 7 8	1 2 3 5 4 6 9 7 8	
1 2 3 4 5 6 8 7 9	1 2 3 5 4 6 8 7 9	
1 2 3 4 5 6 9 8 7	1 2 3 5 4 6 9 8 7	
1 2 3 4 5 6 7 9 8	1 2 3 5 4 6 7 9 8	&c.

1 2 3 5 6 4 7 8 9
1 2 3 5 6 4 8 9 7
1 2 3 5 6 4 9 7 8
1 2 3 4 5 6 8 7 9
1 2 3 4 5 6 9 8 7
1 2 3 4 5 6 7 9 8

Let this woven group of the order 6^3 be J_A; then $J_A + Q_1 J_A + Q_2 J_A$ is a grouped woven group of 648th order.

(99) Theorem M.

Let $N = Aa + Bb + Cc + \ldots + Jj$;

$$A \underset{7}{=} B \quad B \underset{7}{=} C \quad C \underset{7}{=} D \ldots\ldots$$

Let M_R be the number of groups equivalent to a group G, (including G_R in this number) formed with R elements, of S_R substitutions, and such that G_A shall not be equivalent to G_B even though $A = B$.

Let F_r be the entire number of groups, of l_r substitutions, that can be formed (containing unity) with r elements.

We can construct with N elements, upon the given partition of N, and with given groups $G_A \; G_B \cdots G_J$,

$$\frac{\pi N \cdot F_a F_b F_c \cdots F_j (M_A)^a (M_B)^b (M_C)^c \cdots (M_J)^j}{\pi a \cdot \pi b \cdot \pi c \cdots \pi j \cdot (\pi A)^a (B)^b (\pi C)^c \cdots (\pi J)^j}$$

woven grouped groups each of

$$(S_A)^a (S_B)^b (S_C)^c \cdots (S_J)^j \, l_a \, l_b \, l_c \cdots l_j$$

substitutions.

For example, on the partition,

$$10 = 3 \cdot 2 + 2 \cdot 2 = Aa + Bb,$$

where we have

$$M_3 = 1 = M_2 = F_2,$$

we can form

$$\frac{\pi 10}{2 \cdot 2 \cdot 6^2 \cdot 2^2} = 6300$$

woven grouped groups, each

$$3^2 \cdot 2^2 \cdot 2 \cdot 2 = 144 \text{ substitutions, } (S_A = 3),$$

or of

$$6^2 \cdot 2^2 \cdot 2 \cdot 2 = 576 \text{ substitutions, } (S_A = 6).$$

And on the partition,

$$10 = 3 \,.\, + 3' \cdot 1' + 2 \cdot 2, \; (M_3 = 1 = M_3' = M_2 = F_2)$$

we can construct, if we take $S_3 = 6$ $S'_3 = 3$;

$$\frac{\pi 10}{1 \cdot 1 \cdot 2 \cdot 6 \cdot 6 \cdot 2^2}$$

woven groups each of $6 \cdot 3 \cdot 2^2 \cdot 1 \cdot 1 \cdot 2 = 144$ substitutions, all different groups from those above enumerated.

(100) If we take for each of the r groups G_R the R cyclical permutations of $123 \cdots R$, and write

$$S_R = R, \; l_r = (\pi r),$$

we obtain the group of

$$A^a \, B^b \, C^c \, J^j \, \pi a \, \pi b \, \pi c \cdots \pi j$$

substitutions of which Cauchy has demonstrated the existence in the IXth section of his "Mémoire sur les arrangements," &c., in the *Exercises de Mathématique et de Physique Analytique.*

It is evident that the largest woven group constructible on our partition of N is of

$$(\pi A)^a \, (\pi B)^b \, (\pi C)^c \cdots \pi a \, \pi b \, \pi c \cdots = \Omega$$

substitutions. This group has no derived derangement, *i. e.* it is a maximum group, and has $\frac{\pi N}{\Omega}$ equivalent groups, itself included.

This theorem M is, as I believe, in that generality, new.

On the Construction of Functions.

(104) Theo. N. Let G be any group $(1 \, A_1 \, A_2 \cdots A_{L-1})$ of L substitutions, made with N elements $(1 \, 2 \cdots N)$.

Let

$$P = x_1^{\alpha} \, x_2^{\beta} \, x_3^{\gamma} \cdots x_N^{\theta}$$

be the product of N *different* powers $(\gtrless 0)$ of the N variables $x_1 \, x_2 \cdots x$.

Let

$$\Phi = P_1 + P_2 + \cdots P_L$$

be the sum of the N terms, obtained by performing on the subindices of P the substitutions of G.

Φ will have $\frac{\pi N}{L}$ values by the permutation of the N variables, which can be formed upon G and its $\frac{\pi N}{L} - 1$ derived groups.

And the number of different functions Φ, all of the same algebraic degree, of which no one is a value of another, is the number of groups equivalent to G.

Theo. P. Let G be any group of L substitutions.

Let

$$P = x_1^{a} x_2^{\beta} x_3^{\gamma} \cdots x_N^{\theta},$$

where

$$a \not\equiv \beta, \beta \not\equiv \gamma, \text{ \&c. } \cdots \theta \not\equiv 0,$$

be a term such that it changes in its algebraic value by the operation MP performed on its subindices, where MG is any derived derangement of G, and such that no group equivalent to G gives the same algebraic function,

$$\Phi = P_1 + P_2 + \cdot + P_L$$

with G. The function Φ has $\frac{\pi N}{L}$ values, which are constructed on G and on its $\frac{\pi N}{L} - 1$ derived groups.

Theo. Q. If two equivalent groups G and G^1 of L substitutions give for a certain system of exponents of $x_1 x_2 \cdots x_N$ the same algebraic function Φ_1, Φ_1 has not $\frac{\pi N}{L}$ values.

Theo. R. The number of groups equivalent to a group G being given, and any system of exponents of $x_1 x_2 \cdots x_N$ being selected, there is always an assignable number of algebraic functions,

$$\Phi = P_1 + P_2 + \cdots + P_N$$

of the degree determined by that system, such that each function has $\frac{\pi N}{L}$ values, and that no function is a value of another.

1. There are three equivalent functions, and no more, of the 6th degree, made with four letters, which have each six values.

2. There are three equivalent functions, and no more, of the 6th degree, made with four letters, which have three values.

3. There are two functions, and no more, of the third degree, which have each three values.

4. There are two functions, and no more, of the second degree, which have each two values.

5. There are six equivalent functions, and no more, of the 10th degree, made with five letters, which have each six values.

6. There are three equivalent 6-valued functions, and no more, of the 6th degree, made with five letters.

7. There are two 6-valued functions, and no more, of the fourth degree, made with five letters, and these are the simplest 6-valued functions of five letters, one of twenty, and the other of ten terms, of the form $x_a^2 x_b x_c$.

8. There are six 12-valued equivalent functions, of the 10th degree, and no more, made with five letters.

9. There are two 12-valued functions, of the fourth degree, and no more, made with five letters.

10. There is one 12-valued function, and no more, of the 3rd degree, made with five letters.

11. There are six equivalent 24-valued functions, and no more, of the 10th degree, made with five letters.

12. There are three equivalent 24-valued functions, and no more, of the 6th degreee, made with five letters.

13. There is one 24-valued function, and no more, of the 4th degree, made with five letters.

14. There is one 24-valued function, and no more, of the 3rd degree, made with five letters.

15. There are ten equivalent 10-valued functions of the 10th degree, made with five letters.

16. There are six equivalent 6-valued functions, and no more, of the 15th degree, made with six letters, each term having five different exponents.

17. There are three 6-valued equivalent functions, and no more, of the 10th degree, made with six letters, each term having four different exponents.

18. There are two 6-valued functions, and no more, of the 7th degree, made with six letters.

19. There are two 6-valued functions, and no more, of the 6th degree, made with six letters. One of these is, putting $1^2 2^2 3\ 4$ for $x_1^2 x_2^2 x_3 x_4$,

$$
\begin{aligned}
&1^2 2^2 3\ 4 + 5^2 1^2 4\ 2 + 6^2 4^2 3\ 1 + 2^2 4^2 1\ 5 + 5^2 2^2 4\ 6 \\
&+ 5^2 4^2 6\ 1 + 6^2 2^2 3\ 5 + 2^2 1^2 5\ 6 + 6^2 3^2 5\ 1 + 1^2 3^2 6\ 4 \\
&+ 3^2 1^2 2\ 5 + 3^2 6^2 2\ 4 + 5^2 3^2 2\ 6 + 2^2 6^2 1\ 4 + 5^2 6^2 2\ 1 \\
&+ 6^2 5^2 4\ 3 + 1^2 4^2 5\ 3 + 1^2 6^2 4\ 5 + 5^2 4^2 3\ 2 + 3^2 4^2 1\ 2 \\
&+ 2^2 3^2 1\ 6 + 5^2 2^2 1^2 3 + 4^2 1^2 6\ 2 + 3^2 5^2 4\ 1 + 5^2 1^2 6\ 3 \\
&+ 4^2 6^2 5\ 2 + 4^2 3^2 6\ 5 + 3^2 2^2 5\ 4 + 6^2 1^2 2\ 3 + 4^2 2^2 3\ 6
\end{aligned}
$$

which may be compared, as well as the preceding, with the single 6-valued function of the 10th degree, discovered by M. Serret, and given in his Algèbre Supérieure, Note viii. This has, I think, been hitherto the French stock of 6-valued functions, and we have repeatedly heard of it.

20. There are 45 equivalent 45-valued functions, and no more, of the 15th degree, made with six letters.

21. There are nine, and only nine, equivalent 45-valued functions, of eight terms, of the 10th degree, made with six letters.

22. There are eighteen, and only eighteen, equivalent 45-valued functions, each of sixteen terms, of the 10th degree, made with six letters.

23. There are three, and only three, equivalent 45-valued functions, each of four terms, of the 7th degree, made with six letters.

24. There are seven, and only seven, 45-valued equivalent functions, each of eight terms, of the 7th degree, made with six letters.

25. There are seven, and only seven, 45-valued functions, each of sixteen terms, of the 7th degree, made with six letters.

26. There are 9, and only 9, 45-valued functions, each of eight terms, of the 6th degree, made with six letters.

27. There are 3, and only 3, 45-valued functions, each of sixteen terms, of the 6th degree, made with six letters.

28. There are three, and only three, 45-valued functions, each of 4 terms, of the 6th degree, made with six letters.

29. There are three, and only three, 45-valued functions, each of two terms, of the 6th degree, made with six letters.

30. There are two, and only two, 45-valued functions, of four terms, each of the 4th degree, made with six letters.

31. There are three, and only three, 45-valued functions, each of eight terms, of the 4th degree, made with six letters.

32. There is one, and only one, 45-valued function, of sixteen terms, of the 4th degree, made with six letters.

33. There are two, and only two, 45-valued functions, each of eight terms, of the third degree, made with six letters.

34. There are two, and only two, 45-valued functions, each of four terms, of the 3rd degree, made with six letters.

35. There are two, and only two, 45-valued functions, of the 2nd degree, made with six letters.

36. There are sixty 60-valued equivalent functions, and no more, of the 15th degree, made with six letters.

37. There are thirty equivalent 60-valued functions, and no more, of the 10th degree, made with six letters.

38. There are fourteen equivalent 60-valued functions of the 7th degree, and no more, each of twelve terms, made with six letters.

39. There are two equivalent 60-valued functions, and no more, each of six terms, of the 7th degree, made with six letters.

These are

$$f = 1^3 2^2 3\ 4 + 5^3 4^2 2\ 6 + 3^3 6^2 4\ 1 + 2^3 1^2 6\ 5 + 4^3 5^2 1\ 3 + 6^3 3^2 5\ 2$$

$$f^1 = 1^3 2^2 3\ 4 + 4^3 6^2 1\ 5 + 5^3 3^2 4\ 2 + 2^3 1^2 5\ 6 + 6^3 4^2 2\ 3 + 3^3 5^2 6\ 1$$

40. There are six equivalent 60-valued functions, and no more, of the 6th degree, of six terms each, made with six letters.

41. There are thirteen equivalent 60-valued functions, and no more, each of twelve terms, of the 6th degree, made with six letters.

42. There are four, and only four, equivalent 60-valued functions, each of twelve terms, of the 4th degree, made with six letters.

43. There is one 60-valued function, and no more, of six terms, of the 4th degree, made with six lettters.

44. There are two 60-valued functions, and no more, of the 3rd degree, one of six and the other of twelve terms, made with six letters.

45. There is only one 60-valued function, of the 2nd degree, made with six letters.

None of these 60-valued functions is reducible to the product of two functions.

All the above functions, and many others, are given in my Memoir.

The following Paper was also read:

"On the Production of Graphite by the decomposition of Cyanogen Compounds," by Dr. P. Pauli, communicated by Professor Roscoe.

The mother liquors obtained from the evaporation of a solution of the so-called black ash are now commercially worked for caustic alkali.

These liquors contain the following compounds: —

1. Chiefly hydrate of soda.
2. Some quantity of carbonate of soda.
3. Several sulphur compounds of sodium, viz.: sulphide of sodium, hyposulphite of soda, sulphite of soda, and sulphate of soda.

4. Sulphide of iron held in solution by the sulphide of sodium.

5. Chloride of sodium.

6. Several eyanogen compounds of sodium, and especially ferroeyanide of sodium.

These liquors are evaporated down in large cast iron pots and in order to destroy or oxidise the sulphides of sodium and iron, as also the eyanogen compounds, an equivalent quantity of soda-saltpetre is added. All the oxidisable sulphur compounds, together with the small quantity of sulphide of iron, are changed to sulphate of soda and peroxide of iron by the nitrate of soda in the boiling liquor, at a temperature not below 260° to 270° F. The eyanogen eompounds, on the other hand, are only deeomposed by the nitre as soon as the liquor begins to pass from the watery into the dry fusion and the uncombined water of the hydrate of soda has been driven off. When the whole mass of alkali (generally about four tons) reaehes a low red heat, a regular evolution of gas is observed: this is evidently owing to the oxygen produced by the decomposition of the nitrate, and to the nitrogen from the decomposition of the eyanides; at the same time a plentiful liberation of graphite is observed, eovering the whole surface of the liquor with a bright layer of graphite. This liberation of graphite is still more plainly seen if no nitre be added to the liquor at first, or only so mueh as is suffieient to oxidise the sulphur eompounds; but if a few pounds of nitrate of soda be added when the water has been driven off, and the mass is allowed to become red hot, a violent reaetion takes place, and a large quantity of graphite is set free. This sudden liberation of graphite proves that this substanee eannot be derived from the east iron of the pot in whieh the fusion is made. So violent is the evolution of gas, that a eomplete eloud of fine partieles of caustie soda is carried up into the air, rendering it almost impossible to remain in the neighbourhood of the operation. In this way all the eyanogen compounds

are completely decomposed, the iron in the ferrocyanide of sodium becomes peroxide, and this in a few hours falls to the bottom of the pot. If the right quantity of saltpetre has been added, a colourless mass of fused caustic soda remains, but if too large an amount of nitre has been added, the liquor becomes coloured deep green, owing to the formation of manganate of soda. It is remarkable that, in the absence of nitrate of soda, the cyanogen compounds act reducingly upon the sulphide of sodium; this is seen from the fact that a portion of the soda lye, which gives no sulphide reaction with a lead salt, produces a blackening after the caustic alkali has been heated to redness.

The graphite may be skimmed off the surface of the fused alkali, and, when washed with water and hydrochloric acid, it appears in the form of an extremely fine bright powder. If allowed to swim on the top of the almost red hot fused soda, the graphite is oxidized gradually, and, after a lapse of about three or four hours, it altogether disappears. Heated in a platinum crucible by itself it is incombustible, but it generally contains small particles of charcoal mixed with it, and these undergo oxidation.

The temperature at which this evolution of graphite takes place is a very low one, compared with that at which graphite is liberated from cast iron, for a thin iron wire can scarcely be brought to a visible red heat by dipping it into the fused alkali.

From this peculiar decomposition it would appear that we have good reason to assume, that the carbon contained in cyanogen is present in the graphite modification; for, if this be not the case, how is it that the easily combustible charcoal can withstand the oxidizing action of the saltpetre, whilst none of the iron of the ferrocyanide of sodium is reduced to the metallic state?

It has, besides, been lately shown by M. Caron, that the formation of steel, *i. e.* the combination of iron with carbon in

the graphite modification, can only take place in presence of cyanogen compounds, and that no carbon whatever is taken up by the iron when this metal is heated with other carboniferous gases. The mode of the production of graphite noticed in this communication appears to be an intermediate reaction between that from the carbide of iron and from the nitride of carbon.

As in the process of cementation it is seen that the carbon of the cyanogen is taken up by the iron without being set free, so this reaction proves that cyanogen can be split up into its constituent parts without either of them combining with a third body.

Despretz asserts, that the carbonization of iron is always preceded by a combination of this metal with nitrogen, a process which makes it porous and more fit for the unition with carbon. The correctness of this supposition has, however, become rather doubtful, by Caron's recently published experiments ("Comptes Rendus," No. 15 and 24, 1860).

To conclude, I beg to say some words about the formation of native graphite; I do not think that this body has been formed from coal or diamond, but I rather believe it has been separated out of carbon compounds as graphite, by processes perhaps analagous to those above described.

SECTION FOR SOCIOLOGY AND STATISTICS.

April 9th, 1861.

Mr. Arthur Ransome, M.A., M.B. Cantab., M.R.C.S., read a Paper "On Atmospheric Pressure and the Direction of the Wind, in Relation to Disease, especially Hœmorrhages and Neuralgias."

After noticing the important physiological effects of atmospheric pressure upon the human body, and the influence of changes in the degree of pressure observed by aeronauts and mountaineers, and by others, as Vierordt, Lehmann, Junod, Macleod, from special experiments, the Paper next treated of the effects upon *disease* of the ordinary fluctuations of atmospheric pressure, as shown by the barometer. Statements made by Dr. Moffat and others upon the subject were quoted, and from these it appeared that important effects were produced by these fluctuations upon such diseases as apoplexy, menorrhagia, abortions, and neuralgias.

Charts were exhibited which contained records of 286 cases of hœmorrhage, 52 of abortion, 179 of apoplexy, and 697 of neuralgic affections. These had been gathered from medico-meteorological tables, published in the "Medical Association Journal," for the years 1853, 1854, 1855.

The degrees of barometric pressure, on the days and at the several places where the cases occurred, had also been recorded, and reduced to the level of the sea, and a comparison between the two series was obtained by means of curves. It was thus found that of

	Cases occurred below mean pressure.	Cases occurred at, or above, mean pressnre.
Hœmorrhage	120	166
Abortion	23	29
Apoplexy	86	95
Neuralgic Affections	242	455

The largest number of cases of

		Hœmorrhage (28) occurs at	30·150	inches.
,,	,,	Apoplexy (16) ,,	30·200	,,
,,	,,	Abortion (7) ,,	29·900	,,
,,	,,	Neuralgia (53) ,,	30 150	,,

Of Neuralgias also 51 cases occur at 30·000 inches; 50 at 30·200 inches (29·950 inches being the mean height of the barometer.)

Other charts were exhibited, which had been drawn to ascertain whether the extent of barometric oscillation between two successive days, had any predisposing influence upon these diseases—with respect to hœmorrhage, no such influence could be traced; and neuralgias occurred much more frequently when the fluctuations of pressure were comparatively small.

With respect to apoplexy, the enquiry was carried further, in consequence of a statement that "of the number of cases of apoplexy which occurred (at Hawarden) in the years 1850 and 1851, 50 per cent took place on days of decreasing reading of the barometer, and 50 per cent on days *after such* reading." Of 177 cases of apoplexy, 91 occurred with decreasing readings, 87 with increasing readings of the barometer; and of the 87 cases, 44 occurred on days immediately succeeding days of decreasing readings, 43 on days succeeding others of increasing readings.

The sources of error from the influence of warmth or moisture were examined, but no effect was traced to these causes, except in the case of apoplexy.

The following conclusions were drawn from the investigation:—1. That a high degree of barometic pressure is favourable to the production of neuralgias, less evidently so to apoplexies and other hœmorrages, and that abortions are not shown to be affected by it. 2. That increasing readings of the barometer are as frequently accompanied by cases of these diseases as decreasing readings. 3. That a small extent of diurnal oscillation of the barometer seems to be favourable to

neuralgias, no effect from this source being traced upon hœmorrhages.

The action of the several winds was then considered, and statements thereon were quoted from the *Medical Association Journal.** These observations did not correspond with the results obtained by Mr. Ransome. A large proportion of the cases of neuralgia noted were not followed by any change in the direction of the wind the day following; and cases of apoplexy, convulsions, and rheumatism were noted with the wind from nearly every quarter. Charts were shown representing the relative frequency of attacks of neuralgia with the wind in the several quarters. No very definite conclusion could be drawn from these charts; but the prevalent notion, that easterly winds produced these affections, was to some extent corroborated, although it was also evident, that south-west and west winds are often accompanied by cases of these diseases.

MICROSCOPICAL SECTION.

15th April, 1861.

A Letter was read from the West Kent Microscopical Society, requesting specimens of the envelopes and circulars used by this section for collecting soundings.

Mr. Beck, of London, exhibited two of his binocular microscopes, on Mr. Wenham's principle; also, a number of first-class objects in various branches of microscopy. The members were much struck with the advantages of the binocular system, which, under low and medium powers, presents the various parts of objects in full relief; they were also

* Vol. I., p. 129.

pleased with the beauty of certain injected preparations, as brought out by the binocular, such as the eyes of small animals, displaying the clear eyeball, with lenses, cornea, and retina; the smallest blood vessels were seen to be filled with a bright red and transparent injected fluid—in situ—distinctly to be traced and distinguished from each other, instead of appearing as with the single microscope, a tangled mass, all in the same plane. These instruments and objects strongly mark the rapid advance microscopy is making in the present day.

Mr. Hardman presented a number of dissecting needles, with turned handles, which were thankfully accepted by the members.

Mr. Brothers exhibited Melicerta and other infusoria from his aquaria.

Annual Meeting, April 30th, 1861.

Dr. J. P. Joule, President, in the Chair.

The following gentlemen were elected members of the Society :—As Honorary Member: Richard Roberts, M. Inst. C.E. As Ordinary Members: William Henry Heys, Murray Gladstone, F.R.A.S., George Venables Vernon, F.R.A.S., and James Parlane.

The following Report of the Council was then read by one of the Secretaries: —

Since the last Annual Meeting the number of members has somewhat increased. The Society contained at that time two hundred ordinary members. Of these, five have died and four have resigned, whilst twenty-three new members have been elected; so that the number at present amounts to two hundred and fourteen. Of the deceased members, the most generally known were Mr. Isaac W. Long and Mr. Joseph Adshead. Mr. Long was a distinguished member of the Physical Section, and rendered valuable assistance in the establishment of that important branch of our Society. He was specially interested in the science of Astronomy, being a Fellow of the Royal Astronomical Society of London. A short account of his life appeared in the monthly notices of that Society. Mr. Adshead's attention was chiefly directed to subjects connected with Social Science, and his writings were much esteemed. None of his productions were, however, published in the Memoirs of the Society. Three honorary members and four corresponding members have been elected.

The following Papers were read during the Session of 1860-61 : —

October 2nd, 1860.—"On the △ faced Polyacrons in reference to the Problem of the Enumeration of Polyhedra," by Arthur Cayley, F.R.S., &c.

October 16th, 1860.—"On the Estimation of Sugar in Diabetic Urine by the Loss of Density after Fermentation," by William Roberts, M.D.

October 30th, 1860.—"On the Alleged Practice of Arsenic Eating in Styria," by H. E. Roscoe, Ph.D.

November 13th, 1860.—"On a System of Periodic Disturbances of Atmospheric Pressure in Europe and Northern Asia," by Joseph Baxendell, F.R.A.S.

November 27th, 1860.—"On the Prevalence of Certain Forms of Disease, in connection with Hail and Snow Showers, and the Electric Condition of the Atmosphere," by Thomas Moffatt, M.D., F.G.S. Communicated by E. W. Binney, F.R.S., &c.

December 11th, 1860.—"On the Origin of Species," by the Rev. W. N. Molesworth, M.A.

January 8th, 1861.—"On the Nature and Objects of Geological Surveys, with Special Reference to the Progress of the Geological Survey of Lancashire and Cheshire," by Edward Hull, B.A., F.G.S. Communicated by E. W. Binney, F.R.S., &c.

February 5th, 1861.—"On the Kaloscope," by Mr. W. H. Heys. Communicated by Mr. George Mosley.

February 19th, 1861.—"On the Production and Prevention of Malaria," by Dr. R. Angus Smith, F.R.S.

"Brief Notes on the Freezing, Thawing, and Evaporation of Water, and on the Condensation of Steam," by J. C. Dyer, Esq.

March 5th, 1861.—"On the Structure of the Luminous Envelope of the Sun," by James Nasmyth, Esq. Communicated by Mr. Joseph Sidebotham.

"On Changes of Density which take place in Rolled Copper by Hammering and Annealing," by Mr. Charles O'Neill.

April 2nd, 1861.—"Remarks on the Temperature of the Earth's Crust, as Exhibited by Thermometrical Observations, obtained during the Sinking of the Deep Mine at Dukinfield," by William Fairbairn, LL.D., F.R.S., &c.

"Brief Notes on the Nature and Action of Steam in Relation to Boiler Explosions," by J. C. Dyer, Esq.

April 2nd, 1861.—"On Meteorological Observations and Observations of the Temperature of the Atlantic Ocean, made on runs from Liverpool to Gibraltar, and from Gibraltar to Liverpool, in September, 1860," by Thomas Heelis, F.R.A.S.

"On the Irregular Oscillations of the Barometer at Lisbon," by G. V. Vernon, F.R.A.S.

April 16th, 1861.—"Theorems on Groups," by the Rev. T. P. Kirkman, M.A., F.R.S.

"On the Production of Graphite by the Decomposition of Cyanogen Compounds," by Dr. P. Pauli. Communicated by Professor Roscoe.

Several of these have been ordered to be printed, and will be published in the forthcoming Volume of Memoirs, which will also contain several Papers read before various Sections.

The most important event, bearing on the interests of the Society, which has taken place during the past year, is the abolition of the old set of rules, which had been in force since the year 1852, and the enactment of an entirely new code. At the close of last Session, a Committee was appointed by the Council, with the approval of the Society, for the purpose of revising the old rules. This Committee met several times, and after lengthened discussion, agreed to a draft, which was presented to the Council and discussed by them. Another draft, embodying most of the alterations suggested by the Committee, was soon afterwards laid before the Council by two of its members. Both in regard to its form and many of its provisions, the latter was considered to be so far superior to the previous one, that it was resolved to take it into consideration at once, and lay the other aside. After being dis-

cussed clause by clause by the Council, it was referred, for the purpose of final revision, to the Rev. Wm. Gaskell and Dr. R. A. Smith, and then presented to the Society for adoption. It will be seen, therefore, that the subject received a considerable amount of attention and consideration from the Council. It was only after carefully weighing the reasons for and against each proposed alteration, that the alteration was finally adopted. The most important change which has been effected, is that of altering the rate of subscription from twenty-five shillings to two guineas per annum. The financial condition of the Society seemed to the Council to render this change absolutely necessary. In order to prevent the increased rate of subscription proving a bar to the less wealthy members of the community, who might wish to join the Society, a provision was introduced into the new rules, allowing residents of the district, as well as non-residents, to become honorary or corresponding members on being recommended by the Council for election.

Although some dissatisfaction was expressed by several members at the mode in which the proposed rules were adopted, the Council consider that the course taken by them was the only legitimate one open to them, and they trust that as a large majority of the Society decided in favour of the new rules, all feelings of animosity which may have arisen out of the discussion of the subject may be laid aside, and that all the members will cordially unite, for the purpose of increasing the prosperity of the Society and promoting the objects for which it was instituted.

Dr. FROM 20TH MARCH, 1860, TO 31ST MARCH, 1861. Cr.

	£.	s.	d.	£.	s.	d.
To Balance in the Bank of Sir B. Heywood and Co., March 10, 1860	49	18	9			
,, Balance in Treasurer's hands	41	5	6			
				91	4	3
,, Arrears of Subscriptions 1859-60	16	5	0			
,, Subscriptions 1860-61	237	10	0			
,, Subscriptions, on account 1861-62	2	10	0			
,, Half Subscriptions 1861	8	2	6			
				264	7	6
,, Admission Fees				39	18	0
,, Vol. XV. sold	4	4	10			
,, Other Memoirs sold	0	5	3			
,, Carriage repaid	0	4	0			
,, Interest allowed by Bankers	2	0	8			
,, Repayment by Photographic Society	5	0	0			
				11	14	9
,, Special Subscription to Library				16	0	0
,, Sectional Contributions—Mathematical	2	2	0			
,, Ditto Statistical	2	2	0			
,, Ditto Microscopical	2	2	0			
				6	6	0
				£429	10	6

HENRY M. ORMEROD, TREASURER.

Library Special Fund Balance	26	8	7
General Balance	31	13	5
Total Balance	£58	2	0

	£.	s.	d.	£.	s.	d.
By Chief Rent	12	8	11			
,, Fire Insurance	4	17	6			
,, Property Tax	7	1	8			
				24	8	1
,, Water Rent	0	7	0			
,, Gas	4	5	6			
,, Candles	2	5	0			
,, Coals	11	0	3			
,, Cleaning	2	9	6			
,, Furniture	0	10	11			
,, Repairs	1	18	4			
,, Receipt Stamps	0	6	1			
				23	2	7
,, Keeper of the Rooms—Salary				65	0	0
,, Tea, Coffee, &c., for Members				20	5	8
,, Postage and Parcels	28	3	9			
,, Printing and Stationery	19	7	9			
				47	11	6
,, Printing Proceedings	29	19	0			
,, Memoirs, Printing, Engraving, &c.	111	19	9			
				141	18	9
,, Library—Books Purchased	13	8	6			
,, Ditto —Special Fund Account	16	11	0			
,, Ditto —Special Subscription Account	9	11	5			
				39	10	11
,, Keeper of the Rooms for attendance on Sections.				6	6	0
,, Photographic Society for attendance				3	5	0
Total Disburbursements as by Voucher Book.				£371	8	6
April, 1861.—By Balance in the Bank of Heywood, Brothers, and Co	55	7	4			
Ditto in Treasurer's hands	2	14	8			
				58	2	0
				£429	10	6

Audited and found correct,

JOHN PARRY,
THOS. CARRICK, } AUDITORS.

10th April, 1861.

LIBRARIAN'S REPORT.

Since the close of last Session 677 vols., 323 parts of vols., and 151 pamphlets have been added to the Library; of which 141 vols. and 22 parts of vols., by purchase, and the remainder by exchange or donations.

The periodical publications which the Librarian is authorised to procure for the Library by purchase, are:—

The London, Edinburgh, and Dublin Philosophical Magazine.
The Quarterly Journal of Pure and Applied Mathematics.
The Cavendish Society's Publications.
The Ray Society's Publications.
The Palæontographical Society's Publications.
The Annals and Magazine of Natural History.
Les Annales de Chimie et de Physique.
Le Journal de l'Ecole Polytechnique.
Poggendorff's Annalen der Physik und Chemie.
Annalen der Chemie und Pharmacie.
Journal der reinen und angewandten Mathematik.
Die Astronomischen Nachrichten.

On the motion of Mr. Mosley, seconded by Mr. B. Joule, the Report was adopted.

The annual election of officers then took place, when the following gentlemen were elected :—

President.

JAMES PRESCOTT JOULE, LL.D., F.R.S., &c.

Vice-Presidents.

ROBERT ANGUS SMITH, PH.D., F.R.S., F.C.S.
EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
WILLIAM FAIRBAIRN, F.R.S., INST. NAT. SC. PAR. CORRESP.
JOSEPH CHESBOROUGH DYER.

Secretaries.

HENRY ENFIELD ROSCOE, B.A., PH.D., F.C.S.
JOSEPH BAXENDELL, F.R.A.S.

Treasurer.

HENRY MERE ORMEROD.

Librarian.

CHARLES FREDRIK EKMAN.

Of the Council.

REV. WILLIAM GASKELL, M.A.
EDWARD SCHUNCK, PH.D., F.R.S., F.C.S.
FREDERIC CRACE CALVERT, PH.D., F.R.S., F.C.S., &c.
JOSEPH ATKINSON RANSOME, M.R.C.S.
PETER SPENCE.
GEORGE MOSLEY.

PROCEEDINGS
OF
THE LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 1st, 1861.
E. W. BINNEY, F.R.S., F.G.S., Vice-President, in the Chair.

A letter from Dr. Fairbairn, F.R.S., &c., tendering his resignation of office as one of the Vice-Presidents of the Society, having been read, it was moved by Mr. SPENCE, seconded by Mr. J. A. RANSOME, and unanimously resolved, "That the Members of the Literary and Philosophical Society express their regret that Dr. Fairbairn feels it necessary to resign his Vice-Presidentship of the Society, and hope he will still continue to favour them with his presence and his valuable contributions as formerly."

Dr. Schunck, F.R.S., &c., was elected a Vice-President, in place of Dr. Fairbairn, F.R.S.

Mr. Alfred Fryer was elected a Member of the Council, in place of Dr. Schunck, F.R.S.

Dr. SCHUNCK announced to the meeting that Messrs. Spence; Roberts, Dale, and Co.; Tennants and Co., and others had, at his request, presented to the Society a portion of the beautiful products which had formed part of the interesting Exhibition in the Laboratory of Owens College during the late Meeting of the British Association.

It was moved by Dr. SCHUNCK, seconded by Dr. CLAY, and unanimously resolved, "That the thanks of the Society be given to the donors of chemical products."

Mr. Baxendell, F.R.A.S., read a paper entitled "Observations of Comet I, 1861."

Although this comet was not at any time a very conspicuous object to the naked eye, yet some of the features which it presented when viewed with a good telescope at the time of its greatest brightness were sufficiently remarkable to render it an object of peculiar interest to the astronomer; and I have therefore thought that a brief account of the observations made with the excellent instruments of Mr. Worthington's observatory might be acceptable to the members of this Society.

My first observation was made on the night of May 3rd, 1861. The comet was then already visible to the naked eye as a dull, hazy-looking star of the $4\frac{1}{4}$ magnitude. At 10h. 17m. 48·7s. G.M.T. a comparison with the star *Arg.* 178,8=190,112 made with the equatorially-mounted achromatic of 5 inches aperture, and a dark field photographed micrometer constructed by Mr. Dancer, gave the comet's apparent place R.A. 10h. 5m. 27·76 Dec. +48° 52′ 7·7″. Turning the 13-inch reflector upon the comet with powers of 81 and 196, it was found that the nebulosity was more than 20′ in diameter, considerably condensed in the middle, but without any distinct planetary or stellar nucleus. There was a faint tapering elongation extending about a quarter of a degree from the north following side, and stars of the 11th and 12th magnitude were easily seen through the comet at the distance of half a radius from its centre.

May 4th. Three comparisons with *Arg.* 173,122 gave the place of the comet at 9h. 26m. 19·3s. G.M.T. R.A. 9h. 52m. 19·83s. Dec. +45° 18′ 28·1″.

With the 13-inch reflector the diameter of the nebulosity constituting the head of the comet, carefully estimated by comparison with the known diameter of the field of view, was 22′. It was much condensed in the middle, but there was certainly no distinct stellar nucleus. The centre of greatest

condensation was not in the centre of the nebulosity, but towards the *north following* side. The tapering elongation of last night was now a narrow and slightly fan-shaped tail of $2\frac{1}{4}$ degrees in length, but apparently separated from the nebulosity of the head by a remarkable and comparatively dark interval, as shown in the sketch which accompanies this paper. The point of origin of this singular tail was estimated to be from 12 to 15 minutes distant from the centre of the head, and its breadth at this part was about $4\frac{1}{2}$ minutes, and at its extremity about 15 minutes. Its axis was perfectly straight, and its brightness was greatest at the narrow end, where it was equal to that of the nebulosity of the head at two-thirds of the radius from the centre.

COMET I, 1861,
As seen with Mr. Worthington's 13-inch Reflector, May 4th.

May 5th. At 10h. 16m. 59·7s. G.M.T., six comparisons with *Lalande's* 19168 gave the comet's apparent place R.A. 9h. 39m. 37·82s. Dec. + 41° 21′ 34·5″.

The sky to-night was not very favourable for the observation of faint objects, but the general features of the comet did not appear to have undergone any material change. Last

night it occurred to me after leaving the observatory that the axis of the tail was not exactly in the direction of the comet's radius vector, and to-night I found its angle of position at 13h. 35m. sidereal time to be 96·7°. At this time the position of the sun and comet were —

The sun..... R.A. 42° 54′ — N.P.D. 73° 33′.

The comet... R.A. 144° 50′ — N.P.D. 48° 43′.

From these data we find that the angle of position of a prolongation of the comet's radius vector was 69·9°. The apparent deviation of the axis of the tail was therefore 26·8° in the direction of the comet's motion.

May 7th. At 12h. G.M.T. the comet appeared to the naked eye to be nearly equal to μ Leonis, and equal to, if not brighter than, 38 Lyncis.

May 9th. Three comparisons with *Lal.* 17,987 gave the comet's apparent position at 9h. 57m. 30·5s., R.A. 9h. 3m. 23·25s. Dec. + 26° 11′ 26·1″.

At 13h. 15m. sid. time the angle of position of the axis of the tail was 103·2°. At this time the angle of position of the comet's radius vector was 74·5°; the deviation therefore amounted to 28·7°.

With the 5-inch achromatic the tail appeared to be half a degree in lengtn; but with the 13-inch reflector it was fully one degree, though fainter than when last observed, and still much less in breadth than the diameter of the head. The average diameter of the head was about 20′, but the nebulosity extended farther on the south preceding side of the point of greatest condensation than on the north preceding or north following sides. There was still an entire absence of any stellar nucleus. To the naked eye the comet appeared as a star about equal in brightness to μ Leonis.

May 14th. Notwithstanding the moonlight, the comet was still visible to the naked eye, and in the 5-inch achromatic with a power of 68 it was about 10′ in diameter. The tail, however, could not now be seen.

May 17th, 10h. 25m. The comet, though at a very low altitude and with strong moonlight, was still very easily seen with the 5-inch achromatic, and did not appear to have diminished since the 14th instant. This was the last opportunity I had of observing it.

Lalande's stars Nos. 19168 and 17987 occur in Bessel's Zones Nos. 454 and 347, and Bessel's places have been used in making the reductions.

Mr. Baxendell, referring to the photographed mircometer which he had alluded to in his paper, remarked that, at the late Meeting of the British Association, Sir David Brewster read a paper suggesting the application of photography to the construction of micrometers for astronomical purposes, but he did not appear to be aware that a micrometer prepared in that way had actually been constructed and in use for some years. The idea of employing photography for this purpose had apparently occurred to different persons, independently of each other, but the credit of having been the first to reduce this idea to practice belonged, Mr. Baxendell believed, to Mr. Dancer, who, in the early part of the year 1858, furnished him with a micrometer consisting of a system of cross lines, neatly photographed on a small glass plate, which by a proper adapter could readily be placed in the field of view, in a plane perpendicular to the axis of the telescope and with the collodion side of the plate next to the object end of the instrument. He had since had this micrometer in constant use for differential observations, and the results he had obtained were quite as satisfactory as any that could be obtained by the more elaborate and expensive reticle micrometers in ordinary use.

Some remarks having been made by Mr. Atkinson and Mr. Vernon respecting the vibrations of the barometric column which frequently take place during gales of wind

Mr. Fryer stated that, with a view of ascertaining whether the barometer was subject to minute oscillations inappreciable by the ordinary method of observing, he had placed an aneroid barometer under the microscope, using the quarter-inch object glass, and, by bringing one of the striæ on the surface of the steel index into focus, he was able, by means of the micrometer, to observe a movement of the 20,000th of an inch. The index appeared to be in constant motion, but at present he was not prepared to lay any set of observations before the Society. Mr. Fryer also suggested, for the same purpose, the use of a barometer filled with the oleine of olive oil, such an instrument being free from the disturbances caused by the watery vapour present in the water barometer and exhibiting a greater range.

PHYSICAL AND MATHEMATICAL SECTION.

April 25th, 1861.

Mr. Mosley read an extract from a letter received by him from Dr. Martin, of Lisbon, in which were enclosed a series of meteorological observations taken at that place, from the 6th to the 12th February last, both inclusive.

Mr. Vernon produced a printed series of meteorological observations made at Sydney and Paramatta, in 1857, 1858, and 1859, which he presented to the Section.

Mr. Baxendell gave details of observations which he had made during the last few days on a large and remarkable solar

spot, in which the secondary penumbra had been plainly visible, and had been observed by him to consist of a fine network of bright lines. The penumbra was strikingly striated, and the middle of the nucleus had been occupied by a bright spot detached from the penumbra at first, but afterwards joined to it, as the spot began to close up, by one of the projecting spurs usually observed to occur in decaying spots. For the purpose of the observations a trough filled with sulphate of indigo was placed in the cone of rays coming from the large mirror of a Newtonian reflector of seven inches aperture, before they reached the eyepiece. The sun's image was a deep red colour, but the definition was very good.

Professor CLIFTON suggested that the unusual visibility of the secondary penumbra in this case might arise from its being so coloured as to be rendered more visible than usual by the use of the sulphate of indigo.

June 27th, 1861.

Mr. BAXENDELL read a Paper entitled "Observations of Comet I, 1861." [This Paper was afterwards read at the Ordinary Meeting of the Society, held on the 1st October, 1861.]

Mr. BAXENDELL also read a note "On a Solar Spot of Long Duration."

At the last meeting of the Section I exhibited a sketch made on the 24th April, 1861, of a solar spot in which the secondary penumbra had been seen with unusual distinctness. This spot has since twice crossed the visible disk of the sun, and has had a term of existence considerably above the ordinary average. It was first seen on the 17th of April, near

the eastern limb of the sun, and was then a fine spot of not less than the 3rd magnitude, and, after undergoing many considerable changes of form and structure, was finally observed very near the western limb, on the 21st of June, as a spot of only the 9th or 9½ magnitude, and from its previous rate of decrease it is probable that it would become entirely extinct in four or five days afterwards. Its duration, therefore, would not be less than 70 days, and it thus affords a striking instance of the fact that frequent and extensive changes of form and structure do not necessarily tend to produce an early extinction of a spot. Between the 20th of April, at 5h. 13m. G. M. T., and the 15th of June, at 5h. 30m., it moved through 783·3 degrees of longitude, or at the rate of one sideral revolution in 25·74 days. On April 20th its heliographical latitude was 14° 11′ N., and on June 15th 14° 2′ N. These results indicate a direction and rate of drift which agree very nearly with the results which Mr. Carrington has obtained for other spots in and near the same parallel of latitude.

Ordinary Meeting, October 15th, 1861.

Dr. J. P. Joule, President, in the Chair.

Mr. John Whalley was elected an ordinary member.

A Paper was read by G. V. Vernon, Esq., F.R.A.S., M.B.M.S., "On the Irregular Barometric Oscillations at Geneva and on the Great St. Bernard, and their Relations to the Mean Temperature and the Fall of Rain."

The object of this Paper was to deduce the effects produced upon the irregular oscillations of the barometer by considerable difference of elevation. The station at Geneva is the observatory under Professor Plantamour, and is 1,335 feet above the sea. The station on the St. Bernard is the Hospice, and the observations made there are also under the direction of Professor Plantamour; its height is 8,173 feet above the sea, and, consequently, 6,838 feet above the Geneva station.

The maximum amount of oscillation occurs at Geneva in January, and the minimum in August. The maximum at the St. Bernard occurs in December, and there appears to be two minima, one in June and the other in August.

Upon the whole, the amount of oscillation appears to diminish as the mean temperature increases, the minimum amount of oscillation occurring somewhat later than the maximum temperature.

The maximum number of oscillations occurs at Geneva in August; and there appear to be two minima, one in February

and another in November. At the St. Bernard the maximum number occurs in August, and a single minimum in November.

The mean daily amount for the year at Geneva is 0.1069 inches; annual amount, 39.0719 inches: at the St. Bernard—daily amount, 0.0865 inches; annual amount, 31.5941 inches.

The total annual number of oscillations is, at Geneva, 171.3; St. Bernard, 157.2.

	Geneva.	St. Bernard.
Six winter months	84.4	76.2
Six summer months	86.9	81.0

1848 was the year of maximum oscillation, and 1857 of minimum oscillation.

A number of oscillations above the average at Geneva is accompanied by a less amount of oscillation than a number of oscillations below the average. At the St. Bernard the exact converse of this holds good.

In January, February, and December, a temperature above the average, at Geneva, is accompanied by a greater amount of oscillation than when the temperature is below the average. During the remaining months of the year the converse of this exists. For the year, a temperature below the average is accompanied by a larger amount of oscillation at Geneva than when the temperature is below the average.

At the St. Bernard, a temperature above the average, in the months of August and September, gives a larger amount of oscillation than a temperature below the average; during the other months of the year the converse of this holds good. For the year, a temperature below the average gives the largest amount of oscillation, as at Geneva.

A number of oscillations in excess of the average at Geneva, in the months of January, March, June, July, August, and November, is accompanied by a larger amount of oscillation than when the number is below the average; during the rest of the year the converse holds good. For the entire year, an increased number of oscillations is accompanied by an increased amount of oscillation.

At the St. Bernard, a number of oscillations above the average, in the months of January, February, March, April, May, August, September, and November, is accompanied by a larger amount of oscillation than when the number of oscillations is below the average. In the remaining months of the year the converse of the above holds good. The mean of the year gives the same results as Geneva.

A rain fall above the average, at Geneva, is accompanied by a larger amount of oscillation, in every month of the year, than when the rain fall is below the average.

At the St. Bernard, a rain fall above the average, in the months of February, March, May, July, August, November, and December, is accompanied by a larger amount of oscillation than a rain fall below the average; during the remainder of the year the converse of this exists.

On the mean of the year, a rain fall above the average is accompanied by a less amount of oscillation than a rain fall below the average. This result is curious, being the direct converse of what was obtained for Geneva.

The conclusions which may be drawn from this investigation are the following. As we ascend in the atmosphere, the amplitude of the irregular diurnal oscillations of the barometer diminishes, more especially in the winter months; the summer

months having an amount of oscillation not differing much from that of less elevated stations in nearly the same geographical position.

Excessive rain fall at stations of moderate elevation appears to be accompanied by a larger amount of oscillation than when the rain fall is below the average. At more elevated stations it appears as if this law was reversed, and, if found to be so, will be a very important fact.

Temperature below the average for the season greatly increases the amount of oscillation.

Ordinary Meeting, October 29th, 1861.

J. P. Joule, LL.D., President, in the Chair.

Professor A. D. Bache, Superintendent of the United States Coast Survey, and Commander M. F. Maury, of the United States Navy, were elected Corresponding Members of the Society.

John Edward Morgan, Esq., M.B., was elected an Ordinary Member.

Mr. Spence brought before the meeting part of a mass of iron and copper pyrites, containing abundance of large and well defined crystals of pure arsenious acid.

Not only are these crystals a novelty as a natural product, but as an instance of rapid mineralisation they are interesting. The lump was found among a cargo of small disintegrated ore imported from Huelva, in Spain, and containing no solid masses of large size, and the lump was merely an aggregation of small pieces firmly agglutinated together and full of hollow cavities, studded over with the crystals of arsenious acid; and from the history of the cargo of ore it is not probable that more than twelve months has been required for their development. Heat does not seem to have been the cause of the metamorphosis, as there is no evidence of heat at all approaching to ignition having occurred; discoloration of the ore would at once have been the result of this.

The ore is chiefly a sulphide of iron and copper; but as an arsenide of one or both of these metals exists in it, decom-

position of this latter must have taken place; the arsenic has become oxidised, and crystals of arsenious acid are the result.

The piece of ore will be deposited in the Society's mineral collection.

The discovery of these crystals being pure arsenious acid was made by Mr. Bottomley, Mr. Spence's assistant in his laboratory.

An interesting conversation followed, in which the fact was stated that arsenic is a constituent of nearly all the artificial manures which have superphosphate of lime as their basis; and in connection with this a report was named of arsenic having been found in some of the crops grown with such manures.

Professor Roscoe exhibited the beautiful lithographic map representing the dark lines in a portion of the solar spectrum, lately published by Professor Kirchhoff. The lines are printed in ink of six different shades, and are of six different degrees of thickness, so that the leading features of the spectrum can be at once recognised. The position of the bright lines produced by the incandescent vapour of certain metals is also given on the map, and the coincidence of many of these with the dark Frauenhofer's lines rendered evident.

Professor Roscoe stated that the length of the drawings when complete would amount to some twenty feet, and that to give an idea of the scale on which the map was made, he might remark that the distance between the two double lines "D" is upwards of four millimetres. These maps are as yet only printed together with the memoir by Professor Kirchhoff, upon the Solar Spectrum and the Spectra of the Chemical Elements, in the Transactions of the Berlin Academy; an English edition will, however, shortly be published, giving a translation of the original memoir, and containing the same drawings of the spectrum as those exhibited, which accompany the German text.

Dr. R. Angus Smith read the first part of "An Examination into the Products of the Putrefaction of Blood." He found that 54° Fahr., or nearly so, was a marked temperature; that below it there was little putrefaction, but above it a large amount, which increased as the temperature increased as far as he tried, viz., to 72° F. The amount of gas given in twenty-four hours, from three quarts of diluted blood, was one hundred cubic centimetres, at 57° F. (16° Cels.), but on raising the temperature to 72° (22° Cels.) the amount of gas in the same period rose to 397 C.C., or four times the amount of putrefaction by fifteen degrees rise of temperature. When the temperature was below 54°, no gas could be collected for many days. A very short rise above 54° caused sufficient pressure to allow gas to be collected. These facts were used to illustrate climate and sudden spread of disease.

During the early period of putrefaction, the Author found the sulphuretted hydrogen and organic matter to increase rapidly. One hundred cubic centimetres destroyed 29 of a solution of permanganate; the amount then rose rapidly to 36, 40·6, 41, 60·2.

Nearly ninety-eight per cent of the gas that escaped was found to be carbonic acid and gases with a similar action, *i.e.*, absorbed readily by caustic alkalies.

The gases were found to be —

Carbonic Acid.	Sulphuretted Hydrogen.	Residue.
82·68	———	17·32
85·78	———	14·22
89·72	———	10·28
95·40	———	4·60
96·20	———	3·80
96·07	1.58	2·35
96·43	2·78	0·79
97·62	0·06	2·31
97·09	1·93	1·98

The residual gas was found to consist of—

Carbonic Oxide.....	4·8	per cent.
Carburetted Hydrogen.....	2·5	,,
Hydrogen	6·2	,,
Nitrogen	86·5	,,
	100·	

Where the sulphuretted hydrogen is 1·5, the sulphur is to the carbon as 1 to 24·8.

Both the oxygen and carbon of the carbonic acid are derived from the blood, which is therefore carried rapidly away.

The point of greatest importance was said, by the author, to be the separation of these substances, which do not seem to be pure gases, and which are entirely absorbed by alkalies, and partly by acids and metallic salts. The portion absorbed by acid salts was found to contain carbon and nitrogen, in the relation of 140 to 54, or as 100 to 38·5; but part of this was evidently as ammonia. In albumen it exists in the relation of 100 to 28·9 The whole of the putrefactive matters were not removed by acids or by acid salts. When the carbonic acid and sulphuretted hydrogen are removed, the putrefactive matters still remain. These gases, therefore, are not the only substances to be feared.

The condition in which these putrefactive bodies exist was then discussed. The Author believed that one of the conditions in which solid substances were taken into the air was in solution, the solution itself being taken up as a vesicle; and he instanced analogous cases, such as sulphuric acid and zinc when hydrogen is forming. The liquid evaporates and a concrete globule forms, leaving at last a portion of solid matter in various states. This condition can be supposed to occur readily in many cases, but it does not appear to be the probable result in all cases, as he cannot readily imagine vesicles coming through the close pores of bodies such as are

penetrated by these vapours. Between the actually mechanical method of taking solid matter into the air, such as when waves are agitated by the wind, and the purely chemical method, such as when a liquid is transformed into a vapour by heat, there must be many intermediate stages. These stages are required, apparently, as we can scarcely imagine pure gases undergoing transformation similar to bodies in a putrefactive state; and we are not prepared with a theory by which diseases will be communicated without the agency of bodies in such a state of change — one of the oldest of theories and one promising to live long. Besides, the fact of a substance being found capable of being absorbed by metallic salts, and containing carbon with nitrogen in such a large amount, leads us to believe that bodies not very far removed from the substances decomposed are found in the vapours, and, if not far removed, capable of undergoing transformations so as to become farther removed, and by such transformations exercising their special influence.

MICROSCOPICAL SECTION.

21st October, 1861.

Professor WILLIAMSON in the Chair.

The following gentlemen were elected members of the Section:—Mr. Murray Gladstone, Mr. John Whalley, Mr. William Henry Heys, Dr. William Roberts, and Dr. Thomas Alcock.

The SECRETARY presented sixty specimens of soundings received since the last Session, from the commanders of various steamers and sailing vessels, amongst which were a number from the South Coast of Ireland, Banks of Newfoundland, Coast of Nantucket, U.S., North Coast of Brazil, &c. The Secretary was requested to write a letter of thanks from the Section to each contributor.

The Chairman remarked that these specimens deserved the best attention of the Section, not only on account of their intrinsic interest, but to show the contributors that their kindness in preserving the soundings for the Section was fully appreciated.

Mr. Dale offered, with the assistance of the Secretary, to prepare the material, by separation from the tallow, &c., and Mr. Nevill, Mr. Heys, and several other gentlemen, offered their assistance in mounting, examination, and reporting to the Section.

The Chairman observed that the method he employed in the preliminary examination of similar specimens, when freed from tallow and dried, was to stir the mass in a vessel of water, when most of the organic forms rose to the surface, in consequence of containing small quantities of air; the creamings off the top of the liquid would be found to

contain sufficient indications whether the specimens deserved further attention.

The Secretary read a letter from Mr. Joseph Sidebotham, accompanying a specimen and a drawing of the Aulacodiscus formosus, showing the four projecting knobs or handles visible upon that diatom. Mr. Sidebotham states that in all drawings hitherto published, these protuberances appear like simple elevations or bosses, nor could they be seen otherwise until the binocular microscope revealed their true shape. Mr. Dancer first called his attention to this peculiarity.

Mr. Crompton exhibited, and presented to the members, specimens of capillary tubes used by him to collect and preserve fluids for microscopical examination for medical purposes. Mr. Crompton has used such tubes for more than a year, and has preserved specimens of blood, urine, &c., which by any other method would have spoiled. The main feature consists in hermetically sealing the tubes after the introduction of the fluid, by holding their ends alternately in the flame of a candle or lamp until the glass melts, and the orifice closes; the tubes may be about three-fourths filled by capillary attraction or immersion, and care must be taken not to allow the fluid to approach the hot end of the tube whilst being sealed. The Edinburgh vaccine tubes answer the purpose well; they may be about three inches long, and a number of them may be carried in a small pocket case at all times ready to be filled. When required for examination, the tube is broken, and the enclosed fluid placed under the microscope.

The Secretary exhibited a specimen of the compound salt of magnesia and copper, prepared by Mr. Thomas Davies, of Warrington. Doubts having been expressed if it were a true compound salt, or a mere mechanical mixture, Mr. Dale, who at the Secretary's request had prepared some of the salt,

undertook to report further upon it. Some forms of crystal were exhibited, producing novel effects by polarised light.

Mr. Lynde exhibited a fine specimen of copper ore, with jasper, from Cornwall, the colours of which, when illuminated with the Lieberkühn, were very gorgeous.

Mr. Latham exhibited the ovary of a flea, and portions of the skin and teeth of the dogfish.

Mr. Heys exhibited specimens, mounted specially for the Lieberkühn, of various seeds, hairs, and glands of plants; the tesselated spines on the Symphytum asperrimum, or rough comfrey, and the ruby coloured oil glands of the origamme onites, glowing, like precious stones, with the reflected light from above the object, were very much admired. For certain classes of objects no illumination can compare with that of the Lieberkühn in the use of the binocular microscope, and side lights may be obtained, to some extent all around the object, by manipulation with the mirror.

Ordinary Meeting, November 12th, 1861.

Dr. R. Angus Smith, Vice-President, in the Chair.

Mr. Thomas Coward was elected an Ordinary Member.

Mr. E. W. Binney said that some years since he read a Paper before the Society, "On the Drift Deposits found near Blackpool," which was afterwards printed in Vol X. (new series) of the Memoirs. In the gravel at Bispham, most probably the high level gravel of Mr. Prestwich, he found nineteen species of shells, all identical with those now found in the Irish Sea. He also stated that in the lowest bed of till there found, full of scored and striated rocks, he collected shells of the genera *turritella*, *buccinum*, *nassa*, *dentalium*, *nucula*, *cardium*, and *tellina*. Owing to such shells found in these deposits not having so arctic a character as those said to be found in other till beds, it has been supposed that they are of a more recent date than the glacial age of Forbes, or the pleistocene of Lyell. Professor King, of Queen's College, Galway, a geologist of high reputation, in his Synoptical Table of British Aqueous Rock Groups, &c., just published, classes the Blackpool fossils with post-pleistocene, as shell sands occurring just under deposits now forming around the shores of the British Islands, and immediately above the Devonshire raised beaches. The Blackpool gravels, near Bispham, are as good pleistocene as can be found in any

of the high level gravels met with further inland, notwithstanding the fossils discovered in them, which are of the same kind, although not so numerous, as those met with in the gravels of Bowdon, Cheshire, and the sands of Haigh, Lancashire. He also said that the lowest bed of till seen at Blackpool, and containing the shells previously alluded to, had all the physical characters of the Scottish, Irish, and North of England iceberg and glacial drift, and had been subject to considerable elevations since its deposition.

Mr. R. D. Darbishire stated that he had lately found under undisturbed clay at a considerable elevation on the southerly slope of Great Orme's Head, a deposit of bones of different mammalia intermixed with shells of mytilus, littorina, and patella. He hoped to lay the results of further observations before the Society on a future occasion. He supposed the deposit might be connected with the present or past existence of some "bone cave" in the limestone rock of the Head.

He suggested, however, that possibly the bones and shells may have been the remnants of the cookery of former inhabitants of the district, and referred, in illustration, to the researches made amongst the Kjokkenmöddings on the coasts of Denmark.

Dr. Joule, in reference to speculations on the thickness of the earth's crust, stated that he had some time ago received a letter from Professor Thomson, giving an account of the progress of investigations calculated to throw light on this interesting subject. Professor Thomson finds that the

equilibrium lunar tide in a solid glass globe (without mutual gravitation) of the same size as the earth is about five feet. Hence, from the phenomena of the actual tides of the ocean, it follows that the earth, as a whole, is more rigid than glass. The observations of Mallet, with experimental earthquakes, show that the earth's crust is many times less rigid than glass. Hence Professor Thomson infers that the earth, as a whole, is many times more rigid than the rocks and strata on its surface.

Dr. Crace Calvert stated that he wished to draw the attention of the manufacturing chemists of this district to a very simple and rapid method which had been devised by the eminent chemist M. Pelouze, Master of the Paris Mint, for determining the amount of sulphur existing in pyrites. He (Dr. Calvert) was induced to do so, believing that any process which would simplify the long and troublesome operations now followed to ascertain the value of this mineral would be useful to many members now present at this meeting. The process consists in mixing intimately together one part of pyrites, thoroughly pulverised in an agate mortar, with five parts of carbonate of soda, seven parts of chlorate of potass, and five parts of chloride of sodium, and placing the whole in an iron spoon, which is gradually carried to a dull red heat. The mass, when cold, is first washed with cold water and then with boiling water, until the whole of the soluble matter is removed; and this solution is tested with a standard solution of sulphuric acid. As 100 grains of carbonate of soda requires 92·45 of monohydrated sulphuric acid, or $S O_3 H O$, it follows that the quantity of soda in the carbonate of soda employed

will decrease in proportion to the quantity of sulphur from the pyrites converted into sulphuric acid, which will have neutralised a corresponding quantity of the soda in the carbonate.

This mode of assaying is so simple, that the Author states that he can determine, within one or one and a half per cent, the value of a sample of pyrites, in the space of an hour's time.

M. Pelouze also states that by employing the following proportions of the same materials, the manufacturer can determine the amount of sulphur in burnt pyrites. Five parts of the latter substance are mixed intimately with five parts of pure carbonate of soda and five parts of chlorate of potash.

Ordinary Meeting, November 26th, 1861.

J. P. Joule, LL.D., President, in the Chair.

Mr. Joseph Sidebotham exhibited a photograph of the contorted schists seen in the cliff near the South Stack Lighthouse, Holyhead.

Mr. John Parry showed some photographs of fossil woods from the South Lancashire coal field. These displayed beautifully the structure, even to the most minute vessels.

A Paper was read by Mr. E. W. Binney, F.R.S., Vice-President, entitled "Additional Observations on the Permian Beds of South Lancashire." This was a continuation of two previous papers read before the Society and printed in its Memoirs.* Since that time the Author had made further observations on the Permian strata at Heaton Norris, near Stockport; Medlock Vale, between Ashton and Manchester; Chorlton-upon-Medlock, and Ordsal, near Manchester; and Skillaw Clough and Bentley Brook, near Newburgh, in the West of Lancashire.

At Heaton Norris, in the sand delf of Mr. Howard, near the railway station, the lower new red sandstone was seen dipping to the south-west at an angle of 25°. This was succeeded by red and variegated marls having a similar dip These last named strata were overlapped by the Trias, which dips to the south-west at an angle of 12°.

* Vols. xii. and xiv. (New Series) of the Society's Memoirs.

At Heaton Mersey the following section was met with:

	Feet.
Trias	45
Permian—Red and variegated marls containing limestones	129
Lower new red sandstone grooved	402
	576

The Permian beds were cut off by a fault near the railway station at Heaton Norris, first shown to me by Mr. Hull, B.A., F.G.S., of the Geological Survey, which brought in the Trias. This rock occupied the district between that town and Goyt's Hall, in the Marple valley, where the lower part of the middle coal measures was seen in nearly a vertical position.

The Author considered that Mr. Howard's sand delf is a likely place for ascertaining the existence of a coal field under the town of Stockport worth working.

The next was a section made by Mr. John Wood, at Medlock Vale, between Waterhouses, near Ashton-under-Lyne, and Manchester. It was as follows:

	Feet	In.
Drift	26	0
Trias	23	0
Permian—Red marls, with beds of limestone and five beds of gypsum	246	3
Lower new red sandstone	375	11
Coal measures ..... about	90	0
	761	2

What these coal measures were, whether above or under the Bradford Four Feet Mine, it was at present impossible to say; but it was to be hoped that some mine would be met with to enable us to determine the value of the great tract of coal measures lying between Ashton-under-Lyne, Oldham,

Middleton, and Manchester. Mr. Wood had done more than any other gentleman to clear up this point, and it was to be desired that he should meet with a good seam of coal, both for his own sake and that of the public.

The third section mentioned was at the sugar works of Messrs. Fryer and Co., in Chester Street, Chorlton-on-Medlock, Manchester. The following beds were there met with :

	Feet.
Trias	114
Permian...Red marls with limestones	237
Coarse red sandstone with pebbles..	45
Coarse red sandstone	24
Coal measures consisting of red shaly marls and limestones (Ardwick)	126
	546

The limestones in the last named strata contained specimens of *microconchus carbonarius* and scales of *palæoniscus*, which clearly proved them to be similar beds to those of the upper coal field at Ardwick, to which they bear every resemblance in physical character.

The occurrence of coal measures on the south side of the city of Manchester is quite new and of great importance, showing that such strata at places are met with under permian and trias deposits much nearer the surface than was previously suspected, and where the upper rocks gave no evidence of their proximity. The above bore has proved beyond doubt that a band of coal measures lies under the south of Chorlton-on-Medlock, and possibly extends to Heaton Norris, being probably brought up by the great Pendleton fault, which most likely passes through the south of Manchester and joins the fault seen near the railway station at Heaton Norris previously alluded to, and described more fully in the Paper.

In the fourth seetion, at Ordsal, Messrs. Worrall found the trias beds 460 feet in thickness without going through them. At the bottom of the bore the water beeame so salt that they diseontinued the work, it being no longer fit for dyeing and sueh like purposes. This is the first instanee, to the Author's knowledge, where salt water has been met with in the trias near Manehester.

The fifth and sixth sections were at Skillaw Clough and Bentley Brook, to the north of the Newburgh station on the Manehester and Southport Railway. These were some time since discovered by Mr. E. Hull, B.A., F.G.S., of the Geologieal Survey, and described shortly by that gentleman in the sheet explaining the map of the distriet. Further particulars were given of the details of both seetions, and an analysis of the limestone was produced, which showed it to differ in its chemieal eharaeters from the thin ribbon bands found in the permian marls near Manchester, Patrieroft, Astley, and Leigh, and was very like the yellow magnesian found at Stank, in Furness, North Lancashire. Probably it might prove to be a different bed, and more like the great central deposit of magnesian limestone of Yorkshire than the thin beds previously alluded to.

MICROSCOPICAL SECTION.

November 18, 1861.

E. W. Binney, F.R.S., F.G.S., in the Chair.

Dr. Edward Stephens was elected a member of the Section.

The Secretary read a communication from Mr. Thomas G. Rylands, of Warrington, "On the Classification of the Diatomaceæ." The Author desired to call attention to the want of systematic arrangement which characterises this favourite branch of microscopical investigation, and to the necessity of a thorough revision of the entire classification of the natural order. The author presented to the Section two slides to illustrate his arguments. The predominant form of frustules was first named by Dr. Brebisson *Cocconeis lævis*. In 1857 it was published by Mr. Roper (M. I. vol. vi. p. 22) under the provisional name *Coscinodiscus ? ovalis ;* but in consequence of finding on the valves eight to twelve submarginal obtuse processes with tumid bases, quite distinct from the spines or teeth which occur in the Coscinodisceæ, the Author considers this species must be placed in the genus Eupodiscus, and may fitly be called Eupodiscus lœvis. The specimens were obtained at Llandudno, in ripples in the sand below mid-water ; and the Paper concludes with a description of some peculiarities connected with their sudden disappearance.

Mr. John Watson read a paper "On certain Scales of some Diurnal Lepidoptera," in which he recommends a new and careful study of this subject. In some genera peculiar

scales, called plumules, have long been known; but examination with the binocular microscope shows that they are not flat like the ordinary scales, but cylindrical and hollow. They have been found only in certain genera (named in the paper) at present, and on the males alone; they possess generic resemblances and specific differences, each species displaying its own distinguishing variety. One of great beauty and novelty, found only on two African butterflies, Pieris Agathina and Pieris Chloris, was described, and some very fine drawings of it, by Mr. Joseph Sidebotham, were exhibited, and also other figures by him of about one hundred species never figured before. The names and habitats of the insects were given, and the Author pointed out the value of these scales for the assistance of the scientific entomologist in arranging genera and species; he then entered into the question of their probable use as air vessels in the economy of the insects possessing them.

The Chairman remarked that the scales of the Lepidoptera may prove to be as valuable in determining species as the scales of fishes.

Mr. Sidebotham alluded to the value of the binocular microscope in defining the cylindrical form of the plumules, and described the mode of finding them *in situ*, by breaking the wing.

Mr. Watson stated that some of Mr. Sidebotham's excellent drawings were taken under the eighth objective, magnifying 750 diameters. Mr. Watson further said that he had examined the wings of 400 specimens of the Papilionidæ, but had not discovered any plumules in that genera; he also alluded to several so called species from South America, of which no males have yet been found, others of which no females have yet been discovered, and suggested the possibility of some of these being male and female of the same species; to ascertain which, careful examination of the scales might be useful.

Mr. Watson exhibited a number of mounted specimens of the plumules, and four cases of the Lepidoptera from whose wings the 98 drawings figured by Mr. Sidebotham were taken. They were principally Pieris, Anthocaris, Thestias, Euterpe, and Eronia; amongst the former were some new and unnamed species from Celebes, with rare specimens from Venezuela, Quito, East and West Indies, Africa, and other parts of the world.

Mr. Dale placed on the table a number of washed soundings, of which several members took specimens for examination.

Mr. Dale also reported that the sulphate of copper and magnesia has been long known to be a compound salt. When the magnesian salt is in excess, it has seven equivalents of water; and when the copper salt is in excess, it has five equivalents of water. Mr. Dale had also made for the occasion samples of the double sulphate of copper and potash, the double sulphate of copper and ammonia, and the double chloride of copper and ammonia, which he distributed amongst the members. They were all beautiful polariscopic crystals, the chloride particularly so, and each has its characteristic form.

Mr. Linton exhibited the hairs on the Loasa Coccinea (Chili nettle), mounted by Mr. Heys.

Mr. Dancer exhibited a specimen of the Aulacodiscus formosus, which, in consequence of a fracture since it was mounted, shows more distinctly the form of the projections that Mr. Sidebotham brought under the notice of the Section at the last meeting. These handle-shaped spines, Mr. Dancer observed, when seen with the 1-8th power and binocular microscope, are found to project outwards from each of the four elevations on the surface of the valve.

Mr. Brothers exhibited the Floscularia ornata, and a fine group of Lacinularia socialis.

Mr. Mosley exhibited a specimen of Amœba, and described the peculiarity of its motion. He had observed one of them rise in a straight line four-fifths of its entire length, its internal particles appearing to force outwards a transparent or invisible integument; the point then fell over, forming an arch, after which it subsided into the common three or four-lobed form. In many specimens no vacuole was observed; in others, an apparent air or water space was noticed. A portion of the one under examination appeared to be blown outwards like a bladder, in which appeared a small animalcule making desperate efforts to escape. The best illumination for observing the internal motion, he considers to be Wenham's parabola and Lieberkühn, with a 4-10th objective.

Ordinary Meeting, December 10th, 1861.

J. P. Joule, LL.D., President, in the Chair.

Mr. Wm. K. Deane, was elected an Ordinary Member.

Mr. Baxendell made the following communication : —

A paragraph, headed "Rain following the Discharge of Ordnance," appears in the number of the *London Review* for November 16th, 1861. In this paragraph some new facts, drawn from the American war, are adduced by Mr. J. C. Lewis, in support of the view that a violent concussion of the air by the discharge of heavy artillery has a tendency to cause a copious precipitation of rain. Now, if we may be allowed to regard this effect as an established fact, it seems to me to be one of some interest in connection with the disputed question whether, in thunderstorms, a discharge of lightning is the cause or the consequence of the sudden formation of a heavy shower of rain. Almost every day's experience, in this climate at least, shows that the production of rain is not dependent upon sudden discharges of electricity from the clouds; and no evidence has ever been brought forward to prove that a high degree of electrical tension in a cloud has a tendency to prevent the resolution of the cloud into rain. Heavy showers often fall from highly electrified clouds without any visible discharge of electricity taking place. We are, therefore, not entitled to assume that the sudden diminution of the electrical tension of a cloud by a lightning discharge can have any material influence upon the rain-forming processes going on in the cloud. As, however, very heavy showers of rain do almost invariably follow lightning discharges, it seems necessary to seek some other cause to account for them. But if we admit that a violent con-

cussion of the air has a tendency to facilitate the conversion of rain-forming material into actual drops of rain, then we may well suppose that the violent concussions produced by lightning discharges, acting on such enormous and dense masses of rain-forming material as are usually collected in heavy thunder clouds, are amply sufficient to produce these sudden and heavy showers of rain.

I am aware that the effect of a discharge of ordnance is usually supposed to be produced by an upward current of air caused by the heat and the gases evolved during the combustion of the gunpowder; but as an hour's sunshine through an opening in the clouds, especially when the sun is at a considerable altitude, would produce a much greater effect in heating and increasing the bulk of the air, this cannot be received as the true explanation of the mode in which the effect of a discharge of heavy artillery is produced.

Mr. Fairbairn stated that he had been making experiments on the process of cold rolling, as applied to iron. He had tested specimens of cold rolled iron manufactured both by Mr. Lauth and Earl Dudley. In the former case, a black bar from the rolls broke with 26·173 tons per square inch, a a similar turned bar with 27·119 tons, and a cold rolled bar of the same iron sustained 39·388 tons. The elongations, which may be considered as the measure of ductility, were ·200 and ·220 per unit of length in the case of the ordinary iron, and ·079 in the cold rolled iron. A plate of cold rolled iron, from Earl Dudley, sustained no less than 51·3 tons per square inch. Endeavours were being made to apply the invention to railway bars.

Mr. Brockbank described the Bessemer process of manufacturing iron and steel, and stated his belief that the variously colored flames on the surface of newly run steel would afford the means of detecting the presence of metals and other bodies by the new method of spectrum analysis.

A Paper, entitled, "Nouveau Systême de Communication Télégraphique, rendant impossible toute collision de trains sur les chemins de fer," by Professor Baulet, of Perpignan, communicated by William Fairbairn, Esq., LL.D., &c., was read by Professor Roscoe.

In this plan an insulated wire placed between the rails, and divided in its middle, affords a connexion between the instruments at the stations and others situated in the trains themselves. The details of the arrangement could not be understood without the drawings accompanying the Paper.

Mr. Dodwell, the Superintendent of the Magnetic Telegraph, described Mr. Clark's system, which is now in full operation between London and Rugby, and which, he thought, left little further to be desired.

SECTION FOR STATISTICS AND SOCIOLOGY.

November 19th, 1861.

Dr. R. A. Smith, F.R.S., &c., read a Paper, entitled, "Examples of Relative and Absolute Law."

The Author said that it was an easy thing to express the most important laws that ought to rule absolute in society. They were such as had been given in the words, "Love thy neighbour as thyself, do justice, love mercy," but, when it became needful to apply these laws to particular cases, the operations of the greatest minds were needed, and found after all to be wanting. Quoting from a former Paper, he said that even our ideas of property ceased to have influence when our relation to property changed; for example, when millions of our fellow-creatures are dying at a distance, we feel it scarcely right to consider that we have a right to any luxury; where they are dying in our own country, we feel

that we must still further curtail; when we are placed in situations where they are dying around us, all prior right gradually vanishes. This law we acknowledge formally by a rise of poor-rates, according to the circumstances of the country.

Again, to take an example from extremes, if all Britain were in the possession of one man, who desired to send out all the inhabitants, and hunt with a few friends only over London and Manchester, we should no doubt refuse to go; we should then change our ideas of property, and we would adopt the opinions of the Fifth Monarchy men and say, "The earth is the Lord's." If half the country were in this state, we would still give the same answer; but if only a county were in this possessor's hands, we would first hesitate and say, "What county?" If it were Middlesex, surely not — we will allow no individual to rule so despotically on the Thames. Lancaster also not. But when it is Sutherland, Arran, or Skye, we then give the permission, and the permission remains until the inhabitants become powerful enough to say that there are rights belonging to man, as an intellectual and moral being, on which physical rights, without moral modifications, must not be allowed to trample.

This is especially the case with reference to clearances; they are allowed, although they would not be allowed in densely populated counties; and they are allowed because they are in conformity with formal law, although it is generally thought that they are in opposition to a feeling not yet fully expressed. It slumbers in the mind which says that some great law is disobeyed, but on examining the law of the land it is not found which portion is disobeyed, and it may be that the heart is also mistaken in its feelings. It is the business of legislators to put into words and parliamentary law the great laws of justice which are written in our hearts, and to see that all laws made for the nation are in conformity with absolute law. All our laws are relative, or

nearly all; it is extremely difficult to make absolute and relative law run together exactly parallel. Society moves and its relations to all things move at every step; relative laws must therefore always be changing, whilst absolute laws are always the same.

The same applied to the principle of free traders who advocate local and relative conveniences as if they were universal and absolute laws.

PHYSICAL AND MATHEMATICAL SECTION.

October 10th, 1861.

G. V. Vernon, Esq., F.R.A.S., was elected a Member of the Section.

A letter from Mr. Heelis, F.R.A.S., having been read, resigning the Secretaryship of the Section on account of the state of his health, it was resolved unanimously,—That the Section receive with regret the resignation, by Mr. Heelis, of his office as Secretary, and sincerely hope that his health may soon allow of his resumption of official connection with them.

Mr. Vernon, F.R.A.S., read a Paper, "On the Irregular Barometric Oscillations at Geneva and on Great St. Bernard, and their Relations to Mean Temperature and the Fall of Rain." [This Paper was afterwards read at the Ordinary Meeting of the Society, held on October 15th, 1861. See Proceedings No. 2, Session 1861-2.]

November 7th, 1861.

Professor Clifton, B.A., F.R.A.S., was elected Secretary of the Section, in place of Mr. Heelis, resigned.

A letter from Mr. Heelis, F.R.A.S., was read, communicating the following observation of the Zodiacal Light, recently made by him at Smyrna. "September 13th, 1861, 4h. a.m. Observed the Zodiacal light very distinctly; the breadth of it was not observed, but the position of the apex was ascertained, as carefully as an eye unaccustomed to such observations would permit, to be in a line and about midway between Pollux and Procyon. This would give an approximate length of 75° 11′. The cluster Præsepe was seen distinctly through the light shining like a white cloud, and

many meteors about equal in light to the brightness of any point in the Præsepe, (by which I would be understood to mean not the aggregate light of the cluster, but the light which any part of it, if separated from the rest would appear to have,) were seen crossing the beam of light in various directions. The sky was quite clear, the morning just dawning, and the horizon to seaward covered, as is usual at that hour in summer at Smyrna with a low fog bank. Few or no meteors were at the time of observation noticed in any other part of the sky."

Mr. W. L. Dickinson read a Note "On the Transit of Mercury," giving the results of his calculations for Manchester. In these calculations he had used the Nautical Almanac Elements, and found that the planet would leave the Sun's disc on the morning of the 12th instant, at 9h. 18m. 44s., Greenwich mean time, at an angle from the north point of the Sun's disc of 24° towards the west, and from the vortex of 1° towards the west for *direct* image.

Mr. Vernon, F.R.A.S., exhibited diagrams, showing the variations of the barometer and thermometer at various stations in England and Scotland during the storm which occurred on the 2nd instant.

December 5th, 1861.

Murray Gladstone, Esq., F.R.A.S., was elected a Member of the Section.

Mr. Baxendell, F.R.A.S., read a Paper "On the Influence of the Seasons on the Rate of Decrease of the Temperature of the Atmosphere with Increase of Height in different Latitudes in Europe and Asia."

[This paper will be read at the Ordinary Meeting of the Society, to be held on the 24th instant.]

Mr. Dickinson read a Note "On the Eclipse of the Sun, December 31st, 1861."

This eclipse, being small compared with several that have lately occurred, will not attract so large an amount of general attention; it will, however, be of considerable interest to scientific persons, and in the hope that the members of this Society will not consider it an unimportant phenomenon, the following results are submitted to enable them to compare their observations with the computed times.

Calculations for Manchester (Royal Infirmary), lat. N. 53° 29′, long. W. 2° 14′.

	H.	M.	S.
Eclipse begins, December 31st	1	49	19
Greatest Phase	2	49	9
Eclipse ends	3	45	29

mean time at Greenwich.

Magnitude of the Eclipse (Sun's diameter=1) 0·413 on the Sun's southern limb.

Angle from North Pole, of—

First contact, 143° towards the West,

Last contact, 108° towards the East.

Angle from vortex, of—

First contact, 157° towards the West,

Last contact, 80° towards the East,

for *direct* image.

Ordinary Meeting, December 24th, 1861.

J. P. Joule, LL.D., President, in the Chair.

Mr. Brockbank exhibited some samples of steel manufactured by Mr. Bessemer's process. These specimens had been bent and twisted cold, and showed a remarkable degree of ductility. He stated that the Bessemer steel was one of the most plastic and manageable of metals—more so even than copper. It could be bent, flanged, or twisted, either hot or cold, without annealing, and over a considerable range of temperature—which is not the case with ordinary steel or copper.

A plate of 18 inches diameter had been forced through a series of dies until it formed a tube 13 feet long and $1\frac{3}{4}$ inches diameter, without any crack or flaw.

A ring of metal could, at one heat, be hammered into a die to form a locomotive engine chimney top.

In drilling a circular hole into a plate, continuous shavings are formed—whereas, in copper, or Low Moor plates, or any other metal, the shavings break into pieces $\frac{1}{16}$in. long.

Thin sheets of the Bessemer soft steel can be bent backwards and forwards hundreds of times without a fracture, and are almost as flexible as paper.

Mr. Binney stated that many years since he had communicated to the Society a description of some markings on the surface of the Kerridge flags. At that time he could not satisfactorily account for them. He afterwards published, in Vol. X (new series) of the Memoirs, a Paper on similar markings, found in the Upholland flags, near Wigan, and attributed them to the burrowing of an animal similar to the common lug worm of our coast, the *arenicola piscatorum.*

Similar holes have since been found by Mr. Salter, F.G.S., in rocks of various ages, from the Cambrian upwards, and that distinguished palæontologist has called them *arenicolites*.

The position of the Kerridge flags is, probably, one of the best ascertained in the whole coal field. It is in the lower division above the millstone grit. In his lower coal field he gives two main beds of flagstones: the first or lower, the Rochdale series, under the rough rock; and the upper, or Upholland or Kerridge series, above the same rock, the chief workable beds of the lower coal field of Rochdale and other districts, often termed the "mountain mines," lying midway between these two flag deposits. This series of coal is now, and has been for many years, wrought under the Kerridge flags, so as prove beyond doubt the position of the latter. Some discussions have lately taken place in the newspapers at Macclesfield as to whether the Kerridge beds were permian or carboniferous. No one, who ever saw permian beds, could ever for one moment suppose Kerridge flags to belong to those strata. It is possible that permian beds may exist in the low district lying between Kerridge and Macclesfield, as they have been met with at Hug Bridge on the south, and Norbury Brook on the north, but up to this time they have not been proved to be there.

Considerable interest has been excited by the discovery of what were supposed to be the foot-marks of some animals on the surface of the flags. He had been induced to make two journies to Kerridge for the purpose of examining them. Once he found two ripple marks pressed into one, which somewhat resembled a human foot, and which was shown to him as the mark of one; and at another time he was shown what was called a track of some animal, but which was evidently no track at all, but most probably made by running water. Although plenty of worm holes and ripple marks are to be found on the surface of the Kerridge flags, as yet he had seen no tracks of animals upon them.

Mr. Edward Hull, B.A., called attention to instances of glacial striations recently discovered by Mr. G. H. Morton, at Liverpool, during a recent visit to that town in connection with his duties on the Geological Survey. Mr. Hull was kindly conducted by Mr. Morton to the spots where the striæ are visible. One of these is at the south, the other at the north side of the town, and at the latter the extent of surface exposed is several hundred square yards. The rock-surfaces had been protected by a thick coating of boulder clay, which has been removed for brick-making. It is owing to the protection thus afforded to the rock that the striations are preserved in all their original freshness. The rock belongs to the New Red Sandstone, and is a moderately hard reddish-brown and yellowish building stone. There are two systems of striæ, the primary one ranging N.N.W., the secondary nearly east and west. Of the latter, the markings are comparatively unimportant, but are very clear and sharp. The primary striæ run in remarkably straight lines—in the form of deep groovings and scratches, and the whole surface of the sandstone is worn down to one uniform gently-sloping plane.

It appeared evident, from the directions of the striæ, that they had been produced by icebergs coming from the north, in all probability from the Cumberland mountains, where glaciers are known to have existed during the period of the boulder clay, or rather earlier. The secondary groovings might have been produced by bergs coming from North Wales, but this appeared very problematical. The interest attached to these cases of glaciation was stated to arise from their position at so great a distance from the Cumberland range. In the immediate neighbourhood of these mountains, as also in that of North Wales, ice-moulded surfaces have frequently been observed, but never before on the New Red Sandstone of Lancashire or Cheshire. (See Mem. Lit. and Phil. Society, Vol. I., 3rd Series.)

Mr. E. W. Binney referred to the existence of similar striations on the Carboniferous limestone of Great Ormes Head, where the groovings were found to range northward, or outwards from the mountains of the interior. He also noticed the distribution of the Shap granite, blocks of which he had lately seen on the high Silurian and Carboniferous ranges to the south and south-east of Shap Fell.

Mr. Brockbank stated that, on the high lands of Yorkshire and Derbyshire, he had observed erratic blocks which could be traced to their northern sources.

Mr. Hull, in conclusion, stated that it had been abundantly shown, by the collection of a large number of facts, that the direction of the erratic blocks of the Drift period was from north to south, so that there must have been some predominating influence in operation, either prevalent winds, or, more probably, oceanic currents, tending to impel southward the icebergs and rafts which were the vehicles for the transportation of the erratic boulders and pebbles.

A Paper was read by Mr. Baxendell, F.R.A.S., "On the Influence of the Seasons on the Rate of Decrease of the Temperature of the Atmosphere with Increase of Height, in different Latitudes of Europe and Asia."

The determination of the laws of the distribution of heat in the different strata of the atmosphere under various circumstances of season, locality, direction of the wind, barometric pressure, &c., is one of the most important, and, at the same time, one of the most difficult problems which can engage the attention of the meteorologist. Notwithstanding the labours of many able meteorologists and physicists, several points of considerable importance to the future progress of meteorology are still involved in doubt and obscurity; and the necessity for further inquiries has been so generally acknowledged, that at the late meeting of the British Association in this city, a grant of £200. was renewed to defray

the expenses of balloon ascents, to be undertaken for the purpose of obtaining additional data, of a reliable character, to serve as a basis for future investigations. The Author, therefore, thought it might be worth while to submit to the Society some results which, although confessedly imperfect, seem to him to indicate very clearly the existence of a law of distribution of temperature in the higher regions of the atmosphere in the different seasons in different latitudes of Europe and Asia, which appears to have hitherto escaped notice, and which seems likely to have an important bearing upon many interesting questions in meteorology.

From numerous observations made at elevated stations in Europe and India, it has been concluded, 1st,—That the general rate of decrease of the temperature of the atmosphere with increase of height, is least in low, and greatest in high latitudes; and 2nd,—That the rate of decrease is greatest in the summer and least in the winter months. Some results, however, which the Author obtained in the course of an investigation of the relations which exist between falls of rain and changes in the decrement of temperature on ascending in the atmosphere, and of barometric pressure, in different localities, led him to doubt the general correctness of the second of these conclusions, and he has therefore examined all the observations that were accessible to him which seemed likely to throw any light on the subject; and from the results which he has obtained he shows that there exists in the temperate latitudes of Europe and Asia a belt or zone in which the decrease of temperature, for a given ascent in the atmosphere, is greatest in the winter months, while at stations north or south of this belt, so far at least as observations have yet been made, the decrease is greatest in the summer months.

This belt passes over Portugal, Spain, Sicily, Southern Italy, the Caucasian provinces, and Southern Siberia; and at places lying within it the changes of temperature produced by change of season are greater in the higher than in the

lower strata of the atmosphere; while, on the contrary, at places north or south of the belt the changes of temperature are greatest in the lower strata. The details of the results are given in the Paper, and all the temperatures are reduced to Fahrenheit's scale, and the differences of elevation to English feet.

The great changes of temperature which take place in the higher strata of the atmosphere in the belt, indicate a less capacity for heat and a greater degree of dryness of the air in these strata than in the corresponding strata beyond the belt. The Author was therefore led to conclude that the ratios of the quantities of rain falling on the mountain and on the plain would be less at places in the belt than in other localities; and the results which he has given of the comparisons of the mean annual amounts of rain-fall at different stations fully bear out this conclusion. Comparisons are also made of the falls of rain during the winter and summer halves of the year; and it is shown that at places in the belt the ratio of the quantity falling on the mountain to that falling on the plain is greater in the summer than in the winter half of the year, while on the contrary, at places beyond the belt, it is greatest in the winter half.

The Author then draws attention to some results which appear to indicate that the annual rate of decrease of temperature, on ascending in the atmosphere, is subject to a periodical change. Comparing Geneva and Milan with the Great St. Bernard, the annual rate for the years 1848—58 exhibits, with but trifling irregularities, a gradual increase up to the beginning of the year 1854, and afterwards a gradual decrease. The differences of temperature between the two stations Bywell and Allenheads, in Northumberland, at a difference of elevation of 1273 feet, also show a progressive increase from 4·14° in 1856, to 5·07° in 1860. The Author remarks that the epoch when the rate of decrease was at a maximum, as shown by the Geneva and Great St. Ber

nard observations, corresponds exactly with the epoch of minimum magnetic disturbance, as determined by General Sabine from the magnetical observations made at the colonial observatories and at Pekin ; and he shows that there is some probability that the period of the change in the rate of decrease also corresponds with the period of magnetic disturbance.

In concluding, the Author tenders his grateful acknowledgements to Mr. Vernon, F.R.A.S., for the valuable assistance he has rendered him in procuring data, and in referring to original publications for the purpose of clearing up doubtful points; and he also remarks that without the means of reference afforded by the many valuable volumes of meteorological observations now in the Society's library, it would have been quite impossible to have undertaken an inquiry of this nature.

MICROSCOPICAL SECTION.

Meeting, December 16th, 1861.

E. W. Binney, F.R.S., F.G.S., in the Chair.

Dr. Edward Morgan was elected a member of the Section.

Dr. Wallich kindly presented to the Section for mounting several specimens of material, from his private collection, containing Biddulphia of various kinds, and other diatomaceæ, from Guernsey, St. Helena, &c.

Mr. Thomas H. Nevill presented to the Section eight slides, mounted from the specimens of Soundings, No. 131, taken in Lat. 51° 48′ N., Long. 7° 8′ W., off the south coast of Ireland, in 40 fathoms, presented by Captain Moodie, of the R.M.S.S. "Canada." Mr. Nevill reported that the specimen contained Entosolenia Marginata, Entosolenia Squamosa, Lagena Vulgaris, Textularia, Rotolina, Miliolina. Numerous spines and plates of Echini; calcareous prisms from shells, &c., &c., all water-worn. The sand is composed of about half calcareous and half silicious material.

Mr. Latham proposed that the subject for discussion, at the next meeting, should be "On the Cause of the Metallic Lustre on the Wings of the Lepidoptera, both Diurnal and Nocturnal," which was agreed to. Mr. Latham also reported upon the Ovum presented at the last meeting by Mr. Leigh. Mr. Latham presented to the Section a slide, mounted with a portion of the elytra of the Platyomus subcostatus, from Venezuela; also, an oak spangle with stellate hairs.

Mr. Binney exhibited mounted specimens of Fossil wood, from Standish, near Wigan; Trigonocarpon oliviforme, from the lower Lancashire coal bed; and the palate of the Psammodus porosus, from the mountain limestone, county Armagh.

Mr. Joy presented mounted seetions of coal from Bohemia, showing woody fibre.

Mr. Whalley exhibited living ova of the Trout, one month old.

Mr. Brothers exhibited a seetion of Agate from Siberia; Stentor Mülleri, &e.

SECTION FOR STATISTICS AND SOCIOLOGY.

December 17th, 1861.

Mr. Isaac Holden read a Paper "On the Effects Produeed by the Character of their Residenees upon the Physical and Moral Condition of the Working Classes." Mr. Holden believed that although eonsiderable attention had been given to the building of cottages, suffieient progress had not yet been made in making them comfortable and attraetive to the inmates. If this were done it would eontribute greatly towards furthering their domestic happiness, as they so frequently leave their homes seeking pleasure, instead of resting after their labours, cultivating their minds, and preparing themselves for their duties next day. The public has already been frequently told that the aceommodation was insuffieient for eomfort and deeeney, and, he would add, also for health.

The interest of Mr. Holden's Paper eonsisted in the minute knowledge whieh his many facts displayed of the subjeet. He partieularly dwelt on the present most imperfeet method of dealing with the refuse of towns, and the great evils that resulted from its accumulation near every house.

Mr. Henry Ashworth stated that a firm near Bolton had considered it their interest to erect for their workpeople cottages of a superior class, mostly containing three bedrooms, and in other respects commodious and convenient. They were let at a rental of six per cent on the outlay, and were in great requisition. The beneficial effects upon the social and moral condition of the tenants was undoubted.

Ordinary Meeting, January 7th, 1862.

Edward Schunck, Ph.D., F.R.S., Vice-President, in the Chair.

Prof. Dr. Johannes Gistel, of Kempten in Bavaria; Federico Lancia di Brolo, Inspector of Studies in the University of Palermo; and James Nasmyth, Esq., C.E., were elected Corresponding Members of the Society.

A Paper was read by J. P. Joule, LL.D., President, entitled, "Experiments on some Amalgams."

The weakness of the affinity which holds the constituents of amalgams in combination seemed to the Author to offer the means of studying the relationship between chemical and mechanical force. His inquiries were extended to several amalgams, and gave results of which the following is a summary:—

Amalgam of iron was formed by precipitating iron on mercury electrolytically. The solid amalgam containing the largest quantity of mercury appeared to be a binary compound. Iron does not appear to lose any of its magnetic virtue in consequence of its combination with mercury. Its amalgamation has the effect of making it negative with respect to iron in the electro-chemical series. The affinity between mercury and iron is so feeble that the amalgam is speedily decomposed when left undisturbed, and almost immediately when agitated. The application of a pressure of fifty tons to the square inch drives out so much mercury as to leave only thirty per cent of it in the resulting button.

Amalgam of copper. By precipitating copper on mercury electrolytically, a mass of crystals is gradually formed. After a certain time the crystals begin to get fringed with pink, indicating uncombined copper. In this state the amalgam is found to be nearly a binary compound. On applying strong pressure to an amalgam containing excess of mercury, the latter is driven off, leaving a hard mass composed of equivalents of the metals. If, however, the pressure be continued for a long time, the resulting amalgam contains more than one equivalent of copper, indicating a partial decomposition.

The Author gave an account of his experiments with amalgams of silver, platinum, lead, zinc, and tin. In the case of the latter amalgam, long-continued pressure drives off nearly the whole of the mercury, indicating in a striking manner the efficacy of mechanical means to overcome feeble chemical affinities.

Dr. Angus Smith said, It is difficult to tell the exact limits of chemical and mechanical action, because they flow into each other. Let us call the attraction of surfaces a mechanical action, as it is not to our knowledge a chemical combination. Porous bodies exercise this to a very large extent, and yet do not produce chemical compounds. The amount is limited on one side by the pressure of the atmosphere. Chemical compounds are too powerful to be affected by such slight forces. Porous bodies or surfaces do not take up others in chemical equivalents so far as we know; the full capacity of saturation is not satisfied, because of counteracting influences. Water admits air very rapidly, but it is held so slightly that it is affected by atmospheric pressure, and even seems to follow exactly the atmospheric pressure; but a portion is held with such power that it is extremely difficult to remove, and is not ever removable by the mere removal of pressure as far as we know. The small affinity of the great mass or surface of water is equal to a great affinity for a small amount of air. All masses have more or less this mechanical action, but, as

in the case of porous bodies, the attraction is feeble, and not raised into the power of a definite grasp of a given quantity such as an equivalent, which is the case with a powerful affinity forming a chemical compound. Large and watery masses lose their water slowly by the mere force of gravitation. Strong mechanical action rises to an equality with feeble chemical affinity. Weak chemical affinity sinks into an equality with mechanical action. Charcoal absorbs gases more eagerly under pressure, but by a removal of pressure they are still absorbed; so that the mechanical force is greater than the weight of the atmosphere can control. There are many cases in which these two forces, if they be two, meet. This of the mercury and other metal is one case. The feeble chemical affinity is, I suppose, overcome by the powerful mechanical force. The alloy with sufficient chemical affinity remains, that with a weak affinity separates. The mercury flows off following the law of liquids; in like cases it flows off like water flowing slowly from a moist porous mass like wet clay. Instances from the feeblest to the most powerful affinity might be given, showing that only when the power reached a definite point did the law of chemical equivalents come in. At the same time there is a definite point where surface action ceases under certain conditions.

These ideas have arisen partly from experiments on the subject, which may some day be published. I believe they explain the difficulties attending the attraction of masses which seem occasionally to oppose the combination by atomic weights.

A Paper was read "On the Conductibility of Heat by Amalgams," by Dr. F. Crace Calvert, F.R.S., and Mr. Richard Johnson.

The method followed in the investigations described in this Paper is the same as that detailed in their former Paper on the conductibility of metals and alloys.

In the first part of their Paper the Authors treat of the conduetibility of mercury, and prove that if the source of heat be applied at the upper part of a column of mercury, so as to prevent any motion of the solid moleeules of the mereury, this metal becomes the worst conductor of all known metals; for, silver being 1000, mercury is 54.

In the second part of their Paper the Authors examine the eonduetibility of the solid and semisolid amalgams prepared in equivalent quantities of pure metals with mercury, and they show that amalgams may be divided into two classes — those eontaining an excess of equivalents of the amalgamated metal, and those whieh on the eontrary eontain an exeess of equivalents of mercury. The first elass conduet heat at the mean rate of the two metals composing the amalgam, and in accordanee with the calculated result, as shown by the following table.

Amalgam of Tin.

Mercury = 21·63 or 679
Tin.... = 13·45 or 422

	Found.	Calculated.	Silver = 1000 Found.	Calculated.
6 Sn. Hg.	10·60	15·24	332	478
5 „ „	10·30	15·63	322	490
4 „ „	9·65	15·88	302	498
3 „ „	9·45	16·30	296	571
2 „ „	8·65	17·19	271	539
Sn. Hg.	5·15	18·56	161	582
„ 2 Hg.	4·75	19·75	149	619
„ 3 Hg.	4·20	20·26	131	635
„ 4 Hg.	3·95	20·55	124	644
„ 5 Hg.	3·65	20·73	114	650

The second class, eomprising those amalgams containing an excess of mercury, conduct heat as if they contained no other metal, although its proportions may vary from 10 to 34 per cent.

These interesting results were confirmed by observing amalgams of tin, zinc, bismuth, copper, lead, and silver, and applying the source of heat in all cases at the upper part of a perpendicular column of the amalgam.

The third part of their Paper has reference to the conductibility of mercury when mixed with two per cent of various metals, and when the heat is applied at one end of a horizontal column; and they have obtained the following interesting series of results.

	Found.	Calculated.	Found.	Calculated.
Pure mercury	21·63	.....	679	
Mercury with two per cent of				
Silver.....	2·30	21·81	72	684
Tin	5·65	21·43	177	672
Copper	13·19	21·62	413	678
Gold	14·50	21·79	454	680
Bismuth.....	18·75	21·20	588	664
Lead	19·25	21·34	603	668
Cadmium.....	20·20	21·51	633	676
Zinc	21·20	21·56	664	676

This table shows that the greater or less conducting power of the metal amalgamated with it has no influence in modifying the conductibility of the amalgam itself; for we find that the amalgam of bismuth (the worst conducting metal) conducts heat eight times better than that of silver (the best conductor), for

Mercury	+ 2 per cent of	Bismuth	588
„	+ 2 „	Silver	72

They were induced to believe at the beginning of these researches that the cause which impeded the conduction of heat in so marked a manner in some of these amalgams was the presence of small crystals of amalgam floating in excess

of mercury, as they had observed that whilst the crystallised amalgams of silver and tin conducted heat badly, that of zinc, which was perfectly fluid and free from crystals, conducted heat very freely. As they pursued their researches they found these views to be incorrect, for the amalgam of bismuth, a very crystalline one, conducted heat with great facility.

Having observed that tin affected the fluidity of mercury in a most remarkable manner, so that even the one hundred thousandth part of that metal would interfere with the property which mercury has of assuming easily a globular form, they prepared the following series of amalgams of tin.

Silver=1000

			Found.	Calculated.	Found.	Calculated.
Mercury	94·50+	Tin 5·50 ...	4·00 ...	21·14 ...	125 ...	663
„	97·00+	„ 3·00 ...	4·60 ...	21·35 ...	144 ...	669
„	98·00+	„ 2·00 ...	5·65 ...	21·43 ...	177 ...	672
„	98·25+	„ 1·75 ...	5·90 ...	21·45 ...	185 ...	673
„	98·50+	„ 1·50 ...	10·95 ...	21·47 ...	343 ...	673
„	99·00+	„ 1·00 ...	19·30 ...	21·52 ...	605 ...	675
„	99·50+	„ 0·50 ...	19·30 ...	21·56 ...	605 ...	675

This table proves that up to 1·75 the conductibility of mercury remains constant, when by reducing the tin by $\frac{1}{4\frac{1}{0}}$th the conductibility of the amalgam is doubled; by further abstracting one-third of the tin, the conductibility is again doubled.

Ordinary Meeting, January 21st, 1862.

E. W. Binney, F.R.S., F.G.S., Vice-President, in the Chair.

William Arthur Darbishire, Esq., B.A., was elected an Ordinary Member of the Society.

A Communication, "On the Action of Nitrate of Sodium on Sulphide of Sodium at Different Temperatures," by Dr. Ph. Pauli, Union Alkali Works, St. Helens, Lancashire, was read by Professor Roscoe.

The mother liquor obtained in the manufacture of soda ash contains, as is well known, large quantities of sulphide of sodium. In order to oxidise that compound, nitrate of sodium is used. As long as the boiling point of the liquid is between 280—290° F., the sulphide is quietly oxidised to sulphate, nitrite of sodium being formed.

But if the nitrate is added when the temperature of the boiling liquid is about 310° F., a violent evolution of ammonia takes place, according to the following equation—

$$2\,Na\,S + Na\,NO\,6 + 4\,HO = 2\,Na\,SO_4 + Na\,HO_2 + NH_3$$

As the liquor contains a large amount of sulphide, the quantity of ammonia is so considerable that it may prove worth while to connect the evaporating pot with a tower filled with coke, over which a stream of water or dilute acid is running.

If the nitrate be added when the liquor has been heated to a temperature much above 310°, a violent evolution of pure nitrogen occurs.

$$5\,Na\,S + 4\,Na\,NO\,6 + 4\,HO = 5\,Na\,SO\,4 + 4\,Na\,O_2\,H + 4\,N.$$

Mr. Leigh suggested that the evolution of nitrogen in volcanic eruptions might be due to a reaction similar to that described in Dr. Pauli's Paper.

Mr. Spence and Dr. Calvert explained the processes employed in manufacturing caustic soda for commercial purposes. Mr. Spence also described the beds of nitrate of soda in Southern Peru and Northern Chili, from which nearly all the commercial nitrate of soda is obtained.

Mr. Baxendell believed that the preservation of the nitrate of soda in these beds had been due to the dryness of the climate, as rain rarely falls in the region in which they are found. Had the climate been a rainy one, he believes the deposits of nitrate of soda would long since have been washed away.

Mr. Baxendell communicated an observation of Saturn which he had lately made. Owing to the relative positions of the sun and earth, with respect to the plane of the ring of Saturn, the ring ought now to be quite invisible in telescopes of moderate power; but on the night of the 18th instant he had seen very distinctly a portion of the ring on the following or east side of the planet. The teleseope used was Mr. Worthington's achromatic of five inches aperture. He also stated that from observations made by himself and Mr. Williamson, in 1848, he had been led to believe that the plane of the ring was not exactly parallel to the dark belts on the body of the planet. As several members of the Society now possess good telescopes, it is to be hoped they will direct their attention to this interesting point, and favour the Society with the results of their observations.

A Paper, "On the Convective Equilibrium of Temperature in the Atmosphere," by Professor Wm. Thomson, LL.D., F.R.S., &c., was read by Dr. Joule.

The particles composing any fluid mass are subject to various changing influences, in particular of pressure, whenever they are moved from one situation to another. In this way they experience changes of temperature altogether independent of the effects produced by the radiation or conduction of heat. When all the parts of a fluid are freely interchanged and not subject to the influence of radiation and conduction, the temperature of the fluid is said by the Author to be in a state of convective equilibrium. The equations of convective equilibrium in the atmosphere investigated by the Author are as follows, Π, T, and W denoting the pressure, temperature, and mass per cubic foot of the air at the earth's surface, and p, t, and ρ the same qualities of the air at any height x.

$$\left(\frac{p}{\Pi}\right)^{1-\frac{1}{k}}=\frac{t}{T} \qquad \text{(1)}$$

which is the known relation between temperature and pressure.

$$\frac{p}{\Pi}=\left(\frac{\rho}{W}\right)^{k} \qquad \text{(2)},$$

the deduced relation between pressure and density; and

$$dp=-\rho\, dx \qquad \text{(3)},$$

the hydrostatic equation, the variation of gravity at different heights being neglected, and the weight of unit mass (1lb) being taken as unit of force. Hence by integration,

$\frac{t}{T}=1-\frac{Wx}{\Pi}\cdot\frac{k-1}{k}$, Or if, for brevity, we denote $\frac{\Pi}{W}$ by H,

$$\frac{t}{T}=1-\frac{x}{H}\cdot\frac{k-1}{k} \qquad \text{(4)}$$

From (4) and (1) it appears that temperature and density would both vanish at the very moderate height $\frac{1\cdot41}{\cdot41}\times H$

which is about 90100 feet, or between 17 and 18 miles, if convective equilibrium existed and if the gaseous laws had application to so low temperatures and densities. It has always appeared to the Author to be most improbable that there is any limit to our atmosphere; and no one can suppose that there is a limit at any height nearly so small as 17 or 18 miles. It is difficult to make even a plausible conjecture as to the effects of deviations from the gaseous laws in circumstances of which we know so little as those of air at very low temperatures; but it seems certain that the other hypothesis involved in the preceding equations is violated by actions tending to *heat* the air in the higher regions. For at moderate elevations above the surface, where we have air following very strictly the gaseous laws, the rate of decrease of temperature would, according to equation (4), be be $\frac{\cdot 41 \times T}{1\cdot 41\, H}$ per foot, that is to say, $\frac{1^\circ}{329}$ per foot, since $H = 26224 \times \frac{T}{274}$ or 1° cent per 329 feet. Now, the actual decrease, according to Mr. Welsh, is 1° cent in 530 feet, or not much more than half that according to convective equilibrium.

It seems that radiation, instead of partially accounting for the greater *warmth* of the air below, as commonly supposed, may actually diminish the cooling effect, in going up, which convection produces. In fact, since direct conduction is certainly insensible, we have only convection and radiation to deal with, except when condensations of moisture, &c., have to be taken into account. In fair and cloudless weather, then, the lower and lowest air being on the whole warmer (the lowest being of course at the same temperature as the earth's surface), it is perfectly certain that the upper air must gain heat by radiation from the lower—and that the convective difference of temperature must be diminished by the mutual interradiation.

There are difficulties connected with the radiation of air and earth out into space, and of heat from the sun to air and earth; but I think a full consideration of all the circumstances must explain the smallness of the decrease of temperature which observation shows.

Dr. JOULE having suggested that condensation of vapour in upward currents of air might account, to a considerable extent if not perfectly, for the smallness of the lowering of temperature actually found in going up, the Author has added the following investigation, in which the effect of condensation is taken into account.

If a quantity of air, dry or moist, is allowed to expand from bulk v to bulk $v+dv$, it will do an amount of work equal to pdv on the surrounding matter. Now, by the principle established approximately by Dr. Joule, in his experiments on air in 1844,* the change of temperature which the mass will experience will be almost exactly equal to what would be produced by keeping it at constant volume, $v+dv$, and removing a quantity of heat equal to the thermal equivalent of pdv. This is expressed by $\frac{1}{J}pdv$, if we adopt the usual notation, J, for the dynamical equivalent of the thermal unit. Now, if t and $t+dt$ denote the primitive and the cooled temperatures, so that $-dt$ expresses the cooling effect (which is positive, dt being negative), the bulk of the vapour, if at saturation in each case, would be $v\frac{ds}{s}$ if s denote the volume of a pound of vapour at saturation at any temperature t, and $s+ds$ its volume at temperature $t+dt$. Hence if, as it will be seen is the case, $v\frac{ds}{s}$ is greater than dv, a portion equal in bulk to $v\frac{ds}{s}-dv$ of the water primitively in vapour, must

* "On the Changes of Temperature produced by the Rarefaction and Condensation of Air," communicated to the Royal Society June 20, 1844, and published in the "Philosophical Magazine," 1845, first half year.

become condensed. Hence the abstraction of the heat, $\frac{1}{J}\,pdv$ produces two effects; it cools the mass of air at constant volume from temperature t to temperature $t+dt$, and it condenses a bulk

$$v\frac{ds}{s}-dv$$

of vapour. Hence, if L denote the latent heat of a cubic foot of vapour of water at temperature t, and N the specific heat of one pound of air in constant volume, we have

$$\frac{1}{J}p\,dv=N\times(-dt)+L\left(v\frac{ds}{s}-dv,\right)$$

if we suppose the mass of air considered to weigh 1 lb. (with or without the vapour, which will make but little difference on the whole weight). Hence

$$\frac{dv}{-dt}=\frac{JN+JLv\dfrac{d\,log\,s}{-dt}}{p+JL}$$

where, for brevity, $d\ log\ s$ is written in place of $\frac{ds}{s}$, $log\ s$ denoting the Napierian logarithm of s.

To find L and $\frac{d\ logs}{-dt}$, it is necessary to know the bulk of a pound of steam at different temperatures. Dr. Joule and the Author demonstrated,* by experiments on air and by dynamical reasoning, that

$$L=\frac{J}{t}\frac{dp}{dt}\left(1-\frac{\lambda}{\gamma}\right)$$

where p denotes the pressure of vapour at saturation at the temperature t, and $\frac{\lambda}{\gamma}$ denotes the rate of the bulk of liquid to vapour. Since $\frac{\lambda}{\gamma}$ is very small, we have $L=\frac{J}{t}\frac{dp}{dt}$ approximately.

* On the Thermal Effects of Fluids in Motion, Part II., Theoretical Deductions, Section II., Transactions of the Royal Society, June, 1854.

It was shown also in the same Paper, that the density of saturated vapour was to be obtained more accurately from this equation, and Regnault's experiments on the latent heat of a stated weight of vapour, than from any direct experiments on the density of vapour made up to that time. This conclusion has been verified by the recent experiments of Messrs. Fairbairn and Tate. With the assistance of some excellent tables in Rankine's "Steam Engine and other Prime Movers," calculated on these principles, the Author has obtained the following results:—

Temperature centigrade, or $t-273{\cdot}7$.	Volume of 1 lb. of air at pressure 2,117 lb. per square foot.	Dynamical value of latent heat of 1 lb. of saturated vapour.	Proportionate diminution of bulk of saturated vapour per 1° cent. of any wanted temperature.	Augmentation of volume of 1 lb. of moist air required to cool it 1° cent.	Elevation from earth's surface required to cool moist air by 1° cent.
$t-273{\cdot}7$	v.	J L	$\frac{d \log s}{-dt}$	$\frac{dv}{-dt}$	$\frac{dx}{-dt}$
0°	12·38 cubic ft.	249 ft. lbs.	·0698	·1905 of a cubic ft.	499 feet.
5	12·61	348	·0671	·2150	551
10	12·83	481	·0644	·2434	611
15	13.06	655	·0617	·2753	678
20	13·29	881	·0592	·3096	751
25	13·52	1171	·0569	·3455	827
30	13·74	1538	·0546	·3800	900
35	13·97	1999	·0524	·3950	932

The last column of this table, headed $\frac{dx}{-dt}$, is calculated from the column headed $\frac{dv}{-dt}$, by the following formula:—

$$\frac{dx}{-dt} = p\left(\frac{dv}{-dt} + \frac{v}{t}\right)$$

which shows the height, dx, that must be reached to get a lowering of temperature, $-dt$, when air saturated with moisture ascends. The pressure, p, is taken as 2117 lbs. per square foot; and the value of $\frac{v}{t}$, which is the name for the

different temperatures, is $\frac{12 \cdot 38}{274}$. The results, for temperatures from 0° to 35° cent, are exhibited in the last column of the table. For the temperatures 0°, 5°, and 10°, they agree very well with the height in which Mr. Welsh found a lowering of temperature of 1° cent; and we may conclude that at the times and places of his observations the lowering of temperature upwards was nearly the same as that which air saturated with moisture would experience in ascending.

It is to be remarked that, except when the air is saturated, and when, therefore, an ascending current will always keep forming cloud, the effect of vapour of water, however near saturation, will be scarcely sensible on the cooling effect of expansion. Hence the law of convective equilibrium of temperature in upward or downward currents of cloudless air must agree very closely with that investigated above, and must give a variation of 1° cent in not much more or less than 330 feet.

It appears, therefore, that the explanation suggested by Dr. Joule is correct; and that the condensation of vapour in ascending air is the chief cause of the cooling effect being so much less than that which would be experienced by dry air.

The following extract of a Letter from Professor W. Thomson, LL.D., &c., to the President, was also read:—

"About two years ago I wrote to you that a metal bar, insulated so as to be moveable about an axis perpendicular to the plane of a metal ring made up half of copper and half of zinc, the two halves being soldered together, turns from the zinc towards the copper when vitreously electrified, and from the copper towards the zinc when resinously electrified.

"If the copper half and the zinc half of the ring are insulated from one another, and if they are connected by means of wires with two pieces of one metal maintained at any stated difference of potential by proper apparatus for dividing the

electro-motive force of the two plates of a Daniell's element into 100 parts, from 60 to 70 of those parts are required to reduce the zinc half ring and the copper half ring to such a state that the moveable bar remains at rest whether it is electrified vitreously or resinously.

"If the copper half ring is oxydised by heat, the amount of electro-motive force then required to neutralise the two halves is much increased. If, after oxydising the copper one day by heat, I leave the apparatus till the next day, the effect is generally diminished, though something of it still remains. After again heating the copper by laying it for some time on a redhot iron heater and allowing it to cool, I found the effect almost exactly 100 parts. I have no doubt that by making the coat of oxyde very complete and thick enough, and by cleaning the zinc perfectly, I shall be able to get considerably above the electro-motive force of a single Daniell's element. I remembered perfectly what you told me a long time ago about heating the coppers of a battery and getting a strong effect, for some time equal to that of the Daniell's cell, when I tried the effect of oxydising the copper plate by heat.

"I believe there are also electrical effects of heat itself; so that if one half of a ring of one metal is hot and the other is cold, the needle will show a difference according as it is charged positively or negatively.

"For nearly two years I have felt quite sure that the proper explanation of voltaic action in the common voltaic arrangement is very near Volta's, which fell into discredit because Volta or his followers neglected the principle of conservation of force. I now think it quite certain that two metals dipped in one electrolytic liquid will (when polarisation is done away with) reduce two dry pieces of the same metals, when connected each to each by metallic arcs, to the same potential.

"There cannot be a doubt that the whole thing is simply chemical action at a distance. Zinc and copper connected by a metallic arc attract one another from any distance.

So do platinum plates coated with oxygen and hydrogen respectively. I can now tell the amount of the force, and calculate how great a proportion of chemical affinity is used up electrolytically, before two such discs come within $\frac{1}{1000}$th of an inch of one another, or any less distance down to a limit within which molecular heterogeneousness becomes sensible. This of course will give a definite limit for the sizes of atoms, or rather, as I do not believe in atoms, for the dimensions of molecular structures."

Ordinary Meeting, February 4th, 1862.

J. P. Joule, LL.D., F.R.S., President, in the Chair.

Mr. Binney said that soon after the death of Professor Eaton Hodgkinson, F.R.S., one of the former Presidents of the Society, and a man of science, of whom not only this Society, but the city of Manchester, has good reason to be proud, a few of his friends and admirers gave a commission to Mr. Slater, the sculptor, of London, to execute a bust of the deceased, to be presented to this Society. As his valuable memoirs, which gave to the world the formulæ for solid and hollow pillars of cast iron, now the basis of calculation on all structures of that metal, were printed in our Transactions, it was thought that the Hall of the Literary and Philosophical Society of Manchester was the fittest place for the bust of their discoverer.

The following gentlemen, viz., our worthy President, J. P. Joule, LL.D., F.R.S., E. Schunck, F.R.S., James Heywood, F.R.S., John Hawkshaw, C.E., F.R.S., Joseph Whitworth, F.R.S., R. P. Greg, F.G.S., Thomas Turner, F.R.C.S., G. R. Stephenson, C.E., Robert Rawson, and E. W. Binney, F.R.S., present the bust to the Society. In doing so it would not be necessary for him to allude to the great talents and many virtues of the deceased, as his friend Mr. Robert Rawson was now engaged in writing a Memoir, to be communicated to the Society; but he could not omit reading a letter which showed how the present President of the British Association for the Advancement of Science hailed the election of Mr. Hodgkinson as the successor of the late Dr. Holme to the chair of this Society. It was as follows: —"Chester and Holyhead Railway Company, Conway,

June 28, 1848. My Dear Sir,—I cannot resist the temptation to congratulate you on your election to the Presidency of the Manchester Philosophical Society. I think the members have used a sound discretion in the selection, and I am heartily glad, after all our squabbles, to find you in a position to which you are justly entitled. I am yours faithfully, W. Fairbairn. To Eaton Hodgkinson, Esq."

The bust forms a companion to one of another distinguished member of this Society, the late Dr. William Henry, F.R.S., and both as a likeness and a work of art does the sculptor credit.

On the motion of Mr. SPENCE; seconded by Dr. R. ANGUS SMITH, it was resolved unanimously:—"That the thanks of the Society be given to the donors of the bust of the late Professor Eaton Hodgkinson, F.R.S."

Mr. SPENCE brought under the notice of the Society a ball of the dried leaves and stems of a plant imported from the West Coast of Africa, in the Kingdom of Dahomey. This plant, which grows spontaneously in great abundance, is used by the natives in dying cloth, to which it is said to give a good but not very permanent blue colour.

The parties who have imported these leaves are Messrs. Burnet and Thwaites, of Manchester, and they state that two years ago the sample had been examined without any result. About two months ago, Mr. Spence gave Dr. E. Schunck, F.R.S., a portion of them, he kindly undertaking to see whether they contained indigo. Circumstances prevented Dr. Schunck, until very lately, from entering upon the investigation, and the importers being anxious as to the matter, Mr. Spence, assisted by Mr. Bottomley, undertook the investigation, and at once found that the plant contained indigo perfectly formed, and which was easily extracted by the usual modes of deoxidisation and solution, the indigo being then precipitated pure and of a beautiful deep coppery

shade. The only question now was as to its containing indigo in quantity sufficient to render the importation profitable. The solution of this question being partly one of chemical manufacture, has been undertaken by Mr. R. Rumney, who is to operate on a large quantity so as to get results of commercial value.

Mr. Spence was chiefly induced to bring this subject before the Society from the fact that a new source of indigo at the present time would be a matter of great importance to trade, the growth of the article in India being from peculiar causes rather on the decline.

Dr. Schunck corroborated Mr. Spence's statements so far as that he had found indigo fully formed existing in the specimens submitted to him; he had not had time as yet to ascertain what quantity of that body they contained.

Mr. Mosley stated that it had been known for some time that the indigo plant grows wild in many parts of the West Coast of Africa; he believed it would be of great importance at present if a new source of indigo could be found, as the Indian manufacture seemed to be declining. He believed the manufacture had been attempted in Africa, but had not succeeded.

The Rev. Robert Harley, F.R.A.S., communicated to the Society the following statement on the Theory of the Transcendental Solution of Algebraic Equations:—

Certain published Papers of Mr. Cockle, as well as some private communications from that mathematician to myself, have led me of late to study the theory of equations under a new and interesting aspect.

Let $f(y, x) = 0$ be an algebraic equation of the nth degree in y, and such that its roots $y_1, y_2, \ldots y_n$ are all functions of a single parameter x. From this equation we may deduce a linear differential equation of the $(n-1)$th order which it is proposed to call "the differential resolvent." The n roots

of $f(y, x) = 0$, and therefore also any linear function of those roots must satisfy the differential equation. But it is known [see my Paper "on the Theory of Quintics," published in the *Quarterly Journal of Pure and Applied Mathematics*, Vol. III. p. 343] that each of the constituents of the roots of an equation is a linear function of those roots. Consequently each of the constituents of y must satisfy the differential resolvent, these constituents being in fact so many particular integrals of that equation. It follows that every particular integral is a linear function of the constituents, for otherwise there would be more than $(n-1)$ independent integrals, which is impossible, seeing that the resolvent equation is only of the $(n-1)$th order. Hence the solution of the differential resolvent, that is, its complete integration so as to evolve y, or the several constituents of y, in terms of x, will give the required solution (algebraic, trigonometric, or transcendental) of the equation in y.

Of the two trinomial forms, suggested by Mr. Cockle, to which it is known that any equation of a degree lower than the sixth can be reduced by the process of Tschirnhausen or Mr. Jerrard, I have selected the following

$$y^n - ny + (n-1)\,x = 0 = f(y, x)$$

because it has, when $x = 1$, two equal roots, and therefore affords some good verifications, and also because it leads, as I shall show in certain researches which I hope shortly to publish in detail, to some remarkably simple expressions. At present I content myself with placing on record the following results:—

In general, the first differential coefficient $\frac{dy}{dx}$ is equal to

$$-\frac{1}{n}\cdot\frac{1}{1-x^{n-1}}\cdot\left\{y^{n-1} + xy^{n-2} + \cdots + x^{n-2}y - (n-1)\right\};$$

which gives immediately for the quadratic $(n = 2)$ the differential resolvent

$$2\,(1-x)\,\frac{dy}{dx} + y - 1 = 0 \cdots (1)$$

and which also enables us with ease to calculate the resolvent for the cubic ($n=3$), viz.

$$3^2(1-x^2)\frac{d^2y}{dx^2}-3^2x\frac{dy}{dx}+y=0\cdots(2)$$

Results (1) and (2) were first calculated by a different process by Mr. Cockle. The following are now published for the first time. For the biquadratic ($n=4$) the differential resolvent is

$$2^3(1-x^3)\frac{d^3y}{dx^3}-2^4\cdot3^2x^2\frac{d^2y}{dx^2}-2\cdot43x\frac{dy}{dx}+5y=0\cdots(3)$$

And for the quintic ($n=5$) the resolvent is

$$5^4(1-x^4)\frac{d^4y}{dx^4}-2\cdot5^5x^3\frac{d^3y}{dx^3}-3^2\cdot5^3\cdot13x^2\frac{d^2y}{dx^2}$$

$$-3\cdot5^3\cdot17x\frac{dy}{dx}+3\cdot7\cdot11y=0\cdots(4)$$

The Boolian form of (3) is

$$y-\frac{\left(\mathrm{D}-\frac{7}{4}\right)\left(\mathrm{D}-\frac{10}{4}\right)\left(\mathrm{D}-\frac{13}{4}\right)}{\mathrm{D}(\mathrm{D}-1)(\mathrm{D}-2)}\epsilon^{3\theta}y=0\cdots(5)$$

where D is the differential symbol $\frac{d}{d\theta}$, and $\epsilon^{\theta}=x$.

I notice also the following remarkable relations among the differential coefficients for the general case, viz.,

$$\frac{d^2y}{dx^2}=ny^{n-2}\left(\frac{dy}{dx}\right)^3,$$

$$\frac{d^3y}{dx^3}=\frac{n^2}{n-1}y^{n-3}\left\{(2n-1)y^{n-1}+(n-2)\right\}\left\{\frac{dy}{dx}\right\}^5,$$

$$\frac{d^4y}{dx^4}=\frac{n^3}{n-1}y^{n-5}\left\{-(2n-1)(3n-1)xy^{n-1}\right.$$

$$+3(n-1)(n+2)(2n+1)y$$

$$\left.-(2n-1)(3n^2+3n-8)x\right\}\left\{\frac{dy}{dx}\right\}^7.$$

The investigations on this subject, which I intend to publish shortly, embrace a curious and anomalous result in

the theory of quadratics, a new and simple method of deducing the arbitrary constants that occur in the integration of the resolvents, together with the actual calculation of the foregoing differential equations and some interesting formulæ of verification, by which the correctness of those equations may be ascertained. Such formulæ play a somewhat conspicuous part in the general scheme, for, if the differential resolvents be employed as tests of existing theories of differential equations, it is of the utmost importance that their accuracy should be placed beyond dispute. Notwithstanding the complexity of the calculations by which I have arrived at them, the differential resolvents for quartics and quintics are, it will be noticed, of a remarkably simple form. It is proper to mention that a large portion of the calculation of that for the quintic was performed independently by Mr. Cockle, and that on comparing results and making one or two corrections, I found that his calculations coincided (so far as they went, for they only extended to the determination of the differential coefficients) with my own.

A Paper was read "On the Causes of Sickness and Mortality in the Manufacturing Towns of the North-West of England," by Dr. C. J. Shearman, of Sheffield, communicated by Dr. R. Angus Smith, F.R.S.

Previously to any examination of the disturbing causes of vitality, the proportion of age to the whole population should be ascertained for town and country districts; for under all circumstances, favourable or otherwise, age of an individual determines to a great extent the kind of sickness and the consequent mortality. In the towns of this part of England there are up to 15 years of age *less*, from 15 to 55 *more*, from 55 upwards *less* than in the adjacent country. Hence one of two evils results — either that towns kill young people and old fast — or middle age is imported.

As to the feeding of town population, an average of 6 per

cent is imported from purely country districts of those under 20 years of age; and of 26 per cent over 20 years. This constitution of replenishment of towns, associated with what is subsequently shown, *large mortality at early ages*, leads to the view that considerable drafts from the country from 15 years upwards are made by towns, and which latter are responsible for their health.

With the exception of infantile diseases, those of 15 to 55 years of age are the most fatal, and towns present a large field for the operation of disease at that age.

The diseases of infancy and childhood are in a great degree infectious. Hence *density* of population would be considered a great element of mischief at those periods; but smallpox, scarlet fever, and some others, more infectious than others, present a less increase of mortality than measles over that of the country. The same law will apply to fever, influenza, and others at a later age — density and infection do not obey the same law of proportionate increase: neither will Dr. Farr's formula, for mortality increasing according to a certain root of the density, apply to provincial towns.

Imprudent and early marriage, and inebriety have a certain value in the production of town mortality, but only to a slight extent, especially as to the former; the latter evil is not productive of so great an increase in the direct disease consequent upon it as materially to elevate town mortality over that of the country.

Atmospheric causes, those from malarious mischief, in this Paper are not entered upon to any extent: they have a variable value, which is balanced to a great extent by the higher rate of income and consequent improvement of sustenance.

The centralising system of this century is in itself not, therefore, it would appear, a great bane to the country; and yet towns kill considerably greater numbers of people than the country. There is an element of destruction which

sanitary movements have overshadowed — viz. "The special influence of occupation."

In this abstract, to simplify as much as possible, the town population is divided into groups: one-fifth consists of certain occupations not peculiar to towns, but common to the present state of society, viz., *out-door heavy occupations.* This class is amenable to the worst influence of town life, and without the advantage of high wages and consequent choice of abode and addenda to the necessities of life—its mortality in towns is yet only 17·5 in the 1,000, the lowest mortality of the kingdom being 15 in the 1,000. The other four-fifths consists mainly of the skilled operative and commercial and professional classes. The mortality of this section is caused by the skilled workers, and mostly so when constrained position is requisite. One main object of the paper is to draw attention to this special element of town mortality, the alteration in the normal proportion of respiration to circulation of the blood appearing to be the turning point from health to disease. This portion of the subject cannot be entered into without considerable detail, given in the Paper itself. One point appears to be prominent, viz., that in the endeavour to ventilate, cleanse, drain, and distribute our town population, the necessary employment to earn a *livelihood* in towns has carried with it the seeds of disease and death, and escaped to a great extent the notice of those able and philanthropic people who have devoted their energies to the best mode of increasing the health and prosperity of their fellow-labourers.

MICROSCOPICAL SECTION.

January 21st, 1862.

Professor WILLIAMSON, President of the Section, in the Chair.

Mr. William K. Deane was elected a Member of the Section.

A letter was read from Mr. H. A. HURST, late of Calcutta, making a donation to the Section of his entire collection of mounted microscopical objects, consisting of upwards of four hundred specimens; they comprise 90 slides of diatomaceæ; 100 of algæ, mostly marine; about 30 different kinds of starches, and the remainder an assortment of Desmidiæ, preparations of insects, bone sections, and a variety of other objects.

Mr. Hurst also presented a collection of specimens of Asiatic woods, in small blocks, obtained from the Horti-Agricultural Society of India at Calcutta. They consist of 98 specimens from Arracan; 76 from Upper Assam; 6 from Central India; 8 from the coast of Tenasserin; and 13 from Chittagong; 201 specimens of woods in all, most of them with the native names.

Capt. PENRICE, of the ship "*Pegasus*," from Shanghae, forwarded to the Section a number of soundings taken during his last voyage, amongst which may be noted one each from the mouth of the Yang-tse-Kiang river in China, coast of Borneo, Java; and a portion of mud, rich in foraminiferæ, from the anchor fluke, at Gaspar Island.

The Secretary laid on the table sixty specimens of soundings, which had been freed from the tallow "arming" in two evenings after business hours, at Mr. Dale's laboratory, by Mr. Dale, Mr. Dancer, and himself, assisted by Mr. Richard Dale. The system adopted is that described in Mr. Mosley's Paper, read to this Section on 21st January, 1861, published in the Quarterly Journal of Microscopical Science, vol. 1st, new series, p. 143, and is found to answer better than any other method yet made known.

Professor Williamson presented fourteen specimens of dredgings, supposed to be from the mouths of the Ganges.

A communication from Mr. A. G. Latham was read, upon the subject named for the evening's discussion, "On the cause of the metallic lustre on the wings of the Lepidoptera, both diurnal and nocturnal.

Mr. Latham believes that the metallic lustre may be simply referred to the presence of a pigment in the substance of the wing, in some cases light-absorbing, and in others light-reflecting; all the scales seem equally adapted for reflecting the prismatic colours, consisting of three distinct membranous films, covered with minute irregularities. Mr. Latham sent to be exhibited a number of slides for illustration.

A communication was read from Mr. Dancer, in which he referred to a paper, read by Sir D. Brewster at the last meeting of the British Association, containing the following remarks by Professor Dove :—

"In every case where a surface appeared lustrous there was "always a transparent, or transparent reflecting stratum of "much intensity, through which we see another body; it is "therefore externally reflected light in combination with "internally reflected or dispersed light, whose combined action "produced the idea of lustre. * * This effect we see "produced when many watch glasses are placed in a heap, or

"when a plate of transparent mica or talc, when heated red "hot, is separated into multitudes of thin layers, each of "which, of inconceivable thinness, is found to be highly "transparent, while the entire plate assumes the lustre of a "plate of silver."

Mr. Daneer sent for exhibition several pieces of tale, which in places, by the action of the blowpipe, had been heated to redness; the films were thereby separated, and the raised or blistered portion gave a metallie lustre like silver.

Mr. W. C. Unwin believed that the metallic lustre was due not to pigment but to the refleetion of light from internal surfaees of the seales through the transparent outer layer. The light so refleeted appeared to be modified in two ways—by the ribs or striæ; it was dispersed by them so that the seales were lustrous at various angles, and it was also in some eases eoloured by interferenee caused by them. Irideseenee appeared to be also produeed in some seales by the thinness of the laminæ through whieh the light was refraeted eausing interference. Mr. Unwin exhibited a number of specimens to illustrate his arguments.

Mr. Dale referred to beautifully eoloured films whieh arise upon various ehemieal solutions, the metallie brilliancy of which may arise from similar eauses.

Mr. Sidebotham observed that the metallie appearance was not due to any colouring matter in the scales, as ehemical agents, which destroy the eolourcd seales, have no effeet whatever on these metallie ones; he also mentioned a curious polarizing effeet produeed by erossing the metallie seales of Plusia braetea.

Mr. Sidebotham exhibited the metallie seales from Plusia orichaleea, Plusia braetea, Plusia festueæ, Plusia eoneha, &e., illustrative of his remarks.

It was ultimately resolved that the discussion should be adjourned so as to enable the proposer of the subject, and other gentlemen not present, to express their views.

Mr. Sidebotham also exhibited a new finder for high powers. It consists of squares formed by crossing lines, one hundredth of an inch apart, enclosing progressive numbers, executed by photography. He promised to prepare a number for the use of the members, all to be exactly alike

Mr. Joy exhibited a nose-piece, made for him nearly two years ago, consisting of a diaphragm plate, under which are screwed four objectives of different powers; the centreing is so true, that he can use the three-inch as a finder for the $\frac{1}{4}$ or even $\frac{1}{8}$-inch power. Several members of the Section have nose-pieces made upon the same principle.

Mr. Linton and Mr. Watson exhibited the tuft scales on the upper wing of the Peronea Cristana and others.

Ordinary Meeting, February 18th, 1862.

J. P. Joule, LL.D., F.R.S., President, in the Chair.

Henry Ashworth, Esq., The Oaks, Bolton, and Thomas Clarke, M.D., Wilmslow, were elected Ordinary Members of the Society.

Mr. Dyer made some remarks relative to the first invention of the electric telegraph, and read the following extract from Arthur Young's "Travels in France" (2nd edition), London, 1794, which proved that electricity had been employed at that early date for the purpose of transmitting intelligence.

"In the evening to Mons. Lomond, a very ingenious and inventive mechanic, who has made an improvement in the jenny for spinning cotton. Common machines are said to make too hard a thread for certain fabrics, but this forms it loose and spongy. In electricity he has made a remarkable discovery. You write two or three words on a paper; he takes it with him into a room, and turns a machine enclosed in a cylindrical case, at the top of which is an electrometer, a small fine pith ball: a wire connects with a similar cylinder and electrometer in a distant apartment, and his wife by remarking the corresponding motions of the ball, writes down the words they indicate, from which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance; within and without a beseiged town for instance, or for a purpose much more worthy, and a thousand times more harmless, between two lovers prohibited

or prevented from any better connection. Whatever the use may be, the invention is beautiful. Mons. Lomond has many other curious machines, all the entire work of his own hands. Mechanical invention seems to be in him a natural propensity."

A Paper was read "On the Present State of Meteorology," by Mr. Thomas Hopkins, M.B.M.S.

In this paper the Author represented that certain recent meteorological writers had abandoned the Hadleian theory,—of winds being caused by the ascent of sun-heated air in the tropical regions, and its passage through the upper atmospheric space, to descend in the polar regions, and return to the tropics. It was shown that great efforts had been made in different countries to discover the causes of those atmospheric disturbances which often take place, without much uniformity in the conclusions arrived at. From extensive researches made by American observers, Commander Maury had attempted to prove that near to each tropic there was the crest of a large atmospheric wave, from which air flowed down towards the equator on one side, and towards the pole on the other; and that light air ascended from the surface in both the polar regions. Numerous English registrations have been placed in the hands of Admiral Fitzroy, who has not, like Commander Maury, promulgated a new hypothesis, but has exhibited what he considers the general action of cyclonic storms in middle latitudes; this is, however, opposed to the Hadleian theory. Sir J. F. Herschel, in his elaborate work "On Meteorology," omits to notice the disturbing influence of the liberated heat of condensing vapour on the gases; but he also abandons the old theory of winds, and attributes them to the action of aqueous vapour in a new form. It is contended by the writer, that the great cause of atmospheric disturbance is to be found in the local heating of gases by the liberated heat of condensing vapour. It is then pointed out that the term "atmospheric wave" is founded on a false

analogy, and leads the mind in a wrong direction. To speak of storms coming *from* a certain quarter also misleads, as the cause of storms is to be found in the part towards which the wind blows. In conclusion it was suggested that aeronauts, when ascending into the higher regions to ascertain the state of the atmosphere in those regions, should, in addition to the ordinary instruments, use a wet bulb thermometer in conjunction with a dry one, in order that the hygrometrical state of the upper regions may be ascertained.*

A Paper was read entitled "Note on a Differential Equation," by ARTHUR CAYLEY, Esq., F.R.S.

The investigation was suggested by Mr. Harley's remarks on the Theory of the Transcendental Solution of Algebraical Equations, communicated to the Society at the meeting of the 4th February last.

The equation $y=u+ay^n$ (which is used instead of Mr. Harley's equation $y^n-ny+(n-1)\,x=0$) gives by Lagrange's theorem an expression for y in the form of an infinite series, and by means of his series it is shown that y satisfies the differential equation

$$\left\{u\frac{d}{du}\right\}^{n-1} y = na\left\{\frac{n}{n-1}\,u\frac{d}{du} - \frac{2n-1}{n-1}\right\}^{n-1} u^{n-1}y.$$

$\left([m]^{\nu}\text{ denotes as usual the factorial } m\,(m-1)\,..\,(m-\nu+1)\right)$.

It is remarked that the equation may be written in the form

$$\left\{a_0+a_1\,u\frac{d}{du}+a_2\,u^2\left(\frac{d}{du}\right)^2\cdots+a_{n-1}\,u^{n-1}\left(\frac{d}{du}\right)^{n-1}\right\}y=\frac{1}{na}\left(\frac{d}{du}\right)^{n-1}y$$

and the law of the coefficients is obtained.

* Mr. Welsh employed the wet bulb thermometer in his balloon ascents.—PHIL. TRANS., 1853. Pt. 3.—ED.

PHYSICAL AND MATHEMATICAL SECTION.

January 16th, 1862.

The following returns of the rain-fall for 1861 were communicated to the Section.

OLD TRAFFORD, MANCHESTER.

BY G. V. VERNON, F.R.A.S.

Receiving surface of guage, 3 feet above the ground.

1861.	Fall of Rain.	Difference from Dr. Dalton's 47 years' Average.	Days on which Rain fell in 1861.	Difference from 12 years' Average.
	In.	In.		
January	0·388	—1·869	10	—10·1
February	2·522	+0·079	17	+ 0·6
March	4·143	+1·835	25	+11·0
April	2·426	+0·312	10	— 3·5
May	0·734	—1·712	10	— 3·1
June	2·412	—0·279	17	+ 2·3
July	3·646	—0·060	25	+ 8·7
August	2·232	—1·231	15	...
September	4·050	+0·858	19	+ 5·8
October	1·230	—2·524	16	— 2·3
November	3·878	+0·156	20	+ 4·4
December	2·066	—1·371	15	— 3·1
Year	29·727	—5·796	199	

The rain-fall in 1861 was 6·803 inches below the fall of 1860, the fall in that year being 36·530 inches.

Rain fell upon 36 more days in 1860 than in 1861.

The months in which the rain-fall was the heaviest, viz., March, July, September, and November, were accompanied by an amount of barometric oscillation above the average.

Thelwall, near Warrington.

By John Atkinson, F.G.S.

1851.	Inches.	Days of Rain.	Days on which half an inch or upwards fell.
January	0·264	4	
February	2·711	13	8th, 21st.
March	4·276	25	2nd, 20th, 31st.
April	1·710	10	2nd.
May	0·705	10	
June	2·673	17	21st.
July	3·596	24	11th.
August	2·440	18	2nd, 22nd.
September	3·436	19	5th, 14th.
October	1·463	16	
November	3·665	20	5th, 25th.
December	1·986	15	6th.
	28·925	191	

Station, 96 feet above the mean level of the sea. Gauge, 18 inches above the ground.

The Flosh, Cleator, near Whitehaven.

By Thos. Ainsworth, Esq.

	Inches.	Days of Rain.	4 years' Mean.
			In.
January	3·107	18	4·922
February	4·442	17	3·008
March	6·492	28	4·923
April	0·765	10	2·471
May	1·340	12	2·314
June	4·142	16	3·396
July	5·260	22	3·605
August	7·377	24	5·879
September	4·832	21	4·694
October	3·052	18	5·777
November	8·780	23	4·232
December	4·517	26	4·728
	54·106	235	49·949

February 6th, 1862.

The following returns of the rain-fall for 1861 were communicated to the Section.

Sale, near Manchester.

By John Curtis, Esq.

	Fall.	No. of Days.
January	0·480	11
February	2·120	17
March	4·100	22
April	1·580	8
May	0·860	8
June	2·230	18
July	4·020	28
August	2·440	20
September	4·070	21
October	1·140	10
November	3·490	22
December	1·750	13
Year	28·580	198

Longsight, Manchester.

By J. Casartelli, Esq.

	Fall.	No. of Days.
January	0·260	4
February	2·660	14
March	5·260	19
April	1·290	4
May	0·650	6
June	2·120	18
July	3·890	24
August	1·870	11
September	3·950	19
October	1·430	10
November	3·910	18
December	2·040	14
Year	29·330	161

Mr. Vernon, F.R.A.S., read a Paper "On the Direction of the Wind at Manchester during the Years 1849 to 1861, at 8h. a.m."

The prevailing winds in the various months are as follows:—

Month.	Most Prevalent Winds.	Least Prevalent Winds.
January.....	S.W.	N., N.E.
February	S.W.	N., W.
March	S.W.	N.
April	N.E.	N.
May	N.E.	N.
June	S.W.	N.
July	S.W.	E.
August	S.W.	E.
September.....	S.W.	N.
October.....	S.W.	N.
November	S.W.	N.
December	S.W.	N.

The mean order of frequency of each wind is as follows:—

S.W. = 91·5 days per year.
N.W. = 56·0 do.
N.E. = 48·6 do.
W. = 42·0 do.
S. = 40·7 do.
S.E. = 38·7 do.
E. = 30·3 do.
N. = 16·3 do.

When these figures are referred to the four principal points only, we have

N = 68·6; E. = 74·0; S. = 105·8; W. = 115·8;

showing a gradual increase towards the W. The mean yearly direction appears to be exactly S.W.

When the directions of the wind are found for each season of the year, we arrive at the following facts:—

In the winter months, the S.W. wind predominates.

In the spring, the N.E. and S.W. predominate, and are nearly equal: the N.E. wind blows upon more days this quarter than any other.

In the summer quarter the S.W. wind prevails, and next comes the N.W. which has a greater prevalence this quarter than in any of the other quarters.

In the autumn the S.W. is the prevailing wind, next comes W., N.E., and N.W., which are nearly equal: the N.W. wind is at its minimum amount in this quarter.

When the winds are referred to the the four principal points only, we find the very marked prevalence of S. winds in winter: this wind occurring to a much greater extent in winter than in any other season. The E. winds of spring become also very prominent when the above method is adopted. With summer comes the great excess of W. winds, and diminution of E. winds. Autumn brings an increase of N. and E. winds, and a falling off of W. and S. winds.

Ordinary Meeting, March 4th, 1862.

J. P. Joule, LL.D., F.R.S., President, in the Chair.

The Rev. Robert Harley, F.R.A.S., made the following statement:—

I am induced by the interest and attention excited by my communication on the Theory of the Transcendental Solution of Algebraic Equations (see pp. 181—184 of the current volume of the *Proceedings*) to offer to the Society some supplementary observations on the subject.

The Boolian or symbolical form of the differential resolvent for the equation

$$y^n - ny + (n-1)\,x = 0 = f(y, x)$$

is, in general, (D denoting as usual the differential symbol $\frac{d}{d\theta}$, and ϵ^{θ} being written for the independent variable x,)

$$y - \phi(\mathrm{D})\ \epsilon^{(n-1)\theta}\ y = 0,$$

where

$$\phi(\mathrm{D}) = \frac{\left(\mathrm{D} - \frac{2n-1}{n}\right)\left(\mathrm{D} - \frac{3n-2}{n}\right)\left(\mathrm{D} - \frac{4n-3}{n}\right)\cdots\left(\mathrm{D} - \frac{n^2-n+1}{n}\right)}{\mathrm{D}\,(\mathrm{D}-1)\,(\mathrm{D}-2)\ldots(\mathrm{D}-n+2)}$$

The quadratic equation

$$y^2 - 2y + x = 0$$

is an exception; for, in this case the sum of the roots (Σy) is not, as in the other cases, equal to zero, and therefore the differential resolvent must contain a term independent of y. In fact, for this equation, the symbolical form of the resolvent is

$$y = \frac{\mathrm{D} - \frac{3}{2}}{\mathrm{D}}\,\epsilon^{\theta}\,y = \frac{1}{2\,\mathrm{D}}\,\epsilon^{\theta},$$

the sinister member of which, it will be observed, coincides with

$$y - \phi(\mathrm{D})\, \epsilon^{(n-1)\theta}\, y,$$

when in this formula we make $n=2$.

It is noteworthy that the fractions

$$\frac{2n-1}{n},\ \frac{3n-2}{n},\ \frac{4n-3}{n},\ \ldots\ \frac{n^2-n+1}{n}$$

which occur in $\phi(\mathrm{D})$, are in arithmetical progression, the common difference being $\frac{n-1}{n}$.

The form given at the foot of page 183 for the fourth differential coefficients may be simplified and brought into striking symmetric relation with the other forms by the elimination of x. In fact, writing

$$\frac{y\,(y^{n-1}-n)}{n-1}$$

for x, and reducing these results

$$\frac{d^4y}{dx^4} = \frac{n^3}{(n-1)^2}\, y^{n-4} \left\{ \begin{array}{l} (2n-1)\,(3n-1)\, y^{2(n-1)} \\ +4\,(n-2)\,(2n-1)\, y^{n-1} \\ +(n-2)\,(n-3) \end{array} \right\} \left\{ \frac{dy}{dx} \right\}^7$$

The relations among the differential coefficients may also be exhibited under the following forms, viz.

$$\frac{d^2y}{dx^2} = ny^{n-2}\left(\frac{dy}{dx}\right)^3,$$

$$\frac{d^3y}{dx^3} = n^2\, y^{n-4} \left\{ 2(n+1)y - (2n-1)x \right\} \left\{ \frac{dy}{dx} \right\}^5,$$

$$\frac{d^4y}{dx^4} = n^3\, y^{n-6} \left\{ \begin{array}{l} 3\,(n+1)\,(2n+1)\, y^2 \\ -2\,(2n-1)\,(3n+4)\, xy \\ +(2n-1)\,(3n-1)\, x^2 \end{array} \right\} \left\{ \frac{dy}{dx} \right\}^7.$$

I think it important also to notice a transformation of the differential resolvent for the biquadratic similar to that which

is known to lead directly to the solution of the cubic resolvent. If we change the independent variable by assuming

$$x = \frac{1}{\cos^{\frac{2}{3}} t},$$

we are conducted to the equation

$$2^2.3^3 \frac{\cos^3 t}{\sin t} \cdot \frac{d^3y}{dt^3} - 2^3.3^3 \cos^2 t \cdot \frac{d^2y}{dt^2} - \frac{3 \cos t}{\sin t} \cdot (29 - 32 \sin^2 t) \cdot \frac{dy}{dt} - 5y = 0$$

the complete integration of which will of course give the roots of the biquadratic.

In reference to the symbolical form of the biquadratic resolvent given in my last communication to the Society, Dr. Boole, in a letter to myself, under date Feb. 25th, 1862, (of which he kindly permits me to make this use), remarks, "I see how it could be solved by a definite integral; but that is not what we want, I presume. If it do not admit of resolution or reduction to forms recognized as primary in my theory, it must itself be considered as a new primary form, and then it constitutes a real addition to the theory of differential equations. So also," he adds, "for the quintic resolvent, which no doubt is a new form. If you have my *Finite Differences*, I would ask you to look at the conclusion of Chapter IX. I certainly thought that I had found all the primary forms for binomial equations, but it now seems that I had not." These remarks, from one who has contributed so largely to the theory of differential equations, will no doubt be read with pleasure by all who are interested in the progress of Algebra or the cultivation of the Calculus. It will, certainly, as Dr. Boole in a more recent letter to me (dated March 1st) observes, "Be a remarkable result if it should ultimately prove that the primary forms of integrable, linear, differential equations, stand in some close connexion with the solvable forms of algebraic equations."

Mr. HARLEY also laid before the Society the following communication from Mr. Cockle, dated Temple, February, 1862.

The theorem which I gave in my first paper, "On Transcendental and Algebraic Solution," in the *Philosophical Magazine* for May, 1861, viz., that the solution of an algebraic equation of the n-th degree, whereof the coefficients are functions of one parameter, depends upon that of a linear differential equation of the $(n-1)$ th order, may be applied to any algebraic equation whatever, without any preliminary modification of its coefficients. And the simplest, or nearly the simplest, form of the general process indicated in my second paper ("Supplementary Paper," *Philosophical Magazine* for February, 1862) with the above title is, as I have pointed out to Mr. Harley, obtained by treating all the coefficients as constant and multiplying the last into a parameter x, which is to be treated as the independent variable. Thus, given the quadratic

$$y^2+by+c=0,$$

we deduce, successively, from

$$y^2+by+cx=0,$$

the following relations :—

$$2y\frac{dy}{dx}+b\frac{dy}{dx}+c=0,$$

$$\frac{dy}{dx}=-\frac{c}{2y+b}=\frac{c\,(2y+b)}{4cx-b^2},$$

$$\frac{dy}{dx}-\frac{2cy}{4cx-b^2}=\frac{bc}{4cx-b^2},$$

$$y=\mathrm{C}\sqrt{4cx-b^2}-\frac{b}{2}.$$

In this expression x is to be made equal to unity, and the arbitrary constant C determined by substituting for y in the given quadratic, or by processes which will, I hope, soon be explained by Mr. Harley. For the general sextic I should be disposed to deal with the form (attainable by Mr. Jerrard's process, by vanishing groups, or by Mr. Sylvester's method),

$$y^6+3ey^2-6y+g=0,$$

transform it into

$$y^6+3ey^2-6y+gx=0,$$

and proceed as before. Or we might start at once with

$$y^6+3ey^2-6y+5x=0,$$

and regard x as the independent variable, and e as constant.

The simplicity and beauty of the results obtained by Mr. Harley in the case of trinomial biquadratics and quintics suggested to me the following investigation, which I think I communicated to him some months ago. Let

$$\frac{d^n y}{dx^n} = \Sigma\, A_r\, x^r \frac{d^r y}{dx^r},$$

r being taken from 0 to n, and A being constants. Then n particular integrals are obtained from the formula

$$y=\Sigma u_z\, x^{m+nz}$$

by giving to m the values 0, 1, 2,. .n, successively; z being taken from 0 to ∞, and u being defined by

$$\frac{u_{z+1}}{u_z} = \frac{\mathrm{P}}{\mathrm{Q}}$$

where

$$\mathrm{P}=\Sigma\, A_r\, \pi_r\, (m+zn),$$

$$\mathrm{Q}=\pi_n \left\{ m+(z+1)n \right\}.$$

The symbol π here introduced is such that

$$\pi_r\, l=l\ (l-1)\ (l-2)\ldots(l-r+1)$$

is its defining relation.

Mr. Robert Rawson, Honorary Member, read the First Part of a Memoir of the late Professor Eaton Hodgkinson, F.R.S. Thanks having been given to Mr. Rawson, on the motion of Mr. Binney, seconded by Dr. Smith,

The Rev. Mr. Kirkman said, "It is no ordinary renown that the late Professor Hodgkinson secured to himself, and for ever will reflect on Manchester. It is a great thing to outstrip one's cotemporaries in commercial competition, and to accumulate fairly-gathered wealth; it is a great thing to

win university distinctions, and to grow old in the plenitude of college dignities; it is a great thing to wear civic honour, and to enjoy, for any good reason, a social celebrity; but Hodgkinson aspired to more. He thirsted for enduring and world-wide fame, and he has won it. How few are there of the young men of this ardent and crowded Lancashire, even of those who may achieve what are esteemed the greatest successes of life, who will find, when their hair is grey, that their names are printed year by year as seals of science in the industrial manuals of all civilized nations! Hodgkinson diminished instead of increasing his little patrimony, in the search of truth equally abstruse and beneficent; but this proud memory he has left behind him—that, go where you will in any clime of earth, if you meet a man fit to give counsel about constructions, and to take the command of labour, he will have in his breast pocket a little book, in which many of the most precious oracles and most pregnant formulæ are stamped with the great name of Hodgkinson. And this is fame—fame that will grow higher and speak louder, as the world grows happier and wiser. For ages and for ages the discoveries of Hodgkinson will economize millions of treasure to the governments and the nations of the globe, and prevent the destruction of innumerable lives."

A Paper by Professor W. Thomson, LL.D., F.R.S., Honorary Member, was read, entitled "Observations on Atmospheric Electricity."

I find that atmospheric electricity is generally negative within doors, and almost always sensible to my divided ring reflecting electrometer. I use a spirit lamp, on an insulated stand a few feet from walls, floor, or ceiling of my lecture room, and connect it by a fine wire with the insulated half ring of the electrometer. A decided negative effect is generally found, which shows a potential to be produced in the conductors connected with the flame, negative relatively

to the earth by a difference amounting to several times the difference of potentials (or electro motive force) between two wires of one metal connected with the two plates of a single element of Daniell's. I have tested that the spirit lamp gives no *idio-electric* effect amounting to so much as the effect of a single cell. The electric effect observed is therefore not due to thermal or chemical action in the flame. It cannot be due to contact electrifications of metallic or other bodies in conductive communication with the walls, floor, or ceiling, because the potentials of such must always fall short of the difference of potentials produced by a single cell. I have taken care to distinguish the observed natural effect from anything that can be produced by electrical operations for lecture or laboratory purposes. Thus I observe generally in the morning before any electrical operations have been performed, and find ordinarily results quite similar to those observed on the Monday mornings when the electrical machine has not been turned since the previous Friday. The effect, when there has been no artificial disturbance, has *always been found negative, except two or three times*, since the middle of November; but trustworthy observations have not been made on more than a quarter of the number of days.

A few turns of the electrical machine, with a spirit lamp on its prime conductor, or a slightly charged Leyden phial, with its inside coating positive put in connection with an insulated spirit lamp, is enough to reverse the common negative indication. Another very striking way in which this may be done is to put a *negatively charged Leyden phial* below an uninsulated flame (a common gas burner, for instance). The flame, becoming positively electrified by induction, keeps throwing off, by the dynamic power of its burning, portions of its own gaseous matter, and does not allow them to be electrically attracted down to the Leyden phial, but forces them to rise. These, on cooling, become,

like common air, excellent non-conductors,* and, mixing with the air of the room, give a preponderance of positive influence to the testing insulated flame (that is to say, render the air potential positive at the place occupied by this flame).

Half an hour, or often much more, elapses after such an operation, before the natural negatively electrified air becomes again paramount in its influence on the testing flame.

That either positive or negative electricity may be carried, even through narrow passages, by air, I have tested by turning an electric machine, with a spirit lamp on its prime conductor, for a short time in a room separated from the lecture room by an oblique passage about two yards long, and then stopping the machine and extinguishing the lamp, so as to send a limited quantity of positive electricity into the air of that room. When the lecture room window was kept open, and the door leading to the adjoining room shut, the testing spirit lamp showed the natural negative. When the window was closed, and a small chink (an inch or less wide) opened of the door, the indication quickly became positive. If the door was then shut, and the window again opened, the natural effect was slowly recovered. A current of air, to feed the lecture room fire, was found entering by either door or window when the other was shut. This alternate positive and negative electric ventilation may be

* I find that steam from a kettle boiling briskly on a common fire is an excellent insulator. I allow it to blow for a quarter of an hour or more against an insulated electrified conductor, without discovering that it has any effect on the retention of the charge. The electricity of the steam itself, in such circumstances, as is to be expected from Faraday's investigation, is not considerable. Common air loses nearly all its resisting power at some temperature between that of boiling water and red hot iron, and conducts continuously (not, as I believe, is generally supposed to be the case, by disruption) as glass does, at some temperature below the boiling point, with so great ease as to discharge any common insulated conductor almost completely in a few seconds.

repeated many times without renewing the positive electricity of the adjoining room by turning the machine afresh.

The out of doors air potential, as tested by a portable electrometer in an open place, or even by a water dropping nozle outside, two or three feet from the walls of the lecture room, was generally on these occasions positive, and the earth's surface itself, therefore, of course, negative;—the common fair weather condition, which I am forced to conclude is due to a paramount influence of positive electricity in higher regions of the air, notwithstanding the negative electricity of the air in the lower stratum near the earth's surface.

On the two or three occasions when the in-door atmospheric electricity was found positive, and, therefore, the surface of the floor, walls, and ceiling negative, the potential outside was certainly positive, and the earth's surface out of doors negative, as usual in fair weather.

SECTION FOR STATISTICS AND SOCIOLOGY.

February 11th, 1862.

Dr. Angus Smith, F.R.S., in the Chair.

Mr. David Chadwick, F.S.S., read a paper "On the Responsibilities of Trustees in regard to Charity and other Public Funds."

Mr. Chadwick considered the great importance of this question, in regard both to its social and statistical bearings, well worth the earnest consideration of the Section.

He referred to the rule of law that the Sovereign, as *parens patriæ*, is the guardian of all charities, and the Attorney-General, at the relation of an informant, may file an information in the Court of Chancery, to restore any abused or dilapidated foundations; and also to the various acts in relation to charitable trusts, and to the powers and duties of the charity commissioners.

Mr. Chadwick then referred to the duties of trustees in relation to public hospitals, schools, religious endowments, sick, burial, and trade societies; savings banks, charities distributed in money, food, and clothing, &c. And he held that, in consequence of the legislature not requiring all *trustees* to "give an account of their stewardship" in a clear, open, and satisfactory manner, many charities had been lost, and many had been seriously impaired.

Reference was made to some of the principal charities of Manchester and Salford, and the mode of their management by trustees, and of their distribution; and it was strongly recommended that the *trustees*, as well as the *distributors*,

should in all cases publish an account of their income and disbursements; that whenever trustees released, renewed, or sold charity property, the particulars should be duly reported and published with the annual statement of accounts. This is in some cases done, but is not in all.

Where the property was in land and held in leases, and renewed by trustees, it was very important that the terms of the renewal of all such leases should be published.

Mr. Chadwick quoted the instance of the "*Accounts of the Queen in regard to Her Duchy of Lancaster*" as a good instance of a published account of trustees, represented by the Duchy Court, in which the rent, terms, and conditions of each tenant are set forth.

Mr. Chadwick also called attention to the *account* required to be kept by all joint-stock companies, as a good step in the right direction.

He recommended PUBLICITY in every way as the first and main condition, an exact form of accounts, an annual report of proceedings, and the acknowledgment of the principle by public trustees as part of their duties and responsibilities of "*public accountability.*"

MICROSCOPICAL SECTION.

February 17th, 1862.

Professor WILLIAMSON, F.R.S., President of the Section, in the Chair.

Soundings were acknowledged from Captain W. B. Hall, of the P. and O. S. S. "*Tagus*," taken off Ushant, Coast of France, and from Captain J. R. Husband, ship "*Florence Nightingale*," taken off the Coasts of Patagonia and Tierra del Fuego.

Professor WILLIAMSON called the attention of the section to the new rotifer (Cephalosiphon Limnias), recently discovered by Mr. H. J. Slack, in a pond at Hampstead, and an account of which appeared in No. 1 of the *Intellectual Observer* of the present month. Attention was specially directed to the fact, that the animal only possesses *one* of those organs that have been designated "respiratory tubes," "calcars," and "tactile organs;" whereas, the Floscularian Rotifera, when furnished with them, have two. It remains to be ascertained from a study of the embryo, whether this is the typical condition in the Cephalosiphon, or whether there were primarily two, the missing one having been suppressed during the development of the embryo, as sometimes occurs amongst higher animals.

The SECRETARY read a Paper, by Mr. Thomas Davies of Warrington, on Crystallisation.

Mr. Davies treats more particularly upon some of the double salts, which show beautiful combinations of form and

colour by polarised light; and upon his method of obtaining determinate flower-like forms, surrounded by a film of the uncrystalised salt. The novelty of the author's system, consists in the following particulars:—he makes a nearly saturated solution, say of the double sulphate of copper and magnesia; he dries rapidly a portion on a glass slide, allowing it to become so hot as to fuse the salt in its water of crystalisation; there then remains an amorphous film on the hot glass. On allowing the slide to cool slowly, the particles of the salt will absorb moisture from the atmosphere, and begin to re-arrange themselves on the glass, *commencing from points*. "If then placed under the microscope," says the the Author, "we shall see points starting up here and there, "and from those centres, the crystals may be watched as they "burst into blossom, and spread their petals on the plate." Starting points may be made at pleasure by touching the film with a fine needle, to enable the moisture to get under it; but this treatment renders the centres imperfect. If allowed to go on, the crystals would slowly cover the plate, or if breathed upon, they form immediately; whereas, if it is desired to preserve the flower-like forms on a plain ground, as soon as they are large enough, development is suspended, by again applying gentle heat; the crystals are then covered with balsam and thin glass, to be finished off as usual. The balsam must cover the edges of the film, or moisture will probably get under it, and crystallisation go creeping on.

Many crystals which produce similar forms, cannot be preserved in balsam; in the hyposulphite of soda they are very fine, and the Author is endeavouring to preserve them in castor oil.

Mr. SIDEBOTHAM referred to the vegetable forms produced by Mr. Petschler, with bichromate of potash in gelatine, exhibited at the British Association Microscopical Soiree. Since then flower-like shapes had been obtained from nitrate of silver amongst the ramifications of the bichromate; as it

is an interesting subject, he should endeavour to bring it before the next meeting.

The discussion "On the cause of metallic lustre upon the wings of the Lepidoptera" was resumed. Mr. Latham stated that he saw no reason to alter the views he had expressed; but since the last meeting Mr. Watson had called his attention to an article in the "Annales des Sciences Naturelles" for February, 1835, by Bernard Dechamps, "Sur les Ailes des Lepidopteres," which contains much information upon the scales and the cause of their brilliance; he (Mr. Latham) had translated and printed extracts from the paper; copies were handed round to the members present, and may be had (gratis) at the Society's rooms, or from the Secretary of the Microscopical Section.

A Paper was read by Dr. Thomas Alcock "On the Tongues of Mollusca."

The Author remarked upon the great variety and beauty of these objects, and pointed out their scientific value as a help in the classification of shells. On investigation the tongues were shown to arrange themselves into four groups, according to the pattern or type of the lingual dentition, and these groups were stated to correspond with four of the orders established by Cuvier, on the characters of the breathing organs. The four orders illustrated were the Pectinibranchiata, the Scutibranchiata, the Cyclobranchiata, and the Pulmonata; and he believed that, on the evidence of the teeth, it will be necessary to re-establish the order Cyclobranchiata as distinct, instead of including it in the Scutibranchiata, as is done by our latest authorities.

The Author had examined many specimens of Buccinum undatum of both sexes, a series of which were exhibited to prove that the number of points on the central teeth in this

species varies from five to seven, but without reference to sex. The very close agreement both in the lingual teeth and in the general internal anatomy of Fusus and Buccinum was mentioned, and a doubt was expressed as to the propriety of their wide separation in our present systems of classification. The association of Fusus with Murex, and of Purpura with Buccinum, was also commented upon, and shown by the evidence of the tongues, as well as the general anatomy of the animals, to be clearly incorrect.

In conclusion, some remarks were made on the method used by the Author, of extracting the tongues from the different kinds of mollusca, illustrated by specimens, some of which were many times longer than the bodies of the animals, being coiled up near the neck, and brought forward as the teeth are worn away. The Paper was illustrated by beautifully executed drawings of the different types, and a series of dissected animals.

Professor Williamson asked the Author if he proposed to include the Chitons in the order Cyclobranchiata.

Dr. Alcock was satisfied the Chitons ought not to be so placed; but, judging from the general character of their teeth, he thought they might possibly remain with the Scutibranchiata, or perhaps it would be necessary to establish a new order expressly for them.

Professor Williamson was glad to learn that this was the result of Dr. Alcock's observations; for the animals certainly appeared very distinct, and the Chitons, which he remarked have the form of a gigantic woodlouse, were evidently not Cyclobranchiata, as they have a separate gill down each side of the body.

On adjourning to the microscopes, Dr. Alcock exhibited mounted specimens of tongues from thirty different species of Gasteropoda, with the shells from which they were extracted. One of the lingual ribands was two and a half inches long.

Mr. Latham exhibited scales from the wings of the Catarrhactes Papua, a Penguin from the Falkland Islands, which appear to be intermediate between feathers and scales.

Mr. Edward Lund exhibited two forms of stands for holding a microscope, condenser, lamp, &c.; one in the form of a tray fixed on four castors, to run upon an ordinary table, and the other a small round turn-table, thirty inches high and fifteen inches diameter. The lamps were for paraffin oil, fitting into wooden cups secured to the stands.

Ordinary Meeting, Mareh 18th, 1862.

J. C. Dyer, Esq., Viee-President, in the Chair.

The following eommunication from Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S., &e., Honorary Member of the Soeiety, was read by Mr. Baxendell: —

In the report of the Ordinary Meeting of the Literary and Philosophical Society for February 18, 1862, I find an abstraet of a paper "On the Present State of Metcorology," by Mr. T. Hopkins, M.B.M.S., in which he is reported to state that in my reeent work on Metcorology I "omit to notiee the disturbing influenee of the liberated heat of eondensing vapour on the gases," and also that in that work I "abandon the old theory of winds" (meaning, I presume from the eontext, the Hadleian theory,) "and attribute them to the aetion of aqueous vapour in a new form."

With regard to the former of these two statements I beg to refer to Art. 53 of that work, where, alluding to the condensation of the vapour in the atmosphere, it is remarked that "in every ease, such condensation is accompanied with a mitigation of cold *at the point where it actually takes place.*" What effect beyond this the eondensation of vapour can produce on the gases I am at a loss to understand. It can in no case give rise to an actual elevation of temperature *above* that of the mixture of air and vapour which may be introduced into any mass of cold air and which may thereby effect a partial condensation. It can only act in mitigation of the chilling effect of such admixture on the introduced portion which would arise were the vapour not condensed. Inasmuch, however, as its condensation and precipitation as rain diminishes *pro tanto* the total barometric pressure, and therefore allows both air and vapour to flow in from other quarters,

such condensation may, and no doubt does aid in producing atmospheric movements. See *Meteor.*, Arts. 165, 171.

But as respects the statement that I abandon the Hadleian theory of the winds, I can only say that nothing is farther from my thoughts, and that I must protest against any such mode of expressing my views. It is true that in describing the *modus operandi* in which the sun's heat, acting on the equatorial regions of the earth, ocean, and air, produces that ascentional movement and overflow of the atmosphere which is what Hadley assumes as the *primum mobile* of his theory, I have (*Meteorol.*, Arts. 54, 55, 58) brought expressly and prominently into view the very considerable share which the generation and ascent of vapour has in producing that result, but without ignoring or in any way unduly depreciating the effect of the rarefaction of the air itself. On the contrary, it is expressly said (Art. 55), "The general effect" (of the two causes) "is similar, and as the sun cannot generate vapour without at the same time heating the air, it is impossible to separate their dynamical effects. Whether the air go forth from its place *proprio motu* or be jostled out of it by the introduction of a lighter medium, the local relief of pressure is equally produced." When Hadley wrote, the distinction between air and vapour was not recognised. He took the atmosphere *en masse* and attributed to it an ascentional movement due to the heat of the sun, by the process of "rarefaction;" and this, so worded, remains true, although such rarefaction be a more complex process than he understood it to be.

The displacement of air by vapour, the disturbance of statical equilibrium, and the dynamical effects consequent thereon, are no new principles in meteorology. They have been strongly insisted on, and, if I may venture to say so, rather over insisted on, and with a premature air of reduction to computative precision, by Daniell in his Meteorological Essays, and perhaps hardly enough insisted on in my work

on Meteorology which has given occasion to Mr. Hopkins's remarks. I would take this opportunity, however, to call the attention of meteorologists to the very extraordinary and abnormal features of the last two years as strongly illustrative of the important part this element of meteorological dynamics has been playing in their production. The great outbreak of the solar spots occurred in the year 1859 with unusual suddenness, and on the 1st of September in that year phenomena were exhibited in its photosphere indicative of a most remarkable state of excitement, accompanied with magnetic and auroral disturbances of unprecedented intensity and duration. This occurred as the sun was passing southward across the equator, and from the accounts received from Australia, the southern summer of that year 1859-60 appears to have been one of very unusual heat. The quantity of vapour thrown into the atmosphere during that summer from the southern ocean would seem not yet to have been got rid of, and to have given rise to diversions of the aërial currents both of air and vapour from their normal courses which have not even yet subsided into their regular and habitual train. I throw out this, however, rather as a suggestion which I consider worthy of further examination by the light of meteorological records and returns collected on a very large scale, than as having myself arrived at any definite conception of the actual steps of the process that has been going forward.

Mr. Baxendell, in illustration of the remarks in the latter part of Sir John Herschel's communication, read the following extract of a letter dated at sea, near Ceylon, January 30th, 1862, which he had received from Mr. Thomas Heelis, F.R.A.S., who sailed from England for Calcutta on the 18th of November last:—

"We have had very peculiar and unsatisfactory trade winds; we ran down inside of Madeira and the Cape de

Verde Islands, and had the north-east trade almost the whole way down at E.S.E. Our south-east trade, which we picked up in the Bight of Benin, came out at S.S.W., but we afterwards on going to the S.W. got it in its proper direction. We were on the skirts of three cyclones between the Cape and Amsterdam Island; and there have been within the last week evident indications from the set of a heavy swell that another cyclone is now running down to the Mauritius. The result is, that although we have had trade wind clouds, we have had no S.E. trades in the Indian Ocean, and we are now, and have for some days been in the N.W. monsoon, and have been nearly boiled by its warm damp atmosphere. The Captain has told me that for days since leaving the Cape he has not known what to make of the weather, and his experience of these seas (which is great) has only served to puzzle him. This leads me directly to a point which bears strongly upon the theory of hurricanes, and which I want you to put in train. All old seamen agree that the trade winds are variable in force and direction. I should be glad if Mr. Mosley, or some one who is from time to time in communication with Capt. Maury, would try to get him to discuss his collection of above 500,000 trade wind observations in order of time, as this question bears directly upon that of which I have spoken to you, viz., the perturbations, so to speak, of the hurricane orbits of the West Indies, by which their tracks sometimes pass over St. Domingo and sometimes do not."

Dr. Joule made a communication "On the Probable Cause of Electrical Storms."

The very close correspondence between the theoretical rate of cooling in ascending, and the actual, indicates a rapid transmission of the atmosphere from above to below, and *vice versa*, continually going on. We may believe that during thunderstorms this interchange goes on with much

greater than ordinary rapidity. At a considerable distance from the thundercloud, where the atmosphere is free from cloud, the air descends, acquiring temperature according to the law of convective equilibrium in dry air. The air then traverses the ground towards the region where the storm is raging, acquiring moisture as it proceeds, but probably without much diminution of temperature, on account of the heated ground making up for the cold of evaporation. Arrived under the thundercloud, the air rises, losing temperature, but at a diminished rate, owing to the condensation of its vapour to form part of the immense cumulus cloud which overcasts the sky on these occasions. The upward current of air carries the cloud and incipient rain drops upwards, but presently, in consequence of the increased capacity of the mass from the presence of a large quantity of water, the refrigeration of the air, in consequence of its dilatation, will be so far diminished as to prevent the condensation of fresh vapour, and ultimately to redissolve the upper portion of the cloud. This phenomenon, which has been noticed by Rankine in the cylinder of the steam engine, will account for the defined outline of the upper edges of cumulus clouds. The upward current no doubt extends occasionally to regions below the freezing temperature. If cloud be carried with it, snow or hail will be formed, which, if sufficiently abundant, will pass through the cloud and fall to the ground before it is melted. Now, the dry cold air in which the snow and hail are formed is a perfect insulator. Ice has also been proved, by Achard, of Berlin, to be a non-conductor and an electric. Even water, in friction against an insulator, is known from the experiments of Armstrong, explained by himself and Faraday, to be able to produce powerful electric effects, and this fact has been suggested by Faraday to explain powerful electric effects in the atmosphere. Sturgeon has noted the remarkable development of electricity by hail showers. Few heavy thunderstorms occur without the fall

of hail. Hail, whether in summer or winter, is almost, if not invariably, accompanied with lightning. In the presence of these facts, it seems not unreasonable to consider the formation of hail as essential to great electrical storms; although, as has been pointed out by Professor Thomson, very considerable electrical effects might be expected from the negatively charged air on the surface of the earth being drawn up into columns, and although, as the same philosopher has observed, every shower of rain gives the phenomena of a thunderstorm in miniature. The physical action of insulators and electrics in mutual friction must certainly produce very marked effects on the grand scale of nature. If we suppose that the falling hail is electrified by the air it meets, the electrification of the cloud into which the hail falls might thus be constantly increased until the balance between it and the inductively electrified earth is restored by a flash of lightning. If the hail is negatively electrified by the dry air with which it comes in contact, the latter will float off charged with positive electricity, which may account for the normal positive condition of the atmosphere in serene weather, as well as the electrification of the upper strata evidenced by the aurora borealis. The friction of wind has been supposed by Herschel to contribute to the intense electrification of the cloud which overhangs volcanoes during eruption.

Dr. Thomas Alcock read a Paper "On the Tongues of Mollusca." [An abstract of this Paper will be found in the report of the Microscopical Section, Proceedings No. 12.]

Dr. Crace Calvert stated that one of the difficulties which Dr. Alcock had encountered in his extensive and laborious researches, namely, that of preserving his specimens from putrefaction, would be overcome by the use of a saturated solution of pure carbolic acid, taking care that a small excess of this powerful antiseptic should also remain at the bottom of

the vessel in which the anatomical preparations were preserved. His authority was Dr. De Morgan, of the Middlesex Hospital, who stated to him a few days since that he had succeeded by that means in preserving classes of animals which all other means had failed in preserving, namely, Molluscæ, Zoophytes, and Acalephæ.

Dr. Calvert also read a Paper "On the Employment of Galvanized Iron for Armour-plated Ships."

The Author stated that no doubt many gentlemen present were acquainted with the fact that he had been for some time past engaged in ascertaining the chemical composition of various woods employed and susceptible of being employed in the navy. On a recent visit to one of the dockyards he found that while the armour-plates were fixed against a layer of teak, the ribs of the ship were of oak, and that the iron bolts which were to fasten the plates were to pass through the oak ribs. It occurred to him that the inconvenience which would probably result from the action of the oak upon the iron might be obviated by substituting galvanized iron bolts for those now in use, and he therefore instituted a series of experiments, the results of which he had great pleasure in laying before the meeting.

The first series of experiments consisted in having driven through large pieces of oak, bolts and screws of iron and galvanized iron prepared by his friends, Messrs. Richard Johnson and Brother, of Dale-street, Manchester, which were then immersed in soft and sea water for the last three months. The results clearly showed, first, that the friction did not remove the zinc from the galvanized iron; secondly, that the oak and galvanized bolts were unchanged; whilst in the case of the iron bolts, they were much rusted, and the pieces of oak had become quite black by the formation of tannate and gallate of peroxide of iron. During the experiments the waters were changed every week, and those containing the galvanized iron

appeared unchanged, whilst in the case of the iron, they had a dark blue-black appearance, owing to the formation of gallate and tannate of iron.

In order to ascertain the comparative action of soft and salt water upon iron and galvanized iron when in contact with oak under identical circumstances, he made the following series of experiments.

Plates of galvanized iron having 18 inches of surface lost during three months the following weights:—

	SOFT WATER.	SEA WATER.
Plate No. 1....	0.10 grains.	——
„ No. 2....	0.11 „	——
„ No. 3.....		0.095 grains.
„ No. 4.....		0.090 „

Similar plates of iron lost during the same time:—

	SOFT WATER.	SEA WATER.
Plate No. 1....	1.23 grains.	——
„ No. 2....	1.52 „	——
„ No. 3.....		2.40 grains.
„ No. 4.....		2.38 „

There can therefore be no doubt that galvanized iron offers great advantages, the action of water on it being less than a tenth of the same action on ordinary iron. As there is no doubt that iron when galvanized is in the most favourable electrical condition to resist the action of oxygen, being in an electro-negative condition, it follows that in all probability the use of galvanized iron would be very advantageous in armour-plated and other iron ships. The Author hoped that Government and other large ship builders would avail themselves of this suggestion, and make experiments on a large scale to verify the results he had obtained.

PHYSICAL AND MATHEMATICAL SECTION.

February 27th, 1862.

Mr. Baxendell, F.R.A.S., read a Paper "On the Relations between the Decrement of Temperature on Ascending in the Atmosphere and other Meteorological Elements."

According to the theory which attributes the production of winds and storms to upward currents of air, caused by the heat liberated during the condensation of aqueous vapour into clouds and rain, the rate of decrease of temperature on ascending in the atmosphere ought to be less in rainy than in fair weather; and the reasonings and calculations of Dr. Wm. Thomson, in his valuable Paper "On the Convective Equilibrium of Temperature in the Atmosphere," lately read to the Society, point to the same conclusion; but in a Paper entitled "Remarks on the Theory of Rain," read to the Section on the 29th of March, 1860, the Author gave some results derived from a discussion of the Greenwich and Oxford observations, which seemed to militate against this theory, and reference was made to the fact stated by Kæmtz and others, that the diminution of temperature on ascending in the atmosphere is more rapid in rainy than in fine weather. It appears, however, that this fact is not generally admitted by meteorologists, as the observations from which it is derived were mostly of a desultory nature, and continued for only short periods of time. The Author, therefore, thought that a discussion of the monthly results of the observations made during the years 1848-58, at Geneva and on the Great St. Bernard, given by Mr. Vernon in his valuable Paper "On the Irregular Barometric Oscillations" at those places, might throw some light on the subject, and, at the same time, serve to indicate the relations which exist between the decrement of temperature and other meteorological elements, a branch of meteorology which has hitherto been almost entirely neglected.

Tables are given, containing the comparisons of the

monthly differences of temperature between the two stations, with the mean temperature, rain-fall, amount of barometric oscillation, and height of the barometer.

The final results derived from these comparisons may be stated as follows: —

1. On the average of the year a decrement of temperature below the mean is accompanied by a rain-fall and amount of barometric oscillation *below* the mean, and by a mean temperature and barometric pressure *above* the mean.

2. A decrement of temperature above the mean is accompanied by a rain-fall and amount of barometric oscillation *above* the mean, and by a mean temperature and barometric pressure *below* the mean.

3. A decrement of temperature above the mean for the season is due to a cooling of the higher strata of the atmosphere, and not to a heating of the lower strata.

4. The production of rain is attended with a diminution of the general temperature of the atmosphere, the diminution being greater in the higher than in the lower strata. This result, therefore, agrees with that which the Author had previously derived from a discussion of the Greenwich and Oxford observations; and it indicates clearly the influence of a cooling agency sufficiently powerful to neutralise completely the effects of the heat supposed to be liberated during the condensation of aqueous vapour into rain.

The Author remarks that from the relations established by this investigation it may be concluded that in a mass of air moving from a higher to a lower latitude and acquiring an increase of temperature, the change of temperature is more rapid in the lower than in the higher strata; while on the contrary, in a mass moving from a low to a high latitude and losing heat, the change is most rapid in the upper strata. It also seems probable that one of the essential conditions in the formation of a rotatory or cyclonic storm is a greater difference of temperature than usual between the successive strata of the atmosphere at the point where the storm originates.

Ordinary Meeting, April 1st, 1862.

J. P. Joule, LL.D., F.R.S., President, in the Chair.

Mr. David Joy was elected an Ordinary Member of the Society.

Mr. Frederick N. Dyer and Mr. Samuel Cottam were appointed Auditors of the Treasurer's accounts for the present Session.

A letter from Dr. Fairbairn, F.R.S., was read, enclosing a dried specimen of a fibrous bulb which he had received from Mr. James Niven, of Jeffrey's Bay, Human's Dorp District, Cape of Good Hope. In a letter, dated 17th February, 1862, Mr. Niven says, "I enclose a leaf and some of the fibre of a very fibrous wild bulb, very plentiful in this country, and, if of any commercial value, a large quantity in the leaf could be exported annually. The sample is not a fair one, as the bulb is not matured at this season, and has only its outermost leaf dry. I think the fibre is stronger in the matured bulb. I do not know its botanical name. In the Dutch of the country it is called Maager-man boll (Slender-man bulb), probably from its tall and slender flower stem, which sometimes attains the height of six feet. The bulb resembles an onion."

Mr. Binney, after examining the specimen, said that it had always appeared to him most strange for a large manufacturing town like Manchester to be without a museum, in which should be deposited all the new raw products, whether of animal, vegetable, or mineral origin, that were from time to time discovered. At the present time, when public attention was directed to the supply of cotton, the want of such a collection was peculiarly felt. If the Chamber of Commerce

and the merchants would use their influence in collecting specimens, and the town provide a museum for their reception, this Society might appoint committees of scientific men to report on the uses for which such products were best suited, and the result of their labours might be published. Up to this time commerce had not sought the aid of natural history and chemistry to the extent which it might have done. For a commencement the Natural History Society would probably afford the use of a room, in which the specimens could be exhibited.

Mr. Alfred Fryer stated that he had recently been making a series of experiments with the oxyhydrogen light, with a view to determine what substance made incandescent produced the greatest amount of light. He operated on various salts of calcium, magnesium, strontium, barium, and also upon some other substances. The best results were obtained from magnesium. The sulphate of magnesia, when baked, yielded a bright light, but was decomposed by the heat; and the sulphurous acid escaping was very unpleasant. Calcined magnesia succeeded the best of all; but when the powder was used, the gases blew it away. When the powder was mixed with water, and afterwards dried, the cake was friable; and when the dry powder was pressed in a mould by means of hydraulic pressure, the cake split up into laminæ when subjected to the gases. After many experiments with the materials in different proportions, it was found that sulphate of lime one part, and calcined magnesia two parts, mixed with water and modelled into a cake and dried, produced the best results. This, however, is not all that could be desired, as in time the cake becomes cracked and fissured by the gas. The illuminating power is to that of lime, pressure and volume of gas being equal, as 54 is to 27. The experiments have been conducted with oxygen and the coal gas supplied to Manchester. The jet used is a form

supplied by Mr. Dancer, a jet of oxygen being surrounded by an annular jet of the coal gas. Mr. Dancer has further improved the jet by allowing the oxygen pipe to project beyond the hydrogen, and by not contracting the aperture of the hydrogen pipe.

Mr. Alfred Fryer exhibited the light which he had explained, and the effect produced was very striking.

Professor Roscoe read the following communication, by Professor Clifton and himself, entitled, "On the Effect of Increased Temperature upon the Nature of the Light Emitted by the Vapour of certain Metals or Metallic Compounds."

In a letter communicated to the *Philosophical Magazine* for January last, we stated that in examining, with Steinheil's form of Kirchhoff and Bunsen's apparatus, the spectra produced by passing the induction spark over beads of the chlorides and carbonates of lithium and strontium, we had observed an apparent coincidence between the blue lithium line, which is seen only when the vapour of this metal is intensely heated, and the common blue strontium line called Sr δ. We further stated that on investigating the subject more narrowly by the application of several prisms and a magnifying power of 40, we came to the conclusion that the lithium blue line was somewhat more refrangible than the strontium δ, but that two other more refrangible lines were observed to be coincident in both spectra. Having constructed a much more perfect instrument than we at that time possessed, we are now able to express a definite opinion on the subject, and beg to lay a short notice of our observations before the Society. Our instrument is in all essential respects similar to the magnificent apparatus employed by Kirchhoff in his recent investigations on the solar spectrum and the spectra of the chemical elements. It consists of a horizontal plane cast iron plate, upon which three of Steinheil's Munich prisms, each having a refracting angle of 60°, are

placed; and of two tubes fixed into the plate, one being a telescope having a magnifying power of 40, moveable with a slow-motion screw about a vertical axis placed in the centre of the plate, and the other being a tube carrying at one end the slit, furnished with micrometer screw, through which the beam of light passed, and at the other end an object-glass for the purpose of rendering the rays parallel. The luminous vapours of the metals under examination were obtained by placing a bead of the chloride or other salt of the metal on a platinum wire, between two platinum electrodes, from which the spark of a powerful induction coil could be passed. In order to obtain a more intense, and therefore a hotter spark than can be got from the coil alone, the coatings of a Leyden jar were placed in connection with electrodes of the secondary current respectively. When this arrangement was carefully adjusted, the two yellow sodium lines were observed to be separated by an apparent interval of two millimetres, as seen at the least distance of distinct vision.

The position of the blue line, or rather blue band of lithium, was then determined with reference to the fixed reflecting scale of Steinheil's instrument, by volatilising the carbonate of lithium in the first place on a platinum wire between platinum electrodes, and secondly on a copper wire between copper electrodes. A bead of pure chloride of strontium was then placed on new platinum and copper wires between two new platinum and copper electrodes, and the position of the blue line Sr δ read off upon the same fixed scale; a difference of one division on the scale was seen to exist between the positions of the two lines, the lithium line being the more refrangible. The salts of the two metals were then placed between the poles at the same time, and both the blue lines were simultaneously seen, separated by a space about equal to that separating the two sodium lines. When experimenting with this complete instrument, we were unable to observe any other blue lines in the pure lithium

spectrum than the one above referred to; we have, however, noticed the formation of four new violet lines in the intense strontium spectrum, and we now believe that the other two lithium lines mentioned in our letter to the *Philosophical Magazine* are caused by the presence of the most minute trace of strontium floating in the atmosphere, and derived from a previous experiment. We have convinced ourselves by numerous observations that the currents of air caused by the rapid passage of the electric spark between the electrodes are sufficient to carry over to a second set of electrodes placed at the distance of a few inches, a very perceptible quantity of the materials undergoing volatilisation. The greatest precautions must hence be taken when the spectra of two metals have to be compared; and no separate observations of the two spectra can be relied upon, unless one is made a considerable space of time after the other, and unless all the electrodes which have been once used are exchanged for new ones.

Kirchhoff, in his interesting Memoir on the Solar Spectrum and the Spectra of the Chemical Elements,* noticed in the case of the Calcium spectrum, that bright lines which were invisible at the temperature of the coal gas flame became visible when the temperature of the incandescent vapour reached that of the intense electric spark.

We have confirmed this observation of Kirchhoff's, and have extended it, inasmuch as we, in the first place, have noticed that a similar change occurs in the spectra of Strontium and Barium; and, in the second place, that not only new lines appear at the high temperature of the intense spark, but that the broad *bands* characteristic of the metal or metallic compound at the low temperature of the flame or weak spark, totally disappear at the higher temperature. The new bright lines which supply the part of the broad

* Kirchhoff on the Solar Spectrum, &c. Translated by H. E. Roscoe. MacMillan, Cambridge. 1862.

bands are generally not coincident with any part of the band, sometimes being less and sometimes more refrangible. Thus the broad band in the flame-spectrum of calcium named Ca β, is replaced in the spectrum of the intense calcium-spark by five fine green lines, all of which are less refrangible than any part of the band Ca β; whilst in place of the red or orange band Ca α, three more refrangible red or orange lines are seen. The total disappearance in the spark of a well defined yellow band seen in the calcium spectrum at the lower temperature, was strikingly evident. We have assured ourselves by repeated observations that, in like manner, the broad bands produced in the flame-spectra of strontium and barium compounds, and especially Sr α, Sr β, Sr γ, Ba α, Ba β, Ba γ, Ba δ, Ba ε, Ba η, disappear entirely in the spectra of the intense spark, and that new bright non-coincident lines appear. The blue Sr δ line does not alter either in intensity or in position with the alterations of temperature thus effected, but, as has already been stated, four new violet lines appear in the spectrum of strontium at the higher temperature.

If, in the present incomplete condition of this most interesting branch of inquiry we may be allowed to express an opinion as to the possible cause of the phenomenon of the disappearance of the broad bands and the production of the bright lines, we would suggest, that at the lower temperature of the flame or weak spark, the spectrum observed is produced by the glowing vapour of some *compound*, probably the oxide, of the difficultly reducible metal; whereas, at the enormously high temperature of the intense electric spark these compounds are split up, and thus the true spectrum of the *metal* is obtained.

In conclusion, we may add that in none of the spectra of the more easily reducible alkaline metals (potassium, sodium, lithium) can any deviation or disappearance of the maxima of light be noticed on change of temperature.

A Paper was read, entitled, "Notes on Calorific Phenomena," by J. C. Dyer, Esq., V.P.

The Author states that the *essences* of matter, their number and their forms, are only known to us by their observed properties and mutations; that conflicting theories on physics arise from the various interpretations given to the same phenomena; and if unable to reconcile such differences, further inquiry, with that view, may not be improper, whilst the laws of nature rest on debateable grounds. That practically *matter*, in its aggregate, is found to consist of two sorts or classes—the "ponderable" and the "imponderable"—gravity and elasticity serving to distinguish their respective inherent properties. That as no tests of weight or measure can apply to the latter, its mutations and action on other bodies are the sole means we have of forming any judgment concerning its agency in the laboratory of nature. That the calorific element, or *heat*, is assumed to be the *one* "sole imponderable element which pervades matter and space throughout the universe," and *it* constitutes the elastic forces reacting upon and *balancing* the gravitating forces in all other bodies. This *elemental state* of *heat* must be taken as distinct from its other *three* states of sensible, radiating, and specific heat, commonly recognised. That elemental heat is acted upon by mechanical and chemical forces, and the changes which it undergoes from the one to the other conditions of heat, give rise to atmospherical phenomena, known as electrical, magnetic, and optical; as also to the entire range of meteorological changes, as set forth in the Paper. That by the mechanical forces of the earth's motion in its orbit and diurnal rotation, acting upon the elemental medium, its equilibrium is disturbed and motions generated which afford rational explanations of the luminous and ordinary electrical and magnetical conditions of the atmosphere, as indicated by their respective meteors. That by the action of chemical forces, great mutations of heat are continually going on; for

example, the heat which on a vast scale abounds in vapour, is given out as clouds are formed, and accounts for the positive and negative electricity; and also, when redundant, for lightning from thunder clouds. As much heat is evolved above the clouds, where cold prevails, it must become elemental or neutral there, and justifies the inference that it is identical with the electric fluid, as above said. That electricity and magnetism are but diverse actions of one element has been proved, and their action on matter proves their materiality. The mechanical and chemical action of light proves its materiality also; and that light and heat are identical has been clearly established. The plurality of imponderable elements is, therefore, disproved by the fact that the mutations of the one element fully account for all of the phenomena attributed to several. The gravitating and elastic properties of matter constitute their statical and moving forces, for ever balancing each other. The former of these forces would consolidate the material universe "with lightning speed," but for the reaction of the latter force. There is no reason *why* the force of gravity should be measured by the established laws of falling bodies, except that *experiment* has shown the velocities actually attained by them in vacuo. But this vacuum is the absence of air *only*, not that of the "elastic medium;" and it is this that holds the poise of matter throughout illimitable space.

MICROSCOPICAL SECTION.

Mareh 17th, 1862.

E. W. Binney, Esq., F.R.S., F.G.S., in the Chair.

Twelve speeimens of soundings were reeeived from Captain George Randall, of the barque "Brazil," taken on the north coast of Brazil; also five speeimens from Captain George Murray, of the ship "Finzel," taken off Robin Island, Table Bay; coasts of Sumatra, Java, and St. Helena.

Mr. H. A. Hurst made a donation of eight slides of diatomaceæ of various kinds; also speeimens of fibre from the Bombax, or East Indian Cotton Tree, and the fibre of the Aselepias Syriacus from Bengal. Some conversation arose upon the adaptation of these fibres as substitutes for cotton, but, although fine and silky, there is not suffieient strength in the staple to render them fit for manufaeturing purposes.

Mr. Blandford presented, through Mr. Hurst, a number of specimens of the tongues of mollusca from Burmah, upon whieh Dr. Thomas Alcock reported that there were four speeies, two being fresh water, Melania variabilis; a speeies of Paludomus; and two land shells, different species of Cyclophorus.

Cyelophorus belongs to a seetion of the order Pulmonata, distinguished by having an opereulum or door to the mouth of the shell, and by having a type of teeth similar to that of the Pectinibranchiata. Cyelostoma elegans is a British representative of the same group.

Mr. Cheetham exhibited a prism, which he uses to illuminate objects under the microscope with the variously

coloured lights of the spectrum in succession, instead of ordinary light. He finds that details of structure are more distinctly brought out by some of the colours than others; the blue and green rays are also very pleasant to work with, and easily varied by throwing the required part of the spectrum on the mirror below the stage.

Mr. Sidebotham brought before the notice of the meeting Mr. Petschler's process for producing vegetable forms with crystals of bichromate of potash in gelatine, which was discovered by him in the preparation of glass plates for photographical purposes, and exhibited at the Microscopical Soirée given to the British Association at the last meeting. Specimens on large glass plates were handed round, which, when magnified, aptly represent mosses, ferns, and algæ, in beautiful ramifications, which vary in many ways, dependent upon the strength of the solution, temperature, state of the atmosphere, and other causes. Mr. Sidebotham called especial attention to the peculiarity of the form of crystallisation, and to the fact that an inorganic salt, in contact with organic matter, should produce vegetable forms.

The Secretary then read a Paper by Mr. Petschler, describing the plates and the process.

Glass plates, Nos. 1, 2, and 3, were coated with collodion, on the surface of which a hot mixture of gelatine and bichromate of potash had been poured, then allowed to cool and to dry spontaneously. In a few hours the crystals began to form and ramify themselves over the plate. The mixture was composed of three parts of gelatine and water twenty grains to the ounce, to one part of a saturated solution of bichromate of potash.

Plate No. 4, the same mixture spread hot without collodion. On a corner of the plate the crystals have been dissolved out with water, showing skeleton traces in the gelatine left behind.

Plate No. 5 is covered with collodion and a solution of bichromate without gelatine.

Plate No. 6 was first covered with the mixture and then with glycerine, but no crystallisation took place. It was then dried with strong heat, gelatine and bichromate poured over hot, and then allowed to crystallise.

Plate No. 7 prepared as No. 4, with gelatine and bichromate without collodion. After the crystals were formed, the plate was dipped into a solution of nitrate of silver, which changed the salt into the red chromate of silver, insoluble in water, but soluble in hyposulphite of soda, ammonia, &c. In one corner the crystals were dissolved out, leaving their casts in the gelatine.

Plate No. 8 was prepared as 1, 2, and 3, by collodion and the mixture, and after the formation of the crystals changed into red chromate of silver as No. 7.

Plate No. 9, prepared as No. 6, with glycerine dried with great heat, then coated with the mixture and treated with nitrate of silver as No. 7.

The great variety and beauty of these forms of crystals could with difficulty be represented by drawings.

The Author believes that no chemical combination takes place between the salt and the gelatine, but that the latter acts simply as a medium. The gelatine, when firm, retains a certain quantity of moisture, which is favourable to crystallisation; but when the moisture is driven off by heat, the crystallisation is suspended.

In the course of the conversation which ensued, the Chairman referred to the ramified form in which the salts of some metals were found naturally, in agate, slate, and even trap rock, where the oxide of manganese was frequently found to have assumed similar forms.

Mr. Mosley suggested that the arborescent forms might perhaps arise from the tenuity of the solution, from the resistance of the gelatine to allow of crystallisation in the

usual rhombic form, and possibly to the subtle electrical or galvanic action supposed to be excited during crystallisation. Some years ago he had obtained from solution of bichromate of potash, tree-like forms with spreading branches and pendent rhomboids, which under the polariscope appeared like a tree with gems of rich colours for fruit.

Mr. Mosley exhibited an edition of Baker's work on the Microscope (London, 1785), with many engravings of vegetable forms in crystals of manna, salts of antimony, copper, &c.

Mr. Brothers exhibited a drawing of a small animal he found leaping on the surface of the water in his aquarium, supposed to be identical with the species of Podura found last year by Mr. Lynde.

Ordinary Meeting, April 15th, 1862.

E. W. Binney, F.R.S., F.G.S., Vice-President, in the Chair.

The Rev. Robert Harley, F.R.A.S., Corresponding Member of the Society, made the following communication "On the Theory of the Transcendental Solution of Algebraic Equations."

In my first communication to the Society on the Theory of the Transcendental Solution of Algebraic Equations (see pp. 181-184 of the current volume of the *Proceedings*), there is a statement to the effect that any linear function of the roots of $f(y,x)=0$ must satisfy the differential resolvent. This statement requires, I find, some slight modification.

The differential resolvent for the n-ic equation in y may be written as below:—

$$\Phi(y)=\frac{d^{n-1}y}{dx^{n-1}}+X_1\frac{d^{n-2}y}{dx^{n-2}}\cdots+X_{n-2}\frac{dy}{dx}+X_{n-1}y+X_n=0.$$

Now, if Υ be a linear function of the roots and of the form

$$a_0+a_1y_1+a_2y_2\cdots+a_ny_n$$

in which $a_0, a_1, a_2, \cdots a_n$ are arbitrary constants, it is easy to show that

$$\Phi(\Upsilon)=a_0X_{n-1}+(1-\overline{a_1+a_2\cdots+a_n})X_n,$$

the sinister member of which equation vanishes when $a_0=0$ and $X_n=0$. So that the true theorem is—*Any homogeneous linear function of the roots will satisfy the differential resolvent provided that such resolvent is also homogeneous.*

But further, whatever may be the form of the resolvent, it is satisfied by any of the constituents of the roots. For we know by Lagrange's theory that those constituents are severally of the form

$$\frac{1}{n}\Sigma\, y+\omega y_1+\omega^2y_2\cdots+\omega^ny_n$$

or what is the same thing

$$\left(\frac{1}{n}+\omega\right)y_1+\left(\frac{1}{n}+\omega^2\right)y_2\cdots+\left(\frac{1}{n}+\omega^n\right)y_n,$$

ω denoting, as usual, an unreal nth root of unity. And if we put

$$a_0=0, a_1=\frac{1}{n}+\omega, a_2=\frac{1}{n}+\omega^2, \cdots a_n=\frac{1}{n}+\omega^n,$$

we shall have

$$\Upsilon=\left(\frac{1}{n}+\omega\right)y_1+\left(\frac{1}{n}+\omega^2\right)y_2\cdots+\left(\frac{1}{n}+\omega^n\right)y_n$$

and

$$\Phi(\Upsilon)=0,$$

which establishes the proposition. It hence appears that the argument in which the statement above amended occurs, does not require any further modification.

The general form of the differential resolvent for the n-ic equation

$$y^n-ny+(n-1)x=0$$

given in my last communication to the Society (see pp. 199-201 of the *Proceedings*), may be deduced from Mr. Cayley's equation (p. 193, *ibid.*)—

$$\left[u\frac{d}{du}\right]^{n-1}y=na\left[\frac{n}{n-1}u\frac{d}{du}-\frac{2n-1}{n-1}\right]^{n-1}u^{n-1}y,$$

by simply writing $\frac{1}{n}$ and $\frac{n-1}{n}\varepsilon\theta$ in place of a and u respectively. But I think it right to mention that the form was suggested to me by induction from the particular cases, $n=3$, $n=4$, $n=5$. In fact, I found by direct calculation that the several symbolical forms of the differential resolvents are as follow, viz.:—For the cubic the resolvent is

$$y-\frac{\left(\mathrm{D}-\frac{5}{3}\right)\left(\mathrm{D}-\frac{7}{3}\right)}{\mathrm{D}(\mathrm{D}-1)}\varepsilon^2\theta y=0;$$

for the quartie, it is

$$y - \frac{\left(\mathrm{D}-\frac{7}{4}\right)\left(\mathrm{D}-\frac{10}{4}\right)\left(\mathrm{D}-\frac{13}{4}\right)}{\mathrm{D}(\mathrm{D}-1)(\mathrm{D}-2)}\epsilon^{3\theta}y=0;$$

and for the quintie, it is

$$y - \frac{\left(\mathrm{D}-\frac{9}{5}\right)\left(\mathrm{D}-\frac{13}{5}\right)\left(\mathrm{D}-\frac{17}{5}\right)\left(\mathrm{D}-\frac{21}{5}\right)}{\mathrm{D}(\mathrm{D}-1)(\mathrm{D}-2)(\mathrm{D}-3)}\epsilon^{4\theta}y=0,$$

which are all comprchended under the general form given on page 199. The induction, though incomplcte, is yet sufficiently wide for the purposes of the present theory, inasmuch as, when n is greater than 5, the given n-ie equation cannot in general be reduced to the trinomial form with which we are now working. But Mr. Cayley's brilliant piece of analysis, of which an abstract is given on page 193, enables us, as we have seen, to establish the theorem in all its generality.

I noticed in my last communication the exceptional case $n=2$. The following remarks on the same subject by Mr. Cayley will be read with interest. I had taken the liberty of calling his attention to the form of the resolvent for the quadratic, and replying in a letter to me, under date 25th February, 1862, he says, "I ought to have seen, and after writing the note on the Differential Equation did, in fact, see from your paper that $n=2$ is an exceptional case: the *à priori* reason is, that for the equation

$$y=u+\frac{1}{2}y^2, \text{ or } y^2-2y+u=0,$$

we have (not as in the general case $y_1+y_2+\&c.=0$) but $y_1+y_2=0$. Hence for $n=2$, the differential equation cannot be of the form

$$\frac{dy}{du}+\mathrm{P}y=0,$$

for if so, its solution, which would be of the form $y=\mathrm{C}Y$,

could not by any determination of C give each of the roots $y=y_1$, $y=y_2$. The differential equation must have a term independent of y, and the solution is

$$y=y_1+C(1-y_1)$$

which in virtue of $y_1+y_2=2$, is

$$=y_2+(2-C)(1-y_2)$$

and gives y_1 or y_2 as $C=0$ or $C=2$."

Mr. W. H. L. Russell, of Shepperton, Chertsey, has favoured me with the following elegant solution of the quartic resolvent obtained by the aid of definite integrals.

$$y=A\left\{1+\frac{\frac{5}{4}\cdot\frac{2}{4}\cdot\frac{-1}{4}}{3\cdot2\cdot1}x^3+\frac{\left(\frac{17}{4}\cdot\frac{5}{4}\right)\left(\frac{14}{4}\cdot\frac{2}{4}\right)\left(\frac{11}{4}\cdot\frac{-1}{4}\right)}{(6\cdot3)\quad(5\cdot2)\quad4\cdot1)}x^6+\cdots\right\}$$

$$+Bx\left\{1+\frac{\frac{9}{4}\cdot\frac{6}{4}\cdot\frac{3}{4}}{4\cdot3\cdot2}x^3+\frac{\left(\frac{21}{4}\cdot\frac{9}{4}\right)\left(\frac{18}{4}\cdot\frac{6}{4}\right)\left(\frac{15}{4}\cdot\frac{3}{4}\right)}{(7\cdot4)\quad(6\cdot3)\quad(5\cdot2)}x^6+\cdots\right\}$$

$$+Cx^3\left\{1+\frac{\frac{13}{4}\cdot\frac{10}{4}\cdot\frac{7}{4}}{5\quad4\quad3}x^3+\frac{\left(\frac{25}{4}\cdot\frac{13}{4}\right)\left(\frac{22}{4}\cdot\frac{10}{4}\right)\left(\frac{19}{4}\cdot\frac{7}{4}\right)}{(8\cdot5)\quad(7\cdot4)\quad(6\cdot3)}x^6+\cdots\right\}$$

$$=A\left\{1-\frac{1048576x^3}{819\pi^3}\int_0'\int_0'\int_0'\frac{v^{\frac{13}{4}}z^{\frac{5}{2}}w^{\frac{7}{4}}(1-v)^{\frac{3}{4}}(1-z)^{\frac{1}{2}}(1-w)^{\frac{1}{4}}\,dv\,dw\,dz}{1-vzwx^3}\right\}$$

$$+Bx\int_0'\int_0'\int_0'\frac{v^{\frac{5}{4}}z^{\frac{1}{2}}w^{-\frac{1}{4}}(1-v)^{\frac{3}{4}}(1-z)^{\frac{1}{2}}(1-w)^{\frac{1}{4}}\,dv\,dz\,dw}{1-vzwx^3}$$

$$+Cx^2\int_0'\int_0'\int_0'\frac{v^{\frac{9}{4}}z^{\frac{3}{2}}w^{\frac{3}{4}}(1-v)^{\frac{3}{4}}(1-z)^{\frac{1}{2}}(1-v)^{\frac{1}{4}}\,dv\,dz\,dw}{1-vzwx^3}$$

In this solution x is assumed less than unity. An interesting paper by Mr. Russell, on the Theory of Definite Integrals, will be found in the "Philosophical Transactions" for 1854, pp. 157-178.

Dr. Boole has also pointed out to me a method of solving the quartic resolvent, which does not, however, essentially differ from the above. And Mr. Russell remarks that a

similar process is applicable to the more general resolvent. But what is wanted is a solution without the aid of definite integration.

Sir John F. W. Herschel, in a letter to me under date March 15th, 1862, referring to the closing remark in my last communication, calls attention to a paper of his in the "Philosophical Transactions" for 1814, "On various Points of Analysis," "§ IV. On Equations of the First Degree," and also to a paper of his in the "Memoirs of the Analytical Society" of Cambridge, 1813, "On Equations of Differences," in which there is something, Sir John Herschel thinks, tending to confirm the opinion that the primary forms of integrable linear differential equations stand in close connexion with the solvable forms of algebraic equations. In the latter paper, however, Sir John Herschel informs me that he wishes to "repudiate all that occurs from page 100 to page 105, as founded on a mistake." I need hardly add that the writings of so distinguished a member of our Society shall receive, as they deserve, my most careful attention. I hope soon to return to the subject.

Dr. R. Angus Smith, F.R.S., read a Paper entitled "On the Putrefaction of Blood, No. 2." The following is an abstract.

When I first began to examine the products of the putrefaction of blood, it was merely with the object of ascertaining the nature of the gases, and of ascertaining whether any matter in them exists in a so-called organic condition, and, if so, in what quantity. I have ascertained the nature of the gases. So far as I see, however, I have added no new one, but I believe that for the first time I have given the proportionate amount of each.

I have also decided on a simple and certain method of collecting some organic substances from the gases, namely, the use of caustic potash, which I find superior to acid salts.

Other methods also I have found promising, but I have been compelled to give up the inquiry, at least for a long time, on account of the extremely nauseous emanations which penetrated every room in the laboratory, and were, no doubt, waiting for a favourable opportunity of changing into deadly poisons. These, by proper arrangements, might be avoided. I mentioned formerly that the temperature of 54° Fahr., or 12° C, was a very marked one in favoring putrefaction. I now find that on to 120° Fahr., (49° C,) at least, the process, if it ceases, may be set in motion by raising the temperature. After that point it is difficult to induce putrefaction. I give here a specimen of the

PROGRESS OF THE DECOMPOSITION.

	Gases Absorbed.	Not absorbed.
Nov. 9	88·65	11·35
„ 12	91·32	8·68
„ 13	91·56	8·44
„ 14	95·90	4·10
„ 15	96·04	3·96
„ 18	98·26	1·74
„ 19	98·50	1·50
„ 20	98·95	1·05

After the decomposition had proceeded to such an extent that it was difficult to obtain even a few bubbles more, the gases existed in the following proportion :—

Carbonic acid	97.09
Sulphuretted hydrogen	1·93
Hydrogen.....	0·18042
Carbonic oxide.....	0·13968
Marsh gas	0·07295
Nitrogen	2·51715
	100.

A trace of a compound of cyanogen was found, and a small amount of phosphorus was obtained in the acid

solution. Ammonia was found in considerable quantities. These substances exist along with the gases, and are all I have hitherto determined.

Other experiments gave me much more hydrogen, and I am prepared for a considerable variation in the amount of the several gases. The nitrogen came to a minimum whenever the decomposition became slow. This might be interpreted in two ways—first, by the absence of air to continue the process; and second, by absence of the nitrogen from the decomposed albuminoids. I do not see from my experiments a sufficient proof of the elimination of nitrogen. The amount was in a state of constant decrease, suggesting a gradual removal of atmospheric air.

I mentioned that by passing the gas through lead and other metallic salts, only a small amount of organic matter was collected; but by passing it through caustic potash the amount was considerable. A flocculent matter fell, but the chief amount remained in solution. The solution was boiled down, and, when heated, a perfectly fresh odour of soup was spread through the room; everything offensive had been removed, and the smell was for the first time very agreeable. Here we find that the substances sought for are decomposed by the very means which we take to retain them. But in this experiment we see a demonstration that substances of an organic nature pass over with the gases. When strong sulphuric acid was added to the potash solution there was an abundant black precipitate of carbon and carbonaceous matter. More than enough for an analysis had been made. There was a fatty odour from it when sulphuric acid was added, leading me to think of Chevreul's remarks on a similar occasion.

As these compounds were not retained by acid salts, but by alkalies, I concluded that they were acids; but on allowing some of the solution to stand for a few hours, I was surprised to find that the organic matter had almost disappeared.

We see clearly how differently the organic substances act from carbonic acid. I took home a small piece of cotton wool through which the gas had passed for some days. My intention was to examine it with the microscope. Less than a grain of this cotton was taken out of the tube in which it was enclosed, but so thoroughly did the room become offensive that some friends, not aware of my pursuits, were much annoyed.

This is one of those many facts which lead to the conclusion that the amount of carbonic acid is entirely incapable of showing the true condition of an atmosphere unless we estimate that gas at once on its formation, as then it is mixed with organic matter. If, however, we allow even a short time to pass, a separation takes place, the carbonic acid diffuses and the organic matter clings to substances to be gradually given off: the tendencies of the two are entirely different, and the separation begins at once.

When the gases were previously passed through charcoal, it was difficult to obtain a trace of organic matter.

I imagine that I see my way now to a very satisfactory and comparatively easy investigation, although for the time I must leave it to others.

ERRATUM.

Page 245, line 6 from bottom, for "every vertical" read "every first vertical."

Annual Meeting, April 29th, 1862.

J. P. Joule, LL.D., F.R.S., President, in the Chair.

Mr. Andrew Knowles was elected an Ordinary Member of the Society.

A Paper was read "On Non-Modular Groups," by the Rev. T. P. Kirkman, A.M., F.R.S., and Hon. Mem. of the Literary and Philosophical Societies of Manchester and Liverpool.

From the seven triads which exhaust the duads of seven elements, 157 261 372 413 524 635 746, we can write twenty-one triads containing each a capital and two small figures, thus:—

157 **5**71 **7**15 **2**61 **6**12 **1**26 **3**72 **7**23 **2**37, &c.

We can collect the triplets of these triads which contain the same small letter, thus, the order of two small figures being indifferent:—

157	**1**57	**5**17	**5**17	**5**71	**5**71	**7**51	**7**51
327	**2**37	**3**27	**2**37	**4**31	**3**41	**4**31	**3**41
467	**6**47	**6**47	**4**67	**2**61	**6**21	**6**21	**2**61

175	**1**75	**7**15	**7**15	**3**72	**3**72	**7**32	**7**32	**2**73	**2**73
365	**6**35	**3**65	**4**25	**4**52	**6**12	**5**42	**6**12	**6**53	**5**63
425	**2**45	**2**45	**6**35	**1**62	**5**42	**1**62	**4**52	**1**43	**4**13

(A)

723	**7**23	**6**74	**6**74	**7**64	**7**64	**7**46	**7**46	**4**76	**4**76
653	**5**63	**2**54	**3**14	**2**54	**3**14	**1**26	**2**16	**1**26	**2**16
413	**1**43	**1**34	**5**24	**3**14	**2**54	**5**36	**3**56	**3**56	**5**36

where every triad and every vertical row containing three figures is one of the seven fundamental triads. We have thus formed twenty-eight triplets of triads, and have exhausted 3·7·4 of the 21·10 couplets possible with the 21 triads, **1**57, **5**71, &c.

We can next form a quadruplet upon each of the 21 triads thus:—

on (157), 517	on (524), 254	on (563), 653	
126	517	517	(B)
751	452	365	
134;	563;	524;	

on (715), 732	on (134), 126	on (261), 126	on (612), 126
517	341	237;	635
746	157	621	261
157;	431;	245;	647

In the first of these, 157 126 134 are three triads which have the same capital, and 157 517 751 are the three triads which have the same figures; &c.

The twenty-one quadruplets thus formed exhaust the 21·6 duads not formed in the 28 triplets, so that we have once and once only employed every duad possible with the 21 triads 157 571, &c., in these 21 quadruplets and 28 triplets.

We may interpret the three triads 157 126 134 as the three substitutions

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

which obviously determine each other, having all three elements undisturbed, and all being of the second order. We have thus twenty-one similar substitutions, each defined by a distinct triad.

The first of the above written triplets and quadruplets are found to be

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

of which the former are the didymous radicals of θ_3=6153427 of the third order, and the latter are those of θ_4=1362745 of the fourth order, where θ_4^2=(157), which determines the

quadruplet, is permutable with all its four triads. Vide art. 76 of my memoir *On the Theory of Groups and many-valued functions*, in the volume of the Memoirs of this Society for 1861.

It is thus proved that every pair AB or BA of the 21 square roots of unity determined by the 21 triads have for their product either one of 2·28 substitutions of the third order, or one of 2·21 substitutions of the fourth order, or one of the 21 radicals.

The values of the triplets possible with the 21 radicals have next to be discussed. Some of them will be, and some will not be, reducible to a couplet. Let {AB} denote any triplet or quadruplet of the 28+21 above formed, in which the couplet AB (consecutive or not) appears among the didymous radicals. The condition that a triplet ABC should be reducible to a couplet is any one of the following:—

1° That A be permutable either with B or with C,

2° That {BC} contain A′ permutable with A,

3° That {AB} contain C′ permutable with C,

4° That {AC} contain D′ permutable with CBC=D,

for ABC=A·C·CBC=ACD. D is equidistant with B from C in {AC}. Every one A of the 21 radicals has four permutables, which are those of the quadruplet (A).

It is easily proved, or can be seen by inspection when the quadruplets are all written, that any irredudible triplet PQR in which QR=θ_3 of the third order, is identical in value with ABC where BC=ϕ_4 of the fourth order. Hence every irreducible triplet is of the form of $A(BC)_4$=A·**5**17·**1**26= A·1462537·1243765=A 1426735. It can be proved or seen by inspection of triplets and quadruplets (A), (B), that the only values of A which render this ABC irreducible are the eight following—

372, **2**73, **4**25, **2**45, **3**56, **6**35, **4**67, **6**47.

The circular factors of $(BC)_4$ are 2 4 6 3, 7 5, 1. None of

the eight triads has 1, none of them has both 7 and 5. Hence none of them has a transposition which fractures either of the circles 2 4 6 3, 7 5. Consequently the effect of any one of the eight is to unite the circles of $(BC)_4$ into one; that is $A(BC)_4$ irreducible is always a substitution of the seventh order. It is easily demonstrated that if A_1A_2 be any two of the eight values of A, A_1BC can be no power of A_2BC. Hence there are not less than eight substitutions of the seventh order, no one of which is a power of another: that is, there are $8\cdot 6r$ substitutions of the seventh order.

The number of irreducible triplets is eight times that of the substitutions of the fourth order, written each under four forms, BC=CD=DE=EB in terms of the didymous radicals BCDE. That is, there are $8\cdot 2\cdot 21\cdot 4$ irreducible triplets. This must be divisible by $4\cdot 8\cdot 6r$, because each of the substitutions ABC of the seventh order is formed with four values of BC; consequently $r=1$ or $r=7$, the latter of which is easily seen to be inadmissible.

It is thus proved that there are in reality 48 different irreducible triplets, and so many substitutions of the seventh order. We demonstrate easily that every quadruplet ABCD is reducible to a triplet; hence every quintuplet ABCDE, &c., is reducible to a triplet. And we thus prove that the 21 similar radicals form with their products a group of

$$28\cdot 2_3+21\cdot 2_4+21\cdot 1_2+8\cdot 6_7+1_1=7\cdot 6\cdot 4$$

substitutions.

The equivalent groups will have each 48 substitutions of the seventh order. The number of these substitutions is $6\cdot 5\cdot 4\cdot 3\cdot 2\cdot$. Hence if each be r times found in the equivalents,

$$\frac{r\cdot 6\cdot 5\cdot 4\cdot 3\cdot 2}{48}=r\cdot 5\cdot 3.$$

I have shown, in the Memoir above quoted, that two groups of $7\cdot 6\cdot 4$ can be formed to contain the powers of 2345671; and the same thing is deducible from the fact that we might have

begun above with one other only system of seven cyclical triads, exhausting the duads in seven. Hence $r=2$, and there are thirty equivalent groups of 7·6·4. And as

$$\frac{7\cdot6\cdot5\cdot4\cdot3\cdot2\cdot1}{30}=7\cdot6\cdot4,$$

we see by the corollary to my theorem A (art. 9, "Theory of Groups," &c.), that the group has no derived derangement, *i. e.*, it is *maximum*.

Take next the 55 triads:—

124_{36}	125_{90}	157_{38}	235_{47}	267_{15}	274_{80}	340_{29}	$39a_{46}$	$46a_{27}$	570_{2a}	$60a_{95}$
109_{3a}	$17a_{60}$	160_{28}	$20a_{14}$	249_{5a}	280_{35}	378_{26}	457_{69}	480_{6a}	590_{48}	$68a_{13}$
$13a_{25}$	128_{7a}	140_{57}	290_{67}	208_{49}	346_{58}	350_{16}	458_{12}	469_{10}	$59a_{17}$	780_{19}
189_{56}	156_{4a}	136_{79}	236_{a0}	$27a_{39}$	$3a0_{78}$	379_{50}	$45a_{30}$	568_{70}	679_{8a}	$78a_{45}$
$1a4_{89}$	138_{40}	179_{24}	239_{18}	$25a_{68}$	347_{1a}	358_{9a}	489_{37}	569_{23}	670_{34}	$89a_{02}$

which exhaust the duads of eleven elements $12\cdots oa$ three times, and which, disregarding the subindices, fulfil the condition, that if *abc*, *abd*, *abe*, be three triads, *cde* is a fourth. These 55 triads are formed by a simple cyclical kind of process from the triad 128. The subindex under 124 shows that 361, 362 and 364 are triads of the system.

Each of the 55 triads determines a sextuplet. We form

on (347_{a1}),	on $(68a_{13})$,	on (190_{3a}),	on (325_{47}),	on $(a52_{68})$,	on (125_{90}),
$13a_{25}$	$13a_{25}$	$13a_{25}$	$13a_{25}$	$13a_{25}$	$13a_{25}$
670_{34}	679_{8a}	469_{10}	247_{80}	568_{70}	290_{67}
$14a_{89}$	138_{40}	$30a_{78}$	569_{23}	249_{5a}	458_{12}
235_{17}	$25a_{68}$	125_{90}	347_{1a}	$68a_{13}$	190_{3a}
$17a_{60}$	136_{79}	$39a_{46}$	280_{35}	507_{2a}	267_{15}
489_{37};	408_{6a};	780_{19};	457_{69};	268_{49};	590_{48};

which are all the sextuplets containing $13a_{25}$. The first, third, and fifth of $(347)_{a1}$ are the three containing $a1$; the second, fourth, and sixth are the three whose subindices are the circle 34, 47, 73; and so on of the rest. The remaining

12 triads not combined with $13a$ in the above sextuplets form with it six quintuplets thus:—

$13a_{52}$	$13a_{25}$	$3a1_{25}$	$3a1_{25}$	$1a3_{25}$	$1a3_{25}$
$89a_{20}$	$46a_{27}$	891_{56}	401_{57}	463_{58}	793_{50}
$45a_{03}$	$59a_{71}$	241_{63}	281_{7a}	293_{81}	263_{0a}
$27a_{39}$	$20a_{14}$	571_{38}	561_{a1}	503_{16}	583_{a9}
$60a_{95}$	$78a_{45}$	601_{82}	791_{42}	783_{62}	403_{42};

where the subindices form circles of five duads, and every triad of a quintuplet has the same final figure.

We have combined $13a$ with all the other 54 triads, and in the same way we can form 66 quintuplets and 55 sextuplets which shall once and once only exhaust the duads of the 55 triads.

We interpret the triad $13a_{25}$ as the substitution of the second order,

$$(13a_{25})=1\ 5\ 3\ 7\ 2\ 8\ 4\ 6\ 0\ 9\ a,$$

which has $13a$ undisturbed, and whose four transpositions are the subindices 25, 47, 68, 90, of $13a$, 251, 253, $25a$.

The triads of the sextuplet (147_{a1}) are found to be the didymous radicals of a substitution A_6 of the sixth order, whose third power is $\theta_6^3=147_{a2}$, which is permutable with the six triads of (147_{a1}). The quintuplets are sets of didymous radicals of substitutions of the fifth order, having circles of five subindices.

Thus every pair AB of the 55 triads is either θ_6 θ_3 θ_5 or one of the 55 triads. It remains to examine the triplets A B C.

We easily prove that every irreducible triplet can be written as $A(BC)_6$, when $(BC)_6$ is of the sixth order. The conditions that A should make $A(BC)_6$ reducible are those above given in the like case. And we can demonstrate, either *à priori*, or by inspection of the quintuplets and sextuplets, that the only values of A which make

$$(A(BC)_6=)\ A\ (13a_{25}\cdot 670_{39})_6$$

irreducible are the twelve following:— 124_{36}, $30a_{78}$, $78a_{45}$, $46a_{27}$, 157_{38}, $27a_{39}$, 140_{57}, 361_{79}, 179_{24}, $39a_{46}$, 138_{40}, $54a_{30}$.

The substitution $13a_{25}\cdot 670_{31}$ is

$1\,5\,3\,7\,2\,8\,4\,6\,0\,9\,a\cdot a\,9\,4\,3\,8\,6\,7\,5\,2\,0\,1 = a\,0\,7\,3\,6\,8\,4\,2\,5\,9\,1 = \theta_6$

whose circular factors are $2\,0\,9\,5\,6\,8$, $4\,3\,7$, $a\,1$.

It can be demonstrated, either *à priori*, or by simple inspection of the above table of the 55 triads, that none of the twelve just written transposes a consecutive pair of the circle $2\,0\,9\,5\,6\,8$, *i.e.*, none has a transposition which fractures that circle into one of five and another of one. And as each of the twelve has one element of each of the three circles undisturbed, it must have for one of its four transpositions a non-consecutive pair of the circle $2\,0\,9\,5\,6\,8$, while the other three transpositions will of necessity be *junctures* of the four resulting circles into one circle of eleven.

Theor. *A transposition of two letters of any circle always fractures that circle into two: a transposition of elements of two circles always unites those circles into one.*

From this follow many important theorems on substitutions. Hence we deduce easily, as above for substitutions of the seventh order, that there are $12\cdot 10r$ substitutions of the eleventh order, represented by $12\cdot 2\cdot 55\cdot 6$ triplets $A(BC)_6$, each substitution by at least six different triplets having the same A. Hence $r=1$ or $r=11$, of which the former only is the true value; and there are 120 substitutions of the eleventh order. We prove readily that no quadruplet A B C D is irreducible; hence no quintuplet, &c. And the 55 substitutions of the second order, $\mathbf{1}\,5\,7$, $\mathbf{5}\,7\,1$, &c., form with their products a group of

$$66\cdot 4_5 + 55\cdot 2_6 + 55\cdot 2_3 + 55\cdot 1_2 + 12\cdot 10_{11} + 1_1 = 11\cdot 10\cdot 6$$

substitutions. This group is maximum, and has $9\cdot 8\cdot 7\cdot 5\cdot 4\cdot 3\cdot 2$ equivalents.

We thus find that, in the discussion and construction of these hitherto difficult groups, we can dispense with congruences, and with the still more formidable apparatus of imaginary subindices, which MM. Betti and Mathieu have so skilfully handled.

The groups of $7 \cdot 6 \cdot 4$ and $11 \cdot 10 \cdot 6$, which I think ought to be called the groups of Galois, will always be remarkable as being among the earliest discovered and the most difficult to construct. They appear to be a complete family of themselves. One is indeed strongly tempted to believe in the existence of other non-modular groups of $\frac{1}{2}(n+1)n(n-1)$ for higher prime values of $n=2p+1$, p being prime, since they exist for $n=5$, $n=7$, and $n=11$. But the non-existence of a similar group for $n=23$ may be easily proved, in half an hour's labour, by the method pointed out in the 94th article of my Memoir on Groups above quoted. It suffices to write four vertical rows of the powers to be examined. Instead of "As there are N values of h," I should have written in that section, "As there are N—1 values $\gtrless 0$ of h." And in the last line of page 383, art. 90, the word *principal* ought to be substituted for *only*. The latter is correct, if $N=2p+1$, where p is prime. This does not affect the reasoning. The groups E and E_1 should be represented thus—

$$\{2\,3\,4\,5\,6\,7\,8\,9\,0\,a\}_{11}\ \{3\,6\,9\,1\,4\,7\,0\,2\,5\,8\,a\}_{5}\ \{3\,8\,1\,9\,5\,0\,7\,2\,4\,6\,a\}_{2}$$
$$\times\{6\,0\,8\,4\,7\,1\,5\,2\,9\,3\,a\}_{2}\ \{6\,5\,1\,8\,9\,3\,4\,7\,2\,0\,a\}_{3}=\mathrm{E},$$

$$\{2\,3\,4\,5\,6\,7\,8\,9\,0\,a\}_{11}\ \{3\,6\,9\,1\,4\,7\,0\,2\,5\,8\,a\}_{5}\ \{1\,8\,4\,3\,9\,0\,7\,2\,5\,6\,a\}_{2}$$
$$\times\{1\,5\,3\,7\,2\,8\,4\,6\,0\,9\,a\}_{2}\ \{0\,8\,3\,2\,7\,5\,6\,4\,1\,9\,a\}_{3}=\mathrm{E}_1,$$

of which the observations there following are true, except that "non-" should be written before modular in the next line, p. 390; as also in the third line of page 374.

Triads can be formed with 23 elements to exhaust the duads of 23 six times, by perpetual additions of unity to all the elements following:—

1·2·4, 1·2·6, 1·2·8, 1·2·9, 1·2·11, 1·2·12, 1·3·6, 1·3·7,
1·3·10, 1·3·11, 1·3·12, 1·4·8, 1·4·10, 1·4·11, 1·4·12,
1·5·10, 1·5·11, 1·5·13, 1·6·12, 1·6·13, 1·6·14, 1·7·15.

I have a simple tactical method of forming many such systems for all prime numbers, depending on the theory of difference circles, which requires the solution of no equation or congruence.

It is easy to demonstrate and construct, by a method similar to the foregoing, all M. Mathieu's non-modular groups of $(N^i+1)N^i(N^i-1)$, N being any prime number, without taking for granted any other group, and without having recourse to congruences; but I do not think it worth the while to pursue the inquiry, as this method of combinations is certainly less general, although the separate cases may thus be made to appear more simple, than the methods which have been already given. The theory of combinations appears likely to owe more than it can contribute to that of groups.

Two theorems are worth recording in combinations, which I owe to the study of groups.

Eleven quintuplets can be formed to exhaust twice the duads of eleven elements. This can be done by continual additions of 1 1 1 1 1 either to 1 2 3 5 8, or to 1 2 3 7 *a* (*a*=10).

When N *is any prime number,* N^2 *elements can be thrown into* $\frac{1}{2}N(N+1)$ $(N-1)$*-plets,* $N+1$ N*-plets, and* $\frac{1}{2}N(N-1)$ $(N+1)$*-plets, so as once and once only to exhaust the duads of* N^2 *elements.*

This is proved by the systems of didymous radicals in the groups of $(N+1)N(N-1)$, when N is prime. All the triplets of these radicals are easily shown to be reducible to duads.

In the Memoir of which the above is an abstract, this method, of combinations independent of equations, will be applied to other groups, superior and inferior to those here treated.

The following Report of the Council was then read by one of the Secretaries:—

In presenting the Annual Report, the Council congratulate the members on the improved condition of the Society, especially as regards its financial position. The balance in the Treasurer's hands, as seen in his Report annexed, was on March 31st, 1861, £58. 2s.; whilst on March 31st last, it amounted to £248. 6s. 7d.; and this in spite of

necessarily heavy expenditure incurred in the printing of the Proceedings and of the volume I., 3rd series, of Memoirs, which is now ready for distribution. This improvement is mainly owing to the fact that the members have almost unanimously supported the Council in their proposal to raise the subscription to £2. 2s. per annum, as the only available means of enabling the Society successfully to carry out its objects. The number of ordinary members on the books last year was 207; it is now 204. Since the last Annual Meeting seven members have resigned, eight new members have been elected, and four ordinary members have died, viz., Professor Eaton Hodgkinson, F.R.S.; Dr. M. Satterthwaite; Mr. Absolam Watkin; and Mr. George Woodhead.

Professor Hodgkinson's high scientific eminence as an experimentalist and as the founder of the principles of many branches of mechanical science, is now universally acknowledged; and the members will be proud to recollect that our illustrious townsman was for 41 years connected with the Society, and that it was through the medium of our Memoirs that the greater part of Hodgkinson's important researches were made known.

The following is the list of Papers published by Professor Hodgkinson in the Society's Memoirs :—

(1) Vol. iv., 2nd series, p. 225.—"On the Transverse Strain and Strength of Materials," read March 22nd, 1822.

(2) Vol. v., second series, p. 354.—"On the Forms of the Catenary in Suspension Bridges," read February 8th, 1828.

(3.) Vol. v., second series, p. 384.—"On the Chain Bridge at Broughton," read February 8th, 1828.

(4) Vol. v., second series, p. 398.—"A few Remarks on the Menai Bridge," read December 12th, 1828.

(5) Vol. v., second series, p. 407.—"On the Strength and best Forms of Iron Beams," read April 2nd, 1830.

(6) Vol. vii., second series.—"On the Measure of Moving Force," read April 30th, 1844.

The Council congratulate the members on the possession of the life-like bust of the late Professor Hodgkinson, which, thanks to the liberality of a few gentlemen, now adorns our rooms; and they also notice that Mr. Robert Rawson is engaged in preparing a valuable Memoir of our deeply lamented friend, the first half of which has already been read before the Society.

Of the Honorary and Corresponding Members, the Council have to notice the deaths of the celebrated French philosopher, M. Biot, and Dr. Peter Barlow, F.R.S.

Notwithstanding the natural claims which the late very successful meeting of the British Association for the Advancement of Science, in Manchester, made upon the scientific resources of our town, it is gratifying to observe no falling off either in the quality or quantity of the original communications presented to the Society during the past Session.

The following is the list of Papers and Communications laid before the Society in the Session 1861-62:—

October 1*st*, 1861.—"Observations of Comet I, 1861," by J. Baxendell, F.R.A.S.

October 15*th*, 1861.—"On the Irregular Barometric Oscillations at Geneva and on the Great St. Bernard, and their relations to the Mean Temperature and the Fall of Rain," by G. V. Vernon, F.R.A.S.

October 29*th*, 1861.—"On the Putrefaction of Blood," No. 1, by Dr. R. Angus Smith, F.R.S.

November 26*th*, 1861.—"Additional Observations on the Permian Beds of South Lancashire," by E. W. Binney, F.R.S., &c.

"On certain Scales of some Diurnal Lepidoptera," by Mr. John Watson.

December 10*th*, 1861.—"Nouveau Système de Communication Télégraphique, rendant impossible toute collision de trains sur les chemins de fer," by Professor Baulet, of Persignau, communicated by W. Fairbairn, LL.D., &c.

December 24*th*, 1861.—"On the Influence of the seasons on the Rate of Decrease of the Temperature of the Atmosphere with the Increase of Height in different Latitudes of Europe and Asia," by J. Baxendell, F.R.A.S.

January 7*th*, 1862.—"Experiments on some Amalgams," by the President, J. P. Joule, LL.D., &c.

"On the Conductibility of Heat by Amalgams," by Dr. F. Crace Calvert and Mr. Richard Johnson.

January 21*st*, 1862.—"On the Action of Nitrate of Sodium on Sulphide of Sodium at different Temperatures," by Dr. Ph. Pauli, communicated by Professor Roscoe.

"On the Convective Equilibrium of Temperature in the Atmosphere," by Professor William Thomson, LL.D., &c.

February 4*th*, 1862.—"On the Theory of the Transcendental Solution of Algebraic Equations," No. 1, by the Rev. Robert Harley, F.R.A.S.

"On the Causes of Sickness and Mortality in the Manufacturing Towns of the North-West of England," by Dr. C. J. Shearman, communicated by Dr. R. Angus Smith.

February 18*th*, 1862.—"Note on a Differential Equation," by A. Cayley, F.R.S.

"On the Present State of Meteorology," by T. Hopkins, M.B.M.S.

March 4*th*, 1862.—"On the Direction of the Wind at Manchester during the years 1849-61, at 8h. a.m.," by G. V. Vernon, F.R.A.S.

"On the Theory of the Transcendental Solution of Algebraic Equations," No. 2, by the Rev. Robert Harley, F.R.A.S.

"Memoir of the late Professor Eaton Hodgkinson, F.R.S., &c., Part 1st," by Robert Rawson, Honorary Member of the Society.

"Observations on Atmospheric Electricity," by Professor Wm. Thomson, LL.D., &c.

March 18*th*, 1862.—"On the Probable Cause of Electrical Storms," by the President, J. P. Joule, LL.D., &c.

"On the Tongues of Mollusca," by Dr. Thomas Alcock.

"On the Employment of Galvanised Iron for Armour-plated Ships," by Dr. F. Crace Calvert, F.R.S.

April 1*st*, 1862.—"On the Effect of Increased Temperature upon the nature of the Light emitted by the Vapour of certain Metals or Metallic Compounds," by Professors Clifton and Roscoe.

"Notes on Calorific Phenomena," by J. C. Dyer, V.P.

April 15*th*, 1862.—"On the Theory of the Transcendental Solution of Algebraic Equations," No. 3, by the Rev. Robert Harley, F.R.A.S.

"On the Putrefaction of Blood, No. 2, by Dr. R. Angus Smith, F.R.S.

"On the Relations between the Decrement of Temperature on ascending in the Atmosphere, and other Meteorological Elements," by J. Baxendell, F.R.A.S.

April 29*th*, 1862.—"On Non-Modular Groups," by the Rev. T. P. Kirkman, A.M., F.R.S., &c.

The Council have decided to print several of the above Papers in the next volume of the Memoirs.

The Report of the Librarian shows that a very large increase has this year taken place in the stock of valuable scientific books of reference in the Library. The Society is now (through the unwearied exertions of the Librarian) in regular communication and exchanging publications with all the most important academies and learned societies throughout the world; and a scientific library of reference is being gradually collected, the importance of which, especially to those engaged in scientific research, cannot be over estimated. In order to complete the sets of the series of Transactions, the current and future numbers of which are obtained in exchange for the Society's Memoirs, a much larger sum of money is requisite than the ordinary income of the Society can supply. A sum of £85. 7s., being the balances due to the subscribers of the British Association local fund, has been kindly placed by them in the hands of the Treasurer, for the purpose of assisting our Librarian to carry out this important work.

In conclusion, the Council report with satisfaction the increased activity and usefulness of the Sections, as shown by their published Proceedings.

LIBRARIAN'S REPORT.

Since the close of last Session 564 vols., 608 parts of vols., and 206 pamphlets, have been added to the Library; of which 176 vols., 64 parts of vols., and 4 pamphlets, by purchase, and the remainder by exchange or donations.

The periodical publications which the Librarian is authorised to procure for the Library, by purchase, are:—

The London, Edinburgh, and Dublin Philosophical Magazine.
The Quarterly Journal of Pure and Applied Mathematics.
The Cavendish Society's Publications.
The Ray Society's Publications.
The Palæontographical Society's Publications.
The Annals and Magazine of Natural History.
Les Annales de Chimie et de Physique.
Le Journal de l'Ecole Polytechnique.
Poggendorff's Annalen der Physik und Chemie.
Annalen der Chemie und Pharmacie.
Journal der reinen und angewandten Mathematik.
Der Astronomische Nachrichten.

On the motion of Mr. J. W. Maclure, seconded by Mr. G. V. Vernon, the Report was unanimously adopted.

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THE FOLLOWING GENTLEMEN WERE ELECTED OFFICERS OF THE SOCIETY FOR THE ENSUING SESSION :—

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MICROSCOPICAL SECTION.

April 27th, 1862.

E. W. BINNEY, F.R.S., F.G.S., in the Chair.

Contributions were acknowledged from Captain James Clarke, of the ship "Lightning," consisting of a specimen of mud, from Hobson's Bay, Australia; a specimen of Fucus natans, or gulf weed, from the Sargasso Sea, and sand, &c., from a sounding off the south coast of Ireland. Captain Contente, of the Portuguese steamer "Lusitania," forwarded a sounding taken between Cape Carvoëiro and the Berling Islands, off the Coast of Portugal.

Professor CALVERT presented to the members of the Section a number of bottles containing carbolic acid in crystals, for the purpose of experimenting upon its utility as a preservative fluid for microscopical objects, as well as for specimens of natural history.

Mr. THOMAS D. TOASE, of Jamaica, presented, through Professor Calvert, specimens of Diatomacea, from Kingston Harbour; pollen of a West Indian lily; a portion of a plantain leaf, with two mounted slides of the same, showing cells, raphides, &c. Mr. Toase also sent drawings and description of a Rotifer, found upon Conferva, at Jamaica, which is not known to any of the members present. It consists of an oval body or outer case of a brownish colour $\frac{5}{1000}$ of an inch in length; from *near one end* of the oval is protruded a transparent neck or contractile body, furnished when protruded with four hairs or feelers, a lip, and a kind of operculum, around which Mr. Toase recognised the presence of cilia by the current of water, but he failed to discover the cilia for want of defining power in his microscope.

There is not sufficient detail either in the description or the drawings to be of much use to the microscopist, but further information has been written for.

Mr. Brothers presented to the Section photographs of the four drawings by Dr. Alcock, illustrating his Paper on the Tongues of the Mollusca.

Mr. Sidebotham exhibited a drawing of an undescribed species of Zygnema, found by Mr. Watson and himself, at Southport, in brackish water. It exhibited no appearance of conjugation, and the spores were like balls covered with spines, which when released from the cells move rapidly through the water like volvox.

Mr. Mosley reported upon the specimen of the outer coating of a bulb, received through Dr. Fairbairn from Mr. Niven, of Jeffrey's Bay, Cape of Good Hope.

On examination with the microscope, he found that the leaf is about $\frac{1}{100}$ of an inch in thickness; that between the outer and the inner cuticle a number of tubes or vessels run longitudinally through the structure of the leaf; and that these tubes are composed of very delicate fibres, coiled up so as to form spiral vessels. On breaking the leaf, the fibres may be uncoiled and drawn out to an almost indefinite extent. From the thicker middle portion Mr. Mosley had drawn out fibres to the extent of 18 to 20 inches without breaking; they are beautifully fine, but are in his opinion too weak and delicate, as well as too long, to be used as a substitute for cotton. He considers it possible some application may be found for the fibre if a sufficient sample were sent for experimental trials. Desirous of knowing the botanical history of the plant, he wrote to Sir W. J. Hooker, director of the Royal Gardens at Kew; but it was not possible to classify the plant with certainty from a specimen

so imperfect. Sir William observed that in all probability it is one of the Amaryllidaceæ, and possibly of the genus Buphane.

Mr. Mosley also exhibited the leaf of a species of Digitalis, brought by Mr. Hurst from the Hazaree-bagh, Bengal, upon the surface of which the poison glands are closely set in groups of four glands, placed in a lozenge form.

Mr. Nevill exhibited a new form of microscope, by Matthews, of London, for field use or class instruction, which can be used with either transmitted or reflected light.

Mr. Nevill proposed that the subject for discussion at the next meeting should be, "On the Motion of the Naviculæ," which was agreed to.

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