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Manchester Literary and
Philosophical Society

PROCEEDINGS

OF THE

MANCHESTER

LITERARY AND PHILOSOPHICAL SOCIETY.

VOL. XXVI.

SESSION 1886-7.

MANCHESTER:
PRINTED BY T. SOWLER AND CO., 24, CANNON STREET.
1887.

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.

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PROCEEDINGS
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

General Meeting, October 5th, 1886.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., Vice-President, in the Chair.

Mr. George William Sidebotham, of Hyde, M.R.C.S., was elected an Ordinary Member of the Society.

Ordinary Meeting, October 5th, 1886.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., Vice-President, in the Chair.

Professor W. C. WILLIAMSON, LL.D., F.R.S., laid before the society a communication on the relations subsisting between the Calamodendra of Antun and Chemnitz and the ordinary Carboniferous Calamites. M. Renault considers that the former plant belongs to the group of the Gymnosperms, and further, that some spikes of fructification which he has obtained are the staminiferous organs of Calamodendron, the supposed anthers of which are filled with Pollen-grains. Professor Williamson first called attention to the several points of resemblance and of difference between some sections of Calamodendron from his cabinet, and similar ones of Calamites. At the same time he showed that a Calamite which he described in the Memoirs of the

Manchester Literary and Philosophical Society, in 1869, constituted a connecting link between the two extreme modifications represented by Calamites, and the so-called Calamodendron. Hence, believing that all these three varieties were merely differentiations of the common Equisetaceous type, he wholly rejected the conclusion that Calamodendron was a Gymnospermous plant.

As to the supposed stamens and pollen-grains of M. Renault, he demonstrated that they were merely the sporiferous spikes of the Equisetiform Genus Calamostachys, which only differed specifically from the common Carboniferous Calamostachys Binneana which the author had figured in his Memoir X., fig. 13 (Phil. Trans., 1880, Plate 15), whilst in fig. 17 of the same plate he represented the spores in identically the same conditions of form, number, and grouping as characterised the supposed Pollen-grains of M. Renault. Hence, whilst no proof was forthcoming that the fructification actually belonged to Calamodendron, should it eventually be found to do so, it would only establish more completely than before, the Cryptogamic character of that genus.

Ordinary Meeting, October 19th, 1886.

Professor W. C. Williamson, LL.D., F.R.S., Vice-President, in the Chair.

"On Volcanic Dust from Tarawera, New Zealand," by Thomas Kay, Esq.

The eruption of a volcano which has been long quiescent is usually attended with the phenomena of mud streams with scoria in various forms of division.

This scoria is often ejected to a very great height. It is recorded by Sir Wm. Hamilton that jets of it were thrown from Vesuvius in 1779 to a height of 10,000 feet. This spreads out in the atmosphere and is often carried by the wind to great distances. In 1845, during an eruption of Hekla in Iceland, dust was deposited in the Orkneys and Shetland, a distance of 500 miles, in 10 hours.

The finest particles are carried the greatest distance; thus whilst stones of 8 pounds weight are found in Pompeii at the foot of Vesuvius which helped to bury the city in the year 79 none are found of a greater weight than 1 ounce at Castellamare, the ancient Stabiœ, 10 miles away. It is recorded, however, that the north wind, which was then blowing, carried the dust into Africa.

I exhibit a specimen of dust collected by my friend Mr. Morton, who has just returned from New Zealand. It was gathered 45 miles from the volcano and is in a fine state of division. It contains Felspars, Magnetite, Olivine and Augite,

Soluble in water	0·74%
Soluble in Hydrochloric Acid	11·94%

The proportions of its constituents are:

Silica	54·03
Alumina	15·98
Oxides of Iron	13·02
Lime	8·37
Magnesia	3·78
Soda	2·34
Potash	0·78
Phosphoric Pentoxide	0·64
Loss on Heating	0·87
Sulphuric Acid	traces.
Chlorine, Manganese	
Titanium	

It is evident from the above, and the finely divided state of the ash, that by its decomposition the Potash, Soda, Lime, Magnesia and Oxide of Iron will be set free as Phosphates, Sulphates and Chlorides, and that it will form a rich surface soil on those parts upon which it has fallen, and that, although cattle are suffering from want of food occasioned by the burial of the grass, there will be a rich future for the farmer.

I am indebted to Mr. G. W. Davies, F.C.S., for the above analytical report.

Mr. HENRY WILDE, F.R.S., exhibited Volcanic Dust from Krakatoa, collected during the eruption.

Mr. W. W. HALDANE GEE, B.Sc., exhibited and described "An Improved Form of Rheostat." The instrument, which has been made for the Owens College Physical Laboratory, consists of a hollow ebonite cylinder, cut with a spiral groove, within which 23 feet of No. 18 German silver wire is laid. The cylinder is mounted on brass axes to which the ends of the German silver wire are connected. Strong brass springs in connection with binding screws make contact with these axes. One axis is cut with a screw of the *same* pitch as that on the cylinder. The axes are mounted in bearings so that when the cylinder is rotated it also has a progressive motion. Contact is made with the rheostat wire by a platinum wedge fixed to a fine adjusting screw. By pressing a lever the platinum contact is raised above the wire and a knife edge is simultaneously withdrawn from the trace of the axial screw, allowing the cylinder to be slided bodily, so that the platinum contact may be quickly set to any part of the rheostat wire. The working parts of the instrument are enclosed within a box with glass sides and top. The chief mechanical principle of this rheostat is the same as that employed in the construction of the rheostats of Jacobi* and Shelford Bidwell,† but the details of the improved instrument are quite different.

* Pogg. Ann., 59, page 145. 1843.

† Phil. Mag., July, 1886.

Dr. **Schuster**, F.R.S., gave an account of his visit to Grenada in connection with the expedition for the observation of the recent total eclipse of the sun.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, September 20th, 1886.

Professor **Williamson**, F.R.S., President of the Section,
in the Chair.

The **President** gave an address, in which he explained very fully "The present state of our knowledge of the Carboniferous Calamitinæ."

Mr. **Darbishire** exhibited some specimens of *Hydractinia* from Japan, and also a case of fragments of Pumice Stone which had been washed on shore in Mauritius, in September, 1885, and were supposed to have been thrown into the sea by the eruption of Mount Krakatoa in August, 1884, and been drifted, in 13 months, across the Indian Ocean. Floating banks of such stone have been reported by various navigators amongst notes on that eruption. The angles are removed and the sides smoothed.

These stones carried upon them specimens, often crowded together, of *Ostrea multiradiata* and of a small *Chama*, a small *Spondylus*, of *Perna imbricata* and *Meleagrina alaperdicis*, also of two species of *Serpula*, and the tube of another worm delicately made of the shells of a small Anatifa.

O. multiradiata in happier circumstances develops an upper valve of the usual laminated or even flounced character, but in these specimens any trace of such structure has been worn away by the waves, and the valve is smoothed and polished, and often looks more like a corallinous growth than an oyster shell.

The *Spondylus* and *Chama*, though equally affixed, do not exhibit this superficial abrasion. *Perna* and *Meleagrina* are delicately laminated, and even spined; but then they are attached only by byssus, and so yielded to shocks upon their floating island.

Mr. HYDE showed some shells of *Cyclas rivicola* from the Marple Canal, and some living specimens of *Gyrinus marinus.*

Mr. F. NICHOLSON, F.Z.S., showed skins of, the Ring-ouzel, *Merula torquata*; the Merlin, *Falco æsalon*; and the Common Dipper, *Cinclus aquaticus*; all taken within 12 or 15 miles of Manchester.

Mr. H. C. CHADWICK, F.R.M.S., exhibited under the microscopes the following Hydroid Zoophytes. *Clytia Johnstoni*, *Aglaophenia pluma*, and *Eudendrium ramosum*; this last specimen showing very beautifully the sexual cells described by Professor Weisman in "Nature," Nov. 1883.

Mr. CAMERON exhibited (chiefly from Central America) a number of Hymenoptera belonging to different genera, subfamilies, and even families, which showed a remarkable similarity in coloration and markings, and consequently might at first view be regarded as examples of "mimicry." Inasmuch, however, as they chiefly belonged to groups which are not protected, so far as is known, by possessing weapons of offence or defence, nor give out bad odours, they cannot be regarded as examples of "mimicry," as defined by Bates; for that theory requires that a non-protected species should mimic a species which is protected by having a sting, by being uneatable by birds, or otherwise. One example of true mimicry, however, was shown, namely, *Microdus simulatrix*, Cam, which was an exact copy of the common wasp, *Chartergus apicalis.*

Ordinary Meeting, October 11th, 1886.

Professor WILLIAMSON, F.R.S., President of the Section, in the chair.

Mr. P. CAMERON showed a saw-fly, *Nematus pallipes*, Fallen, from Aviemore, which is new to Britain and may possibly be a new species.

Mr. F. NICHOLSON exhibited a specimen of the fork-tailed Petrel, shot on the Lancashire coast between Southport and Formby.

Under the microscopes were exhibited, by the PRESIDENT, some young specimens of *Drosera* from Australia, which he had succeeded in raising in his greenhouse.

By Mr. JAMES FLEMING, F.R.M.S., *Alcyonella fungosa;* a polyzoan new to this district, and some other British fresh-water polyzoa, all in a living state.

By Mr. W. BLACKBURN, F.R.M.S., some beautiful arrangements of *Diatoms.*

By Mr. H. C. CHADWICK, F.R.M.S., a Hemipterous insect, *Æpophilus Bonnarei,* and a Coleopterous insect *Æpus Robinii*, both of which are sub-marine.

By Mr. JOHN BOYD, living specimens of a fish parasite, *Argulus Foliaceus,* which has appeared in great numbers in a reservoir at Weaste, and is destroying the fish.

Mr. PETER CAMERON stated that through his copy of de Saussure's Etudes s.l. fam. d. Vespides wanting some pages, a fact which he had only recently discovered, he had omitted from the list of the Hymenoptera of the Hawaiian Islands, two species of wasps, namely, *Odynerus nantarum,* and *Odynerus sandwichensis.*

Ordinary Meeting, November 2nd, 1886.

Professor **Osborne Reynolds**, LL.D., F.R.S., Vice-President, in the Chair.

"Measurements of the Magnetic Induction and Permeability in Soft Iron," by H. **Holden**, B.Sc., communicated by Dr. A. **Schuster**, F.R.S.

As absolute determinations of the temporary and permanent magnetic induction in rings have, I believe, been published by Rowland only, it was thought desirable to make a few experiments with iron rings, which were prepared in a different and, it is thought, better manner. These experiments were conducted during the summer vacation in the Physical Laboratory of the Owens College, under the superintendence of the Demonstrator, W. H. H. Gee, B.Sc.

Rowland says,* "In selecting the iron, care must be used to obtain a homogeneous bar: in the case of a ring I believe it is better to have it welded than forged solid; it should be then well annealed, and afterwards have the outside taken off all round to about ⅛in. deep in a lathe." In general, absolute measurements of magnetic induction and permeability in soft iron have been made by means of welded rings. It seems to be, at least, doubtful whether a ring prepared in this manner is magnetically homogeneous throughout, especially at the weld.

The ring, with which the results given below were obtained, was made by cutting a disc about ¾in. thick from

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* Phil. Mag., Vol. XLVI., p. 149, 1873.

the end of a cylindrical shaft of best Kirkstall drawn iron, which was then well annealed, and *turned* into a ring of circular section (diameter of section is about $\frac{1}{3}$in.). The metal is of fair quality and softness, but not so ductile as the best Lowmoor iron. The mean external diameter of the ring is 14·6 cm., the mean diameter of section is ·95 cm., and its weight is 230·172 grams. Another ring was made by cutting a disc out of an iron plate, and then treating this disc like the previous one.

Attention was also given to the following point—whether by some process a ring, which had been raised to nearly the maximum of magnetism, could be brought back to its original state, so that a fresh series of observations of the magnetic induction and the permeability should not differ from the previous set. With regard to this, Rowland says, in the paper quoted above, "To get the normal curve of permeability, the ring must only be used once; and then no more current must be allowed to pass through the helix than that with which we are experimenting at the time. If by accident a stronger current passes, permanent magnetism is given to the ring, which entirely changes the first part of the curve."

The method of sending alternate currents (gradually diminishing from the maximum used before, until they become evanescent) through the primary winding was used, and found to give good results.

The ring was wound as follows—it was covered with silk riband, soaked in melted paraffin wax; on this 334 turns of No. 20 double silk covered copper were wound, the whole was covered with silk riband and paraffined, and on this were wound three separate coils, one of 200 turns, and two of 100 turns, of No. 24 double silk covered copper wire. The whole was then immersed for a moment in melted paraffin wax. The resistances of these coils were measured at the beginning and at the end of the experiments, and the results were found to agree with each other and with the calculated values of resistance, thus showing that no short circuiting had occurred.

The apparatus and the method employed were similar to Rowland's, a ballistic galvanometer (made by Elliott Bros., of about 4,000 ohms resistance, and time of vibration about five seconds) being used to measure the induction kicks, which were brought within the range of the galvanometer (1) by using various combinations of the three secondary coils, and (2) by introducing resistance into the secondary circuit. The earth inductor was made in the Owens College workshop, and was wound with three coils, the first consisting of 20 turns of No. 20 copper wire, the second of 363 turns of No. 28 copper wire, and the third of 3 turns of No. 20 copper wire. The area of induction of the first coil ($=n\pi R_2$) is 67699 sq. cm., of the second coil is 1248500 sq. cm., and of the third is 10512 sq. cm. The ring was suspended in a tinned iron cylindrical vessel, which was surrounded by water contained in an outer vessel. The battery was insulated from the earth, and care was taken to avoid leakage between different parts of the apparatus.

Test of Demagnetization Method.—The apparatus being connected, a medium current was sent through the primary coil, and the kick of the ballistic galvanometer needle on breaking the current was observed. (This kick gives a measure of the temporary induction, and it was found necessary, in order that successive kicks should be equal, that the current in the primary winding should be alternated a few times between each observation. If this was not done, the successive kicks gradually diminished for a time.) The maximum current was now sent through the primary coil, and then gradually diminishing alternate currents until they became evanescent, the ring being agitated by taps tapped at the same time. The medium current before used was now passed through the primary coil, and as before the kick due to breaking it was observed, and was found to be equal to the preceding observation, at least, to a close approximation. The ring was again magnetized with the maximum current, the process of demagnetization carried out as before, and another observation of the temporary induction due to the medium current was obtained. This was repeated several times, and the observations were found to agree, thus showing that, though the ring had been magnetized nearly to saturation, yet it could be brought back to its original state by this process of demagnetization.

Measurements of the Magnetic Induction and Permeability.—The ring having been demagnetized by the above method, a set of observations of the magnetic induction and permeability with varying magnetizing force was taken, and the results are embodied in Table I., where—

B is the total magnetic induction;
B_t is the temporary magnetic induction;
B_p is the permanent magnetic induction;

and μ, μ_t, μ_p, are the corresponding expressions for the magnetic permeability. The manner of taking the observations was this: the current being on, in, say, the + direction, the kick on breaking was observed (+ to 0). It was next suddenly passed in the − direction, and the kick due to this was observed (0 to −). The current was now alternated a few times, and finally passed in the + direction. It was lastly reversed, and the ensuing kick noted (+ to −), which should be equal to the sum of the other two kicks. The first kick is due to the temporary magnetism, and the last to double the total magnetism. The ring was now again demagnetized, and a fresh set of observations taken, of which Table II. is a summary.

Remarks on the Tables and Curves.—From Diagram II. it is seen that the maximum value of the total magnetic induction is about 18000, and the maximum value of the permeability $(=\mu)$ is about 2950. In Table I. it is noticeable that μ, μ_t, μ_p, and $\frac{\mu}{\mu_t}=\frac{\text{B}}{\text{B}_t}$ all come to a maximum for the same value of the magnetizing force, and this fact seems to be approximately true in most cases. If the method of demagnetization used was successful, the results in the two tables should correspond. Perhaps the easiest way of comparing the two tables is by drawing the curves having permeability as ordinate and induction as abcessa or induction as ordinate and magnetizing force as abcessa. If this be done, it will be found that the two tables agree fairly well. The two curves attached to this paper have, therefore, been obtained from the combination of the results in the two tables.

In Table II. a remarkable *oscillation* of the value of the permanent induction seems to take place when the iron is near its maximum of magnetism. The same phenomenon is noticeable in Rowland's experiments on iron rings, as will be seen from two instances given below, though he seems to regard the fact as showing a *diminution* rather than an *oscillation* in the value of the permanent induction.

ROWLAND'S TABLE I.

B.	B_p.
8943	6369
10080	6838
12270	7502
12970	7666
13630	7520
14540	7939
15770	8116
16270	7852
16600	7888

ROWLAND'S TABLE V.

B.	B_p.
7770	5607
9300	6400
10590	7066
13410	7913
14240	7959
14910	8061
15680	7974
16580	8109
16850	8064

TABLE I.—C.G.S. units.

$\frac{4\pi Cn}{l} = \frac{B}{\mu}$	B.	B_t.	B_p.	μ.	μ_t.	μ_p.	$\frac{B}{B_t} = \frac{\mu}{\mu_t}$.
·281	145·1	104·8	40·3	516·5	373	143·5	1·385
·553	459·5	322·4	137·1	831·6	583·6	248	1·425
·813	975·5	532	443·5	1200	654·6	545·4	1·833
1·245	2837	950	1875	2278	763·8	1514	2·982
1·852	5384	1612	3772	2907	870·2	2037	3·34
3·409	8124	2644	5470	2383	777·4	1606	3·073
7·99	11948	5575·8	6372	1495	697·6	797·4	2·143
13·75	13640	6970	6670	991·8	506·8	485	1·957
58·01	16727	9856	6871	288·3	169·9	118·4	1·699

TABLE II.—C.G.S. units.

$\frac{4\pi Cn}{l} = \frac{B}{\mu}$	B.	B_t.	B .	μ	μ_t.	μ_p.	$\frac{B}{B_t} = \frac{\mu}{\mu_t}$.
·242	132·7	99·5	33·2	548·6	411·3	137·3	1·333
·335	207·4	141	66·4	618·7	420·7	198	1·47
·468	381·7	249	132·7	816	532·2	283·8	1·53
·573	539·2	331·8	207·4	940·5	578·8	661·7	1·625
·780	1029	547·5	481·5	1320	702·5	617·4	1·88
·929	1584	680·3	904·1	1707	732·6	974·4	2·33
1·175	2763	987·2	1775	2356	841·7	1514	2·79
1·689	4847	1593	3254	2369	943·2	1827	3·04
2·105	6140	1925	4215	2917	914·6	2002	3·19
2·789	7800	2522	5278	2797	904·5	1892	3·09
6·219	10639	4111	6528	1711	661	1050	2 6
12·9	12935	6046	6889	1003	487·5	534·2	2·14
20·47	14027	7495	6532	685·1	366·2	318·9	1·87
38·93	15110	8220	6890	388·2	217·3	177·1	1·84

From the above tables, it is seen that the permeability varies greatly as the magnetizing force increases, and that even with the same magnetizing force, its value is readily influenced by other causes; thus, keeping to the same

DIAGRAM I.

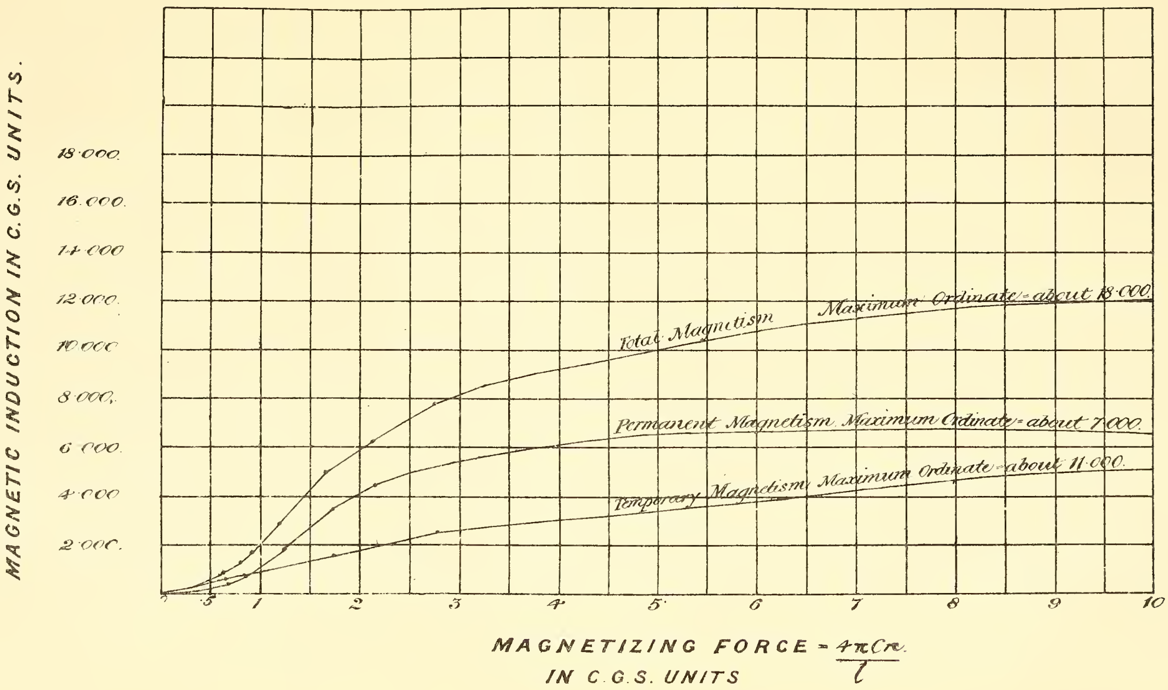
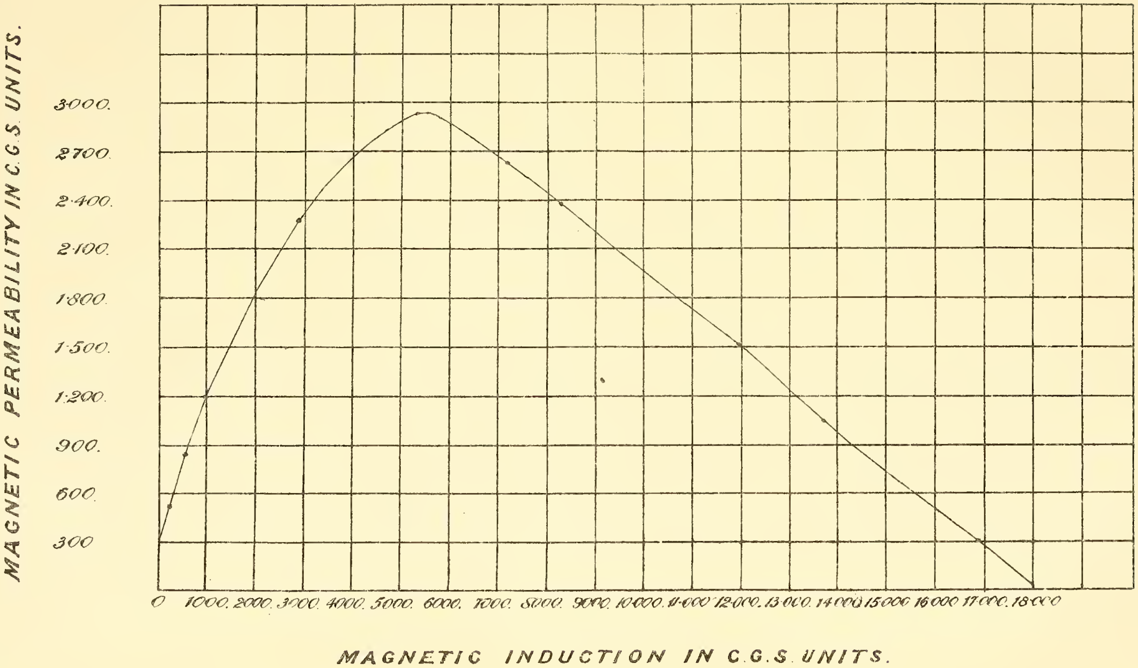

MAGNETIC INDUCTION IN C.G.S. UNITS.
18·000.
16.000.
14·000
12·000.
10·000
8·000.
6·000.
4·000
2·000.
Total Magnetism
Maximum Ordinate = about 18·000.
Permanent Magnetism. Maximum Ordinate = about 7·000.
Temporary Magnetism. Maximum Ordinate = about 11·000.
0
·5
1
2
3
4
5
6
7
8
9
10
MAGNETIZING FORCE = $\frac{4\pi Cn}{l}$
IN C.G.S. UNITS

DIAGRAM II.


MAGNETIC PERMEABILITY IN C.G.S. UNITS.
3000.
2700.
2·400.
2·100.
1·800.
1·500.
1·200.
900.
600.
300
0
1000.
2000.
3000.
4000.
5000.
6000.
7000.
8000.
9000.
10·000.
11·000
12·000.
13·000.
14·000
15·000
16·000
17·000.
18·000
MAGNETIC INDUCTION IN C.G.S. UNITS.

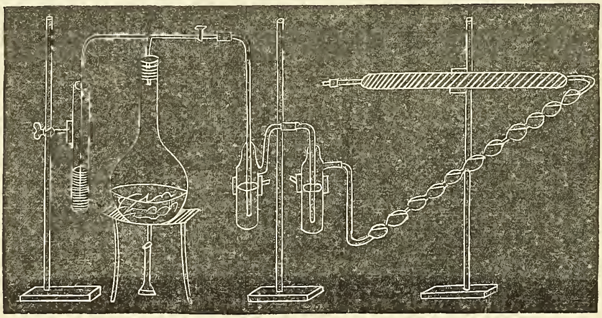
magnetizing force, it was found that the value of μ_t gradually diminished if the current in the ring was not alternated between each observation. Variation of temperature will, no doubt, have a great influence on the magnetic induction and permeability of iron; also, the mechanical vibration of the iron certainly affect the results. These various disturbing causes require to be studied and eliminated before the variation of the permeability with the magnetizing force can be accurately known.

Experiments are now being made in the Physical Laboratory of the Owens College whereby it is sought to electrolytically deposit rings of iron and nickel of sufficient thickness to enable their induction and permeability coefficients to be examined.

"The Action of Hydrochloric Acid Gas upon certain Metals," by J. B. COHEN, Ph.D., F.C.S., communicated by Dr. A. SHUSTER, F.R.S.

From certain considerations, I was led to believe that hydrochloric acid gas, freed from all traces of water, would not act upon certain of the metals. This idea was further supported by the observations of Gore with liquefied hydrochloric acid (Proc. Roy. Soc., XIV., p. 204) who found that zinc, iron, &c., were scarcely acted upon, and that out of fifteen metals only one, viz., aluminium, was dissolved by the pure liquefied acid.

Preparation of Dry Hydrochloric Acid Gas.—The gas was prepared by the action of ordinary concentrated sulphuric acid, previously well boiled, upon lumps of fused sodium chloride. The gas passed through two wash-bottles containing concentrated sulphuric acid (previously boiled), then through a series of eleven bulbs blown on one stem, and placed at an angle of about 45 degrees, also containing concentrated sulphuric acid; and, finally, through a tube about twenty-six inches long and one inch wide, well packed with phosphoric anhydride. The evolution flask was connected by a T piece, with the drying apparatus on the one hand, and with a tube dipping under dry mercury on the other, the latter serving as a safety valve. The form of the apparatus is represented in the diagram. All the joints were well secured with thick india-rubber tubing, wrapped round with copper wire, and then thickly coated with melted paraffin.



The first metal experimented upon was metallic sodium.

Preparation of Metallic Sodium.—The following method was found to give the best results in preparing clean metallic sodium. It is one, however, which requires the exercise of patience, because often as many as a dozen of the tubes employed break before a successful operation is achieved. A clean glass tube, about $1\frac{1}{4}$ft. long and $\frac{3}{4}$in. diameter, is drawn out in the following form. This is placed vertically in a clamp with the pear-shaped bulb downwards. This may be called the bulb end. Through the bulb end a current of coal gas is passed until most of the air is displaced. A plug of glass wool is meanwhile introduced through the upper end so as to fall over the constricted part of the tube, and above this, pieces of clean dry sodium are placed so as to fill about one-half of the upper portion of

the tube. The tube is then closed at the upper end with a cork and sealed at the lower end before removing the connection with the coal gas delivery tube. The cylindrical part is now sealed. There still remains in the tube a considerable quantity of air. To absorb this, the sodium is melted at a gentle heat over the flame, allowed to cool, and the operation performed repeatedly for two or three days, the tube being held in a horizontal position. The sodium is now filtered through the glass wool into the pear-shaped bulb. This is done as follows: The sodium is first melted and the tube tilted with the bulb end downwards. On heating the bulb, bubbles of gas are driven through the melted sodium, and on cooling, the tube being still held vertically, the sodium passes slowly into the bulb through the glass wool, which retains the unmelted oxide. This process of filtration may be hastened by warming at the same time the upper part of the tube. If sufficient time has been allowed, and the remelting of the sodium often enough repeated, the metal runs through and has a bright metallic surface. Out of a large number of tubes prepared in this way only two were successful. The glass easily cracks on warming the metal when firmly adhering to the walls. The pear-shaped bulb is now sealed off and the sealed ends doubled round in the form of hooks. The bulb is placed in one compartment of a tube drawn out in the middle; the other compartment is filled with phosphoric anhydride and separated by a plug of glass wool, as in the diagram. This tube is connected with the hydrochloric acid apparatus, the compartment containing the bulb being attached to the phosphoric acid tube of the hydrochloric acid apparatus. The other end is connected with a wash bottle of concentrated sulphuric acid. All the joints having been carefully secured, hydrochloric acid gas

is slowly bubbled through the apparatus for several hours (both before and after attaching the sodium tube) until a sample of gas issuing from the last wash-bottle is entirely absorbed in water. The tube containing the sodium is also heated gently whilst the gas is passing through to drive off traces of moisture possibly adhering to the sides. The sodium tube is now sealed off at both ends, and the bulb broken by allowing the hooked ends to fall sharply against the ends of the tube. The following results were then noted in two experiments.

1. The sodium retained its metallic appearance for a few weeks, and it slowly assumed a dark grey colour, finally, after several months, a deeper violet grey.

2. The sodium lost its metallic appearance much more quickly, and after a few weeks became dull black, like charcoal. This blackness did not extend far below the surface, that portion of the metal attached to the glass retained its mirror-like appearance.

The composition of this black compound has not been further investigated; but it may possibly be a sub-chloride of sodium.

Experiments with metallic aluminium point to the fact that it is unacted upon by the gas when dry, whereas, as is well known, it is readily tarnished by moist hydrochloric acid gas, and dissolves in the liquefied acid.

These experiments, which have for the present been discontinued owing to want of time, will be taken up again, and a larger number of facts, if possible, collected.

"Capillary Constants of Benzene and its homologues occurring in Coal-Tar," by J. B. Cohen, Ph.D., F.C.S., communicated by Dr. A. Schuster, F.R.S.

The object of the present paper is to bring before you a subject which promises to have special interest to the chemist, viz., capillarity as a property on which a method of analysis may be based. Capillary constants of liquids, and their relation to chemical composition and constitution, have been recently carefully studied by Schiff, who determined these constants at the boiling temperatures of the liquids. More recently, Traube has investigated the constants of substances in solution, a practical outcome of which has been a method for determining the percentage of fusel oil in spirits and wines. This method is fully given in the Berlin Berichte, XIX., 892, and the apparatus described in the Journ. f. Prakt. Ch. (2) XXXI., 177. Wishing to extend this method, and simplify it, if possible, for practical purposes of rapid analysis, I undertook the determination of the capillary constants of benzene, and those homologues of benzene which occur in coal-tar. The reason for attacking this special line was simply because, as those who are acquainted with the coal-tar industry know, the methods at present in use for determining the percentage constituents of benzene and its homologues occurring in commercial coal-tar naphtha, are rough methods, and lack accuracy; and there is, especially, no quick method for determining the presence and estimating quantitatively carbon-bisulphide, paraffin, or petroleum, which are often found in the commercial products. In these determinations I must admit, at the outset, that no very great success has attended them; at the same time, the value of the method should not be overlooked; and, as to the results, I have very little doubt that those who care to pursue the subject will hit upon something which will turn out more useful and successful—for example, in the analysis of mixtures of oils. To fulfil the conditions of a practical analytical method, the apparatus must be of simple construction, easily manipulated, and the determination rapidly performed, consistent, of course, with accuracy. For comparative determinations, the apparatus to be described, will be found to answer well. Instead of using a capillary with a moveable and adjustable scale employed by Traube, I find that a piece of thick thermometer tubing, with a fine round capillary, ·155 mm. bore and about 26 cm. long, which was supplied to me by Mr. L. Casella, of London, served my purpose excellently. Along its whole length it was etched in millimetres. By a very simple arrangement of a mirror, usually used in such determinations, it is a matter of a little practice only, to be able to read off the scale to tenths of a millimetre with a pocket-magnifying glass.

The first point to be determined before employing this tube was, whether a piece of thermometer tubing, ·155 mm. bore, could be thoroughly cleaned and dried without deteriorating with use. The tube was thoroughly cleaned with ether or alcohol, after each determination, by plunging it half way in pure dry ether, so that the ether rose at least two-thirds of the distance up the capillary. By bringing the lower end on to a piece of clean silk cloth, the capillary was rapidly emptied, and this process repeated three or four times, and finally dried by the following arrangement.

The thermometer tube is placed in an outer tube of glass, closed at one end and constricted in two places. At the open end of the outer tube a plug of cotton wool is inserted round the thermometer tube, which serves to filter the air passing into it. The thermometer tube is attached by a piece of india-rubber tubing to a narrow glass tube containing cotton wool; and by a longer piece of india-rubber to a calcium chloride tube, which may be closed by the pinch-cock and india-rubber tube. The glass tube, which is perfectly cleaned before use, is plugged with cotton wool when not required. In order to dry the capillary, the apparatus is fitted up as described, and the outer tube heated.

By partly exhausting the air at the pinch-cock end, which is then tightly closed, a partial vacuum is produced, and with my tube the pressure equalised itself after about six minutes, during which time a constant stream of hot air was passing through the capillary. With such an arrangement, and by always taking the precaution to cover the thermometer tube, whilst in use, with an open glass cap containing cotton wool, I found that a tube of this kind might be employed for an almost unlimited number of determinations. These determinations were made in the following manner: the liquid was placed in a small bottle; the thermometer tube, after being sunk into the liquid and adjusted perpendicularly by a plumb line, was left for a short time. The height to which the liquid had risen was read off on the scale in millimetres with a magnifying glass, and the reading below the meniscus also taken. The difference gives the height in millimetres which the liquid has risen in the capillary. The tube is now raised a few millimetres, and the height again read off; the process repeated once or twice and the mean height taken. With pure benzene, the following gives the height in millimetres of the column of liquid, determined at different times in the course of the present investigations:

	Height in millimetres.	Temp.
1.	83·65	15°
2.	83·4	15°
2.	83·05	16°
4.	83·05	16°

As is well known, in such determinations the temperature is a very important factor. As in the case just given, 1°C. corresponds to a difference of about ·05 cm. I therefore carefully noted the temperature of the room at the beginning of each reading, and took care to leave all the vessels and liquids there several hours before use. During the whole time the temperature remained between 15° and 16°. No precaution against evaporation was taken nor required, except in the case of mixtures, when a plug of cotton wool was inserted in the neck of the bottle. The mixtures were made by running in from a burette a certain number of drops of the different liquids.

	Boiling point.	Height in millimetres.	Temp.
Benzene	80 – 80½	83·65	15°
		83·05	16°
Toluene	109·7 – 110·05	83·95	15°
		83·2	16°
Orthoxylene	143·8	86·95	15¼°
Para ,,	137·6 – 138·8	83·80	15¼°
Meta ,,	138·2 – 138·7	84·3	16°
Pseudo cumene	167 – 169	86·1	16°
Mesitylene	160 – 161	84·75	16°
Alcohol (absolute)		71·5	
200 drops benzene 2 ,, alcohol		82·5	16°
Carbon bisulphide		64·9	15°
200 drops benzene 5 ,, CS_2		82·7	15°
200 drops benzene 10 ,, CS_2		81·45	15°
Petroleum	79 – 81	71·8	15°
300 drops benzene 10 ,, petroleum		82·45	15°
300 drops benzene 6 ,, petroleum		83·1	15°

It appears from the above that in the case of the pure hydrocarbons, the difference is too small to be able to base upon it any reliable method of analysis. In case, however, of small quantities of impurities, which are often found in commercial benzene, the height of the column is sufficiently depressed to be able to detect the presence of small quantities of carbon bisulphide or petroleum.

Ordinary Meeting, November 16th, 1886.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., Vice-President, in the Chair.

"The Application of the Harmonic Analysis to the Regular Solar Diurnal Variations of Terrestrial Magnetism," by CHARLES CHAMBERS, F.R.S., Superintendent of the Colaba Observatory, Bombay; communicated by Professor BALFOUR STEWART, LL.D., F.R.S.

The great virtue of the harmonic analysis, as applied to terrestrial magnetism, lies in its taking the facts of nature as they stand—discarding none because they have a seeming complexity, and selecting none because they have a seeming simplicity—and weaving them all into a definite system, which the mind is capable of grasping as a whole: its application substitutes, as a subject of contemplation, for distributions on the earth's surface of, say, three sets of components of force, or of a single resultant force and its two directions, obtained directly from observation, an equivalent distribution of potential and the forces related thereto.

The mathematical expression for the potential having the form of an indefinite series of terms of increasing degree, its agreement with observation will be closer the higher the degree at which the expression stops; and increasing difficulties and complexity of calculation alone, fix a limit to the degree of the last term, which should be included. To select a particular subordinate term of any one degree, and call that the potential, might well be to evolve from the imagination an interesting exercise, but would obviously be to ignore the fundamental character of the potential in a case of nature, as embodying all the pertinent facts that observation has acquainted us with.

In speaking of attempts of the earlier magneticians to explain the distribution of magnetic force on the earth's surface by hypotheses—first of a central magnet, then of a magnet displaced from the centre, and then of two eccentric magnets, Gauss says, "It will be best to abandon entirely this mode of proceeding, which reminds one involuntarily of the attempts to explain the planetary motions by continued accumulation of epicycles." What would have been his astonishment, then, if he could have foreseen that nearly half a century after the publication of his "General Theory of Terrestrial Magnetism," his investigation had met with so little appreciation, that even a disciple professing to follow in his footsteps could still resort to crude hypothesis where the master had shown the way to knowledge; that time had only substituted hypothesis as to which one or two subordinate terms of the expression of a potential should be tentatively adopted as the whole, in the place of hypothesis as to one or two magnets fixed within the earth; and that on questions of importance, conclusions legitimately deducible only from the evidence of the full potential had been drawn from the restricted potential of such hypothesis.

Yet all this has happened, as I will proceed to show by an examination of a paper "On the Diurnal Period of Terrestrial Magnetism," by Arthur Schuster, F.R.S.,* read before the Manchester Literary and Philosophical Society, on the 20th January, 1886. This paper is occupied, mainly, by an endeavour to prove, by the use of the forms of the harmonic analysis, that the seat of the forces concerned in the production of the diurnal variations lies *outside* the earth; and the author claims that his results, as far as they go, give an emphatic answer in favour of the supposition,

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* Proceedings—Literary and Philosophical Society, Vol. XXV., No. 7, Session 1885-6.

and considers that more detailed investigations can "hardly upset the conclusion that the greater part of the diurnal variation is due to disturbing causes outside the earth's surface."

Now, following Gauss, the full expression of the potential on the surface of the earth, which is equivalent to the periodical part of a system of forces, is

$$V = [Q_1] + [Q_2] + \dots\dots\dots\dots + [Q_i] + \dots\dots\dots \qquad (1)$$

where V is the potential at a point which has u for its co-latitude (measured from the north pole from 0° to 180°) and λ for its longitude (east); and $[Q_i]$ consists of $(2i+1)$ terms, being Legendre's coefficients in order, each multiplied by a periodical function of the form—

$$p_1\cos\theta + q_1\sin\theta + p_2\cos 2\theta + q_2\sin 2\theta + \dots\dots\dots$$

The different periodical functions, which have no necessary relation to each other, may be symbolised by the letters A, B, C......, or (say)—

$$\begin{aligned}[Q_1] &= A\cos u + B\sin u\cos\lambda + C\sin u\sin\lambda \\ [Q_2] &= D\left(\frac{3}{2}\cos^2 u - \frac{1}{2}\right) + E(3\sin u\cos u\cos\lambda) + F(3\sin u\cos u\sin\lambda) \\ &\qquad + G(3\sin^2 u\cos 2\lambda) \quad + H(3\sin^2 u\sin 2\lambda)\end{aligned}$$

&c., &c.

For the values of X_θ, Y_θ, the deviations, at the time θ,* from the mean values, for the full period, of X, Y, the north and west components of the horizontal force, we obtain—

$$X_\theta = -\frac{d[Q_1]}{adu} - \frac{d[Q_2]}{adu} - \dots\dots\dots\dots\dots$$

$$\left.\begin{aligned} &= \frac{A}{a}\sin u - \frac{B}{a}\cos u\cos\lambda - \frac{C}{a}\cos u\sin\lambda \\ &+ \frac{3}{2}\frac{D}{a}\sin 2u - 3\frac{E}{a}\cos 2u\cos\lambda - 3\frac{F}{a}\cos 2u\sin\lambda \\ &\qquad - 3\frac{G}{a}\sin 2u\cos 2\lambda - 3\frac{H}{a}\sin 2u\sin 2\lambda \\ &+ \dots\dots\dots\dots\dots \end{aligned}\right\} \qquad (2)$$

where a is the radius of the earth.

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* The time being expressed by the hour angle θ of the mean sun from the initial meridian.

$$\left.\begin{aligned}Y_\theta &= -\frac{d[Q_1]}{a\sin u d\lambda} - \frac{d[Q_2]}{a\sin u d\lambda} - \dots\dots\dots\\ &= +\frac{B}{a}\sin\lambda - \frac{C}{a}\cos\lambda\\ &\quad + 3\frac{E}{a}\cos u\sin\lambda - 3\frac{F}{a}\cos u\cos\lambda\\ &\quad + 6\frac{G}{a}\sin u\sin 2\lambda - 6\frac{H}{a}\sin u\cos 2\lambda\\ &\quad + \dots\dots\dots\dots\end{aligned}\right\}\quad(3)$$

Limiting ourselves to terms in V of the first and second degrees, the determinations of X_θ, Y_θ, obtained by calculation from the observed values of horizontal force and of declination, may easily be put in the form—

$$P_1\cos\theta + Q_1\sin\theta + P_2\cos 2\theta + Q_2\sin 2\theta + \dots\dots\dots$$

and these, being put on the left sides of equations (2) and (3) respectively, afford, in each case, as many equations of condition as there are stations of observation of the form—

$$\left.\begin{aligned}aP_1 &= p_{1A}\sin u - p_{1B}\cos u\cos\lambda - p_{1C}\cos u\sin\lambda\\ &\quad + \frac{3}{2}p_{1D}\sin 2u - 3p_{1E}\cos 2u\cos\lambda - 3p_{1F}\cos 2u\sin\lambda\\ &\quad - 3p_{1G}\sin 2u\cos 2\lambda - 3p_{1H}\sin 2u\sin 2\lambda\end{aligned}\right\}\quad(4)$$

or—

$$\left.\begin{aligned}aP_{1Y} &= p_{1B}\sin\lambda - p_{1C}\cos\lambda\\ &\quad + 3p_{1E}\cos u\sin\lambda - 3p_{1F}\cos u\cos\lambda\\ &\quad + 6p_{1G}\sin u\sin 2\lambda - 6p_{1H}\sin u\cos 2\lambda\end{aligned}\right\}\quad(4a)$$

for the determination of the numerical coefficients p_{1A}, p_{1B}, p_{1C}, &c., where—it will be observed—P_{1X}, P_{1Y} are numerical quantities, and the additional suffixes of p_1 refer to the particular periodical factor to which the undetermined coefficients belong. Similar equations of condition serve, in like manner, for the determination of p_{sA}, p_{sB}, p_{sC}, &c.; q_{sA}, q_{sB}, q_{sC} &c.; where s stands for 1, 2, 3, &c., successively.

In order, now, that we may be able to see the full significance of the suppositions and assumptions made by the writer of the paper under discussion, let us take, as a standard of comparison, the full surface potential of the first and second degrees, the unknown coefficients of which have to be determined in accordance with Gauss' own mode of procedure.

The writer's first step, and one the consequences of which run all through his investigations, is to assume that—

$$\frac{dX_\theta}{d\theta} = \frac{dX_\theta}{d\lambda}; \qquad \frac{dY_\theta}{d\theta} = \frac{dY_\theta}{d\lambda}; \qquad (5)^*$$

and it is premised by the remark, "Observation tells us, that all over a given circle of latitude we may take the variation to be very nearly the same for a given local time." The correctness of the assumptions must be estimated, of course, by the exactness of the statement on which they are based; and it must be admitted that, except in high latitudes, the variations do, in a rough manner, conform to the rule laid down; but it is known that in proceeding round the north magnetic pole, it is the magnetic meridian of the place and local time to which the variations of declination are referred, when it is said that there is similarity in the type of variation; and as such magnetic meridians have all inclinations (from 0° to 360°) to the respective astronomical meridians, it is obvious that the rule is far from corresponding to the facts in that region, as far, indeed, as it possibly could be in some parts of it. It is to be observed, too, that in another place† the writer has inferred from the variations of this region, that there a vertical component of an electric current should be found to cross the earth's surface: an inference antagonistic to the present assumption of the existence of a potential, unless the vertical current be further assumed to be of constant intensity. I cannot, thus, regard these assumptions as a sound basis on which to build

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[*] Page 123 of the paper where the nomenclature is the same as above, except that t is used for θ, and X, Y for X_θ, Y_θ.

[†] Report of British Association, 1885; and Proceedings—Literary and Philosophical Society, Vol. XXV., No. 7, pp. 115 and 122.

up a general system which is to have far-reaching consequences. But let us see what are the limitations that they require us to admit as probable as to the nature of the potential itself. First we must have—

$$\left.\begin{aligned} X_\theta &= \mathrm{I}\cos u\{\sin(\theta+\alpha)\cos\lambda+\cos(\theta+\alpha)\sin\lambda\} \\ &\quad+\mathrm{J}\cos 2u\{\sin(\theta+\beta)\cos\lambda+\cos(\theta+\beta)\sin\lambda\} \\ &\quad+\mathrm{K}\sin 2u\{\sin 2(\theta+\gamma)\cos 2\lambda+\cos 2(\theta+\gamma)\sin 2\lambda\} \end{aligned}\right\} \quad (6)$$

α, β, γ being constant angles and I, J, K constant numbers,

or $$\left.\begin{aligned} X_\theta = \mathrm{I}\cos u\sin(\theta+\alpha+\lambda)+\mathrm{J}\cos 2u\sin(\theta+\beta+\lambda)+ \\ \mathrm{K}\sin 2u\sin(\theta+\gamma+\lambda) \end{aligned}\right\} \quad (7)$$

that is, we must suppose—

(1) that $\mathrm{A}=0.$

(2) ,, $-\frac{\mathrm{B}}{a}=-\frac{1}{a}(p_{1\mathrm{B}}\cos\theta+q_{1\mathrm{B}}\sin\theta)=\mathrm{I}\sin(\theta+\alpha),$

(3) ,, $-\frac{\mathrm{C}}{a}=-\frac{1}{a}(p_{1\mathrm{C}}\cos\theta+q_{1\mathrm{C}}\sin\theta)=\mathrm{I}\cos(\theta+\alpha),$

(4) ,, $\mathrm{D}=0,$

(5) ,, $-3\frac{\mathrm{E}}{a}=-\frac{3}{a}(p_{1\mathrm{E}}\cos\theta+q_{1\mathrm{E}}\sin\theta)=\mathrm{J}\sin(\theta+\beta),$

(6) ,, $-3\frac{\mathrm{F}}{a}=-\frac{3}{a}(p_{1\mathrm{F}}\cos\theta+q_{1\mathrm{F}}\sin\theta)=\mathrm{J}\cos(\theta+\beta),$

(7) ,, $-3\frac{\mathrm{G}}{a}=-\frac{3}{a}(p_{2\mathrm{G}}\cos 2\theta+q_{2\mathrm{G}}\sin 2\theta)=\mathrm{K}\sin 2(\theta+\gamma),$

and (8) ,, $-3\frac{\mathrm{H}}{a}=-\frac{3}{a}(p_{2\mathrm{H}}\cos 2\theta+q_{2\mathrm{H}}\sin 2\theta)=\mathrm{K}\cos 2(\theta+\gamma).$

And a similar and related set of restrictions must be made with respect to Y_θ, so that it shall become—

$$Y_\theta=\mathrm{I}\cos(\theta+\alpha+\lambda)+\mathrm{J}\cos u\cos(\theta+\beta+\lambda)+2\mathrm{K}\sin u\cos 2(\theta+\gamma+\lambda) \quad (8)$$

Observing, now, that the part $(\theta+\lambda)$ of the angles in equations (7) and (8) may be regarded as a single variable—the local time, we see from those equations that the restricted values of X_θ and $(Y_\theta\sin u)$ consist each of three terms, each of which is the product of a function of u into a function of the local time. And the pair of first terms in X_θ and $(Y_\theta\sin u)$ respectively, the pair of second terms, and the pair of third terms, each separately and of necessity, satisfies the criterion of a spherical surface potential, viz.: that—

$$\frac{d(\mathrm{Y}\sin u)}{du} = \frac{d\mathrm{X}}{d\lambda}.$$

We are now prepared to examine the writer's next step in which, combining the criterion just mentioned with the assumption that $\frac{d\mathrm{X}}{d\theta} = \frac{d\mathrm{X}}{d\lambda}$, and making the new assumption that (Y$\sin u$) is a product of (U), a function of u only, into $\left(\frac{d\mathrm{T}}{dt}\right)$, a function of the time only, he obtains the results—

$$\mathrm{Y}\sin u = \mathrm{U}\frac{d\mathrm{T}}{d\theta} \quad \text{and} \quad \mathrm{X} = \mathrm{T}\frac{d\mathrm{U}}{du},$$

results which have a most delusive appearance of generality. As we have remarked above, this last assumption is consistent with each of the terms of equation (8), after multiplication by $\sin u$, providing T is made a function of the local time instead of the absolute time, and $d(\theta+\lambda)$ be substituted for $d\theta$, when the results become—

$$\mathrm{Y}\sin u = \mathrm{U}\frac{d\mathrm{T}}{d(\theta+\lambda)} \quad \text{and} \quad \mathrm{X} = \mathrm{T}\frac{d\mathrm{U}}{du} \qquad (9)$$

But, in combination, only the first and second terms are consistent with the assumption, and the adoption of the latter necessitates that I and J should each be zero or that K should be zero. Thus, the assumptions—

$$\left[\frac{d\mathrm{X}}{d\theta} = \frac{d\mathrm{X}}{d\lambda}; \quad \frac{d\mathrm{Y}}{d\theta} = \frac{d\mathrm{Y}}{d\lambda} \quad \text{and} \quad \mathrm{Y}\sin u = \mathrm{U}\frac{d\mathrm{T}}{d(\theta+\lambda)}\right]$$

have caused the potential of nature to dwindle away, in the first case, till only two independent constants are left in it, and, in the last case, till only four such constants are left; in other words, if we suppose the time factors in the original potential to have each involved four co-efficients (p_1, q_1, p_2, q_2) of its own, thirty-two arbitrary co-efficients have, by assumptions that will not bear close examination, been cut down to either two only or four only, and this, without our being made aware that any such process was in operation. A little later on the writer elects to work further with the second term of equation (8) only, expressly setting aside the subject matter of the third term, as a detail which it was not his intention then to enter into. And yet, in the mean diurnal variations of declination for the year, the amplitude of the element which has half a day for its period is to that which has a full day for its period,—at Greenwich as 1·96 to 2·88, and at Bombay as 1 to 1. Hence, as the East component of the horizontal variation, in fact, differs in this respect, very slightly from the declination, it is likely that, in throwing out from consideration the element of the potential that has half a day for its period, he discards quantities of the same order as those that he retains, and his hypothetical potential must, consequently, differ largely from that of nature.

But the appearance of generality of the assumed time-function (T) would seem to have deceived even the writer himself. The function cannot, we see from equation (8), have any other form than either $\sin(\theta+\varepsilon+\lambda)$ or $\sin 2(\theta+\varepsilon+\lambda)$ where ε is a constant,* and, consequently, in comparing with observation his conclusion from equation (9), that X should be a maximum or minimum when Y vanishes, the writer should have chosen only the single-wave elements of the observed variations which have the full day for their period, or the similar elements which have half a day for their period;† but his description of the comparison‡ refers to the whole complex variations, and it is obvious that he did not recognise how greatly his previous assumptions had put restrictions on the generality of form of T. At least it might be taken as obvious until it is found, a little further

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* That is, unless the potential is carried beyond terms of the second degree.

† And a pair even of these elements is fit for the comparison only on the assumption that it belongs wholly to the first or second degrees of the potential of nature.

‡ Pages 124 and 125 of the paper.

on, that he still does the same thing* after having expressly put $\sin(\theta - 30^\circ + \lambda)$ in the place previously occupied by T.

We now come to the writer's principal undertaking—the proof that the seat of the magnetic variations lies outside the earth. To adapt our formulæ to his convention that the time (t) should be reckoned from two o'clock in the afternoon on the initial meridian we must take $\beta = -30^\circ$ when $(t + \lambda) = (\theta - 30^\circ + \lambda)$. He first assumes that, with an arbitrary unit, $\mathrm{Y} = \cos u \cos(t + \lambda)$; and then deduces

$$\mathrm{X} = \cos 2u \sin(t + \lambda),$$

and the surface potential $\mathrm{V} = -a \sin u \cos u \sin(t + \lambda)$.

This gives for the vertical force inequality—

$$\mathrm{Z} = -\frac{d\mathrm{V}}{dr} = \sin 2u \sin(t + \lambda) \qquad (10)$$

or

$$\mathrm{Z} = -\frac{d\mathrm{V}}{dr} = -\frac{3}{2} \sin 2u \sin(t + \lambda) \qquad (11)$$

according as the region of origin of the forces is wholly outside or wholly inside the earth.

In comparing the deduced expression for X with observations, the writer says, "If our equation is approximately right, the northerly force ought to be a maximum in the morning, a minimum in the afternoon in the equatorial regions, where $\cos 2u$ is negative; while in latitudes above 45° the minimum ought to take place in the morning. This is exactly what happens, with the exception that the change seems to take place in latitudes smaller than 45°. At Bombay the maximum of horizontal force takes place at 11 a.m. At Greenwich the minimum takes place a little after that time. At Lisbon ($u = 51^\circ$) the minimum lies, as at Greenwich, in the morning, but the range is considerably reduced;" and he concludes, without any further evidence, that the equation represents surprisingly well the general character of the horizontal force variation, both in

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* Pages 125 to 127 of the paper.

the northern and southern hemispheres. But if we substitute, in the extract, for "in the morning" and "in the afternoon" the hours 8 a.m. and 8 p.m., as the formula requires, we shall see that such terms as—exactly happens—and—surprising representation—have no relation, in a matter of this kind, to the approximation of the hour 11 a.m. to the hour 8 a.m. Similarly, the maximum of Z is required by equation (10) (the writer's own) to be at 8 p.m., both at Greenwich and Bombay; the maximum of the simple-wave element that has the one day period does actually occur at Greenwich at 8h. 1m. p.m., but at Bombay not till 11h. 7m. p.m.—a greater discrepancy even than before.

But, as we have said before, the element of the observed variations that has half a day for its period is of the same order of magnitude as the element that has the full day for its period; and we see even from the restricted values of X_θ, Y_θ of equations (7) and (8) that there is in the potential a term of the second degree which is proportional to $\sin^2 u \sin 2(\theta+\gamma+\lambda)$. It is, however, to pairs of values of $-\frac{dV}{adu}$ and $-\frac{dV}{dr}$ derived from each of the terms of the potential of a single degree (or of the corresponding negative degree), equally with those derived from any single term, that the test applied by the writer to the relations between the derived north force and vertical force properly applies; and little value can be attached to the comparison of pairs of values derived from a single term, as indicating which of the two values of Z—that corresponding to external forces or that corresponding to internal forces—best accords with observation. Moreover, as the results derived from the terms of each degree of the potential, taken separately, should concur—when the method is applied in a systematic manner—in attributing the forces to external or internal action, if either alone was effective; and would thus be capable of answering the question with some definiteness; it is vain to form conclusions on so narrow a basis as is afforded by a single pair of terms (together with another related pair) of a single degree.

The attempt to follow the writer, even on his own ground, is, however, beset with considerable difficulties. On page 127 of the paper, he writes, with reference to equations (10) and (11), "Both expressions have their minima and maxima co-incident with those for the northerly components of horizontal force, a fact which finds its confirmation in actual observation. They also give us the phase of vertical force to be the same for each hemisphere, and not to change as in the case of the horizontal force. But there is an important distinction; while $-\frac{dV}{dr}$ has its maxima and minima coincident with the maxima and minima of horizontal force at latitudes greater than 45°, in the equatorial regions the maximum of horizontal force ought to be coincident with the minimum of vertical force, and *vice versâ*." The first of these statements is correct only if it means that a minimum of vertical force coincides with either a maximum or minimum of horizontal force, and a maximum of vertical force does the same. The second is wrong, for whilst $\sin 2u$ has the positive sign in the northern hemisphere and the negative sign in the southern hemisphere, $-\frac{3}{2}\sin 2u$ has, of course, the reverse signs. And the third statement, which embodies the writer's special test, is intelligible only with the help of the cases to which it is presently applied, and on the suppositions that he is speaking now of equation (10) only, and that his mind has become possessed of the wrong impression that $\sin 2u$ has the same sign for all values of u from 0° to 180°.

Lastly, the writer supposes currents of electricity to circulate in a spherical conducting shell just outside the earth's surface, and inquires what should be the intensity and direction of such currents in order that they should produce the diurnal variations of magnetic force observed on the earth's surface. Following Clerk-Maxwell,* he considers the particular case in which the whole spherical surface is divided by successive stream-lines (for each of which the current-function is constant) into annuli, along which the currents flow, and which disappear at the two poles of the system of currents; and where no electricity enters or leaves the shell. And adopting Maxwell's expressions for the values of the current-function and the magnetic potential just within the shell, and again particularising by dealing only with the case in which the latter is a surface harmonic of degree i, he finds that the system of stream-lines is orthogonal to the system of lines of force. Then, remarking that "there seems for diurnal variation no term of the first order, and we may, therefore, take very approximately the currents to be at right angles to the magnetic force at any place," he proceeds to calculate from the observed diurnal inequalities of magnetic force at Greenwich and at Bombay, the equivalent currents that should flow in the hypothetical conducting shell just above these places respectively. Here, to say nothing of the assumption that the potential of the magnetic variations is a surface harmonic of a single degree only, we have the same loose reasoning that pervades the previous investigation; no reason is given why the stream-lines of the aerial currents should be regarded as dividing the earth's surface into annuli, and until that is done we can have no assurance that their character is not such as to place them outside the class to which alone the formulæ used apply. And in the absence of any application of the

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* "Electricity and Magnetism," First Edition, Vol. II., pp. 259 to 262 and 275 to 277.

converse process of examining whether the calculated currents conform to the required condition or not, it must be presumed that the necessity of their doing so was not recognised.

In the course of his discussion of this matter, the writer makes a statement of fact, and adds an insinuation which it behoves me to notice. His words are, "The Bombay observations on magnetic declination refer, as regards time, to twelve minutes past each hour. The observations at the same place on horizontal force to fourteen minutes past each hour. This is only one of the many little devices by means of which the heads of magnetical observatories try to enliven the time of those who want to compare their results." It is strange that he should seem to be unaware that the Bombay Observatory is one of the number of Colonial and Indian Observatories established under the auspices of the Royal Society about the year 1840; and that in the opinion of the Committee of Physics of that Society—consisting of men of the calibre and repute of John Herschell, Sabine, Lloyd, &c. —it was at that time so important that each instrument of the same name should be read simultaneously at the different observatories, that they embodied in their instructions to observers specific directions that the hours of observation were to be hours of Göttingen mean time, and the instruments were to be read in a particular order and at equal intervals. I need only add that the longitude of Bombay east from Göttingen is 4h. 11½m., and that the results which the writer has made use of were derived from eye-observations taken hourly for over a quarter of a century in pursuance of the Royal Society's instructions.

And, now, briefly to summarise my criticism of the paper as a whole:—

(1) Whereas the principal feature of Gauss's theory is to contemplate the magnetic forces through the potential

of nature, the writer substitutes a restricted potential of his own imagining.

(2) Having chosen to deal with an elementary portion of potential of nature, he fails—in comparing it with observation—to use, on the other side, only the corresponding elements of the variations of force, but compares with the whole complex variation of observation.

(3) He describes such agreement of observation with his theory as is displayed in his comparisons in unmeasured language.

(4) He draws conclusions on questions of importance that are unwarranted by the evidence produced; and he expresses them with a degree of confidence that would mislead any reader but the specialist, who is able to appreciate the evidence at its true value, into a belief they are better founded than they really are.

As to the practical object which I have in view in thus exposing the illogical character of the writer's treatment of this question, besides the correction of published fallacies, I may mention that Dr. Schuster is a member of a Committee of the British Association appointed to consider the best means of comparing and reducing magnetic observations, and in that capacity—as in the paper under discussion—he has advocated the application of Gauss' method to the magnetic diurnal variations; and, not agreeing with him that there is urgency in this point, I deem it important that the rest of the Committee should be made aware that his authority in this field does not stand unquestioned. My own opinion is that the effectual application of the harmonic analysis to the diurnal variations of terrestrial magnetism will be a work of such magnitude*

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* How formidable an undertaking, even if the potential include only terms of the fourth degree—as in Gauss's calculation of it from the absolute forces—may be inferred from the fact that, taking each of the periodical factors with four pairs of terms, there would be no less than 192 arbitrary constants to determine for the surface potential, and each of these would divide itself into two when the variations of vertical force were taken into account.

that it would be highly injudicious to attempt it with crude raw material. A considerable work of collation and evaluation of the available results of observation has first to be carried out, and it would be a culpable yielding to impatience to expend funds upon elaborate calculations, until something was known of the probable errors of the data on which such calculations would have to be based. That there is necessity for magneticians, who have the responsibility of directly or indirectly advising the Government on magnetic matters, to be on their guard, is evident when we find Dr. Schuster lightly suggesting that two or three declination magnetographs should be distributed over the northern frontier of India and one additional vertical force instrument be placed in Central India—even when they are to be worked only for a single year.

Remarks on Mr. Chambers' paper entitled: "The Application of the Harmonic Analysis to the Regular Solar Diurnal Variations of Terrestrial Magnetism," by Professor ARTHUR SCHUSTER, Ph.D., F.R.S.

Mr. Chambers has done me the honour of reading my paper on the diurnal variation of terrestrial magnetism, and, if I understand him correctly, he has met with some difficulties, which he desires to have explained. Mr. Chambers has done excellent work as a practical magnetician, and I am naturally anxious that he should be clear about the methods, by means of which, in my opinion, all magnetical observations will have to be reduced. It is for this reason only, that I shall enter into a discussion of the questions he raises.

In the first part of my paper I tried to show that, except perhaps in the arctic regions, we are justified in assuming the existence of a potential on the surface of the earth for the variable part of the magnetic forces. I derived an additional argument by means of an equation which is severely criticised by Mr. Chambers. It seemed to me that the variable part of the potential at different places can be approximately expressed by the product of a function of the local time into a function of the latitude, and I consequently took—

$$V/a = -TU \ldots\ldots\ldots\ldots \qquad (1)$$

where T is a function of the local time t, and U a function of the colatitude; a being the radius of the earth. From (1) we can derive—

$$Y\sin a = U\frac{dT}{dt}, \quad X = T\frac{dU}{du} \ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

as explained in my paper.

Mr. Chambers expresses his opinion that these results "have a most delusive appearance of generality." But where, may I ask, is the delusion?

I have clearly expressed the assumptions on which (1) depends, I have, as far as I know, correctly deduced equations (2) from (1), and, as results of a mathematical investigation, are not generally called "delusive" unless there is some blunder either in the statement of the assumptions or in the analytical deductions, I shall briefly restate my reasons for taking (1) as an approximate expression for the potential.

The equation depends in the first place on the observed fact, that, except perhaps in high latitudes, the diurnal variations of terrestrial magnetism in each circle of latitude are nearly the same for a given local time, so that we may take the time variation at any place to be equal to the longitude variation at the same time. I need not enter into the question raised by Mr. Chambers whether this is, or is not, true in high latitudes, because it is not necessary that equation (1) should hold over the whole surface of the earth, as long as the equations (2) are applied to those parts only for which (1) holds. I have only used the equations in regions where, even according to Mr. Chambers' high standard of accuracy, "the variations do, in a rough manner, conform to the rule laid down." The second part of the assumption involved in (1) is more doubtful, though Mr. Chambers does not criticise it. If that equation was strictly correct, the type of the diurnal variation in different latitudes would be the same, the amplitude only varying. As this is not strictly true, we cannot expect equations (2) to be rigorous, and I never implied that they were. But if we can put the potential into the form of a product of a time function into a latitude function, it is clear that nothing can restrict the generality of those functions, for the value of a potential at the different points of a closed surface is quite arbitrary, and is subject to no condition. I may therefore choose any functions T and U, which best accords with observation.

Being unable to discover the "delusion" in my own work I naturally look into Mr. Chambers' paper to see in what way he supports his charge. Supposing, at any time, the variable part of the magnetic potential to be expanded into a series of a spherical harmonics; we may obtain according to the assumption I have made, the potential at any future time (t) by simply writing $(\lambda+t)$ for λ the longtitude. Mr. Chambers does this in a roundabout way in his equations (6), (7), and (8). Each term of the series thus obtained, consists of the product of a function of $(\lambda+t)$ into a latitude function; but we can combine only those tesseral harmonics which are of the same type, so as to appear for a given longitude in the form TU. From this, Mr. Chambers seems to conclude that if the potential, which has been expanded, is of the form TU, all coefficients must vanish except those belonging to some one single type. The conclusion is wrong, for we can expand *any* function of a latitude and longitude into a series of surface harmonics, and it is impossible to say, *a priori*, whether any coefficients in the expansion will vanish. There is, in fact, no question at all in this part of my work of an expansion of the potential into a series, for we can deal with the complete expression as it stands, and it would simply have been absurd on my part to have tested the formulæ by taking, as Mr. Chambers suggests, "only the single-wave element of the observed variations, which have the full day for their period, or the similar elements which have half a day for their period." I cannot help thinking that Mr. Chambers would have saved himself considerable trouble in his criticisms, had he remembered the fact that any function of two spherical co-ordinates can be expanded into spherical harmonics, and that, therefore, the values of the potential on a sphere, as, indeed, on any closed surface, can be chosen arbitrarily and are not subject to any conditions.

In the second part of my paper, I stated that the following set of equations seemed to me to give the chief characteristics of the diurnal variation:—

$$\left.\begin{aligned} X &= \cos 2u \sin(t+\lambda) \\ Y &= \cos u \cos(t+\lambda) \\ Z &= \sin 2u \sin(t+\lambda) \end{aligned}\right\} \quad (3)$$

where X, Y, Z are respectively the forces on a north pole directed towards the north, the west, and vertically downwards. I described some of the principal points of the equations in a sentence which I admit was badly expressed. I stated, for instance, that the equations "give us the phase of the vertical force to be the same for each hemisphere." The whole context showed that I meant, namely, that the phase is the same *within* the same hemisphere. Mr. Chambers, however, takes me to mean that the phase is the same in the northern as in the southern hemisphere, and on the strength of this interpretation, triumphantly proves me to be ignorant of the fact that $\sin 2u$ is negative when u is greater than 90°. There is, however, one curious point which Mr.

Chambers has failed to notice. My statement would be right even if Mr. Chambers' interpretation of it was correct; for though the force on a north pole changes sign by going across the equator, the change of vertical force also is reversed by crossing the magnetic equator. The maxima and minima of vertical force ought to be the same, therefore, over the whole world, except in the small portions included between the magnetic and geographical equator.

But it is a waste of time to discuss the wording of the sentence which I have used to interpret equations (3); as the truth of the equations can only be tested by their agreement, or non-agreement, with observed facts. Observations of the vertical force variation, all agree to show that the third equation is true to the same degree of accuracy in the southern, as it is in the northern hemisphere.

I have, in my previous paper, only taken into account the term which has the full day for its period, and omitted the term which has a double period each day. Mr. Chambers blames me, in consequence, for omitting terms as important as those which I have taken into account. In reality, terms of different periods can be treated independently of each other. Results which have been obtained by taking account of one period, hold, of course, for that period only; but, as far as that period is concerned, they cannot be affected by any subsequent treatment of the terms of different periods. I find, as a matter of fact, that the semi-diurnal terms only strengthen the conclusion that the disturbing force is outside the earth, but my calculations on this point are not, as yet, concluded.

Mr. Chambers is correct in saying that I ought to have tested my equations by comparing them with the observations of the single period variation. An inspection of the curves is, however, sufficient to show that the maximum of the single period variation, must nearly coincide with the maximum of the whole variation, so that it became a matter of no importance which was taken. If, however, Mr. Chambers wishes to test the formulæ by means of the diurnal period as distinguished from the semi-diurnal period, he ought also to have chosen the origin of the time, so as best to suit the observations on declination. Had he done so, he would have found that the greatest discrepancy in the time at which the maximum of vertical force takes place amounts to about two hours, and a few words are necessary why I did not consider that such a discrepancy seriously affected my argument.

No one who has realised the meaning of the two first equations (3) can doubt that the expression for the potential, from which they are derived, constitutes an important term in the general expansion of that potential. They give a periodic variation, which contains all the characteristic facts of observation. The first equation gives a change in declination gradually increasing in amplitude from the equator towards both sides, the change being such that, whenever the needle deviates towards the east in the northern hemisphere, it deviates towards the west in the southern hemisphere, and *vice versâ.* The second equation gives a horizontal force variation, diminishing from the equator to a latitude of 45°, and then again increasing, the phase being the same for the same latitude, north and south of the equator.

But if there is a term—

$$V = -a\sin u\cos u\sin(t+\lambda)\ldots\ldots\ldots\ldots\qquad(4)$$

in the full expansion for the potential, the corresponding term for vertical force must be, if the cause is inside the earth—

$$\sin 2u\sin(t+\lambda)\ldots\ldots\ldots\ldots\qquad(5)$$

and if outside—

or $$-\frac{3}{2}\sin 2u\sin(t+\lambda)\ldots\ldots\ldots\ldots\qquad(6)$$

According to Mr. Chambers, the phase of the expression (5) differs by two hours from that given by actual observation; but the phase of (6) differs by ten hours, and, if we are to choose between (4) and (5), I must say, that I prefer a difference of two hours to a difference of ten hours. If it was considered necessary to enter into greater detail, we should have to divide the observed vertical force variation into two terms, one having $\sin(t+\lambda)$ and one having $\cos(t+\lambda)$ as factor. The first term only would have to be considered in a comparison of (4) and (5) with observation, for the second term would not belong to that part of the potential which is expressed by (4). If this is done we should find that all over the world, as far as we have any observations, the sign of the factor multiplying $\cos(t+\lambda)$ agrees with (5) and not with (6), and this is a sufficient proof that the greater part of the disturbance, whose horizontal components are derived from (4), must have their seat outside the earth.

The results of my calculations I had expressed, by saying that more detailed investigations "can hardly upset the conclusion arrived at in this paper, that the greater part of the diurnal variation is due to disturbing causes outside the earth's surface." As Mr. Chambers charges me with drawing conclusions unwarranted by evidence, I now formulate my result more definitely, thus :—

In the general expansion of the variable part of the magnetic potential on the earth's surface, there is an important term $V=-a\sin u\cos u\sin(t+\lambda)$, *where* λ *is the longitude reckoned from Greenwich towards the east, and* t *Greenwich time reckoned from three o'clock in the afternoon. The greater part of this term, and possibly the whole term, is due to causes outside the earth's surface.*

No subsequent work can affect this result, unless there is some blunder in my calculations.

In the last part of my paper, I shewed how to calculate electric currents flowing on a spherical surface closely surrounding the earth and producing such magnetic effects as we observe in the diurnal variations. This part of my work has, like the rest, failed to secure Mr. Chambers' approval. I do not doubt that Mr. Chambers did not intend to offer any but fair criticisms, and that nothing but radical misunderstanding can have induced him to make the remark which I shall presently quote.

Supposing, to make my meaning clear by an example, Mr. Chambers had stated that the gravitational attraction of the earth on a point outside was nearly the same as that due to a particle placed at its centre, having a mass equal to the mass of the earth. Would Mr. Chambers have considered it fair criticism on my part, if I had objected by saying: No reason is given why the different parts of the earth should be regarded as placed in the earth's centre, and, until that is done, we can have no assurance that the character of the earth's material is not such as to place it outside the class to which alone the formulæ used apply? It is criticism of exactly the same nature which Mr. Chambers uses when he objects to my representation of the diurnal period by means of imaginary surface currents, because: "No reason is given why the stream-lines of the aerial currents should be regarded as dividing the earth's surface into annuli, and until that is done, we have no assurance that their character is not such as to place them outside the class to which alone the formulæ used can apply."

Any argument against such criticism is, of course, impossible.

In spite of considerable efforts, I have failed to discover any intelligible meaning to Mr. Chambers' remarks on this part of my paper.

There is one sentence, however, in my paper which I should like to qualify. I had explained why the currents which I desired to investigate were nearly at right angles to the magnetic force at the point, and how to obtain approximate expressions for their intensity. But in the explanation of the numbers which I give in a table, I make the following remark: "The direction of the current is as accurate as the observations will permit; the intensity is calculated, as explained above, by multiplying the magnetic force by $5/12\ \pi$, and is, therefore, approximate only as far as its absolute value is concerned, but the relative value of the numbers ought to be correct." The first part of the sentence is true only on the supposition that the magnetic force is strictly normal to the current, which it is not. The second part is not quite correct, the relative values of the numbers will also be approximate only.

The approximation is, however, quite near enough for the purpose for which the table was calculated.

I need not enter into what may be called the ornamental part of Mr. Chambers' paper, except to express my regret that he should have felt hurt by a remark of mine about the times for which he reduces his mesurements.

I was aware that he was following the recommendations which a committee of the Royal Society framed about the year 1840; I was also aware "that in the opinion of the committee" . . . "it was at that time so important that each instrument of the same name, should read simultaneously at the different observatories, that they embodied in their instructions to observers specific directions that the hours of observation were to be read in a particular order, and at equal intervals."

But I knew, in addition, that since that time it was found that the diurnal variations depended chiefly on the local time of the place, and not on Göttingen time, so that in consequence, every observatory of note took the first opportunity of departing from the original recommendations.

Such an opportunity was given by the introduction of self-registering instruments, and, as far as I know, Mr. Chambers stands alone in finding the values of his photographic curves for a time of his own convenience. He has given up Göttingen time, but he has still further departed from the hours of local time by giving the readings for his three instruments, at seventeen, eighteen, and nineteen minutes past each hour. Nobody can object if Mr. Chambers takes any hour he pleases for his reductions, but Mr. Chambers, on the other hand, cannot object if others feel irritated at the additional labour which is thereby imposed on them.

I do not enter into the general question whether it is advisable or not to analyse the diurnal variation in the only way in which it can be analysed; because the question has gone beyond the stage of discussion. The calculations are going to be made, and the result only can show whether I was justified in bringing the matter before the notice of the Magnetical Committee of the British Association.

Ordinary Meeting, November 30th, 1886.

Professor Osborne Reynolds, LL.D., F.R.S., Vice-President, in the Chair.

"*Ranunculus Flammula*, Linn., and *R. reptans*, Linn.; and their connecting links," by Charles Bailey, F.L.S.

In their typical states no two species would seem to be more divergent than *Ranunculus Flammula, L.*, and *R. reptans*, L., and yet the series of these plants now before the members would show that they are resolvable into one super-species through numerous intermediate states.

Ranunculus Flammula is universally distributed over the British Islands; it is as much at home in Jersey as in the extreme north of Scotland, and its distribution on the earth's surface shows that it is almost universal over the northern hemisphere, being absent only from Sicily, southern Spain, and similar warm regions.

Ranunculus reptans, on the contrary, is a rare species in our islands; for a century its only known British station was on the shore of Loch Leven, in Kinross; but, as recently as August 1880, Mr. Bolton King found the plant growing on the eastern shore of Ullswater, all the way from Pooley Bridge to Sandwick, but he could find no examples of it on the western shore of this same lake; see Report of the Botanical Exchange Club of the British Islands for 1880, page 28.

The specimens of *reptans* now submitted were collected 16th July, 1886, on the western shore of Ullswater in the small bay where the Glencoin Beck empties itself into Ullswater, and on the southern or Westmorland side of the beck; this station is in the same county as the localities discovered by Mr. Bolton King, on the opposite shore, viz., Watson's County 69; but, as far as could be judged, there is no reason for believing that the same plant does not occur on the northern side of Glencoin Beck, in which case it would be an additional county record for the plant, viz., Cumberland, County 70. At the time I collected it, I believed I was in Cumberland, and so did not prosecute the search further north. There are several spots between Glencoin Beck and Lyulph's Tower, in which the true *reptans* is likely to occur.

From what I know of the habitats of *reptans* it would seem to be partial to the edges of lakes, as in Loch Leven and Ullswater, in our own country, and on the margin of Lake Geneva, and other continental, Scandinavian, and North American fresh-water lakes. I shall not soon forget the first occasion (in July 1865) upon which I saw the plant in a living state, on the sandy margin of Hiterdals Vand in southern Norway; the sides of the lake were covered with a carpet of this little plant growing in felted masses over many acres, and fruiting most abundantly.

On Ullswater it seemed to prefer the narrow area left between the ordinary full-water mark of the lake and its lower summer-level; and the peculiarity of its distribution was that immediately beyond the full-water mark the typical erect form (var. *suberectus* of Syme) of *Ranunculus Flammula* grew in rank profusion.

The interest was further heightened by the fact that the area between full-water and summer-level also produced some creeping forms of *R. Flammula* which were yet not true *R. reptans*, the chief differences from *R. reptans* consisting only of comparative characters, such as their larger flowers, their somewhat thicker first internodes, and their stronger primary roots—the nodal roots being absent; but the plants receded from *R. Flammula* by their creeping character and their filiform and arching internodes.

Sir Joseph Hooker, in his "Students' Flora," Ed. III. page 8, following Dr. Boswell (J. T. Syme, in Eng. Bot., ed. III.) assigns to *R. Flammula* proper, prostrate or erect stems with straight internodes, and to *R. reptans* very slender creeping stems having arched internodes. The specimens of the Ullswater prostrate forms of *R. Flammula* now before you show decidedly arching filiform internodes with creeping stems; it was difficult to assign the plants to the one species or to the other, and it suggested that a small problem in evolution was being worked out under our eyes, and in a very restricted area.

An interesting question which arises is, which of these two forms is the primary one? or are they both modifications in two different directions of some form which has already undergone evolution? The latter suggestion seems the more likely of the two. Temperature and other climatic agencies may be assigned as the chief factors in producing these two forms, because the distribution of *R. reptans* is decidedly northern or arctic and sub-arctic, whilst that of *R. Flammula* occurs in its highest development in such temperatures as those of our own islands and continental Europe. If *reptans* has been associated with glacial temperature, and has adapted itself to arctic conditions, it accounts for its occurrence in neighbourhoods where glacial action is or has been prepotent, and in our own islands we may look upon it as a relic of an arctic vegetation, most of the members of which have disappeared from our flora, or only occur at considerable northern elevations or latitudes. The creeping habits of the plant, with its power of rooting at every node, and of thus anchoring itself to the ground, fit it to hold its own against the fierce blasts of arctic regions, and in times of short summers, when its seeds could not be brought to maturity, its vegetative organs may have preserved it from decimation or extinction. It is not a little remarkable that of the two forms, *R. reptans* perfects its fruits more frequently than does *R. Flammula*; at least my experience of the latter is that its fruits are infrequently produced in this country, whereas nearly all the British specimens of *R. reptans* which have passed through my hands possessed what appeared to be fertile seeds.

R. reptans bears numerous root-leaves having long petioles surmounted by an ovate lamina, a character which it possesses in common with *R. Flammula, R. Lingua*, and *R. ophioglossifolius*, but the leaves produced at the nodes are mostly linear.

Amongst the intermediate forms which occur in this country is a remarkable plant which I found in the herbarium of the late Mr. John Hardy, possibly from Yorkshire, where all the leaves or nearly all were oval. From the facies of the plant it would appear to have been a wholly aquatic form, and that the almost rotund leaves were floating leaves. It answers to the var. *ovatus* of Persoon "Fol. omnibus ovatis longe petiolatis. Poir. Circa Caen." (Synopsis Plantarum; pars secunda, p. 102.)

I also exhibit a floating form with long and slender stems, and with long rootlets from all the lower nodes, which I collected in October last in a shallow pool in the neighbourhood of the Gurnard's Head, in the south of Cornwall; it appears to answer to Persoon's var. *natans* "fol. inferiorib. ovatis integris, superiorib. linearibus. In aquis prope Montmorency et in Barbaria." (l.c., p. 102.)

The usual habit of *R. Flammula*, L, is to have an erect stem springing from a decumbent base; this is the universal form named by Dr. Boswell var. *suberectus*. When the stem is too weak to bear the foliage and flowers it either trails over the ground, when it is Dr. Boswell's var. *pseudo-reptans*, or floats on the water when it is either Persoon's var. *ovatus*, or *natans*, just referred to. In these three forms as well as in the true *reptans*, it is only the terminal portions of the stems, or of the stem-branches, which bear flowers.

The typical form *suberectus* of *R. Flammula* passes into the form *pseudo-reptans* by innumerable intermediate conditions, so that it is not always possible to assign the one name or the other to some of these forms. I exhibit an extreme form of *pseudo-reptans* which I distributed last year to botanists through the Botanical Exchange Club; it occurred in a small bay about half a mile below The Ferry on the western side of Windermere, where it was wholly submersed in from half an inch to six inches depth of water. It was a somewhat strong-growing form, having numerous creeping stems, radiating from a central root, and branching at their upper end. The separate plants interlaced in all directions, and covered the bottom of the water with a dense growth; a complete individual plant would cover a patch two feet in diameter; and its small flowers, never raised more than an inch above the ground, were completely submersed. The stems were somewhat robust, and their nodes produced two or three long rootlets, and with usually only a single linear leaf, but rarely a mass of roots, or a tuft of leaves, as in the filiform stems of *reptans.* The plant, however, advances beyond Dr. Boswell's definition of the variety, in possessing arched internodes for all internodes after the first, which latter is erect, but very short. It is the most extreme form of *pseudo-reptans* which I have met with, and may possibly be Nolte's var. *radicans.*

From the recently published "Lake Flora" of Mr. J. G. Baker, it would appear that the *pseudo-reptans* form is frequent on the margins of the English Lakes. I have myself only noticed what may pass as this form on Rydal Lake, but the true *reptans* is quite likely to occur on the sandy shores of any of our lakes, northern or southern.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, November 8th, 1886.

Professor W. C. WILLIAMSON, F.R.S., President of the Section, in the Chair.

Mr. W. Moss, F.C.A., Ashton-under-Lyne; Mr. J. B. Robinson, F.R.M.S., Mossley; Mr. James Fleming, F.R.M.S., Lower Broughton, were elected Associates of the Section.

Mr. CHARLES BAILEY, F.L.S., shewed specimens of *Ranunculus Flammula*, L. var *pseudo-reptans* from Windermere, and *Ranunculus reptans* from Ullswater.

Mr. Bailey also exhibited some lithographic stones, shewing very beautiful dendritic markings.

Mr. CAMERON exhibited (1) *Nematus fagi*, Zaddach, a saw-fly unrecorded as British, from Sale, where the larvæ were found feeding on a beech hedge;

(2) A number of thorns of *Mimosa* and *Acacia* from Guatemala, which had been used by Ants as nests;

(3) An Ant's nest, apparently formed of masticated wood, from Panama;

(4) A series of forms (male and female, and three forms of neuters) of a species of *Atta* from the same nest, and

(5) A similar series of a species of *Eciton*, all from Panama.

Mr. Cameron also stated that he had been experimenting with *Eriocampa annulipes* (whose larvæ were very destructive to the beech and hawthorn hedges at Sale during the last summer) and had succeeded in getting virgin females to lay eggs from which he had reared some males.

Specimens of the following marine fishes were exhibited:—

By Mr. H. C. CHADWICK, Short-spined Sea Bull-head, *Acanthocottus scorpius;* Fry of Bull-head, *Cottus bubalis*, just emerged from the ova; Black Goby, *Gobius niger*; Montagu's sucking fish, *Liparis Montagui*; Spotted Gunnel, or Butterfish, *Murœnoides guttata.*

By Mr. R. D. DARBISHIRE, F.G.S.,

Leptocephalus Morrisii, found amongst a number of fishes placed on a field at Lancaster for manure. The Bimaculated sucker, *Lepidogaster bimaculatus*; Viviparous Blenny, *Zoarcus vivaparus* from Oban; and the red-band fish, *Cepola rubescens*, which was offered in considerable quantities in the market at Nice, in March.

Mr. W. BLACKBURN, F.R.M.S., shewed specimens of the eggs of the Vapourer moth, *Orgyia antiqua*, under the microscope.

The female Vapourer Moth has only rudimentary wings, and when she has undergone her transformation in her silken cocoon, she lays her eggs upon it, crawling all over it in order to do so. Her mouth is rudimentary, there is no proboscis, and when she has deposited her eggs she dies exhausted.

The specimen from which I obtained the eggs which I exhibit to-night was dug out of the earth as a chrysalis. In about two weeks the imago issued from the pupal case, and began to lay eggs. She continued the process for about twenty-four hours, during which she laid more than 300 eggs. The egg has the shape of a deep kettle-drum, the round surface of which is creamy white, and is coated with a glairy secretion, which serves to fix it to the object upon which it falls, and also to fasten the eggs together. The egg was invariably discharged with this surface foremost, and the force of expulsion was sufficient occasionally to eject it a distance equal to two-thirds the length of the body of the moth. The flat surface of the egg, which was the last to appear, is covered with a cellular structure, and has a yellowish brown ring round the margin, and a round spot of the same colour in the centre, which give the egg a very interesting appearance under the microscope. When the egg is dried, the flat surface sinks in, and becomes concave. The diameter of the egg is about the $\frac{1}{33}$ of an inch.

Ordinary Meeting, December 6th, 1886.

Professor W. C. WILLIAMSON, F.R.S., President of the Section, in the Chair.

Mr. PETER CAMERON exhibited a Saw-fly, *Blennocampa faliginosa*, Schrank (*non* Klug) = *aterrima*, Klug,—from Chobham. It has not been found in Britain since it was discovered 40 years ago by the present Earl of Ripon.

Mr. J. C. MELVILL, F.L.S., exhibited seven of the rarest and most beautiful of the Heterocera of Europe, all belonging to the family Noctuina, as follows:

Jaspidea Celsia (Linn.), with apple-green forewings, a straight brown transverse fascia or band, slightly projecting in the centre to enclose the orbicular stigma, and the hind margin with crenated brown marking; hindwings uniformly grey. Locality, east and north Europe, including Sweden; but always rare, not occurring in this country.

Chariclea Treitschkei (Friv). Forewings straw-coloured, suffused with rosy-red, with red transverse lines to the base, hindwings grey, with rosy fringes. Locality, Turkey and south Russia, allied to C. Delphinii; a very beautiful species, formerly found in England, but now extinct.

Chariclea Victorina (Sodoffsky). Wings pale, suffused with pale red blotch and transverse lines of same colour. From Caucasus and Armenia, borders of Europe and Asia.

Plusia V. argenteum (Esper) = *Mya* (Hubner). Forewings olive, with red-brown pattern surrounding the orbicular and reniform stigmata in a somewhat triangular fashion, the lower edge of the orbicular stigma, an angular mark, and some other dots silvery. A very rare moth, inhabiting the Valais, near Zermatt. Larva feeds on Isopyrum thalictroïdes, a Ranunculaceous plant.

Cucullia argentina (Fabr.), one of the Shark Moths, of which there are several species in this country, has pale olive forewings, with a very broad longitudinal silvery mark; it much resembles an enlarged Crambus margaritellus, as Mr. Kirby has aptly remarked in his work on European Moths, and is a native of the Altai Mountains and south Russia.

Oxytripia orliculosa (Staudinger), allied to Valeria oleagina, a reputed British species, is a native of Hungary, but very rarely found. It is brownish grey, with large white round blotch in the middle of each forewing; hindwings white, edged with sandy grey.

Xanthodes Grœllsii (Feisthamel). Forewings yellow, with a broad red longitudinal stripe diagonally across each wing—fringes dark silvery grey. Larva feeds on Lavatera, and the insect is an inhabitant of Spain, and has a wide range also in the East Indies, as far as Mauritius. There are several species of this genus, which is allied to Chariclea, in the Himalayas, and one other (X. Malvæ) in S. Europe, which is also a very beautiful species.

Mr. Thomas Rogers exhibited a number of varieties of *Lastrea Filix-mas*, collected from wild plants, and described them as follows:—

A short time ago my friend Mr. Forster showed me a collection of dried fronds of *Lastrea Filix-mas*, which he had collected from wild plants in the neighbourhood of Patterdale during an excursion in the autumn of this year. The collection was made purposely to show variation, and to present sets of the same to a Pteridological Society of which Mr. Forster is an ardent member. On looking over the set the ordinary observer, or persons whose eyes have not been educated to the differentiation, may not at the first see the value of the differences, but on further pursuit, and with an eye open to the value of evidence favouring evolutionary principles, they may see the dawn of a new species. *Lastrea Filix-mas,* like many other British ferns, is to be found in all parts of the world, from Northern Europe to Southern Asia, South and North America, the Andes and the Rocky Mountains, Africa and the Malay Islands. Its allies under various specific names are numerous; but my object to-night is not to speak of these, but to confine our attention to the series which I place before you, and some few other forms which are indigenous to the British Isles.

The British varieties of this species have been known for a long time under various names, but it is only within a few years that some attempt has been made to systematise these variations, and Mr. Wollaston divides *Lastrea Filix-mas* into three forms or sections; the types of each section he raises to the rank of species under the names *Lastrea propinqua, Lastrea-Filix-mas,* and *Lastrea pseudo-mas.* I will not, however, trouble you with the characters of these sections at the present time. Suffice it to say that extreme variations are admitted, and have been admitted for a long time, and by the best authorities. My object is attained if I have interested you in the number of varieties that may be collected in one excursion and over a limited area. One other object is to exhibit to you an excellent new variety of handsome form, which was found during the excursion, and which has been named in honour of the finder, Mr.

Smithies. It is a very large and robust form; the texture of the frond is very thick, and the pinnæ are close and foliose; the pinnules are also very closely set, and so broad that they overlap one another, and give the whole frond a curly or crispy appearance. There is another remarkable character, and that is the absence of spores. In all probability its non-sporiferous character will remain so long as it spends its energies in the prodigal reproduction of frondose tissues. In this respect it follows the general rule, as instanced so remarkably in the fronds of *Scolopendrium crispum,* with its wide luxurious and wavy fronds, that very rarely produce spores.

The lines of variation in ferns are almost numberless, but when continued through force of circumstances in some particular direction—either natural or artificial (as in cultivation)—the forms assumed are so far removed from the typical form as to obscure identification. It has been said that aberrant forms are not permanent, which is quite true in some degree, but not to the extent generally imagined. There are some forms of ferns which would require all the ingenuity of man for a long time to get back to their typical form. I will show you one from this particular genus Lastrea, which was found about thirty years ago by a friend of mine named Schofield, of Milnrow. It is a curious little variety, never growing more than 2 or 3 inches high, and singularly enough, it is barren, like the robust form 3 feet high found by Mr. Smithies. Mr. Schofield's form of *Lastrea Filix-mas* is certainly not frondose or leafy; and therefore cannot be non-sporiferous in consequence of wasting its strength in producing frondose tissues. But it does waste its strength, if you will allow me the term, in excessive subdivisions of the rhizome. It must have room for this constant division into offshoots for the formation of new plants. If it has not room to spread it dies in the attempt to find it, rather than revert to the typical form.

Mr. John Barrow read a paper "*On the microscopical structure of some seeds.*" This paper was illustrated by a large number of beautiful double-stained sections of seeds, &c., shown by means of an oxy-hydrogen lantern microscope on a screen of transparent paper.

Mr. Barrow said: I have undertaken to show you a few slides to-night, which exhibit the position of the nutrient vessels in certain seeds. Secondly, I shall show you a few other sections illustrating the provision made after germination has commenced for absorbing the material stored up in the Cotyledons and applying it to the use of the young plant; and lastly, I shall show another set of sections which may possibly give rise to some discussion, and which may probably change a widely-held opinion that the stores of nutrient material laid up in the Cotyledons is used alike for the development of the Radicle and the Plumule.

The first section, that of the Testa or integument of the Broad Bean, will show the outer covering of the seeds made up of cellular tissue arranged in the same way as muriform tissue, and inside this another layer of cellular tissue, the Perisperm; the inner cellular layer or Endopleura is not shown, as it remains attached to the Endosperm, which breaks away in the process of staining; also the Funiculus or attachment of the ovule to the Placenta, with vessels entering by the Chalaza and embedding themselves within the Perisperm, and distributing themselves round the nucleus but not entering it. On the opposite side of the Hilum to the Chalaza is the Micropyle, and a hollow indentation of the Perisperm shews the position of the Radicle approaching the Micropyle.

Sections in different stages of growth were shown, illustrating the same thing, namely, the distribution of the vessels round, but not in, the nucleus of the seed, as, for instance, the Bean, the Gooseberry, the Plum, the Cherry, the Hazel-nut, and lastly the Walnut. In the slides of the

Walnut, the first illustrates the position of the vessels in the perisperm, and the last is a mounted specimen of the Endopleura, showing a cellular structure with a complete absence of any vessels, so that I conclude as the Endopleura surrounds the nucleus and is probably the enlarged Embryo-sac, that the nutrition of the Embryo must take place by some analogous process to that of Endosmose, no vessels entering it.

The second series of sections will not take much time, but it will give us some information as to the way that the stored material of the Cotyledon is absorbed and conveyed to the young plant.

In the section of maize exhibited, cut after germination, that system of absorbent vessels is well shown, growing like true rootlets within the Cotyledon, and conveying the nutrient fluid to the young Radicle, the Endosperm being considerably wasted. Sections of the Pea and Bean show these vessels through the Cotyledons.

The third series of sections is not as numerous nor as complete as I should have wished it to be; but it is interesting, and will require further attention.

It has often puzzled me as to why the Radicle of the embryo should in germination take such a decided advance over the Plumule, being then under the impression that Radicle and Plumule were nourished alike by the material of the Cotyledon. I think that this is not the case, and I hope to give you some reasons for this statement. I believe at present that the whole, or a very large portion, of the nourishing material of the Cotyledon is exhausted in the development of the Radicle, and that the Plumule makes only a slight growth until the rootlets of the plants springing from the descending central axis are enabled to obtain from the soil the nutriment that the Plumule or ascending axis requires.

Sections of the Garden Mustard cut longitudinally through the central axis and through the petioles of the two Cotyledon leaves shew very clearly vessels arising within the Cotyledon passing down the petiole and after uniting with the central axis passing downwards along the axis towards the rootlets, another set of vessels appear to arise at the rootlets and passing upwards between the pith and a layer of cells which appear to separate the vessels descending from the Cotyledon, forms the commencement of the Medullary sheath. These vessels travel on to the upper portion of the axis from which the true leaves spring—a similar appearance is shown in sections of the French Bean stem cut when the Cotyledons have begun to wither away.

The cross sections of these two plants cut through the central axis, below the junction of the Cotyledon (the Hypocotyl), shew these two rings, the descending and the ascending, with the separating zone of cellular tissue. The ascending spiral vessels are easily dyed with Aniline Green. The descending do not take the dye so easily, if at all.

As growth proceeds this outer or descending zone disappears.

General Meeting, December 14th, 1886.

Professor Osborne Reynolds, LL.D., F.R.S., Vice-President, in the Chair.

Mr. T. B. Cohen, Ph.D., of Owens College, was elected an Ordinary Member of the Society.

Ordinary Meeting, December 14th, 1886.

Professor Osborne Reynolds, LL.D., F.R.S., Vice-President, in the Chair.

"On Methods of Investigating the Qualities of Lifeboats," by Professor Osborne Reynolds, LL.D., F.R.S.

The lamentable accidents to the St. Annes and Southport lifeboats on the 9th inst., seems likely to lead to steps being taken to obtain a more systematic investigation as to the qualities of these boats than has yet been undertaken.

It seems, therefore, a proper time to direct attention to certain facts and general considerations, the importance of which have impressed themselves upon me during many years' investigation.

Before entering upon this, it may be remarked that there is probably no class of boats, on the design and construction of which more attention and skill have been spent, than on lifeboats, or of which the qualities are so well adapted to to the circumstances, taken all round. If we compare the results of the use of these boats with the results obtained in the use of the navies of this or any other country, it will, without a moment's hesitation, be admitted that the designers of lifeboats and lifeboat paraphernalia have arrived much nearer perfection than the designers of war vessels and their armaments.

That the high standard already obtained by these boats has not been the result of scientific investigation, or the theoretical application of any known principles of equilibrium, does not render the method less scientific, for the base of all science is observation and experiment, and these boats are the result of such a course of direct experiments and experimental observation as has not been expended on any other modern structure, nor is this method of arriving at the best form peculiar to lifeboats.

With the exception of the large modern steamers and ironclads, the peculiar construction of boats of all sizes is the result of a prolonged process of trial and failure, and that, although certain general principles connecting the qualities of ships with their shapes have been discovered and recognised during the last thirty years, still, the recognition of these principles has not resulted in the suggestion of any considerable improvement to be effected in what were before high class vessels, such as yachts and fast sailing vessels, but rather have confirmed the form previously arrived at in these as the best, and led to their being copied in larger vessels.

The discovery and recognition of principles has undoubtedly been of immense service in improving the types of our large modern vessels. But this is mainly because with large ships there is not the same opportunity for trial and failure as with the small, the number is so much smaller, and experiments are so much slower and more costly; but the main reason is, that the circumstances which call out the highest qualities of the large vessels become so extremely rare. There is no doubt that many large vessels pass through their lives without meeting weather which tests their sea-going qualities in the way in which those of a fishing boat are tested many times every winter. It was, therefore, an immense step in the way to study the resistance qualities of large ships, when the late Mr. Froude brought into practice the rules connecting the resistance of the full-sized vessel with that of an exact model to scale.

By means of a tank 200 feet long, and models on scales of 1 to 50, or 1 to 20, the resistance and rolling qualities of all Her Majesty's ships have since been verified before they are constructed. And the same is now done by manufacturers of mercantile vessels, like Mr. Denny, who have tanks of their own. The qualities of ships thus tested were originally limited to those of resistance and of rolling, and so far as I know, no extension has taken place; for although in 1876 it was pointed out by the author before Section 9 of the British Association, that by constructing models of our war ships on a scale large enough to enable them to be used as launches, say 1 to 16, and supplying these launches with power as the cube of their dimensions—then the manœuvering qualities would be similiar if conducted on scales proportional to their lengths, the time occupied by the launches in executing a particular evolution, as compared with that occupied by the ships, being as the square root of their lengths. So that with such models, the officers and seamen could be instructed in the handling of their ships without cost of risk. This has not been done. The Admiralty replying, so far as they did reply, that their officers were continually experimenting with the launches—disregarding the fact that the launches in use were in no sense models of the ships, and were supplied with power five or six times too great in proportion—thus ignoring the point of the suggestion, namely, that the experience gained by the models might be applicable to the ships, which with their present launches it is not, and only tends to mislead those who attempt a comparison.

Since making this suggestion, I have been much engaged in experiments with water, which have enabled me to extend this law of similarity, until I find it is possible now to lay down the conditions under which to test the seaworthy qualities of a vessel from those of its model.

Certain conditions have to be observed, but, in general, it may be asserted that provided the models are to scale, that the height and length of the wave are to the same scale, the velocity of the wind being as the square root of the scale, or in other words, the corresponding depressions of the barometer in the same scale as the models—the behaviour of the model would be similiar to that of the boat.

Thus, the behaviour of a model three feet long in waves two feet high, and with a wind twenty miles an hour, would correspond with that of a boat twenty-seven feet long in waves eighteen feet high, and a velocity of the wind sixty miles an hour.

The main object of this communication is to point out that this similarity in the behaviour of models and larger boats under circumstances as regards the stress of weather, corresponding in scale to that of the models and boats, affords an opportunity of testing the sea-worthy qualities of the lifeboats in a degree that they cannot otherwise be tested. For, although the size of the boats does not preclude the possibility of their qualities being actually tested under any circumstances of sufficiently common occurrence to afford opportunities, yet the circumstances which call for the highest qualities in these boats, and in which the boats are most needed, are of extremely rare occurrence; this appears at once, when it is considered that it is years since anything approaching such a storm as wrecked the two boats has been experienced, and that in order to submit any modified boat to a similar test, it may be years before there will be another chance, even if it could be made available when it did come. To make satisfactory tests on the full-sized boats, command is wanted of the extreme circumstances, and this cannot be had; while on the other hand, to test the same qualities in their models, these extreme circumstances, modified to scale, are all that is wanted, and these are of such common occurrence as to afford ample opportunity, even if they cannot be commanded by artificial means.

If the qualities to be tested involved the handling of the boats, then the models must be large enough to carry a crew; that is to say, they would have to be small lifeboats. Even with such, much experience can be and has been gained, which could not be obtained with larger boats for bad weather, for the smaller is only moderate for the larger, and is of comparatively common occurrence compared with that which affords a similar test for the larger boats.

It is, however, the self-righting qualities of these boats that is for the moment in question; this requires no crew, or at most a dummy crew, so that there is no limit to the smallness of the models, except what arises from the conditions of dynamical similarity, and these would admit of models as small as two or three feet.

It may be well to say one word as to the powers of self-righting, and the question as to how far these powers may be affected by the wind and waves. I do not know that it has ever been suggested that wind and wave have any such effect. But it is equally certain, that there is no *a priori* reason why they should not, and short of actual experience, that any boat which would right itself in calm water would do so equally well in any storm that might blow, no reason would be satisfactory. On the other hand there are reasons; wind and waves must, individually and collectively, affect the stability of an upturned boat.

In the first place, the wind will keep such a boat broadside on, which will be in the trough of the sea raised by the wind, although the swell may, of course, be running in another direction. The wind, acting on the bottom, will further drive the boat broadside on through the water. This horizontal thrust of the wind, acting on the part of the boat above water, and balanced by the resistance of the water on the submerged portion, will tend to right the boat by turning her keel to leeward, and so far, it would seem that the wind would help to right her, but owing to the shape of the bottom of the boat when broadside on, there will be a vertical force resulting from the wind as well as the horizontal, and this vertical force will bear down that side of the boat toward the wind, and this effect will be enhanced by the weight of the waves breaking on this side of the boat tending to right her by turning her keel to windward, or in direct opposition to the horizontal effect; and, more than this, the vertical effect of the wind and waves to turn the keel to windward will be greatest when the windward side of the boat's bottom has some definite inclination to the horizontal, while the horizontal effect to turn the keel to leeward will continually increase as the keel turns to windward, so that it is possible that in a particular wind and sea there may be a position of very stable equilibrium, towards which, if the keel is to leeward, the vertical effect of the wind and the waves predominating over the horizontal effect will bring it back, and *vice versâ*; if the keel is turned to windward, the horizontal effect predominating will also tend to bring it back.

The fact that two boats were found stranded bottom upwards, with part of their crews underneath, and that one of these is known to have upset in comparatively deep water, and to have remained in that position during a long time while drifting into shallow water, seems altogether inconsistent with the supposition that these upturned boats were in their normal condition of instability as when in calm weather. For although in a calm sea the effect of three or four men hanging on to each side of the boat might prevent the initial motion of turning, before the weight of the iron keel and ballast obtained sufficient leverage to lift the weight of the men and so keep the boat stable, this could hardly be the case in a rough sea, when the waves would be continually altering the balance of the boat.

These are questions which can only be set at rest by experiments, and the method of models thus affords a means of testing the righting qualities of these boats under circumstances as severe or more severe than any to which they will ever be subjected, and this without waiting and without danger; while with full-sized boats such tests are impossible, for even should an extreme storm occur opportunely for making the experiment, the danger involved with full-sized boats would preclude the possibility of their being undertaken. It is this last consideration which has led to these suggestions, and not the idea that the experiments on models would be more satisfactory; while the fact that the experiments on models could be made at much smaller cost, is too small a matter to be considered, when, as in this case, the lives of some of the most heroic of our fellow countrymen, and the sentiments of the entire nation, are involved.

"The Determination of the total Organic Carbon and Nitrogen in Waters by means of Standard Solutions," by Charles A. Burghardt, Ph.D.

The members of this Society may remember that I read before them a preliminary note on a method for rapidly determining the total organic carbon in waters, on the 23rd of February, of this year. The communication I make to-day must also be considered as a "preliminary note," because the method of analysis applied in this case is entirely distinct from that given in my first communication, and I wish to collect all the material I can before venturing to criticise fully the work of other chemists in regard to the analysis of waters.

I have during the last six months had many excellent opportunities for thoroughly testing the working of the chromic acid method for the determination of organic carbon in waters of various qualities, and am perfectly certain that the results are eminently satisfactory so far as the *complete* estimation of the organic carbon is concerned. I wished, however, to estimate in an easy and accurate manner the total amount of organic nitrogen, and also to make the determination of the organic carbon simpler and less complicated. There is no doubt at all in my mind, in the case of a sewage-polluted stream or well, that the determination of the carbonic acid gas given off (after driving off the free dissolved carbonic acid gas at 94° C.) on heating the water to 100° C. is a nost valuable portion of water examination, because *that particular carbonic acid gas* has been formed entirely *from organic matters in a partially decomposed or putrescent condition.* This organic matter is entirely lost in the course of evaporation as required by the "combustion process," and it certainly constitutes a large proportion of the total organic matter present in a sewage-polluted water, a fact which has been proved by my analyses of the Irwell water, and experiments made with it. I find that Professor J. W. Mallett, F.R.S. of the University of Virginia, mentions (in his report to the National Board of Health, Washington, 1880) the source of error; he says: "As regards the combustion process we find distinct confirmation of the existence of the two forms of constant error which have been pointed out as affecting the Corporation. The weaker the solution—or in other words the larger the quantity of water to be evaporated for a given amount of organic matter—the less is the amount of organic carbon contained, indicating relatively greater loss of this element. On the contrary, the weaker the solution, or the greater the quantity of water to be evaporated, the larger is the figure for organic nitrogen, indicating relatively greater gain of this element from the atmosphere.

I conclude, therefore, that in many cases it will be necessary to determine the carbon *corresponding to the organic matter volatile at 100° C.* in the manner I point out in my previous paper on the subject.

As one proof out of many which I could lay before you, I will give an analysis made by the "ammonia process," the "permanganate process," and the "chromic acid process," the sample being one taken from the Irwell at Throstlenest, on the 19th of February, 1886, and the results are expressed in grains per gallon:—

(1) Free ammonia .... 0·196.
Albuminoid ammonia ... 0·226.

(2) Oxygen required to oxidise the organic matter

in *3 minutes.*	*1 hour.*	*3 hours.*
0·413.	1·442.	1·694.

(3) Carbonic acid given off on heating to 96° C. = 1·512.
" " " 100° C. = 7·224.
Carbonic acid estimated separately by precipitation with ammoniacal barium chloride solution (therefore as carbonates) ... = 2·681.
Carbonic acid obtained by oxidation by means of chromic acid .... = 2·733.

As the water was carefully heated to a temperature not exceeding 96° C., until all the *dissolved free* carbonic acid was liberated and no more was given off, it is clear from these results that the carbon of the 7·224 grains of carbonic acid gas given off on boiling the water (1·9701 grains) was derived from organic matter undergoing rapid decomposition at 100° C., *and from no other source.*

I venture to think that a result of this kind shows the necessity of devising a method for the accurate determination of the carbon in the water itself, and not by burning the residue obtained on its evaporation, and then measuring the amount of carbonic acid gas thus obtained.

On comparing the total carbon obtained by my process (calculated from the two amounts of carbonic acid gas, viz.: $7{\cdot}224 + 2{\cdot}733 = 9{\cdot}057$ $CO_2 = 2{\cdot}667$ carbon), with the amount of carbon corresponding to the amount of oxygen required to oxidise it in 3 hours, viz.: 2·329 grains of carbon, it is evident that there is a loss of 14·51 per cent of the carbon in the permanganate process, or in other words *that* process in this particular instance failed to estimate the amount of carbon present by 14·51 per cent. I have found, however, in some cases that it expresses fairly well the amount of organic carbon present in a water, but it cannot be safely relied upon to do so.

I will pass from this part of the subject to the modification of my process which I have arrived at after considerable experiment and expenditure of time.

The principle of my first process consisted in the oxidation of the carbon in the water to carbon dioxide, this being affected at the expense of the chromic acid, consequently the latter must be reduced to a lower oxide of chromium during the process. Bearing this fact in mind I at last concluded that a determination of the amount of oxygen given off by the chromic acid to the carbon must necessarily give me the equivalent to it of carbon in the water. The reaction which occurs on adding a solution of chromic acid in water (acidulates with sulphuric acid) to water containing organic matter is as follows, viz.:

$$4CrO_3 + 6SO4H_2 + 3C = 3CO_2 + 2Cr_2(SO4)_3 + 6H_20.$$

As an excess of chromic acid is always used in the process all that is therefore necessary is to estimate the amount of chromic acid still remaining unreduced, by means of some convenient standard solution, which is itself oxidised by the excess of chromic acid. In order to carry out the process I first prepare the necessary standard solutions.

Preparation of the standard solutions.

1st. Ordinary decinormal permanganate of potassium solution (3·16 grams to 1 litre).

2nd. A solution of pure chromic acid in pure distilled water (about 10 grams to the litre).

3rd. A solution of ferrous sulphate in pure distilled water (about 25 grams to the litre).

First I titrate the ferrous sulphate solution by means of the decinormal permanganate solution and find in this way how much permanganate is equal to the ferrous sulphate solution, and knowing the "oxygen value" of the permanganate solution, it at once furnishes me with the "oxygen value" of the ferrous sulphate solution.

Next I take a known volume of the chromic acid solution and titrate it with the standard ferrous sulphate solution, until all the chromic acid is reduced, a point easily seen with a little practice as the slightly yellowish green colour at the final stage of the titration changes sharply to a bluish green on the addition of *one* drop, and one further, at this point using a solution of ferricyanide of potassium as an indicator, it is seen that there is a very slight indication of excess of ferrous sulphate present, whereas before the addition of this drop there was no such indication. This operation furnishes the value of the chromic acid solution *expressed as ferrous sulphate solution.*

The chromic acid solution will keep a very long time, but it is advisable to prepare the ferrous sulphate solution freshly at least once a week.

Having prepared the standard solutions the process of analysis is as follows, viz.:—

Determination of the organic carbon.

Place 250 c.c. of the water sample in the "boiling flask," of 16 oz. capacity, add 100 c.c. of the chromic acid solution, and 10 c.c. of strong sulphuric acid, and boil for about thirty minutes, when the oxidation of the organic matter is complete, the water in the "boiling-flask" having become perfectly clear. I then dilute the contents of the flask to 1 litre, and take out 100 c.c. of this solution and titrate it with the standard ferrous sulphate solution until there is a very slight excess of the latter. By calculation I find how much *carbon,* the *oxygen* thus indicated, is equal to.

Determination of the organic nitrogen.

Contrary to expectation I found that the nitrogen in organic compounds is converted into ammonia and not into nitric acid, or nitrous acid, by the action of chromic acid or sulphuric acid. A similar fact was discovered by Kjeldahl (Zeits. Anal. Chem., XXII. 366) where he describes the conversion into ammonia of nitrogenous matter, by boiling it with strong sulphuric acid, phosphorous pentoxide, and powdered manganate of potassium.

Märker tested this method thoroughly (Zeits. Anal. Chem., XXIII. 553—557) against the well-known method of Varrentrap and Will, and found the results by Kjeldahl's method sufficiently correct.

To determine the organic nitrogen in the water I take 250 c.c. or more of the solution obtained by the previous organic carbon process (the solution made up to 1 litre), place it in the "boiling-flask," pour down the funnel tube a perfectly ammonia-free caustic soda solution *in excess*, and attach the exit-tube of the "boiling-flask" to the Liebig's condenser and flask as used in the organic carbon determination, placing, however, in this case, about 50 c.c. of ammonia-free water and a few drops of pure hydrochloric acid into the "receiving-flask." It is also better to take the necessary precautions to prevent the sucking of the water in the "receiving-flask" back into the "boiling-flask." I boil the contents of the flask for about 30 minutes (keeping the condenser cool), then I make up the condensed water in the "receiving-flask" to 1 litre, take out 100 c.c. and determine the amount of ammonia present in it in the usual way with Nessler's reagent, and calculate how much nitrogen it corresponds to.

I do not lose any nitrogen by this method, because all the ammonia evolved from the "boiling-flask" is passed into cold acidulated water, whereas by the old "ammonia-method," the violent bumping in the retort often drives steam and no doubt ammonia right through the long condensers used in that process, consequently there must be a loss of ammonia.

I have not yet had sufficient time to work out by my method the limits at which a water can be said to be *unsafe* to drink, but I hope to do so shortly.

Example of analysis of sewage water from Devizes.

(1) *Ammonia process.*

Contains free ammonia		0·560	grains per gallon.
,, albuminoid ammonia :			
	1st distillate	1·435	,,
	2nd distillate	0·420	,,
	Total ammonia	= 2·415	

= nitrogen 1·988 grains per gallon.

The albuminoid ammonia in the first distillate was obtained by distilling in the usual way until no more ammonia could be estimated by Nessler's reagent. The retort and apparatus was then carefully closed for the night and the contents distilled again next morning, the result being a second crop of ammonia (distillate No. 2).

(2) *Oxygen process.*

Oxygen required to oxydise organic matter, in grains per gallon

in *3 minutes.*	*1 hour.*	*3 hours.*
1·862.	3·472.	5·48.

5·48 grains of 0 = 4·11 grains of C.

(3) *Chromic acid process.*

(*a*) by titration with ferrous sulphate.

250 c.c. of sample taken, added 20 c.c. of the chromic acid solution, and 10 c.c. of strong sulphuric acid, and boiled for 30 minutes, diluted to 1 litre, and took 100 c.c. of this solution with the standard ferrous sulphate solution, required 19·0 c.c. of $FeS0_4$, therefore the whole litre would require 190 c.c. $FeS0_4$.

20 c.c. of the chromic acid solution required, on being titrated, 210·0 c.c. of the ferrous sulphate solution.

210 − 190 = 20 c.c. of $FeS0_4$ (equal to the chromic acid reduced by the carbon in the water).

Strength of the $FeS0_4$ solution.

3·6 c.c. $FeSO_4$ = 100 c.c. of permanganate solution (5 c.c. permanganate solution = ·0004 oxygen).

$$3\cdot6 \text{ c.c. } FeSO_4 = \cdot0004 \times 20 = \cdot008 \text{ oxygen.}$$

$$20 \text{ c.c. } \quad " \quad = \frac{\cdot0008 \times 20}{3\cdot60} = 0\ 04444 \text{ \&c. oxygen}$$

or 9·3824 grains of carbon per gallon.

(*b*) By the lime-water method and distillation.

50 c.c. lime-water = 50 c.c. standard oxalic acid.

1 c.c. oxalic acid solution = ·001 CO_2.

250 c.c. of the Devizes sewage-water taken.

Took 200 c.c. lime-water altogether and titrated back with *72 c.c.* oxalic acid solution.

128 c.c. of lime-water used.

128 c.c. = 0·128 CO_2.

= 9·72 grains of carbon per gallon.

This contained a little carbon present as carbonate.

Sale, Cheshire, sample of sewage water.

Chromic acid process.

By lime-water method.........	0·1444 grains C.
By $FeSO_4$	0·1487 „ C.

Ordinary Meeting, January 11th, 1887.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., Vice-President, in the Chair.

The Chairman announced that the Secretaries had received a letter from Mr. R. D. DARBISHIRE, B.A., F.G.S., expressing his wish to resign the office of President of the Society. The letter will be submitted to an Extraordinary General Meeting.

"On a Comparison of Drawings and Photographs of Sun-spots, and the sun's surface," by A. BROTHERS, F.R.A.S.

The receipt, a few days since, from Mons. J. Janssen, of

Meudon, of copies of some of his very beautiful photographs of the sun's surface, caused me to refer to a paper communicated to this society by Mr. Nasmyth, in March, 1861. This paper appears to have been the means of directing the attention of astronomers to the structure of the surface of the sun. The appearances referred to do not relate to the spots or faculæ, but generally to the mottled character of the solar surface. It was, however, in the neighbourhood of a large spot that Nasmyth pictured the "willow-leaves," so as to show the distinct character of the markings, although he could see the characteristic forms away from spots. It is not denied that other observers had noticed peculiarities, but the term *mottled* appears to have been considered sufficient to describe what was seen, but it was not until Mr. Nasmyth published his drawings that special notice was given to the matter. The subject was soon warmly discussed amongst astronomers, and the publication of Mr. Nasmyth's paper led to the production of many drawings, each observer having his own idea of the term suitable to describe the appearances seen. One of the keenest and most careful observers, the late Rev. W. R. Dawes, thought the objects "much like a piece of coarse thatching with straw, the edges of which had been left untrimmed." Mr. Stone, at the Greenwich Observatory, called the objects "rice-grains." Secchi, at Rome, in 1869, described them as "leaves." "The leaves," he says, "in the neighbourhood of the spot were oval, the greater diameter about three times the less," and he asks, "What are these things? They are veils of the most intricate structure." It will be noticed that Secchi's description agrees very well with Nasmyth's. Dr. Huggins differs from the other observers, and calls the luminous objects "granules" (an old term—Herschel calls them "nodules"), and does not think that they interlace as Nasmyth supposed. The American astronomers were not idle during this discussion. One of the most beautiful drawings yet produced is by Mr. S. P.

Langley, and was made at the Alleghany Observatory in 1873. The appearance suggested to Mr. Langley was that of snow-flakes spread over grey cloth. In order to see this wonderful structural detail of the solar surface, it is not only necessary that the telescope must be a good one, but the atmospheric conditions must also be very good. Anyone who has studied the surface of the sun must have noticed that the moments are very rare when the definition may be said to be good; and it is only at such moments when the practised eye can detect the structure, such as those who have made the drawings referred to, show. A careful comparison of the drawings and the descriptions appears to me to indicate that the various observers all mean the same thing; but, as is well known, two draughtsmen seldom give the same representation of the same object,—not even of any portion of the moon's surface, could two exactly similar drawings be made by different artists, so difficult is it for the hand to delineate what the eye can see, and in the case of the sun the intervals of good definition are so fleeting that the imagination must influence the hand of the artist. Now this is not the case when we employ photography to supply the place of the eye and hand. This has been done in a most successful manner by M. Janssen. The photograph of the entire surface of the sun which I show by means of the optical lantern is on a small scale, and therefore gives very little detail, but we see in those taken on a larger scale that the structure becomes visible. It will be noticed that when compared with Dr. Huggins' drawing there is a great similarity between the drawing and the photograph. The term "nodule" used by Herschel appears to me to be better than any other, but it would be equally as good to say that the appearance is that of a "mosaic" pavement. But any term fails to describe the real appearance.

It is difficult to find words to describe the extreme beauty of M. Janssen's photographs. In the photograph before you, taken on a scale of the sun's surface of about three feet, but much larger as I show it on the screen, we have the true appearance of the sun's luminous envelope produced by its own light, and shown here in black and white entirely by means of photography. With this photograph before him, the most skilful wood engraver would find it difficult to give a truthful reproduction of the picture. I believe it to be impossible by any other than a photographic method to show what is here seen.

I also show a photographic copy of two photographs of parts of the sun's surface, including a group of spots taken in 1878—one at 6h. 47m., and the other at 7h. 37m. In the 50 minutes interval, it will be seen that changes have taken place distinctly observable in the photographs, but they would probably have altogether escaped eye observation.

Before leaving this subject I wish to refer to a very remarkable passage in a paper read before the Academy of Sciences in Paris, on the 11th January, 1886, by M. Janssen, in which he says:—"In a note presented to the Academy on December 31st, 1877, in the notice inserted in the *Annuaire du Bureau des Longitudes*, for the year 1879, and in the opening discourse of the Congress of the French Association for the advancement of Science, held at Rochelle in 1882, I said that photography offered, not only as is generally believed, the means of fixing luminous images, but that it constitutes a method of discovery in the sciences, and especially in astronomy. I added that the sensitive film of the photographic plate, by reason of its admirable property of giving us fixed images, of forming them with a collection of rays much more extended than those which affect our retina, and then of permitting the accumulation of radiations during a time, as one may say, unlimited; that this sensitive film, I said, ought to be considered as the true retina of the scientist;"—and while exhibiting to you specimens of the very beautiful work of Messrs. Paul and Prosper Henry of the Paris Observatory, I wish to call attention to the fact that in this work we have the fulfilment of the remarks made by M. Janssen in the above quotation.

The discovery of the nebula surrounding the star Maïa in the Pleiades was a clear gain to science, and a demonstration of the advantage of photography in mapping the heavens. It must be stated here that by prolonged exposure, and checking the clock-motion of the apparatus used by means of eye observation at the same time, M.M. Henry have achieved the almost perfect results I am enabled to show here this evening. The method employed is that of using a photographic lens of large aperture and corresponding focal length, the plate used being about 11 × 9 inches, though why a square plate is not used I do not know. The almost true circular discs are obtained by correcting the clock during the exposure of the plate by means of a telescope in the same mounting as the camera directed to the same object and constantly watched; and as the plate marked No. 1 was exposed 3 hours ("trois poses d'une heure") the execution of the work needs the exercise of a large amount of patience, and in order to detect defects in the plates duplicate negatives are necessary. It need scarcely be said that the process employed in this case is the gelatine. For his solar work M. Janssen uses the collodion process, the extreme sensitiveness of the gelatine film would, for solar work, be a disadvantage.

It is considered that with care and patience the whole heavens could be mapped by this means, and it is proposed that the work should be undertaken by a number of observers using the same kind of apparatus. There may be some difficulties to overcome with the apparatus. A careful scrutiny of the photographs of portions of the constellation Cygnus shows that the stars in the corners of the plates are drawn out towards the centre, and this, no doubt, is caused by the lens not "covering," as it is termed, so large a flat surface—for the stars may be said to be on a flat surface for photographic purposes—and no doubt the full aperture of the lens is used.

Extraordinary General Meeting, January 25th, 1887.

Professor W. C. Williamson, LL.D., F.R.S., Vice-President, in the Chair.

A letter was read from Mr. R. D. Darbishire, B.A., F.G.S., and it was thereupon moved by Professor Osborne Reynolds, LL.D., F.R.S., seconded by Dr. Edward Schunck, F.R.S., and resolved unanimously:—That while compelled, to their very great regret, to accept Mr. Darbishire's resignation of the office of President, the Society hope that in doing this they have removed all necessity for the further step indicated in his letter.

Ordinary Meeting, January 25th, 1887.

Professor W. C. Williamson, LL.D., F.R.S., Vice-President, in the Chair.

The following communication from the Secretary of the Manchester Jubilee Exhibition, addressed to the Honorary Secretaries of the Society, was read:—

The Photographic sub-section of the Jubilee Exhibiton are devoting a portion of their space to a history of the rise and progress of the Photographic Art, and are anxious to hear of specimens or apparatus bearing upon this department of the subject. They will be obliged by possessors of any such objects of interest communicating with them at the offices, Albert Chambers, Albert Square, Manchester.

Will you kindly bring this communication before the members of your Society at an early meeting, or in any other way you may consider most suitable.

Professor W. C. WILLIAMSON, LL.D., F.R.S., brought before the Society the substance of a communication which he had received from James Nasmyth, Esq., of Penshurst. Experimenting upon the action upon glass of the coke used for heating the boilers of locomotives, Mr. Nasmyth found that a piece of hard coke "possesses the diamond property of cutting a clean diamond-like cut into glass, not a mere scratch, but a true cut through it." Mr. Nasmyth further points out that if this is done when the glass is held at a slight inclination to the direction of the sun-light showing through it, the cut thus made gleams with prismatic rays. These effects all correspond so closely with those produced when a diamond is similarly used, as to suggest that the coke bears some humble relationship with the diamond so far as glass-cutting is concerned.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, January 17th, 1887.

Professor W. C. WILLIAMSON, LL.D., F.R.S., in the Chair.

Mr. R. T. Burnett, F.G.S., was elected an Associate of the Section.

Mr. HENRY HYDE exhibited a leaf of *Bryophyllum calycinum*, with young plants growing out of the margin.

Dr. ALEX. HODGKINSON read a paper "On Cavities in Minerals containing fluid, with Vacuoles in motion, and other inclosures."

It is matter of common observation that salts in crystallising from their solutions frequently shut off spaces containing portions of the fluid. If at the time of crystallization the temperature of the liquid was higher than it subsequently comes to be, contraction of the fluid in the enclosed cavity takes place, and a bubble or vacuole is formed. The relative volume of the vacuole to the dimension of the cavity may be taken as a rough indication of the temperature of the solution at the time of crystallization.

The minerals most commonly containing fluid cavities are quartz (rock crystal, chalcedony, &c.), topaz, emerald, &c. In some specimens of quartz, the milky appearance is entirely due to myriads of minute cavities.

The contained fluid usually consists of either water or an aqueous solution of salts—commonly chloride of sodium. In this latter case crystals of chloride of sodium may often be seen in the fluid. Besides the above, solution of carbonic acid is met with, and even pure liquid carbonic acid.

No. 1 is a specimen of chalcedony from Uraguay, and is chiefly remarkable for the quantity of fluid contained, it being about 60 grains. On shaking, the fluid may be heard to rattle, and the mineral being transparent the bubble may easily be seen on holding the specimen to the light. Another peculiarity is the absence of any indications of attachment to any other body on the surface of this mineral, rendering its mode of formation a matter of doubt.

No. 2 is a crystal of quartz from Brazil. Three cavities may be seen; one about one-eighth of an inch in diameter contains a viscid fluid, together with a vacuole and an irregular black fragment of mineral matter. Both these are movable when the specimen is rotated. One of the other cavities contains fluid and a portion of rock magma. In neither of these specimens (1 and 2) can the vacuoles be made to disappear by heat.

No. 3. A piece of rock-crystal containing numerous flattened irregular cavities. Each is seen to contain a flattened vacuole, surrounded by fluid, which fluid is separated from the walls of the cavities by a space which, according to Brewster, contains a second fluid of different optical density. On heating, the vacuole is seen to decrease in size, and finally to disappear. The contour line of the second fluid remains unchanged. On cooling, the vacuole reappears.

No. 4. Section of quartz containing fluid cavities, each containing a crystal of common salt and a vacuole. The vacuoles are motionless and do not disappear on heating.

No. 5. Section of Granite. The fragments of quartz in this specimen abound with minute more or less spherical cavities. Each contains a vacuole which in the large and medium sized cavities may be seen when highly magnified ($\frac{1}{8}$in.) to rise to the upper part of the cavity when the specimen is rotated. Warming facilitates this, apparently rendering the fluid less viscid. The feature of interest in this specimen is the spontaneous movement of the vacuoles. At ordinary temperature the motion of the largest vacuoles consists in a faintly perceptible throbbing motion; in the medium sized this is increased, while in the smaller cavities the vacuole wanders about its cell with a rapid jerking motion; on applying heat the vacuoles gradually decrease in size, and become more active as they become smaller, until finally, before disappearing, their motion becomes too rapid to follow, but is chiefly confined to the upper part of the cavity. If allowed to cool, the vacuole suddenly reappears of its full volume at the lower part of the cavity, instantly rising to the top. The motion of the smaller vacuoles seem incessant, but I have never observed them at a freezing temperature. If the source of heat, whether a heated metal or glass rod, be applied either on one side or at the upper or lower part of the cavity, the vacuole at once passes to that side, and in this way may be made to pass to any part of its cell by moving the heat source in the desired direction. Whether such movement is an attraction of the vacuole, or a repulsion of its surrounding fluid, is not easy to decide. That it is not due to the nature of the heating body is shown by its occurrence from proximity of any heated substance, whether of glass or metal. The vacuoles in the smaller mineral cavities are interesting as being the smallest isolated portions of gaseous matter observable, and their extraordinarily active movements in a comparatively dense medium seems suggestive of the kinetic theory of matter.

Professor W. C. WILLIAMSON, F.R.S., gave a practical demonstration by means of sections, shown by the oxy-hydrogen camera, of the structure and development of young roots. Beginning with those of the Maize, as they appear within the seed; those of the Vine, of the Bean, of the Crown Imperial, and of several species of Cycads were exhibited and explained, illustrating the changes which roots undergo between the uniform structure seen near the root or tip, to their more advanced condition, as seen, first in the roots of Endogenous plants, and afterwards in the more complicated ones of Exogens.

General Meeting, February 8th, 1887.

Professor W. C. Williamson, LL.D., F.R.S., Vice-President, in the Chair.

Mr. Charles Moseley, of Grangethorpe, Manchester, and Mr. William Harold Dixon, F.R.S., Professor of Chemistry, Owens College, were elected Ordinary Members of the Society.

The Secretaries announced that a letter had been received from Mr. R. D. Darbishire acceding to the resolution passed at the preceding general meeting.

Ordinary Meeting, February 8th, 1887.

Professor W. C. Williamson, LL.D., F.R.S., Vice-President, in the Chair.

Professor Williamson exhibited the glass referred to in Mr. Nasmyth's communication, read at the preceding meeting, as having been cut by a piece of coke. Other specimens cut by Mr. Francis Jones, and showing the prismatic colours referred to by Mr. Nasmyth, were also exhibited.

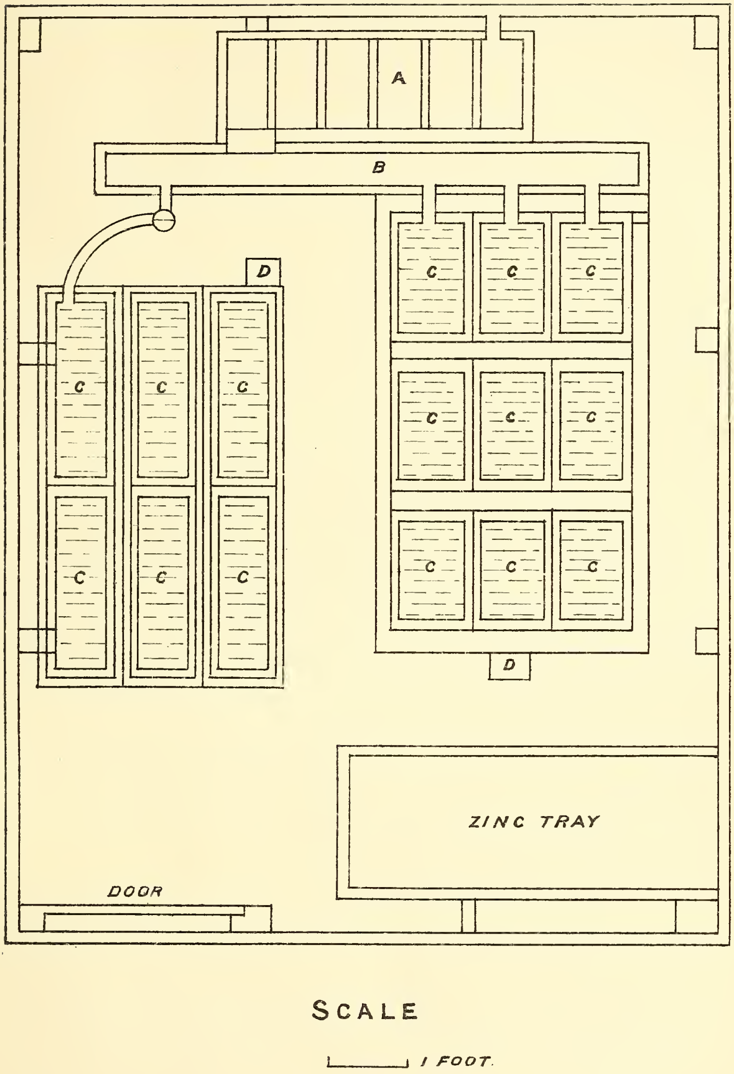
"Notice of a fish-breeding house erected by the Manchester Anglers' Association at Horton-in-Ribblesdale, Yorkshire," by F. J. Faraday, F.L.S.

The fish-house, to which I wish to direct the attention of the Society, was erected by the Manchester Anglers' Association, in 1884, in the romantic dale above Settle, through which the upper waters of the Ribble flow, and along which the Settle and Carlisle extension of the Midland Railway has been carried. The waters of the Ribble, with its tributaries, from its source at Ribble-head beneath the wild slopes of Cam Fell and Whernside down to Helwith Bridge—a course of about ten miles, flanked by Ingleborough, Penyghent, Moughton, and Attermire—are preserved by the Association. The river is inhabited by a peculiarly robust breed of trout, whose wariness has apparently been developed to a high degree by the almost uniform and crystal clearness of the river, which flows over a rocky and boulder-strewn bed, with here and there pools of great depth and stillness. During the construction of the railway, however, when large bodies of men were encamped for years in the dale, the river was almost depopulated by unrestrained netting and fishing; and the comparative solitude of the dale has also made it peculiarly liable to the destructive operations of poachers. The river is now carefully watched by the Association, and it is with a view to replenishing the waters that the fish-house has been erected. A considerable natural tarn, or small lake, at New Houses, in a depression on the flanks of Penyghent—which is believed to derive its water-supply from springs fed from Ingleborough on the opposite side of the valley, by subterranean channels running beneath the bed of the Ribble—is also preserved, and has been stocked with young trout obtained from Loch Leven.

Though it may be frankly confessed that the primary object of the ichthyological operations of the Association is sport, I hope that those operations will not be less interesting to the members of the Society. The true fly-fisher is always something of a naturalist, and to anglers we owe some of the most charming and instructive books on natural history. The pursuit of angling, moreover, has ever been found favourable to the development of the philosophic mind. The quiet contemplativeness, which is its necessary accompaniment; the solitude of romantic scenes, where the stillness is unbroken, save by the cadences of the stream, the cry of birds, the hum of insects, the rippling vegetation, or the slowly-passing cloud casting its shadow on the solemn hillside or on the sunlit pool, are conditions which not only enable the mind to shake itself free from crystallising tendencies, but provide recreation which is peculiarly effective, according to all experience, in reinvigorating and giving tone to the mental faculties which have been exhausted by severe strain. I need scarcely refer to Sir Humphrey Davy, an angler from his youth, and the author of a classic book on the subject, in illustration: but it is not generally known that a contemporary investigator, who has opened up for us a new world of science—M. Louis Pasteur—was an angler as a student, and still finds rest and refreshment in "the contemplative man's recreation." I desire also to direct attention to the district as eminently suitable for excursions by the British Association during the forthcoming Manchester meeting.

The operations of the Manchester Anglers' Association are carried on amidst scenes full of scientific interest. It was amidst the beautiful and awe-inspiring dales of this district that the ancestors of our great Faraday, on the male and female side, lived, for at least a century before his birth, and developed those mental and religious qualities which found a culminating expression in him. Though now used as a cottage, there still stands the humble Sandemanian chapel in which his father and mother worshipped, and to which may undoubtedly be traced the peculiar beliefs and observances which so largely influenced his own life and work. The dale in which the fish-house stands may be spoken of as a complete library of natural records in several departments of science: its peculiar characteristic is the successive series of volumes—if I may be allowed the term—which are offered to the study of the inquirer. In Horton Church the archæologist will find a venerable memorial of successive stages in the history of English Ecclesiastical architecture, not less interesting because of the secluded locality in which it stands and the quaint and mellowed beauty of the structure. The student of the earlier and mysterious period which immediately followed the departure of the Romans, and the inquirer into pre-historic and pre-glacial palæontology will find here the Victoria Cave, besides many other caves doubtless still containing silent memorials awaiting the investigator who will make them speak. Nowhere in England are more remarkable series of problems and illustrations presented to the geologist than are found in these dales—from the Pleistocene back to the so-called primary formations there are innumerable exposed sections of singular impressiveness. On the one hand we have the boulder clay resting on the upturned edges of Silurian slates, and right opposite these same slates surmounted unconformably by the carboniferous limestone; while, a little beyond, the face of the millstone-grit is seen; and the diligent explorer will find traces of many other intervening series. All around are evidences of wreck and change; synclinals and anticlinals abound; perched blocks—Silurian and sandstone—are strewed in hundreds, often of enormous size; the limestones are of the most varied composition and texture; and innumerable waterfalls, chasms, and ravines at once charm the lover of the picturesque, tempt the adventurous, and present examples of the various stages in the formation of valleys. The little islands, carpeted with the painted cups of the grass of Parnassus, the deep fissures shading the green spleenwort, and the abundant pink of the bird's-eye primrose will suggest to the botanist the still unspoiled floral richness of the region: and not less suggestive to the ornithologist will be the pensive heron startled by the lone rock-girded pool, or pursued by the hawk; the sky-blue flash of the kingfisher, and the silvery splash of the "dipper." Amid such scenes the visitor has still a profound sense of the primeval brooding of Nature, majestic and eternal.

The fish-house erected by the Association stands in a little glen formed by Horton beck or brook, a tributary of the Ribble, which, like the Aire at Malham and many other water-courses of the district, flows from a cave at the foot of a limestone precipice known as Douk-Ghyll Scar. The house is thus in a sheltered situation, protected from the strong and cold winds which blow across the hills or sweep along the dales. It stands on the edge of the brook, which affords a ready drainage, and is a strong wooden structure on a foundation of solid rock. The water-supply is obtained from a spring, on the side of Penyghent, which feeds a cistern, the overflow from which formerly found its way to the brook and is now carried through the tanks in the fish-house. A good and permanent supply of unpolluted water is thus obtained, for the spring has never been known, within the memory of the oldest inhabitant, to run dry. The vast fells and moorlands which stretch around may be compared to stupendous sponges retaining a practically inexhaustible store of moisture which supplies the subterranean reservoirs, whence the springs are fed and what may be spoken of as full-grown and partly subterranean brooks proceed. The building of the house was entrusted to the village joiner, and it will, therefore, be unnecessary for me to inform anyone who is familiar with the still primitive qualities of the district, that it was done in a thoroughly substantial manner. Before the house was erected the water-supply was duly tested by Mr. Charles Estcourt, the Manchester City Analyst, and the present President of the Association, and was pronounced eminently suitable for the purpose. It is conveyed through lead pipes a distance of 65 yards from the cistern before-mentioned to the house, and as there is a descent of from 10 to 12 feet, or say 1 in 16, from the cistern to the hatching tanks, a good pressure is secured. The troughs and trays were made at Bowdon under the superintendence of the authorities of the Bollin fish-house. The annexed plan shows the arrangement. The water first enters a filter-box (A) supplied with loose gravel, and then passes into a long trough (B). This trough is connected with six trays over tanks on the left hand side of the plan, arranged in the form of steps, over which the water successively flows, escaping by the waste pipe (D). On the right hand side is another series of trays also arranged in three series of steps independently supplied with a constant flow of water from the trough, and with a waste-pipe also marked (D). The trays are supplied with the usual glass-rod grills, the ova being placed on the rods, and each tray is calculated to hold 1500 trout eggs. As the fish are hatched they escape through the grills into the boxes or tanks. The bottoms of the tanks are covered with fine gravel in which the young fish take refuge from the light. Small pieces of slate are mingled with gravel, and under these the fish find what appears to be often a very welcome shelter. On the right of the door a large zinc tank has been provided, and into this the fish are removed as they increase in strength. Provision is, of course, made for a continual flow of water through it. The water, though roughly filtered, still appears to contain a considerable natural supply of food; indeed, as Dr. Angus Smith has shown, even very pure spring water is abundantly supplied with microbia. It would be interesting to ascertain how



GROUND PLAN.

far these micro-organisms minister to the life of the young fish. The fish are, however, also fed daily with well-boiled liver, finely grated, and on Sundays, Mr. Walker, the Association's keeper, treats them to a hard-boiled egg. Close to the breeding-house, a slate tank, 24 feet long by 8 feet broad, and with a depth varying from 2 feet at one end to 4½ feet at the other, has been constructed; and, in this, 4,000 fish are kept until they are yearlings, when they are placed in the small streams and allowed to work their way down to the Ribble. This tank, however, is far from sufficient to accommodate the whole of the fish hatched, and hence a considerable quantity are placed at an earlier age than one year in the brooks, the larger and stronger fry being selected for this experience as being more likely to survive in the struggle for existence. The Association has the satisfaction of knowing, however, that a considerable proportion of young fish are specially protected from their natural enemies until they are yearlings, when they measure from 3 to 5 inches. The trout is believed to become reproductive at the age of two years. The total cost of the installation was about £80.

The first experiments in collecting the ova were conducted by two amateur members of the Association, in the early part of December, 1884. In a small neighbouring brook scarcely two yards wide, with a sandy bottom, where the fish had repaired to spawn, about 100 fish were netted within about 50 yards. The weight of the fish ranged from ¼lb. to 1lb. The spawn was taken only from the larger ones. On a subsequent day over 170 fish were captured in the same brook. On both occasions there were 20 males to 1 female. The ripe female fish were first held over a shallow dish containing a little water, and the belly gently stroked. The ova fell singly into the dish, no pain being caused to the fish. The male fish were then treated in the same way and the milt allowed to fall on the ova. A slight swaying of the dish from side to side tends to ensure the impregnation of all the eggs. Contact with the milt causes the colourless virgin eggs to change to a golden pink hue. The proportion of the sexes netted varied on different days; thus, on one day, six female fish to one male were taken. It is stated that the milt from one male is sufficient to impregnate the ova from two or three females. An excess of milt was supplied, however, in these experiments. This may have had something to do with the remarkable success of the hatchings. Possibly it may have assured the effective impregnation of all the ova. The impregnated ova showed signs of life about six weeks after being placed in the trays. I ought to say that the ova and milt were all obtained from the native trout of the dale, it being considered that the vigour and size of the breed could not be improved. The umbilical sac was absorbed within a month or six weeks after the hatching of the living and moving fry.

In 1885 about 12,000 fry were hatched from the spawning of 1884, and in 1886 about 28,000 fry from the spawning of 1885. The loss from the ova to the fry state was only about 2 per cent. The young fish have proved remarkably vigorous. From the spawning of this winter, about 26,000 ova have been placed on the trays, and the loss has been only about ½ per cent. As comparatively few of the fish can yet have attained the size at which it is permissible, according to the rules of the Association, to take them from the river, and only the earliest hatchings can yet be approaching the re-productive age, the effect of the artificial hatchings upon the wealth of the river cannot yet have been felt. There is, however, already decided evidence of improvement in the yield to the rod, and my own observation of a water which I knew before the railway was constructed has convinced me that the Association will in due time reap a rich harvest from its enterprise. Apart from the credit due to the Manchester Anglers' Association for having thus utilised its opportunities for assisting in the work of replenishing our rivers with a most important food supply, the experiment has considerable biological interest. A careful record of statistical and other facts is being kept by the Association, and such data will afford material for solving many interesting ichthyological problems. Thus, the relations between the meteorological character of the seasons, the time of spawning, and the relative abundance of the spawning and success of the hatchings are being observed. In his latest report as Inspector of Fisheries in England and Wales, Mr. A. D. Berrington comments on evidence of apparent changes in the spawning time of the salmonidæ in different rivers which cannot be traced to any visible changes in the natural conditions of the rivers in question; and in a previous report Professor Huxley calls attention to remarkable changes in the productiveness of different rivers from year to year, extraordinary fallings-off and sudden revivals, which cannot be explained by any of the hypotheses advanced, such as pollution, rainfall, and so on, being witnessed. The question of spawning time and the effect of meteorological and other conditions upon it, and also upon the hatching, have an important bearing upon the close-time regulations, as it is obvious that with fixed dates the rivers may occasionally be closed and opened too early; and it is just possible that it may eventually be found desirable to adapt close-time regulations to the special character of the season and other conditions of fish-life and maturity. I have to thank Mr. Robert Burn, who has taken an active part in the fish-breeding enterprise on behalf of the Association, for much of the information relating to the fish-house in this paper; and I have authority to add that the Association will welcome any member of this Society who may take a scientific interest in the matter to an inspection of the fish-house, and will afford facilities for any scientific investigation which he might like to carry on in connection therewith.

Ordinary Meeting, February 22nd, 1887.

Professor **Osborne Reynolds**, LL.D., F.R.S., Vice-President, in the Chair.

Mr. H. **Grimshaw**, F.C.S., and Mr. **John Angell**, F.T.C., F.C.S., were appointed auditors of the Treasurer's Accounts.

Professor W. C. **Williamson**, LL.D., F.R.S., announced the discovery near Oldham of new specimens of a fruit identical with one described by him in 1869, as being the fruit of a Calamite. The specimen then described was identified as being Calamitean, on the ground of peculiarities of internal organisation. In three at least of the new specimens each fruit is borne at the summit of a short Peduncle, which latter is a young twig of an ordinary Calamite.

"Electrolytic Polarisation," by **Charles H. Lees**, B.Sc., and **Robert W. Stewart**, Student in the Owens College. Communicated by Dr. Arthur Schuster, F.R.S.

In making some experiments on Polarisation in the Physical Laboratory of the Owens College, under the direction of the Demonstrator, W. W. Haldane Gee, B.Sc., use was made of the dead beat galvanometer designed by Deprez and D'Arsonval, which proved to be very well adapted for the study of rapidly changing currents. The instrument being little known in England, it has been thought that it would be of interest to bring it under the notice of the Society. In addition, some of the results obtained are, as far as we can ascertain quite new.

Description of Galvanometer.

The Deprez and D'Arsonval Galvanometer consists of a rectangular coil of fine wire suspended between the poles of a strong horse-shoe magnet by an upper and a lower silver wire. The current to be observed is sent through these silver wires to the rectangular coil, which is deflected from its normal position, the plane of the magnet.*

Under proper conditions the galvanometer was found to be very delicate, and quite dead-beat, and therefore suitable for the investigation of currents of rapidly varying intensity, such as those considered below.

To obtain the best results it was found:—

(1) *That the resistance between the terminals of the galvanometer must not exceed a certain limit.* This is necessary to maintain the dead-beat character of the instrument. The limit was about 90 ohms in the one used. As the resistance of the galvanometer was about 220 ohms, the resistance of the shunt was kept below 150 ohms.

(2) *That the coil must not suffer a violent or a long continued deflection in any one direction,* otherwise the suspending wires take a temporary "set" from which they recover only after some time.†

The instrument was calibrated, and the deflection was found proportional to the current passing.

Apparatus and Method of Experiments.

In these experiments it was desired to notice:—

(1) The variation of the current in a circuit containing an Eletrolytic cell in series with a battery. (This we shall call the *Polarising Current.*)

(2) The variation of the current given by the polarised cell, the battery being out of circuit. (*Depolarisation Current*).

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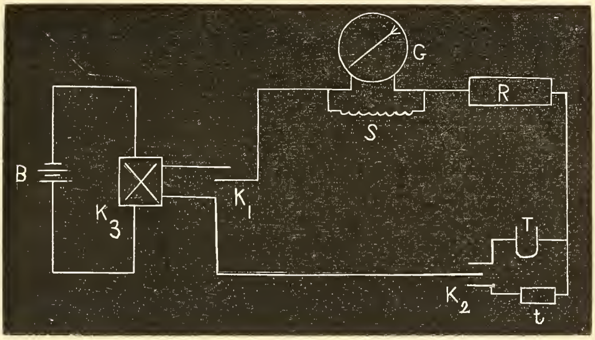
* A full description of the galvanometer will be found in the *Comptes Rendus* 94, p. 1347 (1882).

† This appears to point to the fact that the "Elastic Recovery" of silver is slow.

Preliminary experiments showed that the deflection produced when the battery current was first sent through the electrolytic cell was not as great as it should be, owing to the time occupied in the coil moving to its deflected position, and to the great rapidity of the initial polarisation. It was finally found that with the arrangement of the apparatus shown in the figure—



B	Battery.
K_3	Commutator.
K_1 and K_2	Two way keys.
G	Galvanometer.
S	Shunt.
R	Large resistance (about 4,000 ohms).
T	Electrolytic cell.
τ	Compensating Resistance = that of T, which was measured by Kohlrausch's method.*

the best results could be obtained by the following method:

(*a*) Deflections were obtained indicating the strength of the current from B, when T was out of, τ in, circuit.

(*b*) The cell T was put in circuit, and scale readings taken every five seconds till the deflection became constant. If the reading (*a*) is proportional to E of battery, the final reading (*b*) is proportional to $E-e$, where e is the back E.M.F. due to polarisation.

(*c*) The battery B was switched out of circuit, and read-

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* Wiedemann's, *Annalen* 11, p. 63 (1880).

ings taken every five seconds of the polarisation deflection as it diminished to zero.

(*a*) and (*b*) give e in terms of E.

The cells on which observations were made were:—

1.—U tube containing dilute H_2SO_4, 20 %, with platinum foil electrodes.

2.—Ditto ditto ditto with platinum wire electrodes.

3.—Rectangular battery cell containing concentrated solution $ZnSO_4$, with Zn plate electrodes of 50 sq. cms. area.

4.—Rectangular battery cell containing concentrated solution $CuSO_4$, with Cu plate electrodes of 50 sq. cms. area.

Experiments.

1. Dilute H_2SO_4 20%. Pt. foil electrodes.

The curves representing the relation of current to time are shown at A for different values of the resistance in circuit. They indicate:—

(*a*) A very rapid decrease of current during first instants after closing circuit.

(*b*) After the first 30 seconds the decrease becomes very slow, and after some time the readings become constant, *i.e.*, the polarisation attains its maximum for the current used.

The curves representing the variation of the depolarisation current are shown at B; they will be considered more fully presently.

2. Dilute H_2SO_4, 20%. Pt. wire electrodes.

In this case the bulk of the decrease from E to E—e is over in 15 seconds, and a minimum is quickly reached. The same rapid decrease occurs in the "depolarisation" curve (e to 0), in which the bulk of the decrease takes place in the first 15 seconds.

The curves are similar to those for 1, but indicate that the changes are more rapid.

3. Concentrated solution of $ZnSO_4$, with Zn plate electrodes.

When the cell was first put into circuit with the battery, the current began to increase, and gradually reached a maximum. When the battery was cut out of circuit, a deflection due to polarisation could be obtained on altering the shunt of the galvanometer. This deflection diminished slowly and regularly to zero.

4. Concentrated solution of $CuSO_4$ with Cu plate electrodes.

With this cell it was also found that a gradual increase set in on making the circuit. The current reached a maximum in about 8 minutes, and remained steady at its maximum.

This cell also gave a weak but persistent polarisation current, which first began to increase, reached a maximum, and then decreased, taking over one hour with 200 ohms in circuit to reach its initial value. It was but slightly diminished at the end of several hours.

Numerical values of 'e.'

From above experiments—

1. Pt. foil in dilute H_2SO_4, 20 %, $e = 1{\cdot}69$ Daniell.
2. Pt. wire ,, ,, $e = 1{\cdot}92$,,
3. Zn plate in concentrated $ZnSO_4$, $e = {\cdot}004$,, } *q.p.*
4. Cu ,, ,, $CuSO_4$, $e = {\cdot}01$,, }

The last two values are not to be considered as absolute, but rather as showing the orders of magnitude of the two polarisations.

Observations were made of the value of e under varying conditions of circuit. Thus if one of the three variables, current, EMF, and Resistance was kept constant, while the other two were varied, the following results were obtained:—

1. C kept constant, E and R varied.

$E = 1$ Daniell, $R = 3{,}100$ ohms, $e = {\cdot}9$ Daniell.
$E = 2$,, $R = 5{,}860$,, $e = 1{\cdot}6$,,
$E = 3$,, $R = 8{,}290$,, $e = 2{\cdot}0$,,
$E = 4$,, $R = 11{,}040$,, $e = 2{\cdot}1$,,
$E = 6$,, $R = 18{,}510$,, $e = 2{\cdot}1$,,
$E = 8$,, $R = 24{,}990$,, $e = 2{\cdot}1$,,

2. EMF kept constant $=4$ Dan., R and C varied.

R = 8,000 ohms, Current = C, $e=2·16$ Daniell.
R = 4,000 „ „ = 2C, $e=2·28$ „
R = 2,666 „ „ = 3C, $e=2·32$ „
R = 2,000 „ „ = 4C, $e=2·36$ „
R = 1,333 „ „ = 6C, $e=2·48$ „
R = 1,000 „ „ = 8C, $e=2·56$ „

3. R kept constant $=4,070$ ohms, E and C varied.

E = 1 Daniell, $e=$ ·92 Daniell.
E = 2 „ $e=1·55$ „
E = 3 „ $e=1·85$ „
E = 4 „ $e=2·13$ „
E = 6 Daniell, $e=2·33$ Daniell.
E = 8 „ $e=2·54$ „
E = 10 „ $e=2·75$ „
E = 12 „ $e=2·97$ „

These tables shew that e is a function of not less than two of the variables E, C, R.

When one Daniell is employed to polarise the cell, there is a large deflection immediately on closing the circuit. It rapidly diminishes, however, to a very small amount, which indicates the existence of the "convection current" of Helmholtz. This current is greater the longer the cell has been in use, owing, probably, to the liquid becoming more charged with gas.

Depolarisation Curves for Pt. foil electrodes in dilute H_2SO_4.

After a cell containing dilute H_2SO_4 10% had heen polarised by a battery of two Daniells, till the deflection became constant the battery was put out of the circuit and the deflection due to the polarisation produced in the cell was observed. During the decrease of this deflection readings were taken every five seconds, and the curves shown at B plotted out. By varying the resistance in circuit three curves were obtained, each of which had two points of inflection.*

These curves never having, as far as we can ascertain,

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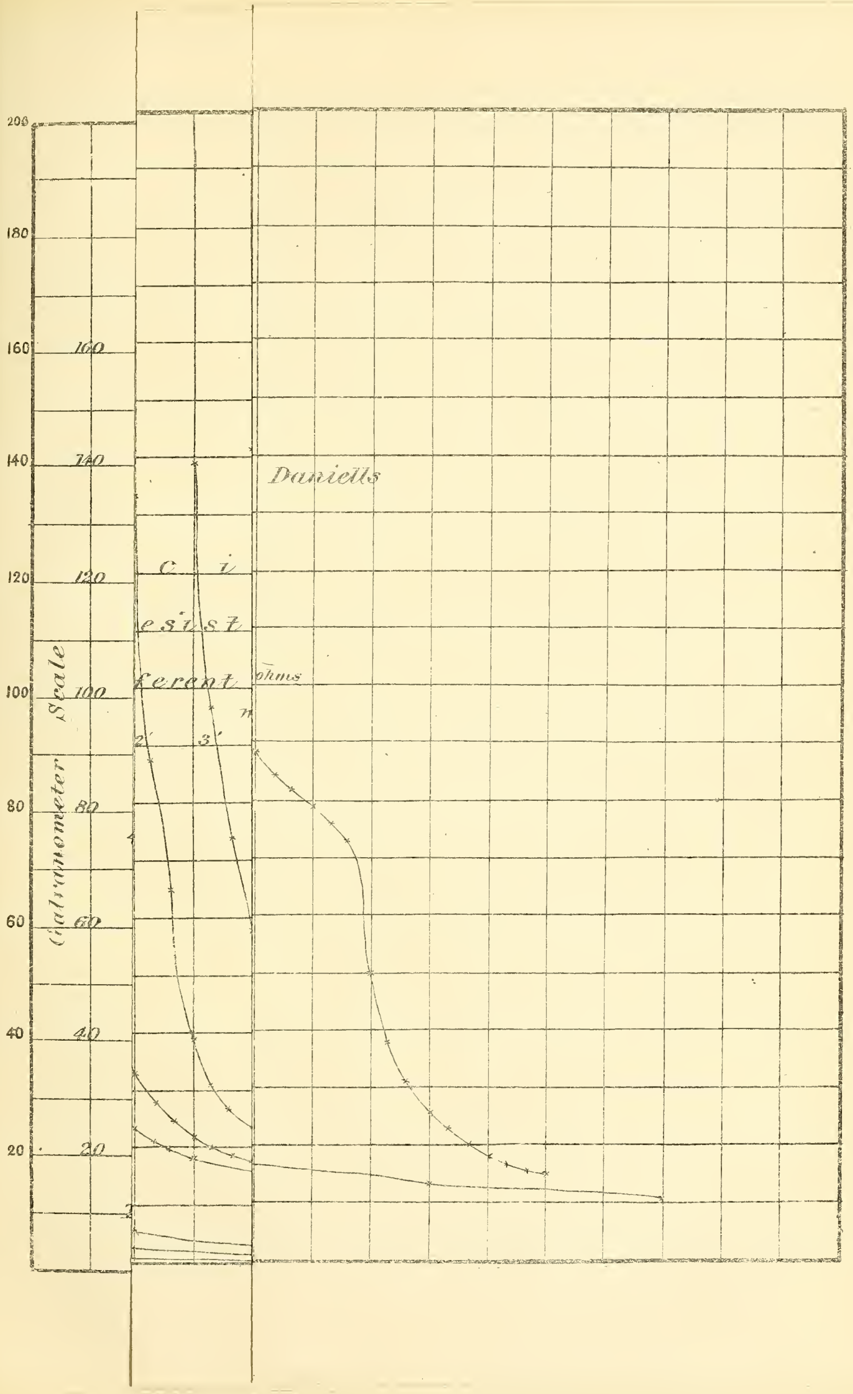
* Inflected curves have recently been obtained under somewhat different conditions by C. Fromme. See Wiedemann's *Annalen*, 12, 1886.


200
180
160
140
120
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160
140
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60
40
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Galvanometer Scale
Daniells
C i
e si s t
ferent
ohms
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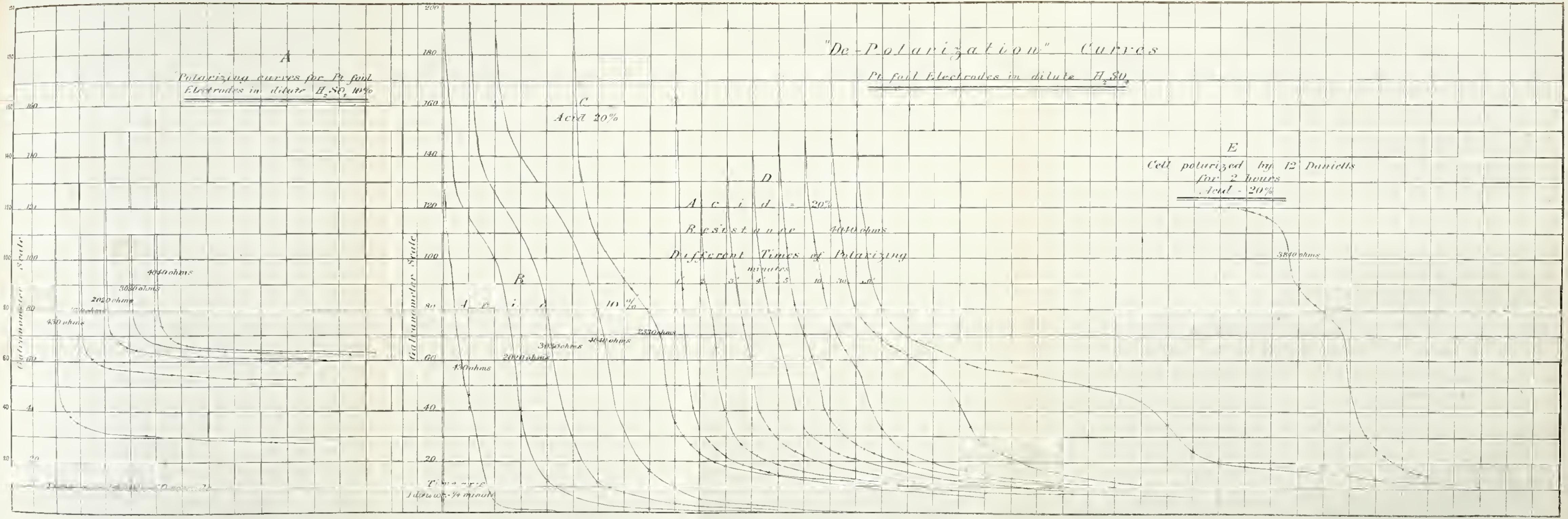
2'
3'

"De-Polarization" Curves
Pt foil Electrodes in dilute H_2SO_4
A
Polarizing curves for Pt foil
Electrodes in dilute H_2SO_4 10%
Galvanometer Scale
160
140
120
100
80
60
40
20
4040 ohms
3030 ohms
2020 ohms
1010 ohms
430 ohms
Time scale 1 div = 50 seconds
200
180
Galvanometer Scale
Time scale
1 div = ¼ minute
B
Acid 10%
430 ohms
2020 ohms
3030 ohms
4040 ohms
2530 ohms
C
Acid 20%
D
Acid = 20%
Resistance 4040 ohms
Different Times of Polarizing
minutes
1'
2'
3'
4'
5'
10'
30'
60'
E
Cell polarized by 12 Daniells
for 2 hours
Acid - 20%
3840 ohms

been obtained before, it was thought advisable to observe the effect of varying circumstances on their form.

(*a*) Effect of resistance in circuit:

From the three curves mentioned above it is seen that an increase of resistance increases the time taken by the polarisation to sink down to a given value, the general form of the curve remaining the same. The time is nearly proportional to the resistance.

(*b*) Effect of alteration of percentage of acid.

The solution was made 20% acid, and a curve (C) for resistance =2,500 ohms drawn. The alteration of the curve seems due only to the alteration of resistance of the circuit, it comes between the 2,000 ohms and 3,000 ohms curves of the 10% solution.

(*c*) Effect of variation of time of polarising.*

The cell was polarised during different periods of time extending from 1 minute to 90 minutes, and the curves of depolarising taken. These curves are shown at D.

The two points of inflection are not recognisable till the curve for 5 minutes polarising is reached. The curves show that increase of time of polarising increases the time of depolarising down to any given value.

(*d*) Effect of increase of EMF of battery.

A battery of 12 Daniells was used to polarise the cell, the current being kept on for two hours.

The depolarising curve (E) is then for the first quarter minute nearly parallel to the time axis, and therefore totally different to the curves obtained with two Daniells, which for the first few seconds are almost parallel to the deflection axis. This last effect appears to indicate; either that none of the gas liberated at the poles of the voltameter exists as a superficial film on the Pt. foil when the polarising current is strong and has acted for a considerable time, or that the electromotive force due to such a film has vanished

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* This was suggested to us by Dr. Schuster.

before the coil of the galvanometer has had time to take up the position of equilibrium due to it, *i.e.*, in less than $\frac{3}{4}$ths of a second.

To show that gas is occluded by the electrodes during polarising, and soaks out during depolarising, the cell was polarised up to a fixed point, and then allowed to depolarise down to a second fixed point. On breaking circuit for a period, and then making again, a deflection was observed which was greater than the one before breaking circuit, and which increased with the time of insulation.

The analogy between an electrolytic cell and a condenser, seems extended by the similarity of the depolarisation current to the oscillatory discharge of a condenser.

The experiments are being continued with the object of finding the relation between the actions of the occluded and superficial gas during depolarisation, as referred to by Helmholtz.*

"On the delicacy of spectroscopic reaction in gases," by T. W. Best. Communicated by Dr. Arthur Schuster, F.R.S.

Seeing that very minute quantities of a great many bodies can be detected with ease in the spectroscope; at the request of Sir Henry Roscoe the following experiments were undertaken with the view of testing the efficiency of the spectroscope as a means for ascertaining the purity of gases.

The three gases, hydrogen, nitrogen, and oxygen only were experimented upon; thus the smallest amount of hydrogen, whose spectrum could be observed in that of nitrogen, and *vice versa*, was first determined; and then the smallest amount of nitrogen in oxygen, and oxygen in nitrogen respectively, at the atmospheric pressure.

Apparatus used.

1. Spectroscope. 2. Induction coil. 3. Eudiometer.

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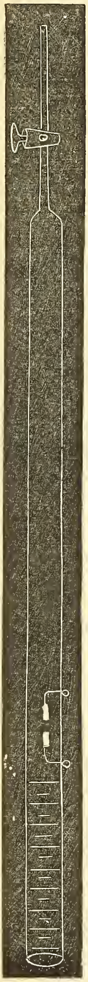
* See *Wissenschaftliche Abhandlungen*, of Helmholtz, p. 823.

1. The collimator, prism stage and telescope of the spectroscope were mounted on separate stands; only one prism was used whose angle is 59° 33′, and the magnifying power of the telescope is 26·9.



Only about a quarter of the length of the spectrum could be seen in the spectroscope at once, and there being no scale, the position of the lines sought after had to be measured from known gas lines, by a micrometer screw and pointer attached to the eyepiece.

2. An induction coil was used with a small Leyden jar in the circuit to obtain the spectrum. Under ordinary conditions the length of spark in air, with jar in circuit, was 1·5c.m, while without the jar a spark = 5·2c.m. in length could be obtained.

3. Two eudiometers were used of the shape shown in the margin, being 70c.m. long, 1·9c.m. wide, graduated up to 160 c.c.s, and having aluminium electrodes ·25c.m. apart sealed into the side at a distance of 30 c.m. from the bottom; the tap at the top serving to let in, from a burette, the required amount of gas.

To get rid of all the air, the eudiometer was filled with mercury, by exhausting the air above it with a water pump.

In most cases when the spectrum was observed, the gases were under a pressure reduced by one inch of mercury, *i.e.*, the mercury stood about one inch higher in the tube than in the trough.

Unless specified to the contrary the gases were thoroughly dried by standing for a few hours over phosphoric anhydride.

The phosphoric anhydride was rammed tightly into a small tube which can be slipped into the eudiometer through the mercury; a hole being bored through the mass of P_2O_5 to allow the mercury to run off the top of it, and thus expose its surface to the gas.

Each gas had its own tube of P_2O_5, so that each tube of P_2O_5 did not become contaminated with more than one gas.

Experiments were tried with

(*a*) Nitrogen in hydrogen.
(*b*) Hydrogen in nitrogen.
(*c*) Nitrogen in oxygen.
(*d*) Oxygen in nitrogen.

(*a*) *Nitrogen in hydrogen.*

The hydrogen was generated by the action of sulphuric acid on zinc, washed and dried by passing through water and strong sulphuric acid, and after coming off for some time was collected over mercury.

The eudiometer is then placed in front of the spectroscope slit (at a distance of $\frac{1}{2}$ metre), the spark focussed on to the slit by means of a small lens, and the spectrum examined.

If nitrogen or oxygen are not visible, and only the three hydrogen bands are present, then air (or, in some experiments, pure nitrogen) is added to the hydrogen in small quantities (about 1 c.c.) at a time, and the spectrum observed between each addition.

Thus, in one case, to 143 c.c. hydrogen was added to 1 c.c. air and the nitrogen lines were not visible, so another 1 c.c. air was added; but now the nitrogen green line wave length 5004 was seen very faintly, and on the addition of another 1 c.c. air it could easily be seen. Therefore the amount of nitrogen that must be present in hydrogen in order to be detected in the spectroscope is 1·1 per cent.

Again, to 130 c.c. hydrogen 1 c.c. pure nitrogen (made by passing air over thin sticks of phosphorus in Hempel's gas analysis bulbs) was added, from a Hempel's burette, but the nitrogen line was not seen; so ·5 c.c. more nitrogen was added, and now the nitrogen green line was seen, but it was rather faint. This gives 1·1 per cent.

To another 130 c.c. hydrogen, not dried at all, 1 c.c. nitrogen was added, but no nitrogen lines appeared; ·6 c.c. more nitrogen was added, and the nitrogen line was then seen. This gives 1·2 per cent.

To 118 c.c. hydrogen, dried by having concentrated sulphuric acid in the eudiometer on the top of the mercury, 1 c c. nitrogen was added, and the nitrogen line was not then visible: on addition of ·2 c.c. more nitrogen the nitrogen line was not visible, but on addition of ·2 c.c. more it came into view.

This gives 1·2 per cent. Mean of the four experiments is 1·15.

Therefore the amount of nitrogen that must be present in hydrogen to be detected in the spectroscope is 1·1 per cent.

Again, 4·5 c.c. nitrogen were added to 143 c.c. hydrogen, and the nitrogen line wave length 5004 was easily seen; on adding 1 c.c. more nitrogen the yellow nitrogen lines wave lengths 5681 and 5666 came out, and another green line wave length 5164 makes its appearance on the addition of 2·5 c.c. more.

The result is not affected in the least, whether air or pure nitrogen is added to the hydrogen.

(*b*) *Hydrogen in nitrogen.*

To 112 c.c. pure nitrogen (made by the method already given) 6·7 c.c. hydrogen were added, and the green and red hydrogen bands were distinctly visible.

To 144 c.c. nitrogen 1·6 c.c. hydrogen were added and the green band became visible, not as a band but as a very broad, thick line, quite sharp at the edges, and on the addition of more hydrogen it widened out into a band. The red hydrogen band was also visible at this time as a broad line.

To 140 c.c. nitrogen ·35 hydrogen was added; the red hydrogen band was easily seen, but the green band only flashed in occasionally as a broad line.

On addition of ·3 c.c. more hydrogen it was still a broad line, and broadened out into a band on adding more hydrogen.

Therefore the amount of hydrogen that must be present in nitrogen in order that the green band in its spectrum may be observed in the spectroscope is ·25 per cent.

(c) *Nitrogen in oxygen.*

The oxygen was made by decomposing potassium chlorate, passing the gas through N*a*OH and H_2SO_4 and collecting over mercury, as usual.

To 153 c.c. oxygen 2·9 c.c. nitrogen were added, and the nitrogen green line wave length 5004 was visible.

To 132 c.c. oxygen 2 c.c. nitrogen were added, and the nitrogen line was again seen. The gas was not dried in the above two experiments at all.

To 130 c.c. oxygen 1 c.c. nitrogen was added, and the nitrogen line was seen, but it was very faint. This gives ·78 per cent.

To 128 c.c. oxygen ·6 c.c. nitrogen was added, and the nitrogen line was not seen; on adding ·8 c.c. more nitrogen the green nitrogen line wave length 5004 was visible, and on addition of ·3 c.c. more nitrogen it could easily be seen.

Therefore the smallest amount of nitrogen that must be present in oxygen in order to be detected in the spectroscope is ·8 per cent.

(d) *Oxygen in nitrogen.*

To 127 c.c. nitrogen 30 c.c. air had to be added before the oxygen blue line wave length 4648 became visible; this gives 4·7 per cent.

To 108 c.c. nitrogen 22·6 c.c. air were added before the oxygen line became visible; this gives 4·5 per cent.

To 104 c.c. nitrogen 5 c.c. oxygen were added and the oxygen line was seen very easily.

To 138 c.c. nitrogen 4 c.c. oxygen were added and the oxygen line was not visible, but on adding 3 c.c. more oxygen it could be seen easily; this gives 4·4.

In the last two experiments the gas was not dried at all.

Therefore the amount of oxygen that must be present in nitrogen in order to be detected in the spectroscope is 4·5 per cent.

The addition of air to the oxygen gives the same result as adding pure nitrogen to the oxygen, so that it is immaterial which is used; neither does the dryness of the gas seem to affect the results.

The following experiments were made at diminished pressures to see how the above results are affected at different pressures.

Thus, to 95 c.c. hydrogen, at 11 inches mercury pressure, 1·5 c.c. air was added, and the nitrogen line was just visible.

Now 95 c.c. hydrogen at 11 inches pressure = 35 c.c. at 30 inches pressure, and this gives 3·5 per cent nitrogen.

Again, to 90 c.c. at 10 inches pressure were added
·5 c.c. air, and no nitrogen lines were visible,
·3 c.c. air more, „ „
·4 c.c. air more, „ „
·2 c.c. air more, and nitrogen line became visible.

Therefore 1·4 c.c. air in 30 c.c. hydrogen = 3·7 per cent nitrogen.

Thus a diminution of pressure from 29½ inches to 10½ inches mercury alters the amount of nitrogen that must be present in hydrogen in order to be detected in the spectroscope from 1·1 per cent to 3·6 per cent.

96 c.c. hydrogen at 2 inches pressure *showed the three hydrogen bands as wide lines, sharp at the edges, the red being the broadest.* On the addition of ·25 c.c. air the nitrogen line wave length 5004 was seen at the edges of the field only, and not extending across.

On adding further small quantities of air (up to 3·8 c.c.) more nitrogen lines came into view, till at last they were all in view, but they were only visible at the edges of the field, and would not extend across the field. The hydrogen lines became broader on each addition of nitrogen, and ultimately they became bands. At the end of the experiment the pressure had increased to 2¾ inches mercury.

To 101 c.c. hydrogen at 3½ inches pressure

·04 c.c. air was added, but no nitrogen lines appeared.
·16 c.c. air ,, ,, ,, ,,
·26 c.c. air ,, ,, ,, ,,
·1 c.c. air the nitrogen green line appeared at the edges only.
·2 c.c. air the nitrogen green line became much clearer.

Thus ·36 c.c. air = ·29 nitrogen in 11·8 c.c. hydrogen = 2·5%.

Therefore at 3½ inches of mercury pressure the smallest amount of nitrogen that must be present in hydrogen in order that it may be detected in the spectroscope is 2·5%.

Complete Results.

a.	Nitrogen in hydrogen at atmospheric pressure..			1·1% N.
	Nitrogen in hydrogen at 10½ inches		,,	3·6% N.
	Nitrogen in hydrogen at 3½	,,	,,	2·5% N.
b.	Hydrogen in nitrogen at atmospheric		,,	·25% H.
c.	Nitrogen in oxygen	,,	,,	·8% N.
d.	Oxygen in nitrogen	,,	,,	4·5% O.

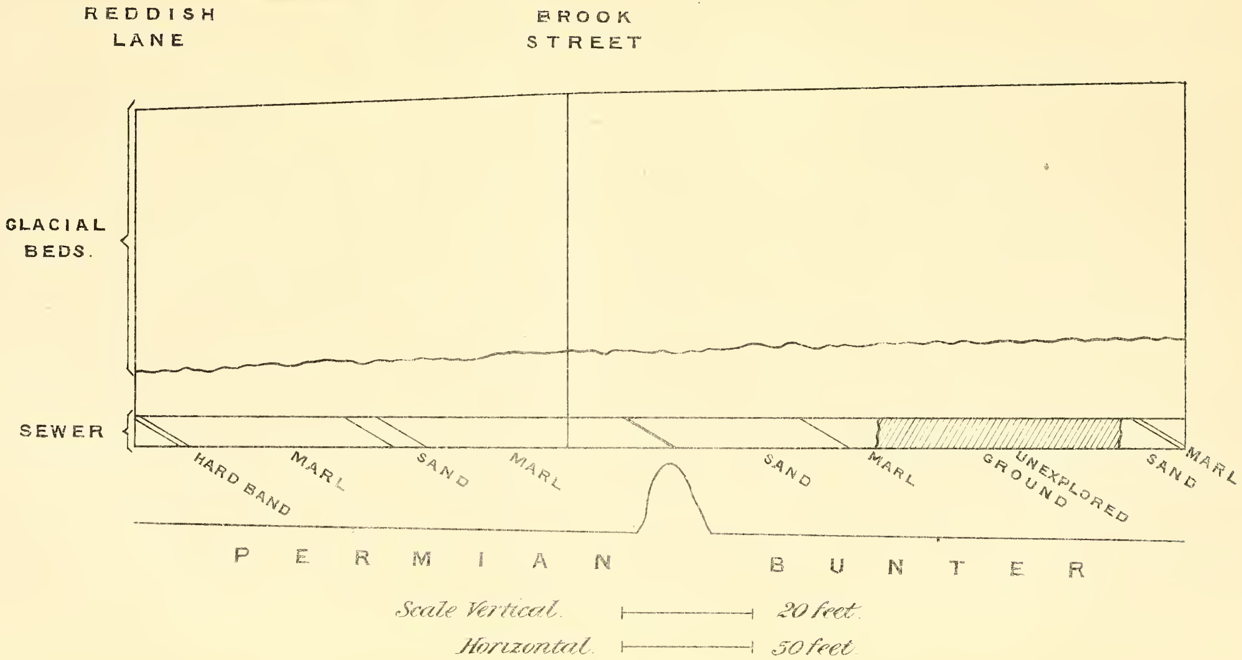
"Lower New Red and Permian—Stockport," by J. W. GRAY, Stockport Society of Naturalists, and PERCY F. KENDALL, Berkeley Fellow of Owens College. Communicated by Thomas Kay, Esq.

These notes are offered as a contribution to the literature of a subject which has received considerable attention from Geologists for many years, viz., the relations between the Triassic and the so-called Permian rocks.

The subject is of great interest, by reason of a supposed interval of greater or shorter duration between the Palæozoic and Mesozoic Periods occurring between the lower New Red Sandstones and the Permian rocks, and corresponding to the undoubted organic break which marks the close of the Palæozoic Period.

The Permian (? Lower New Red) Sandstone is estimated

SECTION IN SEWER AT CORPORATION ST., REDDISH.



to be about 1,000 feet thick at Stockport, but the base has not been reached. It is easily distinguished by a bright red colour, and contains no pebbles. Small seams of well-rounded grains of sand frequently occur through the whole of the beds. With the exception of a small outlier at Torkington, the Permian Sandstone is first seen near Stockport on the west or downthrow side of the Red Rock Fault, where the undisturbed Permians are in contact with highly-inclined beds of the Middle Coal Measures. From this exposure to Tiviot Dale Station, near the confluence of the rivers Goyt and Tame, which thence continue as the Mersey, the members of the Permian series succeed each other with a steady westerly dip, but are occasionally obscured by Glacial and Alluvial deposits. From the river to Sandy Lane the ground rises abruptly to about 250 feet above Ordnance datum, but at the summit the solid geology is masked by 40 feet of Boulder clay, with intercalations of sand.

A shaft has been sunk through the line of junction between the older beds and the glacial clays and sands laid down upon the old escarpment, and large boulders have been observed pressed into the Permian Marl, probably by the glacier which ploughed out the valley, now extending many yards below.

At the corner of Coronation Street and Sandy Lane a shaft has been carried to a depth of over 60 feet, giving a valuable opportunity for studying the underlying rocks. As such an opportunity very rarely occurs, every effort has been made to take observations as the work proceeded, and a large fund of information has been obtained from the few hundred feet excavated up to the present time. The shaft just mentioned touches the lowest point in the so-called Permian beds yet reached in the excavation. A deep well boring at a short distance has, however, afforded evidence as to the thickness of the Marl, for on referring to the section, it will be seen that it was found at 63 feet from the surface, which is a few feet higher than Coronation Street, and was perforated at a depth of 132 feet, so that, allowing for dip, the marl is at this point about 60 feet thick. Near the bottom of the shaft the marl is fossiliferous, and contains bands of stone and cavities containing crystals. The prevailing colour is a rich dark chocolate or brown, with occasional mottlings of green and white. One of the green bands distinctly shows a small reversed fault, having a throw of 10 inches, which is worthy of note, as the hade is to the S.S.E., agreeing in direction and amount with that of several fissures filled with Marl, which are to be observed in other sandy beds further to the N.N.W. It may be remarked in passing that the statement is made in at least one modern Geological Text-book that all faults hade to the downthrow.

One of the hard bands in the marl is of great interest. The lower part consists of about 10 inches of false bedded sandstone, capped by a thin seam of highly ferruginous marl, containing myriads of fossil shells, most of which are small, many being microscopic. The following species have been identified: Serpula pusillà, Bakevellia antiqua, Cardiomorpha modioliformis, Rissoa, Loxonema, &c.

A hard calcareous band of about three inches thick lies four feet above the last bed, and fossils are thickly scattered through the stone.

The soft marl in the vicinity of these bands is also fossiliferous, and geodes containing crystals of calcite are numerous. The following species occurring in the hard band have been determined:—Schizodus obscurus, Schizodus Schlotheimi, and Bakevellia antiqua. Some of the species are identical with those found at Collyhurst, and the beds are probably of the same age.

About six feet of marl lie above the last hard band, and the Permian beds in this shaft are capped by two feet of sand and 10 feet of glacial clay without pebbles, and partaking slightly of the colour of the marl, of which it appears to be partly composed.

The conditions under which the series of beds known as the Permian Marl were deposited appear to have been subject to considerable variation, for in addition to the fossiliferous and calcareous bands, beds of sandstone occasionally occur. One of these beds, as shown in the section, is 15 feet thick, the dip of which agrees with that of the marl. After passing through several feet of marl, sandstone is again reached, and this is succeeded by sandy marl, with seams of fine hard marl. In this rock the heading at present ceases, but at a distance of about 120 feet to the west the heading driven from the next shaft is in sandstone, with a few pebbles. Then comes a band of fine marl and sand about 14 inches thick, after which sandstone, with numerous pebbles, is penetrated for about 200 feet. With the exception of very small faults, no break of importance has been observed, but the variable conditions suggested by the frequent changes in the marl appear to be brought to a close by the 14 inch band of marl and sand, and the immediate appearance of sandstone with pebbles, without any perceptible change in the dip.

The fossiliferous Marl has not previously been described as having been observed near Stockport: in fact, according to the Geological Survey Map, the marl is absent at Sandy Lane. A band of marl 25 feet thick is mentioned as occurring at Hope Hill, three-quarters of a mile S.W. of Coronation Street, but the surveyor accounts for its appearance by the occurrence of a large fault, supposed to be a continuation of the great Irwell Valley Fault. We have seen the characteristic Permian Sandstone, with the large rounded grains, at this point, near which the Pebble beds again appear, overlying the 25 feet of marl. Amongst the Pebbles found in the sandstone, both above and below the 14 inch marl band, the following rocks have been identified:—

Permian Marl, Coal Measures Sandstone, Millstone Grit, Quartzite, and Quartz.

It would be foreign to the purpose of this communication were we to enter at large upon the vexed question of the value of the supposed breaks in the succession of the beds included under the comprehensive, but convenient, denomination of the Poikilitic series, but strictly limiting the application of our remarks to the immediate vicinity of Stockport, no satisfactory evidence has yet been adduced to prove the existence of any considerable stratigraphical break between the Permian beds and the overlying Bunter. The deductions of the surveyor were apparently drawn from inadequate information. It will have been noticed that in describing the section we have not ventured to make any definite assertion regarding the precise point at which the Permian beds are succeeded by the Bunter, but have offered as alternatives the view that the top of the great marl bed 30 feet N.N.W. of the Brook Street shaft, or the top of the 14in. marl bed further on, may be taken. In either case the evidence of nonconformity is inconclusive; for if we take the lower horizon, then, with a scarcely perceptible change of dip, we have an absolutely identical lithological composition, the upper marl being indistinguishable from the lower, while if we draw the line at a higher point, the dips are exactly conformable.

Ordinary Meeting, March 8th, 1887.

Professor **Balfour Stewart**, LL.D., F.R.S., in the Chair.

A brief discussion took place on the Magnetic Phenomena observed during the earthquake in the Riviera on February 23rd.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, February 14th, 1887.

Professor W. C. **Williamson**, LL.D., F.R.S., President of the Section, in the Chair.

Mr. W. **Blackburn**, F.R.M.S., exhibited a specimen of cremated bone, and described the method of cremation at Milan.

"Notes upon the Discovery in Scotland of *Triticum (Agropyrum) violaceum* (Hornemann) and *Aira (Deschampsia) flexuosa* (Trin) var: nov: *Voirlichensis* (Melvill)," by J. **Cosmo Melvill**, M.A., F.L.S.

I. Triticum violaceum (Hornemann).

In the summer of 1878 I paid a visit to Ben Lawers, a mountain I had previously visited several times, and on a ridge of rocks overhanging Lochnagat, between Ben Lawers proper and the Stuic-an-lochan rocks at about 3000 feet elevation, came upon a tract rich in Alpine plants. Here were Erigeron alpinum (L), Salix reticulata (L), Potentilla maculata (Pourr.), Viola amœna (Syme), and a very curious woolly stalked and leaved variety of Lychnis diurna (Sibth), with deep crimson flowers. Altogether the spot was a veritable Alpine garden, its beauty intensified by the blue of Myosotis alpestris (Sm.), which grew in profusion. Close by this spot I plucked two specimens of a Triticum, which I could not determine, but placed them in my Herbarium unnamed. Last year Dr. Buchanan White entered into some correspondence with me relative to the Flora of Perthshire, which he had undertaken, and I accordingly went through the whole of my Herbarium for localities, and in due course arrived at this Triticum, and forwarded him one of the two specimens, at the same time comparing the other with the Agropyra and Tritica of my general Herbarium. I very soon perceived that it in every way coincided with specimens of T. violaceum (Hornemann) I possessed, collected by Reutermann and S. N. C. Kindberg, the former labelled "Lapponia occidentalis, in montosis ad Alten, July, 1879," the latter "Norvegia Dovre, Kongswold 900 metr., 1884." This I told Dr. White, who had in the meantime forwarded Mr. Arthur Bennett, F.L.S., the other specimen for his opinion. He in due time compared it with the Tritica of the Kew Herbarium, including Don's specimen of T. alpinum from Ben Lawers, a plant which had been lost and expunged from the British lists, and came to the same conclusion as mine. A few months ago I visited the British Museum Herbarium with the same object in view, and again my feelings of certainty were strengthened by the inspection of Don's specimen there preserved, though it is but a poor one; and also by the sight of their Triticum violaceum series.

Nyman Conspectus Floræ Europeæ, p. 841, places T. violaceum (Hornemam) between T. repens and caninum. He gives as localities

"Lapponia occidentalis, Suecia borealis, Norvegia alpestris," and queries it as = T. alpinum Don (Scot).

This suspicion I now think is amply confirmed. T. violaceum is evidently nearly allied to T. caninum, and differs from it principally in being of more compact growth, shorter and somewhat narrower leaves, fewer flowered spikelets, with conspicuous purple tinge, this latter circumstance suggesting the trivial name. The awns not as long as the pales, excepting occasionally in case of the two upper spikelets.

Root fibroso cæspitose, not creeping. This fact militates against Sir J. D. Hooker's theory that Don's plant is but a form of T. repens.

T. biflorum (Mitten), specimens of which I have not seen, is probably the same plant. This must not be confounded with the biflorum of Brignol, a native of W. Tyrol and Italy: but Mr. Charles Bailey, F.L.S., possesses specimens of typical T. violaceum from the Tyrol. These are of peculiarly luxuriant growth.

It is always satisfactory to re-discover a lost species, but more especially one of George Don's, whose memory has of late often been the subject of opprobrium amongst certain botanists who failed to detect species recorded as found by Don, and Don only. Let us hope that after all Ranunculus alpestris, Caltha radicans, and other similar lost species may, in like manner, reward the future searcher.

II. *Deschampsia flexuosa* (L) var: c. *Voirlichensis* (Melvill).

Differs from var. b. montana (Hudson) by its possessing three perfect florets in each spikelet.

Hitherto the old Aira flexuosa (L) has been placed in the subgenus Avenella (Koch), one of the chief characteristics of that subgenus being two perfect florets, but no rudimentary third one, as opposed to Deschampsia, another subgenus of Aira, where the rudiments of a third floret are occasionally present.

This curious variety of a well-known species I found early in August on the actual summit (about 3300 feet) of Ben Voirlich, Perthshire, just S. of Loch Earn, where, in company with Carex rigida (Good), it formed the only vegetation.

At first it was taken for a very luxuriant form of montana (Hudson) which is common on the summits of many Highland mountains, but Mr. J. G. Baker, F.R.S., of Kew, pointed out to me the fact of its varietal distinctness from its possessing three fertile florets; hence it must be removed from Avenella.

I exhibit specimens from various parts of the northern hemisphere; normal forms of D. flexuosa from Kersal Moor, Manchester, where it grows abundantly; also specimens from Surrey, Lithuania (Poland), Spain, and both Northern and Southern States of N. America. These last, collected by Buckley from the mountains of N. Carolina, appear sometimes to have only one perfect floret, and a rudimentary second, the English specimens invariably two, and the variety b. montana (Hudson), which I show from Lochnagar and Ben Macdhui, Aberdeenshire, two also. This variety is principally conspicuous for its large dark purple glumes.

Aira alpina (L.) is reported from Ben Voirlich by Dr. Boswell, but I have never seen it there, and this grass is evidently not that species. It is always found viviparous in this country, and I have only seen it at the summit of Lochnagar, whence I show specimens.

The only other British, or indeed European, form of this grass I have seen which might at all belong to this new variety, called Voirlichensis, after the mountain on which it was observed, are from Glen Sannox, I. of Arran, where I have detected, in a small example I possess in my Herbarium, collected in September, 1883, by Rev. Augustin Ley, and labelled montana, among a great many spikelets with but two florets, as is usual, one with an apparently almost, if not quite, complete third floret. It is most probable that this variety will be found mingling with the other forms, and I would recommend its being looked for at the extreme summit of mountains, as this grass would seem to attain its greatest strength and perfection when entirely exposed to the bleakness and cold of the most uncongenial situations.

"Descriptions of one New Genus and some New Species of Parasitic Hymenoptera," by P. Cameron, F.E.S.

So little has been done in the way of describing foreign parasitic *Hymenoptera*, that undescribed species are to be found in most of the collections (however small) brought home by naturalists. For the species here described I am indebted (along with many other species) to Professor Trail, of Aberdeen; the Rev. Thos. Blackburn, B.A., of Port Lincoln, South Australia; Mr. George Lewis (so well known for his investigations into the insect fauna of Japan), and to that indefatigable discoverer of rarities, Mr. J. J. Walker, R.N.

CHALCIDIDAE.

Chalcis Mikado, sp. nov.

Niger, scapo antennarum, coxis, trochanteribus femoribusque posticis, rufis; tegulis, apice femorum, basi et apice tibiarum tarsisque posterioribus, albis; tarsis anticis testaceis; alis hyalinis. ♀

Long. fere 8 mm.

Antennæ short, thick, shorter than the thorax, the flagellum not double the length of the scape; covered with a close microscopic pile and with some fuscous hairs. Head coarsely rugosely punctured, a stout keel down either side close to the eyes; antennal groove deep, shining, impunctate, glabrous; a keel down the centre; covered with short glistening white hair. Thorax coarsely rugosely punctured, covered with glistening white hair; mesopleuræ deeply excavated, shining, finely obscurely reticulated. Scutellum ending at the apex in two blunt teeth. Metanotum reticulated, with two blunt teeth on either side, an elongated—rounded at either end—area in the centre. Abdomen subsessile, shining, impunctate, the basal half glabrous, the apical sparsely covered with white hairs. Legs covered with short white hair; the white on the anterior femora large, on the posterior four small; the anterior four tibiae are white at the extreme base and apex; the base of the hind tibiae is black, but there is a white spot not far from it, and the apex is broadly white; on the underside of the hind femora are ten teeth; the apical not very large and closely set, the others stout, large, and widely separated; the second from the apex is small. The humerus is pale testaceous, the ulna and radius fuscous-black.

Chalcis Callipus, Kirby (Journ. Linn. Soc., XVII, p. 75) comes very near the above described species, but it must, I think, be distinct; for the words, "femora armed below with a series of small teeth," can scarcely apply to the large and stout teeth of *C. Mikado*; *Callipus*, moreover, has the antennæ entirely black, and the antennal groove and the underside of the abdomen are reddish. *C. Mikado* also is fully a line larger. As with most of the species the white on the tibiae and tarsi runs into fawn.

Hab Hugita, Japan *(George Lewis).*

Halticella tinctipennis, sp. nov.

Nigra, geniculis, tarsis anterioribus, apice tibiarun, coxis posterioribus femoribusque posticis, rufis; alis fumatis, basi fere hyalinis. ♀

Long. fere 6 mm.

Antennæ 11-joined, a little longer than the head and thorax united, covered with a slight microscopical pile; originating from distinct tubercles, the scape more than double the length of the flagellum; a little dilated at the apex; first joint of flagellum double the length of the second, which is the shortest, apical joint conical, double the length of the tenth. Head covered with silvery white hair;

the antennal groove very wide, reaching quite close to the eyes and distinctly margined; the centre finely and closely transversely striated; the sides punctured somewhat strongly; the front ocellus placed in the groove, the hinder pair on the other side of the margin; the vertex and sides of the head punctured; thorax strongly punctured; the upper side covered with a fuscous, the pleuræ and sternum with white pile; the pleuræ not deeply excavated, obliquely, rather strongly striated; scutellum ending in two blunt, stout teeth; metanotum reticulated; two keels converging at base and apex, in the apex in the centre, and there is a more roundly curved one on either side of them; the metapleuræ are densely covered with silvery white hair; abdomen semisessile, the third and following segments at the sides bearing longish silvery white hair. Legs shortly pilose; hind femora stout, a black, deeply fringed border on the apical three-fourths; a tooth at the apex of the four anterior; basal joint of fore tarsi curved; hind tarsi black, reddish on the underside. Wings irregularly smoky, the base almost hyaline, the apex much lighter in tint than the middle; ulna about four times longer than broad, cubitus short.

H. apicalis, Walker (Trans. Ent. Soc., 1874, p. 400), is closely allied, but judging from the description, is different, the coxæ being all black, the metanotum with only three keels, the prothorax "about four times as broad as long"—in *tinctipennis* not much more than double—the wings are uniformly coloured; the antennæ shorter than thorax.

H. tinctipennis belongs to Kirby's genus or subgenus *Stomatocerus*, so far as I can make out.

Hab. Nagasaki, Japan *(George Lewis).*

Epitranus erythrogaster, sp. nov.

Niger, scapo antennarum, pedibus, abdomineque, rufis, coxis posticis (apice excepto) petioloque, nigris; alis hyalinis.

Long. 5·5 mm.

Antennæ about as long as the abdomen, the flagellum about one-fourth longer than the scape; 11-jointed, the flagellum becoming thicker towards the apex, the third joint nearly three times the length of the second. Head finely punctured—the punctures very shallow—the face in centre finely transversely striated; two keels run down from the centre to the antennæ, diverging towards the apex; the face is nearly perpendicular and is continuous with the vertex; ocelli in a curve, and placed on the top of the head, the top of the eyes being on a level with them. Thorax rather strongly punctured; the prothorax four times broader than long; parapsidal sutures deep; a transverse furrow in front of the scutellum, which is large, very strongly punctured and unarmed; mesopleuræ excavated obliquely, the excavation reaching to the sternum, shining, obliquely irregularly striated; in front of it the pleuræ are crenulated; metathorax reticulated, flattish; two keels run down the centre united by some transverse ones; and on either side of them are some irregular areæ. There are no teeth on the sides, but there are two irregular ones on each side under the petiole, which issues from the upper side of the metathorax. Petiole about three-fourths of the length of the abdomen, stoutly keeled, the space between the keels deep, shining. The second segment a little longer than the petiole, being as long as the petiole and the other segments united; the back is irregularly black, and the abdomen altogether is rather compressed. The thorax is covered with short hairs; the metapleuræ with rather long white ones; the abdomen is glabrous. Legs shortly pilose; hind coxæ as long as the femora, which bear beneath ten short stout teeth; the hind tibiae bear a stout black keel on the underside, and end in a stout curved tooth; the four anterior tibiae have no spurs. Wings hyaline, suffused with fuscous in the middle; the ulna about one-fourth shorter than the humerus; cubitus very short.

If Kirby's views of the limits of genera are to be carried out consistently, this species will require to have a new genus erected for its reception. (Cf. Journ. Lin. Soc., xvii., p. 53).

Hab., Nagasaki, Japan (*Geo. Lewis*).

Panthalis, gen. nov.

Antennæ 9-jointed (including the annellus, which is small and broader than long); the 3rd joint a little longer than the fourth; the others subequal to the last, which is one-half longer than the penultimate; stout, of nearly equal thickness throughout; situated well up on the face. Head much broader than long, concave in front and behind; the front excavated, the excavation not reaching to the foremost ocellus; the face keeled below the antennæ; cheeks margined; eyes large, oblong, bare. Prothorax longish, narrowed in front; mesonotum flattish, parapsidal furrows narrow, but deep; pleuræ deeply and widely excavated obliquely in the middle; scutellum large, flat, of nearly equal width throughout, the apex rounded; at the sides, at the base, deeply excavated; metathorax scarcely one-half the length of the scutellum; keeled down the centre. Abdomen subsessile; the first segment longer than the following three united; the third is produced into a broadly triangular sharp point in the middle above; the fourth similarly produced, but blunter. Ovipositor longer than the abdomen, closely clasped by the segments; the sheaths closely united; from the centre above and laterally is developed a large plate, which becomes gradually larger to the apex, which is rounded. The lateral plates curve slightly downwards. They are shining, obscurely ribbed, and bear short stiff, widely-separated hairs; the edges are fringed with hair. Legs slender; coxæ large; spurs short, slender. Ulna elongated, thick; cubitus curved, thick, three times longer than broad.

The affinities of this genus lie with *Belonea*, *Prionopelma*,

&c., but it is readily distinguished from any of the described genera by the extraordinary structure of the ovipositor. Other noteworthy characters are the 9-jointed antennæ, placed high up on the face, the structure of the third and fourth abdominal segments, &c. The tarsi in the only specimen I have are incomplete.

Panthalis Blackburni, sp. nov.

Antennæ black; head, prothorax in front, pleuræ and metanotum (the latter much brighter in tint) green, suffused with coppery tints, the rest of thorax coppery; basal three segments of abdomen reddish-testaceous; the other segments black, suffused with coppery tints; base of ovipositor black; the flanges brilliant coppery; the coxæ, trochanters and femora, metallic green; the upper side of hind femora, the knees broadly and tibiae testaceous, and tarsi red. Wings hyaline; the nervures fuscous. Head and thorax closely punctured; the excavation on pleuræ and the pleuræ behind more shining and but slightly punctured; the scutellum less strongly punctured than the mesonotum and more shining. There is a stout, straight central, and two lateral, converging keels on the metanotum. Abdomen shining, the apical segments obscurely shagreened. Coxæ (especially the hinder, which are hollowed behind) punctured. The face, pleuræ, and apical segments of the abdomen are covered with a spare, whitish pubescence.

Length 6 mm.; terebra 4 mm.

Hab. Port Lincoln, South Australia (*Rev. Thos. Blackburn*, B.A.)

Belonea erythropoda, sp. nov.

Head and thorax black, suffused with green and coppery tints; abdomen steely purple, darker towards the apex and beneath; legs ferruginous-red; the tips of tarsi, a large mark on the upper side of the femora, the knees more or less, and the base of the tibiae, blackish; wings hyaline, suffused with fuscous towards the base, and a dark fuscous triangular cloud is at the cubitus; antennæ black, the centre of the flagellum red, whitish above. Head opaque, except on the front; closely punctured, above the antennæ transversely striolated; antennal grooves deep, the space between them sharply triangular; eyes faintly pubescent, converging slightly above; thorax rugosely punctured, opaque, except the pleural depression; parapsidal furrows indistinct; scutellum not clearly defined; metanotum short, crenulated; the sides densely covered with long, white hair. Abdomen shining, impunctate, the apical segments fringed with white hair. Legs stout, the tibiae and tarsi densely pilose; hind coxæ rugosely punctured; hind femora thickened, finely punctured; hind tibiae curved and thickened at the apex, ending above in two short, stout spines; and in the centre are three widely separated short spines; spurs short, stout. Head and thorax covered with a depressed pile.

The male, *mutatis mutandis*, agrees with the female, the antennæ as usual being thicker.

Length 8 mm.; terebra 19 mm.

Hab. Port Lincoln, South Australia (*Rev. T. Blackburn*).

The very much longer ovipositor, among other differences, distinguishes *B. erythropoda* from the South Australian *B. australica*, West., the ovipositor in that species being scarcely longer than the body.

CHRYSIDIDÆ.

Hedychrum japonicum, sp. nov.

Brilliant green, the abdomen rosy red, the antennæ, legs and ventral surface of abdomen, blackish, wings fuscous, lighter at the base. Antennæ with the scape metallic green, longitudinally punctured and striated; the scape covered with a very short, sparse microscopic pile, almost glabrous. Head coarsely and uniformly punctured, except the hollow over the antennæ, which is rather strongly transversely striated, and the part immediately between and on either side, the latter being finely punctured, and the former aciculated; the clypeus shining, impunctate in the centre. Pro- and metanotum punctured like the head, the scutellum somewhat stronger and the metanotum still more strongly except on the projecting sides, where the punctuation is closer and finer than on the mesothorax; the hollow on the side of prothorax large, shining, striolated, the hollow on the hinder part of the mesopleuræ is also striolated, and shallower than that on the propleuræ; sternum rather weakly punctured. Abdomen finely and closely punctured, if anything weaker laterally; the apex entire, fringed with white hair. The anterior femora and tibiae are dull metallic green, finely punctured, the tarsi are fuscous; the hind femora are dull black; the tibiae are green, strongly punctured and densely pilose; the hind tarsi black, fuscous at the apices of the joints. Upper median cellule bluntly acute at the apex, reaching to the commencement of the radius.

All the coxæ are metallic green, the hinder closely punctured, the anterior more shining and more sparsely punctured; the spurs are testaceous, the claws blackish.

Length, 8 mm.

Very nearly related to *H. lucidum;* differing from it in the head, thorax, and antennæ being almost glabrous; in the more slender antennæ; in the prothorax being longer compared to the part of mesothorax in front of the scutellum, in the projecting hinder edge of the metanotum being stouter, in the abdomen being longer compared to the thorax, in the fifth tarsal joint being as long as the preceding joints united; in the second joint being about one half longer than the third, and in the thorax being entirely green.

Hab. Fukui, Japan, (*Geo. Lewis*).

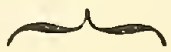
Hedychrum Lewisi, sp. nov.

Bluish-green, variegated with purple, antennæ and tarsi blackish; wings fuscous, the posterior only at the apex. Antennæ covered sparsely with a microscopic down, the scape green, bluish at base and apex, punctured. Head coarsely punctured, the frontal hollow shining, striated, the space between the antennæ impunctate, on either side of them finely punctured; mandibles blackish. Pro- and metanotum coarsely rugosely punctured, scutellum and metanotum bearing large, roundish, or angled punctures, pleural hollows striated, but not strongly; the toothed hinder edge of metanotum coarsely punctured, striolated at the base; the tooth triangular; the central part of pro- and mesonotum is bluish-purple. Abdomen shining, covered with shallow, clearly separated punctures; the ventral surface very shining, finely punctured in the middle. The coxæ are shining and rather strongly punctured (compared to the femora), the femora are very finely punctured, and fringed with longish hair; the tibiae much more strongly punctured; the metatarsus is bent considerably; the spurs not one third of its length, the last joint is about the length of the preceding two united. Upper medial cellule rounded at the apex (not acute), reaching beyond the commencement of the radius.

Length, 6 mm.

Hab. Hitoyoshi, Japan (*Geo. Lewis.*)

Chrysis japonicus, sp. nov.

Apex of abdomen entire. Blue with a purplish tinge, variegated with green, flagellum of antennæ black, wings fuscous hyaline, the nervures black; head and thorax covered with longish fuscous hair; antennæ as long as the thorax, the scape bare, black, more or less marked with green and irregularly punctured. Head above coarsely rugosely punctured; along the inner side of the eyes much less strongly and more irregularly; the central part of hollow striolated; below the antennæ the punctures are moderately large and distinctly separated; between them almost impunctate; the keel over the depression -shaped; clypeus incised; mandibles black. Thorax covered with large, round, clearly separated punctures; they are smallest on the lateral lobes of the mesonotum, and are, if anything, smaller on the scutellum than in the centre of mesonotum; on the metanotum they are more irregular in shape (but not larger than on the scutellum) and run into reticulations; on the pleuræ the punctuation is closer and finer; the depressions are shining and striated in the centre; a little below the middle of the mesopleuræ is a large broad longitudinal furrow. Abdomen closely punctured, the punctures interlacing on the basal segment; on the apical segment they are much weaker. The apical segment is waved in the centre and on either side, but there are no teeth; the foveæ are not very deep. The coxæ, trochanters, femora, and more or less of the tibiae are green; the former three parts bear longish fuscous hairs; the tibiae are more sparsely haired; the tarsi are almost glabrous; the coxæ are punctured; the femora are finely punctured, and bear also some large punctures among the smaller, and the hinder four are hollowed on the underside behind. The metatarsus is as long as the following three joints united; the second joint is as long as the fifth.

The ground colour of the body is blue, the face, the orbits of the eyes more or less, two lines on the pronotum, the mesonotum laterally, the edges of the metanotum, the greater part of the pleuræ, and the edges of the abdominal segments are greenish or greenish-blue.

Length 9-10 mm.

Hab. Hitoyoshi, Japan *(Geo. Lewis).*

Chrysis pulchellus, sp. nov.

Apex of abdomen with four teeth. Green, variegated with blue, antennæ black, the scape green. Head coarsely punctured above the frontal hollow, which is much more closely and finely punctured, in the centre transversely; between and below the antennæ they are larger, but more sparse; mandibles black; the keel over the hollow is slightly incised in the middle; a stouter keel runs into it from the outer ocelli; below the central ocellus is a deep hollow. Pronotum covered with large round punctures; the mesonotum less strongly punctured; the scutellum somewhat stronger than the pronotum, and with the punctures more widely apart; the metanotum more strongly than the pronotum, except laterally; and along the edge of the central region are some very large punctures; the two foveæ on the apex are very large and deep. The pleuræ are strongly and coarsely punctured except on the hollows; the transverse furrow on the mesopleuræ is shining, almost impunctate. The abdomen is smooth, covered with moderately large widely-set-apart shallow punctures; the teeth are short; the foveæ deep and large (especially the central) and fourteen in number; the legs are green and punctured, the tarsi black; the hind tibiae (especially) and tarsi are densely covered with white stiff pubescence; the claws and spurs are testacious. Wings violaceous, strongly iridescent, the nervures black; the upper median cellule acute at the apex.

Length 7 mm.

Hab. Ceylon *(Geo. Lewis).*

From Hiojo, Japan, Mr. George Lewis has brought back a *Chrysis* which I cannot separate from *ignita*, Lin.

ICHNEUMONIDÆ.

Ichneumon patricius, Haliday.

The description of this species (Trans. Lin. Soc. XVII. p. 317) is too laconic to enable me to say with certainty if a specimen taken by Mr. J. J. Walker, R.N., at Punta Arenas, Straits of Magellan, is identical with it. If so Haliday's description may be usefully supplemented. In Mr. Walker's example the front is deeply excavated, smooth, and shining; the rest of the head punctured, the face transverse, covered with a sparse fulvous pubescence; the apex of the clypeus is nearly transverse, shining, sparsely punctured; the palpi testaceous; the pro- and mesothorax strongly punctured, more strongly laterally; scutellum shining, bearing some widely separated punctures; longer than broad, narrowed towards the apex, the sides scarcely keeled; post scutellum rugose; metathorax rugosely punctured, the apex slightly hollowed in the centre, semi-oblique; there are six areæ, the supra median horse-shoe shaped, large; petiole shining, impunctate, curved; post petiole longitudinally striated; gastrocoeli obsolete; hind coxæ rugosely punctured; areolet longer than broad, five-angled; the lateral nervures parallel, complete, the recurrent nervure is received in the middle; there is a small projecting branch on the cubital nervure. In colouration it agrees with Haliday's description.

Patroclus (Ichneumon) venezuelensis, sp. nov.

Rufo-testaceous, the face, orbits, and base of four front legs inclining to yellowish; the flagellum of antennæ (except a broad yellow ring towards the centre), the base of the first to four abdominal segments broadly, the apex of hind tibiae broadly and the hind tarsi, black; wings smoky-fuscous, paler towards the apex, the stigma fuscous, testaceous at the base. Face punctured, the centre projecting into a ∧-form from the antennæ to the clypeus, mandibles punctured; front broadly, but not deeply, excavated; vertex punctured. Thorax punctured all over, but much weaker on the pleuræ; the metanotum more strongly transversely punctured, on the apex running into reticulations; the metapleuræ strongly longitudinally punctured. Tubercles on metathorax viewed laterally triangular; there are no areas; and only two complete keels, one outside the spiracles, the other uniting the tubercles. Petiole shining, impunctate, the sides raised; post petiole strongly punctured depressed in the centre (between the continuation of the raised sides of the petiole) and laterally. Abdomen closely and strongly punctured on the basal four segments; the apical impunctate, shining, somewhat acutely pointed; sheath of ovipositor black at apex; gastrocoeli transverse, wider than long, deep in the centre, the outer edges striolated. The head and thorax covered with a fuscous or pale pubescence; on the metathorax it is double the length of that on the mesonotum. Coxæ punctured; the femora sparsely, the tibiae and tarsi densely pilose. Areolet scarcely 5-angled, the lateral nervures almost meeting at the top; the nervures at the base are dull testaceous; at the apex fuscous.

Length, 14 mm.

Hab. Venezuela, (*Dr. Moritz*) Mus. Vienna.

Patroclus is an *Ichneumon* with pectinated claws.

Colpognathus ? *magellansis*, sp. nov.

Black: the abdomen from the apex of the petiole (except a black mark on either side of the second and third segments above, that on the third being the longer), and legs fulvous-red; the orbits broadly and more or less of face, the tegulæ, the edge of the pronotum near them and two lines on the pronotum, yellow, the scutellum (except a black band across in front of the middle) and post-scutellum brick-red; the basal six joints of the antennæ on the lower side reddish-testaceous; wings yellowish-smoky hyaline, the stigma testaceous, the nervures fuscous. Antennæ thirty-jointed, the flagellum a little attenuated at the base of the flagellum, densely shortly pilose; the scape at the apex on the upper side deeply incised. Head rather strongly punctured, covered with a pale sparse pubescence, almost transverse in front, deeply excavated above the antennæ, the excavation shining, obliquely striated and finely punctured, the centre raised; clypeus shining, almost impunctate, transverse at the apex, not projecting, a minute fovea on either side at the base; mandibles broadly curved; bidentate, the inner tooth the larger. Thorax strongly punctured above the scutellum, shining, and with the punctures more widely separated, the pleuræ not so strongly punctured on the upper side, and on the lower part, running into a strong course striation; the central part of the mesopleuræ shining, impunctate; sternum shining, punctured, deeply furrowed in the centre. Metathorax large, the apex obliquely vertical; areolas obsolete; a keel runs down the side on the inner side of the spiracle; one goes round the top of the vertical part of the metanotum from a large obtuse tubercle or blunt tooth situated a little above the middle, and from the incomplete supramedial area (which is square, but wants the apical keel) a keel runs in a curve to the lateral longitudinal keel, joining it below the middle. Petiole broad at the apex, the narrow apical part slightly hollowed at the base, and with a stout keel on either side, this keel running into the base of the post petiole, which is keeled along the edge; shining, closely longitudinally striated, except the extreme apex of the post petiole. The base of the second segment is finely longitudinally striated; without any gastrocœli; the rest of the abdomen shining, impunctate. The apical segments of the abdomen are compressed laterally, and bear a fringe of fulvous hair; the sheaths of the ovipositor are pilose. Legs (especially the femora) stout; covered with a fulvous pile, especially thick on the tibiae and tarsi, hind coxæ rugosely punctured; the hollow on the upper side transversely striated; the femora and tibiae are punctured. Areolet pentagonal, the under nervure obsolete; the recurrent nervure received a little beyond the middle, and not received in an acute angle.

The face is obscured with black on the upper side; the four anterior femora are lined with black above, and there is a black mark on the upper side of the posterior tibiae at the base.

Length, 11 mm.; ovipositor, 1·5 mm.

Gray Harbour, Straits of Magellan (*J. J. Walker*, R.N.)

This species belongs to the "Ichneumones Pneustici" of Wesmael. In the table which that author gives in his Tentamen Dispos. Method. Ichn. Belgii, p. 165, it comes nearest to *Colpognathus;* but it is doubtful if it really belongs to that genus.

Podogaster striatus, sp. nov.

Head and thorax yellow, the occiput, vertex, a broad line on the mesonotum proceeding from the pronotum to about the middle, where it is joined by a transverse band, which occupies the remainder of the mesonotum to the scutellum; a broad line on metanotum projecting at each angle at the apex, a large spot immediately below the tegulæ, and a smaller and rounder one on either side of sternum, black. Antennæ black, the scape brownish beneath, abdomen black, fulvous at the sides and ventral surface from the second segment. Legs yellow, the four front tibiae and femora of a more reddish hue at the apex; hind coxæ black, except at the extreme apex; the hind tibiae and tarsi fuscous black, paler at the joints. Wings hyaline, fuscous at the apex; tegulæ brownish. Head and prothorax impunctate; mesonotum to the tegulæ very faintly punctured, from tegulæ to scutellum rugose; scutellum faintly blistered at the base, a transverse ridge at the apical third. Metanotum reticulated, the reticulations large, fainter at the base; sides of sternum faintly punctured; the edge of prothorax on its lower half near the mesothorax slightly obliquely striated. The scutellum is depressed in the middle; the mandibles are piceous. Abdomen much compressed laterally, sabre-shaped; petiole almost cylindrical, thickened at apex, and longer than the second segment. Legs covered with a close and moderately long pile.

Length, 12 mm.

Differs from the type (*P. coarctatus*, Brullé), in wanting the ferruginous colour of the thorax, the yellow front tarsi, in the different arrangement of black on the thorax, &c.

Hab. Amazons (*Prof. J. W. H. Trail*).

Lissonota maculiceps, sp. nov.

Red: the front in the centre, vertex, occiput, the abdomen, a large spot on the hind coxæ, the trochanters broadly at the base, the base (narrowly), and apex (broadly), of the hind femora and the apex of the hind tibiae broadly, black; antennæ black, fuscous beneath, the scape reddish on the under side; the basal four segments broadly reddish at the base, the apical narrowly; the ventral surface pale; wings hyaline, a smoky fascia at the apex. Antennæ as long as the body, covered with a fuscous microscopic pile. Head smooth, shining, impunctate, a large black mark in the centre of the face which is convex in the centre, as is also the clypeus which is scarcely transverse at the apex; tips of mandibles black; palpi pale testaceous. Thorax shining, the pleuræ punctured; metanotum transversely striated. Abdomen impunctate, shining, legs shining, impunctate, the tibiae and tarsi covered with a close pale pile; the front legs are of a paler red than the others. Areolet absent.

Length, 10 mm., terebra, 7 mm.

Hab. Amazons (*Prof. J. W. H. Trail.*)

Anomalon fulvo-hirtum, sp. nov.

Black: the head and thorax covered with a dense longish fulvous, inclining to golden, pubescence; the mandibles, scape of the antennæ, tegulæ, the pronotum in front of them, the anterior coxæ, the trochanters and base of femora, the tibiae except at base and apex (the anterior almost entirely) yellow; the femora fulvous, the anterior running into yellow, the posterior darker than the middle; the base and apex of the tibiae and the hind tarsi, black; anterior tarsi and spurs yellowish; wings hyaline, nervures and stigma black. Finely rugosely punctured, opaque; the petiole and base of the second segment, finely longitudinally aciculate, the rest of abdomen finely shagreened. Petiole long, slender, a deep longish shining impunctate furrow above, extending from a little beyond the middle to the post petiole; there is a small roundish, fulvous depression on either side of the second segment near the base. Abdomen compressed, densely covered with a long fulvous pubescence; the base of the segments marked with black above. Hind coxæ coarsely punctured. The pubescence on the scutellum is long and dense.

Length, 12 mm.

Hab. Amazons (*Prof. J. W. H. Trail*).

EVANIIDÆ.

Gasterupton japonicum, sp. nov.

Black: a broad ring at the base of the femora, the apex of the anterior tibiae; the basal three fourths of the four basal joints of posterior tarsi, yellowish-white; the anterior tarsi obscure testaceous, the base inclining to yellowish-white; the second, third, and fourth abdominal segments reddish-testaceous at the apex; the apex of the sheaths of the ovipositor broadly white. Wings hyaline, suffused with fuscous, the stigma and nervures black. The third joint of the antennæ is about one fourth longer than the second; the fourth is about as long as the first and second joints united. Head sub-opaque, almost alutaceous; microscopically pilose; edge of the occiput sharply raised; hinder ocelli as wide apart (if not wider) as the length of the third antennal joint. Mandibles piceous at the base; palpi and maxillæ testaceous. Thorax opaque, the pro- and mesothorax aciculated, the mesonotum marked with scattered punctures; parapsidal furrows wide, deep, marked with transverse keels; a wide shallow irregularly reticulated oblique furrow on the side of prothorax; the lower part of the mesopleuræ irregularly reticulated; on the other side of the scutellum are four large foveæ; metathorax reticulated, the metanotum roughly, the sides more irregularly. Abdomen nearly three times the length of the thorax, aciculated, the petiole nearly as long as the thorax, ovipositor longer than the body. Posterior coxæ coarsely aciculated; metatarsus nearly as long as the four remaining joints united.

Length, 20 mm., terebra, 19 mm.

Hab. Kobe, Japan (*Geo. Lewis*).

Aulacus flavipennis, sp. nov.

Luteus, antennis, pedibus posticis abdomineque, nigris, alis flavis, apice fumatis, stigmate nigro. Mas.

Long: 17 mm.

Antennæ scarcely so long as the thorax and abdomen united; closely pilose, the scape with a few long hairs; the third joint considerably shorter than the fourth; the apical joints piceous on the under side. Head shining, impunctate, closely covered with golden yellow hair, tips of the mandibles and sometimes the labrum in the middle, black; palpi yellow. Thorax coarsely rugose, running into course reticulations on the pleuræ, scutellum and metathorax; the mesothorax in front transverse, coarsely transversely striated; perpendicularly excavated; covered thickly with golden yellow pubescence; prothorax impunctate, smooth. Abdomen shining, impunctate, covered with a depressed pile, except on the basal two segments, and not so conspicuously on the base of the other segments; the basal half of the first segment pale yellow. Legs at the base pilose, the tibiae and tarsi with a closer and shorter pile; the coxæ transversely striated, the hind coxæ are luteous at the base; the base of hind femora and knees are testaceous.

There are two forms of this species (at least I can find no other valid points of distinction between them beyond the difference in the colouration of the wings). One (and this is also smaller in size) with a small cloud below the stigma, and a narrow irregular cloud along the edge; the other with the wings violaceous from a little before the base of the stigma, and with a lighter cloud in the second cubital cellule and in the radial below the apex of the stigma. The second recurrent nervure is received not far from the second transverse cubital. The latter is largely bullated.

Aulacus signatus, Shuckard (also from Ceylon) resembles this species, but has the head and thorax black.

Dekaya, Ceylon *(Mr. George Lewis).*

BRACONIDÆ.

Chelonus filicornis, sp. nov.

Black, densely sericeous; the anterior knees and tibiae in front sordid testaceous; wings smoky, the apex lighter in tint; the stigma black, the nervures fuscous. Antennæ double the length of the thorax, the scape thick, nearly as long as the third joint, from where the joints become gradually thinner, until at the apex they are very attenuate; about twenty-jointed, but the basal joints are very difficult to distinguish. Face elongated, the eyes separated from the oral region by fully half their length; trophi elongated, black; face transversely rugosely punctured; the clypeus more shining, finely rugose; front and vertex coarsely transversely rugosely punctured; the frontal depression smooth, shining; eyes but sparsely pilose. Thorax strongly punctured; the metathorax coarsely reticulated; its apex oblique; the sides ending in a stout blunt tubercle; scutellum coarsely rugosely punctured; the sides raised, margined. Abdomen scarcely so long as the head and thorax united; the apex bluntly rounded; the dorsal surface longitudinally rugosely striolated, running into reticulations, and becoming finer towards the apex, which is also (as usual) more densely pilose. Legs (especially the coxæ, tibiae and tarsi) closely pilose; the coxæ stoutly punctured; laterally and in front there is an obscure brownish ring towards the base of the hind tibiae; the spurs are clear white. The radial nervure is sharply elbowed upwards at the second transverse cubital nervure, which is very oblique and bullated largely; the second cubital cellule, double the width of the apex at the base; the cubital nervure beyond the second cubital cellule is faint.

Length 7·5 mm.

This comparatively large species is known from all the American species known to me by the very attenuated antennæ, and by the greatly elongated face.

Hab. New Mexico.

Mr. P. Cameron drew attention to the importance of the examination of the male organs of Bees and Wasps, as in many cases they furnish great aid to their classification. He exhibited a series of drawings of these objects executed by Mr. Chaffers, and under the microscopes a large number of specimens.

There were also shown by means of the microscopes, by the President, some very interesting Macrospores of Lycopods, from the Scotch coal-beds;

And by Dr. Hodgkinson some sections of silicified wood.

Ordinary Meeting, March 14, 1887.

Mark Stirrup, F.G.S., in the Chair.

Mr. Stirrup exhibited slides of *Sporangites Huronensis* (Dawson), from the Devonian shales of Ohio.

Mr. H. C. Chadwick exhibited a series of twenty-five original drawings illustrating the minute anatomy of *Antedon rosaceus.* In a few explanatory remarks he briefly described the fibrillar envelope which encloses the chambered organ, and from which cord-like processes extend through all the arms and cirrhi. Reference was made to the experiments of Dr. Carpenter and Prof. Milnes Marshall, which point to the conclusion that these structures constitute a nervous system. Mounted preparations of various parts of *Antedon rosaceus* were exhibited under the microscopes.

Ordinary Meeting, March 22nd, 1887.

Professor Osborne Reynolds, LL.D., F.R.S.,
Vice-President, in the Chair.

Mr. A. Brothers, F.R.A.S., read a portion of a letter from Mr. Arthur W. Waters, dated from Davos Dôrfli, in which was inclosed a series of photographs of snow crystals. Mr. Waters says: "My main object in writing is to send you some photographs of snow crystals. I have only had the opportunity of trying this on two occasions, and did not hit off the exposure in these experimental trials. It is very difficult, as everything must be done with great rapidity, and there should be an assistant, so that no seconds may be lost, seeing that the crystals are always changing, and you are likely to get them melting on the stage. Of course much better results might be obtained, but working in the cold (23° F.) with the snow falling in the apparatus, makes it very trying work, as it is often some time before an isolated crystal can be caught on the slide; and if there is any clumsiness this may be lost, if it remains too long exposed to the reflector."

"A Perfect Standard of Value: considered from a scientific stand-point," by F. J. Faraday, F.L.S., F.S.S.

It has appeared to me during the recent discussions on the currency question that too little attention has been paid to the scientific aspect of the problem. It has been too readily assumed, on the one hand, that the proposals of the advocates of a bi-metallic standard are opposed to what may be spoken of as the fundamental laws of economic science as taught by Adam Smith; while, on the other, the conditions which should be fulfilled by a theoretically perfect standard, itself subject to those laws and operating in harmony with them, have not been presented, the case having been made to rest mainly upon considerations of expediency.

The primary purpose of a standard of value is clearly to express readily the mutual relations of all exchangeable commodities in common terms. Now, if all exchanges were direct and simultaneous, and we could conceive the standard as a thing apart, not itself exchanged, a variation in the value of the standard would not affect the exchanges. We can express the ratios of the temperatures of different bodies by the scale of Fahrenheit, Réaumur, or Celsius, and whichever scale we use the relations between the temperatures remain the same. If it were bargained that cotton and woollen cloths should be directly exchanged in the ratio of two yards of the former to one of the latter, the exchange would be in no way affected were the standard yard to be elongated from 36 to 40 inches or contracted to 30 inches. Or, again, if a skilled labourer agreed to exchange his labour in the proportion of eight hours against the labour of three unskilled labourers each working eight hours, a variation in the length of the standard pendulum would not affect the bargain, provided that all worked simultaneously. With a standard fulfilling the function of a measure even in this simple sense, however, the problem might be complicated in two ways. In the first place, if the exchanges were not simultaneous, a variation in the standard would disturb the ratio; and in the next place, by the introduction of a third party entitled to a fixed toll as rent or interest in terms of the standard. In this case it is clear that, were the standard to continue to elongate, the landlord or mortgagee would ultimately reduce the producers to a condition of serfdom, by absorbing all the product of their labour.

Proceeding now from the concrete idea of length to the more abstract and complex notion of value, we find the problem further complicated by the fact that we have to abandon the notion of the standard as a thing apart. To be a measure of value in exchange, it is in the nature of the case that the standard must itself be an exchangeable commodity; in other words it must have currency. Moreover, as, under the conditions of advanced civilisation, direct barter is impossible, it must have the attribute of legal tender. Finally, as the last-named condition implies that exchanges cannot be simultaneous, and, moreover, the conditions of continued production imply prudential provision for the future, involving rent and interest, or, to sum up the whole in a single phrase, the arrangement of fixed payments, if not in perpetuity, at least for considerable periods ahead, it follows that the standard ought, if it is to be a perfect and just measure, to have the quality of relative quantitative invariability.

The previous metals—gold and silver—have currency not merely by what is called the common consent of mankind, but because of their intrinsic utility as metals. This latter quality is a guarantee of their currency; their acceptability in exchange does not depend merely upon fashion. Like corn as food, so gold and silver as malleable metals are assured of a permanent utility, and as labour is required for their production, they are also assured of a permanent value in exchange. The attribute of legal tender is conferred by law, but the fundamental economic tendency to produce given results with the minimum expenditure of labour or force makes it inconceivable that society will voluntarily revert from the legal tender method of exchange to the cruder and more costly method of pure barter. It only remains, therefore, to devise a legal tender standard of value which will have the theoretic desideratum of relative invariability.

In the endeavour to solve this problem I have found Adam Smith very helpful. The *Wealth of Nations* is essentially an analytical work. Its analyses are sound, and, therefore, if we accept the conclusions of Adam Smith as the basis of argument, we may save ourselves considerable preliminary trouble. But there is nothing in Adam Smith's analyses which bars the way to a modification of existing conventional arrangements, any more than an analysis of the constitution of water bars the way to the re-combination of oxygen and hydrogen in other forms in accordance with their physical nature.

In treating of the problem of value in exchange and "the real and nominal price" of commodities, Adam Smith earnestly entreats both the patience and attention of the reader, and admits that, after the fullest explication which he is capable of giving it, the subject may still appear obscure. It is worth while to call attention to the warning, in order that readers may be guarded against the imminent danger of too hastily assuming, in connection with a matter of so common-place and yet abstracted a character, that they fully understand all that Adam Smith means.

"Labour alone," says Adam Smith, "never varying in its own value, is alone the ultimate and real standard by which the value of all commodities can at all times and places be estimated and compared. It is their real price; money is their nominal price only." Again, speaking of labour, he says, "Its real price may be said to consist in the quantities of the necessaries and conveniences of life which are given for it; its nominal price in the quantity of money." Speaking of tangible commodities, he observes, "As a measure of quantity such as the natural foot, fathom, or handful, which is continually varying in its own quantity, can never be an accurate measure of the quantity of other things; so a commodity which is itself continually varying in its own value, can never be an accurate measure of the value of other commodities." And, once more, "Labour, therefore, it appears evidently, is the only universal as well as the only accurate measure of value, or the only standard by which we can compare the values of different commodities at all times and at all places." Writers who ought to have known better, have been guilty of injustice to the memory of our great economist, in confusing labour cost of production with labour value in exchange when reading the chapter of the *Wealth of Nations* in question. It is with the latter that Adam Smith deals in this chapter, as is quite evident when he says further that the value of anything, "to those who possess it and who want to exchange it for some new production, is precisely equal to the quantity of labour which it can enable them to purchase or command." In speaking of "labour value" in this paper I of course use the term in the same sense.

In order to clear the ground, let it be said, that though labour varies in quality, yet all labour may, for the purposes of the argument, be reduced to a common term by regarding such variations of quality as variations of quantity.

The only real standard of value, then, is labour. But labour in itself is not a tangible commodity which can be passed from hand to hand; we cannot use it as currency or give it the attribute of legal tender. We must, therefore, select some commodity which is the product of labour as the concrete standard. But if labour is the real standard, then the commodity which we select as legal tender currency must, if it is to be a perfect standard, be always strictly representative quantitatively of the real standard—labour. It must always bear the same relation to commodities in general which labour itself bears to those commodities. It must be free from purely arbitrary influences.

Now, what is the law which tends to preserve a steady relation in terms of labour, or in other words in value, between all commodities producible by labour ? It is that a given quantity of labour will always endeavour to obtain in exchange the maximum quantity of the products of labour. Hence if a given commodity is produced in excess, and its exchangeable labour value declines, the labour employed in its production will seek some more remunerative channel of activity until the equilibrium is restored. And conversely, if the production of a given commodity is deficient, and its value in terms of other commodities is increased, labour will be diverted to that production until the production is increased sufficiently to bring down the value of the quantity of labour employed therein to the average. It is obvious, however, that in order that this law may operate, the production must be susceptible of increase or diminution at will, according to the reward obtainable.

So far as over-production, or depreciation of exchangeable value in terms of commodities generally, is concerned, the check is automatic, because it merely involves the cessation of labour, and labour will always tend to cease (in accordance with the law already stated) in proportion as it becomes less remunerative than other labour against which it is exchanged. Herein we have the final reply to what is known as the "wheelbarrow argument" in the currency controversy. It has been urged, for instance, that the employment of silver as currency in a fixed ratio with gold might theoretically result in such an inflation of prices that it would be necessary to employ a wheelbarrow in order to convey the money required for the purchase of a four-pound loaf. Now the production of a commodity such as silver implies not only the labour of obtaining from the ground and refining, but the labour of transport to the mint or market; and if the remuneration for a barrowful were only a four-pound loaf, all the labourers concerned would have died of starvation long before a thin film had been spread over the bottom of the barrow.

I am not losing sight of what is called the imperishable quality of the precious metals. A better and more accurate term to use would be the accumulative quality. If we employ this term we see that it is a quality which is shared in by all commodities, the difference being only one of degree. Thus even food-stuffs have a certain accumulative quality; the heavy harvests of one year may result in unusually heavy stocks being held over for the next; the exchangeable value of the commodity being depressed in consequence. But in this case the farmer will put his land under oats or some other crop, or the consumption may be increased until the exchangeable value rises again to the average labour value. The decline of the exchangeable value of all productions through the accumulation of stocks is checked in the same way. Now the precious metals are perishable like all other commodities, though in a vastly slower manner. There is no probability of their utility being diminished, and, therefore, with the growth of population and the increase in the quantity of other commodities, the demand for the precious metals will increase rather than diminish; it will never be less than the existing stock. A constant addition to the supply, therefore, is necessary to prevent an enhancement of exchangeable value. And if that addition were at any time sufficiently large to tend to depress the real or labour value, the decline would tend to check the production or increase the consumption. Of course it is conceivable in the case of these commodities, as in that of others, that certain discoveries might make their production easier, and might, therefore, tend to depress their labour value quantitatively. This is so improbable in the case of the precious metals, however, that it may be treated as a practical impossibility. There is not the remotest probability that either of the precious metals will ever be obtained more easily than silver has been obtained during the last ten years. Yet the real or labour value of silver has remained practically unchanged. Moreover, a greatly increased production would still be only a small percentage on the existing stock, and would, therefore, be not at all likely to perceptibly lower its exchangeable value; the saving in the labour cost of production would disappear in the form of rent or dividends to the owners of the particular mines. In the case of other commodities it has of course frequently happened that their relative labour value in exchange has been lowered by scientific discoveries, which have greatly diminished the labour required for their production; but these very labour-saving discoveries tend to extend their influence to the production of the general mass of commodities, the labour cost of which will sooner or later be reduced proportionately, and the general relations will thus tend to remain steady. But in selecting commodities as the permanent representatives of the real or labour standard of value, it is obviously desirable to select those of which the labour cost of production is least likely to be depreciated by any possible scientific or other discoveries; and in the precious metals we have such commodities.

But while, therefore, we find that the ordinary play of economic laws tends to prevent the depreciation of the real or labour value of the precious metals in terms of other commodities also produced by labour, when we come to consider variation in the other direction, that is in the direction of appreciation of their value in exchange, we find that there is no exchangeable commodity in existence the exchangeable value of which is not liable to appreciation under the influence of physical conditions which are beyond the operation of economic laws. This is because, though the production of any commodity may be always diminished at will by the cessation of labour, there is no commodity which can be always increased at will by the continuance of labour. "Which of us by taking thought can add a cubit to his stature?" A sudden expansion of demand beyond the possible limits of supply in the case of mining products,—or natural conditions, such as unfavourable seasons—in the case of agricultural products—or epidemics, in the case of live stock, may cause a rapid rise in exchangeable value, which, as it is beyond the control of labour, is practically a divergence from the average labour standard of value. Thus, even wheat, the most widely cultivable of products and one which, as a primary food-stuff, will always be widely cultivated, is liable to sudden variations of exchangeable value in accordance with the character of the season, and regardless of the quantity of labour or extent of land devoted to its production; so much so, that Adam Smith tells us that, though the exchangeable value of corn-rents is likely to be most steady from century to century, it is likely to vary even more than that of money rents from year to year.

Now in the case of the precious metals we have commodities which, though never likely to permanently depreciate in their exchangeable value, and though more suitable than any other commodities to fulfil the functions of currency and legal tender, have, in common with all commodities, a liability to appreciation in exchangeable value. And it so happens that, because of the enormous stock of these metals in circulation as currency, their value in exchange can only be appreciated by a demand for them as currency beyond the limits of supply. An increased demand for them for consumption in the arts beyond the limits of the new production would always be supplied at the expense of the stock used as coin. We may therefore dismiss from consideration all the demand except for the purposes of currency, and say that only by the demand for them as currency outstripping the supply can the exchange value of the precious metals be appreciated. How then are we to prevent such appreciation?

In attempting to solve this problem the economists may again learn something from physical science. In constructing an unvarying measure of time the physicists have taken two metals of unequal contractility, and so arranged them in what is known as the gridiron pendulum, that a shortening in one direction is always exactly balanced by a lengthening in another, so that the pendulum as a whole in any change of temperature remains the same length. In other words, they have adopted the principle of compensation, and compensation implies duality.

As a general rule it may be stated that the probability of two commodities being appreciated simultaneously by the same arbitrary influences is much more remote than the probability of any one commodity being appreciated. Thus a poor wheat year is generally a good grass year. Hence if we take two commodities and say that a given quantity of either shall represent a given figure of account, we shall find that, as the debtor would always pay in the cheaper commodity, and the alternative increase of demand for one or the other for the special function of currency would tend to counteract the cheapening tendency, we must necessarily have in an alternative or compensating legal tender a more steady representative, quantitatively, of the real standard of value, labour, than in a mono-legal tender.

In the case of the precious metals, however, we have seen that there is no danger of a lowering of their exchange value in terms of labour. The operation of the alternative or compensating principle, therefore, would simply be to check appreciation. The proposal of the bi-metallists is not to erect two standards; the standard remains—labour. Neither is it to give an artificial value to the cheaper of the two metals. Their proposal amounts simply to the provision of two legal tenders, a given quantity of each of which shall be taken to represent a given figure of account. These legal tenders would be susceptible of alternate use strictly in accordance with the natural economic laws enunciated by Adam Smith. That is, payment would always be made in that legal tender which represented the least quantity of labour given in exchange for the thing purchased, and as its value as a commodity would never be depreciated in terms of labour, the tender used would always be the nearest exact expression of the real standard of value—labour.

In writing on this subject eight years ago, I said that the object of the bi-metallic proposal was not to enhance the exchange value of silver in terms of commodities generally, or labour; but to tie down the exchange value of gold. Other things being equal, gold will always be the preferable legal tender because its smaller bulk will make it the most economical currency. We have seen that the exchange value of gold can only be enhanced by an increase in the demand for it as legal tender. The proposal of the bi-metallists is, therefore, simply that whenever in consequence of this arbitrary influence a given quantity of gold tends to represent more than a given quantity of labour, the variation shall be automatically checked by the use of the alternative legal tender, silver. The effect would be to make a given quantity of gold invariably representative of a given quantity of the real standard of value, labour, in its turn represented by the commodity silver.

I am aware that it is theoretically conceivable that by the failure of supplies, hoarding, the increase of population, and so on, the exchange value of both legal tenders might rise. But this is so remote a contingency that it may be treated for the present as a practical impossibility.

Annual General Meeting, April 19, 1887.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., in the Chair.

Mr. J. R. Williamson, and Mr. Ralph Holmes, B.A., were elected ordinary members of the Society.

The following gentlemen, recommended by the Council, were elected honorary members:—Professor Emile de Laveleye, Liége University; Professor S. P. Langley, Alleghany Observatory, Pittsburg, U.S.; Professor Simon Newcomb, Johns Hopkins University, Baltimore; Professor Alfred Cornu, École Polytechnique, Paris; J. Norman Lockyer, F.R.S., Science Schools, South Kensington; Sir William George Armstrong, C.B., D.C.L., LL.D., Newcastle-on-Tyne; Dr. H. D. Buys Ballot, Superintendent of the Royal Meteorological Institute of the Netherlands, Utrecht, Holland; Professor Asa Gray, LL.D., Harvard College, Cambridge, U.S.; and Dr. F. Römer, Breslau.

Annual Report of the Council, 1st April, 1887.

The Treasurer's Accounts which accompany this Report will show that last year's balance against the General Fund of £104 6s. 8d. has been increased this year by a further debit of £91 10s. as the difference between the year's ordinary receipts and expenditure, and the debit balance against the General Fund stands at £195 16s. 8d. on the 31st March, 1887. All the accounts which have been presented for payment have been discharged by the Society, and at the time of closing the books there are subscriptions, &c., owing by members amounting to £69 6s. 0d., as well as sums owing to the Society for the use of rooms. To bring the finances of the Society into a healthy state, your Council can point to no more satisfactory method than that of increasing the number of the members, and while it is satisfactory to observe that there is a slightly larger roll of members, as compared with the number at the corresponding date last year, much greater extension in this direction is still a desideratum.

A financial review of the Society's affairs during the previous fourteen years was given in detail in last year's report, and the accounts for the session here presented do not call for any lengthened explanations.

The *Charges on Property* show a decrease as compared with previous years, but it is more nominal than real. After the fire which took place in the adjoining warehouse, and the consequent repairs to our own property which followed, your Council considered it prudent to cancel the old policies of insurance against fire, and take out new ones after the insurance companies had resurveyed the buildings and its contents. These new policies now fall due at Midsummer instead of at Christmas, and the smaller amount now appearing in the accounts is owing to the sum of £7 4s. 10d., being allowed for unexpired præmia upon the cancelled policies. The building is insured for £2,000, and its contents for £9,500 in the Sun Fire Office and Royal Exchange Assurance.

In *House Expenditure* there is a slight decrease in each of the headings of expense. In order to make the new electric and gas lantern more useful, two new gas bags and pressure boards have been purchased by the Council, the Microscopical and Natural History Section contributing one-half the cost.

In *Administrative Charges* there is an increase upon last year's figures. Your Council voted the sum of £4 to the housekeeper for the additional work caused by the renovation of the Society's building during the enlargement and alterations. Your Council last July reappointed Mr. Alfred Brothers, F.R.A.S., for a further period of one year, giving him the additional title of Assistant Secretary. The present arrangement was not intended to be a permanent one, and the Council recommend their successors to discontinue the office of curator and assistant secretary.

It is with great regret that your Council has just received the resignation of Mr. William Roscoe, the Society's housekeeper and collector, his failing health and that of his wife not permitting him to discharge any longer the increasing duties consequent upon the enlargement of the Society's premises, and the more extensive use made of the rooms. Mr. Roscoe has served the Society during the last twenty-three years with faithfulness, diligence, and courtesy; and his long services, orderly habits, exact knowledge of the positions of books in the library, his respectful bearing and ready willingness to oblige, have secured the esteem of the members. The appointment of a successor will be one of the earliest duties devolving upon the incoming Council.

In the *Publishing Account*, the printing of the Society's publications shows an increase, as it includes an item for printing which belonged to the previous session. The payments for wood-engraving, &c., are larger, but your Council continues to charge to the Natural History Fund the cost of the illustrations required for the natural history papers, which are printed in the 'Memoirs.' The Council has had under consideration all through the session the change in the mode of publishing the Society's papers, referred to in the Report for last year, and it has resolved that one publication only shall, in future, be issued in parts at convenient intervals, entitled "Memoirs and Proceedings of the Manchester Literary and Philosophical Society." Each member will have the option of receiving the parts separately on publication, or collectively in an annual volume. The Council considers it important that some attention should be given to the paper and type in which the new publication should appear.

The expenditure upon the *Library* has continued on the previous limited scale, except in the item for binding. An appeal was made to the members for special funds in order to proceed with the binding of the books, as it is found from experience that the prompt binding of serial publications ensures their preservation and completeness. The following donations are included in the receipts for the session just closed, viz. :—

Mr. Oliver Heywood	£5	0	0
Mr. W. H. Johnson, B.Sc.	10	0	0
Mr. Thomas Kay	5	5	0
Mr. Andrew Knowles	2	0	0
Mr. Ludwig Mond	2	0	0
Mr. William Radford	2	0	0
Dr. Arthur Ransome, M.A., F.R.S.	1	0	0
Mr. Archibald Sandeman, M.A.	1	0	0
Dr. Edward Schunck, F.R.S.	10	0	0
Mr. Edmund S. Schwabe, B.A.	2	0	0
Mr. William Thomson, F.C.S.	1	1	0
Mr. Thomas Ward	1	1	0
	£42	7	0

The following amounts are promised towards the same object, and the Society would be pleased to receive additional promises, viz. :—

Mr. Wm. Brockbank, F.G.S.	£5	5	0
Dr. Henry Browne, M.A.	1	1	0
Mr. J. P. Holden	5	5	0
Mr. Richard Peacock, M.P.	5	5	0
Mr. John Ramsbottom	5	0	0
Prof. Osborne Reynolds, M.A., F.R.S.	5	5	0
Prof. Arthur Schuster, Ph.D., F.R.S.	3	3	0
Mr. S. C. Trapp	1	1	0
	£31	5	0

The special thanks of the Council are due to the contributors of this kind help. It will be seen from the Treasurer's accounts that the sum of £38 13s. 10d. has already been expended upon this work, and other volumes have been given out for binding which will absorb the remainder of the sums promised. It is estimated that a further sum of £100 would complete the binding of the books now in the library.

The question has been discussed as to whether it is advisable to allow the books in the library to be consulted by the members of other societies using our rooms; a majority of the members of the Council was in favour of granting this privilege, but considerd that the matter could only be decided by the general body of the members, and the following resolution will accordingly be submitted to the members at the annual meeting, viz.:—"That the privilege of using the books in the library, for reference only, be granted to the members of such societies as hold their meetings in the rooms of the Society, for a remuneration to be arranged between the Council and the societies, as soon as the Council is satisfied that the necessary attendance required can be provided."

During the past year the Librarian reports that the number of books, pamphlets, and part volumes received has been 1460, of which 899 are English and 561 foreign. A very large number of these works are of the greatest value and interest.

The *Natural History Fund* shows a balance of £7 17s. 6d. remaining at its credit at the close of the session. £25 has been granted to the Microscopical and Natural History Section for the purchase of natural history works; and £17 17s. 8d. has been spent upon the illustration of natural history papers in the Society's 'Memoirs.'

The *Centenary Fund* is brought to a conclusion with the present closing statement. The balance at its credit on the 1st April, 1886, was £64 18s. 5d., and the expenditure during the past session has been £87 16s. 6d. To meet the deficiency under this head Mr. Henry Wilde has continued his previous generous benefactions by paying the sum of £22 0s. 4d. to the Society's bankers. The total expenditure, since the commencement of the Fund in the session 1883-4, has amounted to £4077 11s.

The *Fire Account.*—It was stated in last year's report that the Insurance Companies had paid the claims in full which the Society had made upon them in respect of losses suffered from the fire in the adjoining block of buildings. In the session just closed the payments for renovating the premises have amounted to £176 16s. 2d., and, with the expenditure of £8 10s. 6d. in the previous session, there remains a sum of £60 12s. 7d. at the credit of this account.

In the receipts it will be noticed that the account for the *Use of the Society's Rooms* shows an increase upon the figures of last year, £116 having been received in the course of the session. The Societies which are now accommodated in the building are the following:—Manchester Geological Society; Manchester Medical Society; Manchester Scientific Students' Association; Manchester Photographic Society. The Manchester Microscopical Society has also met in the rooms since January.

The following papers and communications have been read at the ordinary and sectional meetings of the Society during the session:—

September 20th, 1886.—"On the present state of our knowledge of the Carboniferous Calamitinæ," by Prof. W. C. Williamson, F.R.S.

October 19th, 1886.—"On Volcanic Dust from Tarawera, New Zealand," by Thomas Kay.

"On an Improved Form of Rheostat," by W. W. Haldane Gee, B.Sc.

November 2nd, 1886.—"Measurements of the Magnetic Induction and Permeability in Soft Iron," by H. Holden, B.Sc., communicated by Dr. A. Schuster, F.R.S.

"The Action of Hydrochloric Acid Gas on certain Metals," by J. B. Cohen, Ph.D., F.C.S., communicated by Dr. A. Schuster, F.R.S.

"Capillary Constants of Benzene and its homologues occurring in Coal-Tar," by J. B. COHEN, Ph.D., F.C.S., communicated by Dr. A. SCHUSTER, F.R.S.

November 16th, 1886.—"The Application of the Harmonic Analysis to the Regular Solar Diurnal Variations of Terrestrial Magnetism," by CHARLES CHAMBERS, F.R.S., Superintendent of the Colaba Observatory, Bombay; communicated by Prof. BALFOUR STEWART, LL.D., F.R.S.

"Remarks on Mr. Chambers' paper entitled: 'The Application of the Harmonic Analysis to the Regular Solar Diurnal Variations of Terrestrial Magnetism,'" by Prof. A. SCHUSTER, Ph.D., F.R.S.

November 30th, 1886.—"*Ranunculus Flammula*, Linn., and *R. reptans*, Linn.; and their connecting links," by CHARLES BAILEY, F.L.S.

December 6th, 1886.—"On the microscopical structure of some seeds," by JOHN BARROW.

"On Varieties of *Lastrea Filix-mas*," by THOMAS ROGERS.

December 14th, 1886.—"On Methods of Investigating the Qualities of Life-boats," by Prof. OSBORNE REYNOLDS, LL.D., F.R.S.

"The Determination of the total Organic Carbon and Nitrogen in Waters by means of Standard Solutions," by CHARLES A. BURGHARDT, Ph.D.

January 11th, 1887.—"On a Comparison of Drawings and Photographs of Sun-spots, and the sun's surface," by A. BROTHERS, F.R.A.S.

January 25th, 1887.—"On the Cutting Action of Coke on Glass," by JAMES NASMYTH, F.R.A.S., &c.

February 8th, 1887.—"Notice of a fish-breeding house erected by the Manchester Anglers' Association at Horton-in-Ribblesdale, Yorkshire," by F. J. FARADAY, F.L.S.

February 14th, 1887.—"Notes on the discovery in Scotland of *Triticum* (*Agropyrum*) *violaceum* (Hornemann) and *Aira* (*Deschampsia*) *flexuosa* (Trin) var: nov: *Voirlichensis*," by J. COSMO MELVILL, M.A., F.L.S.

"Descriptions of one New Genus and some New Species of Parasitic Hymenoptera," by P. CAMERON, F.E.S.

February 22nd, 1887.—"Electrolytic Polarization," by CHARLES H. LEES, B.Sc., and ROBERT W. STEWART, Student in the Owens College; communicated by Dr. A. SCHUSTER, F.R.S.

"On the delicacy of spectroscopic reaction in gases," by T. W. BEST, communicated by Dr. ARTHUR SCHUSTER, F.R.S.

"Lower New Red and Permian—Stockport," by J. W. GRAY, Stockport Society of Naturalists, and PERCY F. KENDALL, Berkeley Fellow of Owens College; communicated by THOMAS KAY.

March 22nd, 1887.—"A Perfect Standard of Value: considered from a scientific standpoint," by F. J. FARADAY, F.L.S., F.S.S.

The deceased members this session are Mr. Joseph Carrick, Mr. Henry Newall, Dr. John Watts, and Sir Joseph Whitworth.

Mr. Joseph Carrick was the son of the late Thomas Carrick, who was for many years an active member and former Treasurer of the Society. He had travelled a good deal in America and in Norway, and was a good botanist, but never contributed to our 'Proceedings.'

Dr. John Watts was born at Coventry on the 24th March, 1818. He was the son of James Watts, a ribbon weaver, and was one of twelve children. His grandfather, Guy Watts, had removed to Coventry from Shipston-on-Stour where the family had lived for many generations. John Watts' early education was acquired at the various charity schools of his native town. When five years old, an attack of scarlet fever left him partially paralysed on the left side and rendered him unable to follow his father's trade. What then was considered to be a great affliction was in later life regarded by him as the most fortunate occurrence, for the inability to use his hands stimulated him to cultivate his mental powers. From being assistant at the Coventry Mechanics' Institution, he became librarian and secretary, spending all his spare time in studying the books in his charge. In May 1840 he went to Manchester to preach Communism, visiting Glasgow for the same purpose. He was thus engaged up to June 1844, teaching a boys' school during the week and lecturing on Sundays. Being dissatisfied with the progress made and losing faith in the practicability of communistic schemes, he resigned. During these four years he assiduously pursued his private studies, and in 1844 he obtained the degree of Ph.D. from the University of Giessen. In 1842 he wrote a pamphlet entitled "The Facts and Fictions of Political Economists, being a review of the principles of the Science, separating the true from the false." In the following year (1843) he wrote a pamphlet entitled "Robert Owen, the Visionary." It was originally delivered as a lecture on the third anniversary of the opening of the Manchester Hall of Science. In 1847 Dr. Watts became interested in the establishment of the Lancashire, afterwards known as the Public School Association. He became the principal advocate of the scheme and held over a hundred public meetings throughout the kingdom. The agitation resulted in the presentation of two opposing bills to Parliament for the promotion of popular education. Dr. Watts was under examination for three consecutive days before the Select Committee. He took a leading part in the agitation for the repeal of the so-called "Taxes on knowledge," including the duty on advertisements, the newspaper stamp, and the excise on the manufacture of paper. In 1853 he wrote a "Report upon the statistical enquiry instituted by the Executive Committee of the National Public School Association in St. Michael's and St. John's Wards in November and December, 1852." In 1860 he published a pamphlet on "Machinery, its influence on Work and Wages," showing that an increase in successful machinery leads to prosperity, by making profit and so increasing the fund for the future employment of labour. "The Incidence of Taxation," published in the following year, shows the quantity and value of articles, paying customs and excise duties, consumed by the working classes as deduced from data obtained from the Rochdale Co-operative Stores. In the same year he published a pamphlet on "Trade Societies and Strikes, their good and evil influences on the members of Trades' Unions, and on society at large," in which he discussed the methods in which Trade Societies were then worked, and offered suggestions as to how their operations might be more beneficial to their members. He considered that the societies should be worked more as agencies, through whose organizations the men could be drafted to wherever labour commanded the highest price. Above all he pointed out that workmen generally lose more in wages during a strike than the equivalent of the increased rate under dispute. In September, of the same year, he read a paper before the Manchester Statistical Society, on "Strikes and their effects on Wages, Profits, and Accumulations." "The Workman's Bane and Antidote," published about the same time, comprised (1) "An Essay on Strikes," read before the British Association; (2) "The history of a mistake," being a tale of the Colne Strike of 1860-61; and (3) a lecture on "The Power and Influence of Co-operative Effort," delivered at the Mechanics' Institution, Manchester, November 6th, 1861. There was also a reply to the criticisms made by the daily papers and by working men on the first paper, which had been extensively commented upon. During the winter of 1866, which Dr. Watts' health compelled him to spend at Torquay, he wrote a pamphlet called "The Catechism of Wages and Capital," believing that a more general knowledge of the conditions by which wages must at all times be regulated, would prevent strikes and lockouts, and the great loss of wealth which is consequent thereon. He therefore made an effort to so simplify that knowledge that every reader should be able to comprehend and appreciate it. "The Facts of the Cotton Famine," published in 1866, is an octavo volume of 472 pages recording the labours of the Cotton Famine Relief Committee, and giving a detailed account of the origin and effects of the famine. In 1867 the Parliamentary Bill Committee appointed at a conference in the Manchester Town Hall, entrusted to Dr. Watts the drafting of a bill; and he gave valuable assistance to Mr. Forster in the compilation of the Education Act of 1870. Having seen the disastrous failure of the European Assurance Society, he determined to attempt a legislative reform of the entire system of life assurance. He got up a deputation to the Vice-President of the Board of Trade, and with a Bill (prepared by himself) paved the way for the Life Assurance Act. Dr. Watts was chiefly instrumental in reviving the usefulness of the Union of Mechanics' Institutes. He was from the beginning one of the most zealous and successful promoters of the co-operative movement. In 1871 he gave a course of free lectures at Downing Street, Ardwick, on "Co-operation, Past, Present, and Future." In 1872 he wrote on "Co-operative Banking and Printing," and read a paper before the Manchester Statistical Society on "Co-operation considered as an economic element in Society." In the same year he wrote a paper on "Medical Charities and the Working Classes." In 1873 he wrote three articles in the *Co-operative News* on "The Industrial Bank," and read a paper before the Co-operative Congress on "Productive Co-operation." On the 27th January, 1874, Dr. Watts was elected a member of the Manchester Literary and Philosophical Society. In 1875 he took a leading part in the establishment of the Manchester Provident Dispensaries. In November of that year he delivered a lecture at the Mechanics' Institution, entitled "The Working Man: a Problem," in which he showed that different classes are not inherent necessities of society, and that in co-operation the working classes have the means of improving their own condition ready to their hand. In 1877, he read a paper before the Social Science Congress at Aberdeen, on "The Social Aspect of Trade Unions," discussing the principal elements of well-being in society generally, and examining to what extent trades unions contribute thereto. During the next seven years the *Co-operative News* was enriched by many articles from Dr. Watts' pen, among which may be mentioned those on "Bonus to Labour," "Charitable Donations, good and good for nothing," "The Rochdale Corn Mill, a struggle and a success," "Co-operative Manufactories and their workmen," "Centralization and Disintegration," "Productive Co-operation," and "The Co-operative Scheme and the Function of the Wholesale Society therein." In 1879, he read a paper before the Social Science Congress on "Economy in National Taxation," and made a statement before the Committee for the Parliamentary enquiry into Co-operative Trading. In the same year appeared a pamphlet entitled "The loss of Wealth by the loss of Health," being an examination of vital statistics in various districts, made with a view of showing how enormous is the pecuniary loss through sickness which is preventible by more careful living and paying greater regard to sanitation. During the later years of his life Dr. Watts wrote several papers on the Progress of Education in this city. He was associated with very many public institutions in Manchester, being Secretary to the Manchester Reform Club; a member of the Manchester School Board; Secretary to the Cotton Districts' Convalescent Fund; Chairman of the Council of the Botanical Society; Chairman of the Council of the Technical School; Chairman of the Union of Lancashire and Cheshire Institutes; and a member of numerous Committees. He died on the 7th of February, 1887, in the 69th year of his age, and was buried at Bowdon Parish Church.

Sir Joseph Whitworth, Bart., was one of the oldest members of the Manchester Literary and Philosophical Society, he and Sir John Hawkshaw having both been elected on 22nd January, 1839.

He was born at Stockport, on 21st December 1803, and was the eldest son of Charles Whitworth, who had a private school in that town. His mother was Sarah, daughter of Joseph Hulse. He was educated at home until twelve years of age, when he was sent to school with a Mr. Vint, at Idle, near Leeds, where he remained for about 18 months. Then, being about fourteen years of age, he was sent to his uncle, who was a cotton spinner in Derbyshire, to learn the business. Here he made such rapid progress that in less than two years he was appointed assistant manager, and was associated with his uncle in the superintendence of the mill; but, like Watt and Babbage, he found the machinery very imperfect, and that it was almost impossible to get true workmanship. From the first he appears to have been distinguished by a strong desire for thoroughness, accuracy, and perfection in his work, and this was characteristic of him in all that he undertook throughout life. His strong desire to improve the machinery and methods of manufacture led him, contrary to the wishes of his relatives, to leave the cotton mill and become a mechanic. At the age of 18 years he came to Manchester, and became a workman in the shop of Messrs. Crighton and Co. For twelve years he worked at the bench under a succession of employers including Messrs. Crighton, Marsden, and Walker, in Manchester, and was afterwards attracted to London by the names of the great mechanicians. There he worked first at Maudslay and Field's, then at Holtzapfell's, and finally at Clements', where he was engaged on the calculating machine or difference engine of the late Professor Charles Babbage. At all these workshops young Whitworth soon obtained the reputation of being one of the best workmen, and had ample opportunity of becoming acquainted with such self-acting tools and machinery as existed in those days and the direction in which they required improvement. While in London at Messrs. Maudslay's he made his first great discovery, that of the method of obtaining a truly plane surface. Previous to this discovery the most accurate planes had been obtained by first planing and then grinding the surfaces. But they were very inaccurate, and Whitworth worked long at the problem and ultimately completely solved it. Here is his own account of the solution: "My first step was to abandon grinding for scraping. Taking two surfaces, as accurate as the planing tool could make them, I coated one of them thinly with colouring matter and rubbed the other over it. Had the two surfaces been true, the colouring matter would have spread itself uniformly over the upper one. It never did so, but appeared in spots and patches. These marked the eminences, which I removed with a scraping tool till the surfaces became gradually more nearly coincident. But the coincidence of two surfaces would not prove them to be planes. If the one were concave and the other convex they might still coincide. I got over this difficulty by taking a third surface and adjusting it to both of the others. Were one of the latter concave and the other convex, the third plane could not coincide with both of them. By a series of comparisons and adjustments, I made all three surfaces coincide, and then, and not before, knew that I had true planes. When they were perfect, I took them one Sunday morning to a fellow-workman who had laughed at my attempts and thought I was mad. When I showed him what I had done he was thunderstruck, but he rejoiced over the work." The importance of this discovery cannot be overestimated, and it laid the foundation for the present accuracy with which mechanism can be constructed. From this time it became possible to construct surfaces such as the valves of steam engines, the tables of printing presses, and all kinds of slides requiring a high degree of truth, with an accuracy practically perfect. The first set of true planes having been obtained, the work of producing copies of them sufficiently accurate for all practical purposes of the workshops became comparatively easy. Quite recently a planing machine has been made in Sir Joseph Whitworth's own shop, whose bed is fifty feet long, and the grooves in which the table works are probably the longest true planes ever made. So exactly are these surface plates now made that if one of them be placed upon the other, both being clean and dry, the upper one will appear to float upon the lower one without being actually in contact with it. But if the thin film of air between them be expelled, the plates will adhere, so that by lifting the upper one the lower one will be lifted along with it as if they formed one plate.

In 1833, being then about thirty years of age, Whitworth returned to Manchester and started in business on his own account, thus founding the great works which have ever since taken the lead for the best and most accurate workmanship.

He next turned his attention to the improvement of the screws and bolts used in fastening together the various parts of steam engines and all kinds of machinery. Different manufacturers had each his own kind of thread, differing in shape and pitch, so that the screws from one workshop would not fit those from another. Hence, repairs were very expensive, as each railway workshop or shipbuilding yard required as many different sets of screwing apparatus as there were makers who supplied them with machinery.

Whitworth saw that this would be obviated by making the thread of a definite shape and making the pitch depend upon the diameter. He obtained an extensive collection of screw-bolts from the principal workshops in Great Britain, and the average thread was carefully observed for the different diameters. He finally determined that the angle made by the opposite sides of the thread should be 55° in every case, but the extreme depth which this angle would give he reduced by rounding off the top and bottom, each to the extent of one-sixth. Thus, the depth given to the thread is only two-thirds of that which it would have if its sides intersected.

He further constructed tables giving the pitch of the screw for a given diameter, which tables have ever since been universally employed. It took long to introduce them and overcome prejudice, but now every locomotive, every marine engine, and every machine tool in use in this country has the same screw for every given diameter, and any one will fit the other, the dies for producing them having been originally copied from those of Whitworth in Manchester. He proposed to the great Railway Companies—The London and North Western, Midland, and Great Northern—that they should carefully determine the fewest possible number of sizes of engines and carriages that would suffice, and also how every single piece might have strictly defined dimensions, in order that greater economy might result from the smaller number of patterns and machines required in the construction. He also suggested to architects and builders that the principal windows and doors of houses should be made in only three or four different sizes. By this means doors and windows could be manufactured without regard to any particular builder or any special house and could be kept in stock, thus obtaining the best possible windows and doors at the least possible cost, and all fitting perfectly.

He next invented his standard gauges and measuring machine capable of measuring lengths differing by so small an amount as one millionth of an inch. This degree of accuracy is due to the sense of touch, and is not obtained by that of sight. The council of the Society of Arts awarded him the Albert Gold Medal "for the invention and manufacture of instruments of measurement and uniform standards, by which the production of machinery has been brought to a degree of perfection hitherto unapproached, to the advancement of arts, manufactures, and commerce."

In 1842 he invented a simple machine for sweeping the streets, which was adopted by the authorities in Manchester. It did the work of about thirty men.

Of his various improvements in machine tools, including his duplex lathe, planing, drilling, slotting, shaping, and other machines, we cannot give details; but all his inventions were displayed at the Great Exhibition of 1851, and the reports of the juries were very complimentary. They say that "Mr. Whitworth has contributed one or more specimens of first-rate excellence under each head." In addition, it is necessary to direct particular attention to his measuring machine (which, however, properly belongs to the class of philosophical instruments), and to the admirable collection of apparatus by the employment of which a uniformity of system in the dimensions and fitting of machinery and in the sizes and arrangement of screw-threads is rendered practicable among engineers in general.

He visited America in 1853, having been appointed one of the Royal Commissioners to the New York Exhibition of that year. He wrote a Special Report on American Manufactures, and was very favourably impressed with what he saw, and also with the readiness to adopt mechanical improvements shown by both masters and workmen throughout the United States.

When the war with Russia broke out in 1854, it became a matter of serious anxiety to the Government as to how the rifles in use might be rendered more efficient. Sir Joseph Whitworth was consulted on the subject by Lord Hardinge, and the improvements which he made in rifles and artillery would have given him a very high position even had he done nothing else. At this time the Enfield rifle was considered the best weapon, and it was very popular on account of the reports of its performances at the battles of the Alma and Inkerman. But the rifles were made by hand, and when they were required in large quantities, the private makers were not able to supply them in time, nor were the rifles alike. Hence it was proposed that the Government should erect a small-arms factory, but the Birmingham gunmakers strongly opposed this. A Select Committee of the House of Commons was appointed to consider the subject, and among other witnesses was Mr. Whitworth, who explained that it was possible to measure the barrels to the millioneth of an inch, and so ensure the greatest accuracy.

As a result of the enquiry, Mr. Whitworth was requested by Lord Hardinge in 1854 to furnish designs for a complete set of new machinery for making good rifles. This Mr. Whitworth declined to do, as he considered that experiments were required in order to determine what caused the difference between good and bad rifles, what was the proper diameter of the bore, what was the best form of bore, and what the best mode of rifling, before any machinery could be made which would be satisfactory. He offered to conduct the experiments if the Government would pay the expense of erecting a shooting gallery for the purpose. This the Government at first declined to do, but ultimately they agreed to erect the gallery, not, however, before Mr. Whitworth had declared that he would rather defray the cost himself than proceed without the experiments. The Government required a million rifles at once. Birmingham could not supply them in less than twenty years with the means of production then in existence. The gallery was erected at The Firs, Fallowfield, near Manchester. It was 500 yards long, 16 feet wide, and 20 feet high. The target was on wheels, so that it could be used for different ranges, and there were rests for fixing the rifle in taking aim. Thin paper screens were fixed at short intervals apart, and thus it was possible to track the bullet throughout its entire course. As soon as the gallery was finished it was blown down by a great storm, and some delay took place before it could be again erected. The experiments did not begin until March, 1855. They showed that the Enfield rifle was wrong in every particular. In the Enfield rifle the bore was cylindrical with grooves; the new Whitworth rifle was hexagonal with the edges rounded; in the Enfield the diameter was ·577 inch, and the rifling had one turn in 78 inches. The new Whitworth rifle had a diameter of ·45 inch, and the rifling one in twenty. The experiments were carried on for more than two years, and the new rifle based thereon gave very much better results than the old rifle, both in deviation and power of penetration. The best form of bullet was also determined, and was found to be one with a conical front and a length of about three diameters. It had a velocity of about 60,000 feet per minute, and rotated about 60,000 times per minute. Notwithstanding its very great superiority, the Government did not adopt the new weapon. In 1860, the National Rifle Association had a competition open to the whole world, when the Whitworth rifle was decided to be the best known, and was at once adopted. On the 2nd July, 1860, the Queen inaugurated the first prize meeting at Wimbledon by firing the first shot with a Whitworth rifle mounted on a mechanical rest, constructed so as to secure accuracy of aim. The Queen pulled a silken cord attached to the trigger, and the bullet struck the target an inch and a half from the centre, making a bull's eye. The range was 400 yards, and this was certainly a very remarkable shot. The new rifle was tested in France and adopted by the French Government. It is not possible here to describe in detail the experiments by which the accuracy, range, and penetrative power were increased far beyond anything previously known, nor how Whitworth extended the principles to the production of artillery—suffice it to say that in 1868 he produced a gun which threw a projectile weighing 2¼ cwt. a distance of six and a half miles. Further, with respect to the duration of the gun, while the Krupp guns usually burst after from 600 to 800 shots; between 3,500 and 4,000 shots were fired from the Whitworth guns without a single case of bursting or serious damage having occurred. He further made great improvements in the metal of which the guns were made. After some 2,500 experiments he succeeded in making his compressed steel, in which all the gas and air bubbles are pressed out while the steel is in a fluid state. He found that a pressure of from six to nine tons on the square inch was most effective, and experiments have shown the very great superiority of this over any other kind of metal. Still the Government continued to make inferior guns and to use the inferior metal, and it was only after years of struggling that they were induced to adopt the improvements which had long before been recognised everywhere else. A full account of the matter will be found in Sir James Emmerson Tennant's "Battle of the Guns."

The great interest which Mr. Whitworth took in technical education was shown by the foundation of the Whitworth Scholarships in 1868. For this purpose he set aside £100,000, and, by his will recently published, he has left the bulk of his fortune for the promotion of education.

In 1877 he converted his extensive works at Manchester into a Company under the Limited Liability Act, at the same time encouraging the workmen to take shares. He, his foremen, and others in the concern, 23 in number, held 92 per cent of the shares and had practical control; no good-will was charged, and the plant was taken at a low valuation. The shares were £25 each, and were offered to the foremen, clerks, draughtsmen, and workmen. The workman who could not afford to take a share was assisted as follows:—When he received his wages he deposited with the clerk what he thought fit. This money was employed by the concern as capital, and whatever dividend was paid to the shareholders, the workman was paid on his deposits as interest on them. If a workman wished to withdraw his deposits, he could by giving three days' notice receive a quarter, six days' notice a half, and twelve days' notice the whole amount standing to his credit. When a workman left he was obliged to withdraw his deposit, and if a shareholder to sell his shares to the Company at the price originally paid for them.

For nearly twenty-five years Whitworth lived at The Firs, Fallowfield, near Manchester, and afterwards at Stancliffe Hall, Darley Dale, in Derbyshire. He was a great gardener, and converted some old quarries into terraces and wonderful gardens. His stables, cowhouses, and cattle troughs were models, and he had an iron billiard table, remarkable for its true surface and great strength and solidity.

He was elected a Fellow of the Royal Society in 1857, and the degrees of LL.D. Dublin, and D.C.L. Oxford, were conferred upon him about the same time. At the Paris Exhibition, 1867, he received one of the five great prizes given to England. In September, 1868, the Emperor Napoleon III. made him a member of The Legion of Honour. In 1869 he was created a Baronet.

He was twice married, first in 1825, to a daughter of Mr. Joseph Ankers, she died in 1870, and in 1871 he married the widow of Mr. Alfred Orrel, of Stockport.

Sir Joseph Whitworth died on Saturday, January 22nd, 1887, at Monte Carlo, where he had been in the habit of wintering for some years past.

The Council considers it desirable to continue the system of electing sectional associates, and a resolution on the subject will be submitted to the Annual General Meeting for the approval of the members.

MANCHESTER LITERARY AN

CHARLES BAILEY, TREASURER, IN ACCOUNT WITH THE SOCIETY, FRO

Dr.

STATEMENT OF THE ACCOUNT

				1886-7.			1885-6.		
1886-7.	£	s.	d.	£	s.	d.	£	s.	
To Cash in hand, 1st April, 1886				88	2	10	846	16	1
To Members' Contributions:—									
Arrears, 1884-5, 2 Subscriptions at 42s.	4	4	0						
„ 1885-6, 7 „ „	14	14	0						
„ „ 4 Half- „ 21s.	4	4	0						
„ „ 4 Admission Fees at 42s.	8	8	0						
Old Members, 1886-7, 112 Subscriptions at 42s.	235	4	0						
„ 1887-8, 2 „ „	4	4	0						
New Members, 1886-7, 3 „ „	6	6	0						
„ „ 2 Half- „ 21s.	2	2	0						
„ „ 6 Admission Fees at 42s.	12	12	0						
				291	18	0	287	14	
To Library Subscriptions, 2 Associates', 1886-7, at 10s.				1	0	0	1	0	
To Contributions from Sections, 1886-7:—									
Physical and Mathematical Section	2	2	0						
Microscopical and Natural History Section	2	2	0						
				4	4	0	4	4	
To Contribution towards Curator's Salary, 1885-6:— Mr. R. D. Darbishire				10	0	0	..	..	
To Contribution for half cost of Gas Bags and Pressure Boards:— Microscopical and Natural History Section				3	0	0	..	..	
To Use of the Society's Rooms:—									
Manchester Medical Society, to 30th September, 1886	55	0	0						
Manchester Geological Society, to 31st March, 1887	30	0	0						
Manchester Scientific Students' Association, to 30th Sept., 1886	25	0	0						
Manchester Field Naturalists' Society, to 31st March, 1886	6	0	0						
				116	0	0	33	0	
To Sale of the Society's Publications				9	3	6	5	19	
To Natural History Fund:— Dividends on £1,225 Gt. Western Ry. Co.'s Stock				59	4	2	59	6	
To Property Tax returned by the Commissioners				..	..	..	11	9	
To Bank Interest, less Bank Postages				2	13	5	11	1	
To Centenary Fund:—(see separate account, page 172)									
Donation, Mr. Henry Wilde	22	0	4						
Sale of Old Materials	0	10	0						
				22	10	4	1807	12	
To Binding Fund:— Donations, as per detailed list in Report (page 152)				42	7	0	..	..	
To Fire Account:									
Sun Fire Office	122	14	8						
Royal Exchange Assurance	122	14	7						
				245	9	3	..	..	
				£895	12	6	£3068	4	

1887—April 1.	To Cash in Manchester and Salford Bank Ld.	£1	6

PHILOSOPHICAL SOCIETY.

1st April, 1886, to the 31st March, 1887, with a Comparative
for the Session 1885-1886.

Cr.

1887.—March 31.	1886-7. £ s. d.	£ s. d.	1885-6. £ s. d.	£ s. d.
By Charges on Property:—				
Chief Rent (Income Tax deducted)	12 9 8		12 10 3	
Income Tax on Chief Rent	0 16 9		.. .. ..	
Insurance against Fire	6 12 8		13 17 6	
Repairs, &c.	1 9 1		0 14 3	
Cleaning Pictures and Marble Busts	.. .. ..		39 11 6	
		21 8 2		66 13 6
By House Expenditure:—				
Coal, Gas, Candles, Water, &c.	25 1 0		30 6 11	
Tea, Coffee, &c., at Meetings	15 18 6		18 9 6	
Cleaning, Brushes, &c.	4 8 9		6 14 11	
Gas Bags, Pressure Boards, and Carrier Frame	6 7 6		.. .. ..	
		51 15 9		55 11 4
By Administrative Charges:—				
Curator and Assistant Secretary	70 0 0		52 10 0	
Keeper of the Rooms	57 4 0		57 4 0	
Ditto Extra remuneration during Alterations	4 0 0		.. .. ..	
Postages and Carriage of Parcels	21 2 10		21 14 6	
Attendance on Sections and Societies	12 4 0		9 4 0	
Stationery, Printing Circulars, and Receipts	14 17 0		17 16 3	
Distributing 'Memoirs'	.. .. ..		4 18 6	
Legal Charges	6 14 0		.. .. ..	
		186 1 10		163 7
By Publishing:—				
Printing and Binding 'Memoirs'	114 2 6		.. .. ..	
Printing 'Proceedings'	51 13 0		50 2 0	
Wood Engraving and Lithography	25 2 6		5 7 6	
Editor of 'Memoirs' and 'Proceedings'	50 0 0		50 0 0	
Binding 'Proceedings'	.. .. ..		4 3 10	
		240 18 0		109 13 4
By Library:—				
Binding Books (from Fund specially contributed)	38 13 10		.. .. ..	
Books and Periodicals	14 15 5		19 4 2	
Assistance in transferring books to new shelves	12 0 0		9 4 0	
Palæontographical Society for the Year 1887	1 1 0		1 1 0	
Ray Society ditto ditto	1 1 0		1 1 0	
		67 11 3		30 10 2
By Natural History Fund:—				
Works on Natural History	19 10 7		22 6 4	
Grant to Microscopical and Natural History Section	25 0 0		20 0 0	
Plates for Natural History papers in 'Memoirs'	17 17 8		27 7 0	
		62 8 3		69 13 4
By Centenary Fund:—				
Expenditure as per separate account (page 172)		87 16 6		2476 2 6
By Fire Account:—				
Repairs, Painting, Renovation, &c., as per account (p. 172)		176 6 2		8 10 6
By Balance		1 6 7		88 2 10
		£895 12 6		£3068 4 9

Note.—The Accounts (of which the above is a summary) are in course of audit by Mr. H. Grimshaw and Mr. John Angell.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

CHARLES BAILEY, TREASURER, IN ACCOUNT WITH THE SOCIETY, FROM 1st APRIL, 1886, TO THE 31st MARCH, 1887, WITH A COMPARATIVE STATEMENT OF THE ACCOUNTS FOR THE SESSION 1885-1886.

Dr.

1886-7.	£ s. d.	1886-7. £ s. d.	1885-6. £ s. d.
To Cash in hand, 1st April, 1886		88 2 10	840 10 11
To Members' Contributions :—			
Arrears, 1884-5, 2 Subscriptions at 42s.	4 4 0		
„ 1885-6, 7 „ „	14 14 0		
„ „ 4 Half- „ 21s.	4 4 0		
„ „ 4 Admission Fees at 42s.	8 8 0		
Old Members, 1886-7, 112 Subscriptions at 42s.	235 4 0		
„ 1887-8, 2 „ „	4 4 0		
New Members, 1886-7, 3 „ „	6 6 0		
„ „ 2 Half- „ 21s.	2 2 0		
„ „ 6 Admission Fees at 42s.	12 12 0		
		291 18 0	287 14 0
To Library Subscriptions, 2 Associates', 1886-7, at 10s.		1 0 0	1 0 0
To Contributions from Sections, 1886-7 :—			
Physical and Mathematical Section	2 2 0		
Microscopical and Natural History Section	2 2 0		
		4 4 0	4 4 0
To Contribution towards Curator's Salary, 1885-6 :—			
Mr. R. D. Darbishire		10 0 0	.. .. ..
To Contribution for half cost of Gas Bags and Pressure Boards :—			
Microscopical and Natural History Section		3 0 0	.. .. ..
To Use of the Society's Rooms :—			
Manchester Medical Society, to 30th September, 1886	55 0 0		
Manchester Geological Society, to 31st March, 1887	30 0 0		
Manchester Scientific Students' Association, to 30th Sept., 1886	25 0 0		
Manchester Field Naturalists' Society, to 31st March, 1886	6 0 0		
		110 0 0	33 0 0
To Sale of the Society's Publications		9 3 0	5 10 3
To Natural History Fund :—			
Dividends on £1,225 Gt. Western Ry. Co.'s Stock		50 4 2	50 0 9
To Property Tax returned by the Commissioners		.. .. ..	11 9 0
To Bank Interest, less Bank Postages		2 13 5	11 1 5
To Centenary Fund :—(see separate account, page 172)			
Donation, Mr. Henry Wilde	22 0 4		
Sale of Old Materials	0 10 0		
		22 10 4	1807 12 11
To Binding Fund :—			
Donations, as per detailed list in Report (page 152)		42 7 0	.. .. ..
To Fire Account :			
Sun Fire Office	122 14 8		
Royal Exchange Assurance	122 14 7		
		245 9 3	.. .. ..
		£805 12 0	£3068 4 9

1887—April 1. To Cash in Manchester and Salford Bank Ld. £1 6 7

Cr.

1887.—March 31.	1886-7. £ s. d.	£ s. d.	1885-6. £ s. d.	£ s. d.
By Charges on Property :—				
Chief Rent (Income Tax deducted)	12 0 8		12 10 3	
Income Tax on Chief Rent	0 10 9		.. .. ..	
Insurance against Fire	0 12 8		13 17 0	
Repairs, &c.	1 9 1		0 14 3	
Cleaning Pictures and Marble Busts	.. .. ..		30 11 6	
		21 8 2		60 13 6
By House Expenditure :—				
Coal, Gas, Candles, Water, &c.	25 1 0		30 0 11	
Tea, Coffee, &c., at Meetings	15 18 6		18 9 0	
Cleaning, Brushes, &c.	4 8 0		6 14 11	
Gas Bags, Pressure Boards, and Carrier Frame	0 7 0		.. .. ..	
		51 15 9		55 11 4
By Administrative Charges :—				
Curator and Assistant Secretary	70 0 0		52 10 0	
Keeper of the Rooms	57 4 0		57 4 0	
Ditto Extra remuneration during Alterations	4 0 0		.. .. ..	
Postages and Carriage of Parcels	21 2 10		21 14 0	
Attendance on Sections and Societies	12 4 0		9 4 0	
Stationery, Printing Circulars, and Receipts	14 17 0		17 16 3	
Distributing 'Memoirs'	.. .. ..		4 18 6	
Legal Charges	0 14 0		.. .. ..	
		180 1 10		163 7
By Publishing :—				
Printing and Binding 'Memoirs'	114 2 6		.. .. ..	
Printing 'Proceedings'	51 13 0		50 2 0	
Wood Engraving and Lithography	25 2 0		5 7 0	
Editor of 'Memoirs' and 'Proceedings'	50 0 0		50 0 0	
Binding 'Proceedings'	.. .. ..		4 3 10	
		240 18 0		109 13 4
By Library :—				
Binding Books (from Fund specially contributed)	38 13 10		.. .. ..	
Books and Periodicals	14 15 5		19 4 2	
Assistance in transferring books to new shelves	12 0 0		9 4 0	
Palæontographical Society for the Year 1887	1 1 0		1 1 0	
Ray Society ditto ditto	1 1 0		1 1 0	
		67 11 3		30 10 2
By Natural History Fund :—				
Works on Natural History	10 10 7		22 6 4	
Grant to Microscopical and Natural History Section	25 0 0		20 0 0	
Plates for Natural History papers in 'Memoirs'	17 17 8		27 7 0	
		62 8 3		60 13 4
By Centenary Fund :—				
Expenditure as per separate account (page 172)		87 10 6		2470 2 6
By Fire Account :—				
Repairs, Painting, Renovation, &c., as per account (p.172)		170 0 2		8 10 6
By Balance		1 0 7		88 2 10
		£805 12 0		£3068 4 0

NOTE.—The Accounts (of which the above is a summary) are in course of audit by Mr. H. Grimshaw and Mr. John Angell.

	£ s. d.	£ s. d.	£ s. d.
Compounder's Fund :			
Balance, 31st March, 1887			125 0 0
Natural History Fund :			
Balance in favour of this Account, 1st April, 1886	11 1 7		
Dividends received during the Session 1886-7	59 4 2		
		70 5 9	
Expenditure during the Session 1886-7		62 8 3	
Balance in favour of this account, 31st March, 1887			7 17 6
Fire Account :—			
Received from the Insurance Companies, 8th April, 1886		245 9 3	
Balance against this account, 1st April, 1886	8 10 6		
Expenditure during the Session 1886-7	176 6 2	184 16 8	
Balance in favour of this account, 31st March, 1887			60 12 7
Binding Fund :—			
Donations received during the Session 1886-7		42 7 0	
Expenditure during the Session 1886-7		38 13 10	
Balance in favour of this account, 31st March, 1887			3 13 2
			£197 3 3
Centenary Fund :—			
Balance in favour of this account, 1st April, 1886	64 18 5		
Receipts during the Session 1886-7	22 10 4		
		87 8 9	
Expenditure during the Session 1886-7	87 16 6		
Transfer to General Account to close Centenary Fund	0 7 9		
		87 8 9	.. .. ..
General Account :—			
Balance against this account, 1st April, 1886	104 6 8		
Expenditure during the Session 1886-7	529 1 2		
Transfer from Centenary Fund, 31st March, 1887	0 7 9		
		633 15 7	
Receipts during Session 1886-7		437 18 11	
Balance against this account, 31st March, 1887			195 16 8
Cash in Manchester and Salford Bank Limited, 31st March, 1887			£1 6 7

THE CENTENARY ENLARGEMENT FUND.

Charles Bailey, Treasurer, in account with the Society, from 1st April, 1886, to 31st March, 1887.

Dr. Cr.

Date	Dr.	£ s. d.	Date	Cr.	£ s. d.
1886.			1886.		
April 1.	To Cash in hand	64 18 5	June 11.	E. Hatton, Opal Sun-lights, &c.	9 8 0
1887.			Aug. 7.	W. S. Thaw, Chairs, Tables, Cupboards, &c.	48 16 0
Jan. 27.	,, Old Drawers	0 10 0	,, ,,	W. S. Thaw, Kneehole in Cabinet	4 5 0
March 8.	,, Donation (5th) Mr. H. Wilde	22 0 4	Oct. 30.	E. Goodall & Co., Library Steps	1 1 0
,, 31.	,, Transfer to General Account	0 7 9	Nov. 1.	Wm. Southern & Sons, Balance of Alterations Account	24 6 6
		£87 16 6			£87 16 6

FIRE ACCOUNT.

Charles Bailey, Treasurer, in account with the Society, from 1st April, 1886, to 31st March, 1887.

Dr. Cr.

Date	Dr.	£ s. d.	Date	Cr.	£ s. d.
1886.			1886.		
April 8.	Sun Fire Office	122 14 8	April 1.	By Balance	8 10 6
,, ,,	Royal Exchange Assurance	122 14 7	May 1.	Wm. Roscoe, Extra Remuneration during and since Fire	4 0 0
			,, ,,	Kendal, Milne & Co., Matting	15 6 0
			June 11.	Worthington and Ellgood, Surveying	2 2 0
			,, ,,	E. Hatton, Opal Shade, &c.	2 9 6
			Nov. 1.	Wm. Southern & Sons, Repairs	127 5 6
			Dec. 11.	P. Ashworth, Repolishing	0 9 9
			1887.		
			Jan. 7.	J. J. Harwood, Painting, Distempering	21 16 6
			,, ,,	J. J. Harwood, Painting pointing	1 5 0
			,, 8.	P. Ashworth, Repolishing	0 9 3
			Mar. 5.	E. Goodall & Co., Binding carpets, &c.	1 2 8
			,, 31.	By Balance	60 12 7
		£245 9 3			£245 9 3

1887.—April 1. To Balance £60 12 7

It was moved by Mr. John Boyd, seconded by Mr. R. E. Cunliffe, and resolved: "That the Annual Report be adopted, and printed in the Society's Proceedings."

It was moved by Mr. John Boyd, seconded by Mr. F. J. Faraday, and resolved: "That the system of electing Sectional Associates be continued during the ensuing session."

In accordance with the intimation in the Annual Report, it was moved by Dr. A. Schuster, and seconded by Professor W. C. Williamson: "That the privilege of using the books in the library, for reference only, be granted to the members of such societies as hold their meetings in the rooms of the Society, for a remuneration to be arranged between the Council and the societies, as soon as the Council is satisfied that the necessary attendance required can be provided." On being put to the vote the resolution was rejected.

It was moved by Dr. A. Schuster, seconded by Mr. F. J. Faraday, and resolved: "That the Society has heard with great regret that the failing health of Mr. William Roscoe, and that of his wife, have compelled him to resign the office of housekeeper and collector for the Society, and begs to tender him its special thanks for the faithfulness, diligence and courtesy with which he has served the members for a period of twenty-three years."

The following gentlemen were elected Officers of the Society and members of Council for the ensuing year:—

President.

BALFOUR STEWART, LL.D., F.R.S.

Vice-Presidents.

WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.
JAMES PRESCOTT JOULE, D.C.L., LL.D., F.R.S., F.C.S.
SIR HENRY ENFIELD ROSCOE, B.A., LL.D., F.R.S., F.C.S., M.P.
OSBORNE REYNOLDS, M.A., LL.D., F.R.S.

Secretaries.

ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S.
FREDERICK JAMES FARADAY, F.L.S., F.S.S.

Treasurer.

CHARLES BAILEY, F.L.S.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council.

JAMES BOTTOMLEY, D.Sc., B.A., F.C.S.
JOHN BOYD.
REGINALD F. GWYTHER, M.A.
WILLIAM HENRY JOHNSON, B.Sc.
JAMES COSMO MELVILL, M.A., F.L.S.
SAMUEL BARTON WORTHINGTON.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Annual Meeting, April 18th, 1887.

Professor W. C. Williamson, LL.D., F.R.S., President of the Section, in the Chair.

The Hon. Secretary read the Annual Report of the Council.

In presenting the Twenty-ninth Annual Report, the Council has again the satisfaction of being able to congratulate the members and associates on the continued healthiness and increased vigour of the Section.

At the meetings there has been a very good average attendance, better than in many recent years, and there has been no lack of original papers, and interesting communications to discuss, and exhibits to examine; and it may be confidently asserted that the past session will compare very favourably with any previous one.

As a very full account of exhibits, communications, and papers has been printed in the Society's proceedings, it is not necessary to recapitulate them here; but perhaps special mention should be made of the two admirable addresses of our president, Professor Williamson, one "On the present state of our knowledge of the Carboniferous Calamitinæ," the other "On the structure and development of young Roots." The various records and descriptions of new species of *Hymenoptera,* by Mr. Peter Cameron; Mr. J. C. Melvill's papers on rare *Heterocera,* and on two rare grasses discovered by him in Scotland; Mr. Bailey's paper on *Ranunculus Flammula,* and *R. reptans* and their connecting links; Mr. Rogers' paper on the varieties of *Lastrea Filix-mas*; Mr. J. Barrow's admirably illustrated description of the microscopical structure of some Seeds; Dr. Hodgkinson's paper on Cavities in Minerals containing fluid, &c.; and Mr. H. C. Chadwick's paper on the minute structure of *Antedon rosaceus*, with the large series of beautiful drawings to illustrate it. These, and the numerous and interesting communications and exhibits made, bear testimony to the fact that there is no lack of vigour in the Section, and it is sincerely to be hoped that this satisfactory state of affairs may be continued and perpetuated.

To illustrate Mr. Barrow's paper on Seeds, and the President's address on the structure and development of young Roots, the oxy-hydrogen lantern microscope was used, and this method was so exceedingly successful that it is to be hoped that it may often be employed at the meetings of the Section in the future. To facilitate this, and to render the lantern available in any of the rooms, the Section has joined with the Parent Society in bearing the expense of procuring two gas bags and pressure boards.

The new Powell and Lealand microscope has been of great service, and has been made good use of at every meeting. To its possession may be attributed the increase in the number of the microscopical exhibits made.

The following is a list of members and associates of the Section.

Members.

Alcock, Thos., M.D.
Bailey, Chas., F.L.S.
Barratt, Walter Edward.
Barrow, John.
Baxendell, Joseph, F.R.S.
Bickham, Spencer H., Junr.
Boyd, John.
Brogden, Henry, F.G.S.
Brothers, Alfred, F.R.A.S.
Brown, Alfred, M.D.
Cottam, Samuel, F.R.A.S.
Coward, Edward.
Coward, Thomas.
Cunliffe, Robert Ellis.
Dale, John, F.C.S.
Darbishire, R. D., B.A., F.G.S.
Dawkins, Prof. W. Boyd, M.A., F.R.S., F.G.S.
Dent, Hastings C., F.L.S.
Deane, F. K.
Faraday, Frederick James, F.L.S.
Hodgkinson, Alex., B.Sc., M.B.
Hurst, Charles Herbert.
Howorth, Henry Hoyle, F.S.A., M.P.
Marshall, Prof. A. Milnes, M.A., M.D., D.Sc., F.R.S.
Melvill, J. Cosmo, M.A., F.L.S.
Moore, Samuel.
Morgan, J. E., M.D., M.A.
Nicholson, Francis, F.Z.S.
Schwabe, Edmund Salis, B.A.
Williamson, Prof. W. C., LL.D., F.R.S.
Wright, William Cort, F.C.S.

Associates.

Blackburn, William, F.R.M.S.
Bles, E. S.
Brooke, H. S., B.A., M.B.
Burnett, R. T., F.G.S.
Cameron, Peter, F.E.S.
Chadwick, Herbert C.
Cunliffe, Peter.
Dawson, G. J. Crosbie.
Fowler, G. H., B.A.
Fleming, James, F.R.M.S.
Hardy, John Ray.
Huet, Frank, L.D.S., R.C.S.
Hyde, Henry.
Jones, Leslie, M.D.
Kennedy, G. A.
Knoop, H. L.
Moss, W., F.C.A.
Pettigrew, J. B.
Quinn, E. P.
Robinson, J. B., F.R.M.S.
Rogers, Thomas.
Smith, John, M.R.C.S.
Stirrup, Mark, F.G.S.
Sington, Theodore.
Tatham, J., B.A., M.D.
Ward, Edward, F.R.M.S.
Young, Sidney, D.Sc.

Total, 31 members and 27 associates, against 31 members and 23 associates at the corresponding period of last year.

The Hon. Treasurer submitted the annual balance sheet, a copy of which is herewith appended.

On the motion of Mr. Cunliffe, seconded by Dr. Hodgkinson, the report and accounts were adopted.

The Microscopical and Natural History Section of the Manchester Literary and Philosophical Society in account with the Parent Society for Grants from Natural History Fund, from 5th April, 1886, to 15th April, 1887.

Dr.		£	s.	d.	Cr.		£	s.	d.
1886.					1886.				
Nov. 8.	To Grant from Parent Society	25	0	0	April 5.	By Balance due to the Section	2	1	11
					July 6.	,, Challenger Reports, Zoology, Vol. XIV.	2	2	0
					Oct. 5.	,, do., Vol. XV.	4	10	0
						,, Balance of Grant unexpended	16	6	1
		£25	0	0			£25	0	0
	To Balance of Grant unexpended ...	16	6	1					

MARK STIRRUP, *Treasurer, in account with the Microscopical and Natural History Section of the Manchester Literary and Philosophical Society, from 5th April, 1886, to 15th April, 1887.*

Dr.

Date		£	s.	d.
1886.				
April 5.	To Balance in Manchester and Salford Bank	30	4	1
Dec. 20.	„ Interest allowed by Bank	0	7	6
Nov. 8.	„ Grant by the Parent Society from the Natural History Fund	25	0	0
1887.				
April 15.	„ Subscriptions and Arrears received during the Session 1886-87	26	0	0
		£81	11	7
	To Balance to credit of Section	£52	8	6

Cr.

Date			£	s.	d.
1886.					
April 20.	By	J. E. Cornish, Microscopical Journal, Feb. & April	0	16	8
July 6.	„	Thos. J. Day (Challenger Reports, Zool., Vol. XIV)	2	2	0
„ 12.	„	J. E. Cornish (Naturalist, Jan. to June)	0	3	0
„ 30.	„	Carriage of Microscope, per J. B.	0	6	9
„ 30.	„	Jas. Collins & Co. (Paper and Envelopes)	0	12	6
Aug. 11.	„	Chas. Simms & Co. (Circulars, etc.)	1	15	0
Oct. 5.	„	Thos. J. Day (Challenger Reports, Zoology, Vol. XV).	4	10	0
„ 29.	„	J. E. Cornish (Micro. Science and Naturalist)	0	18	2
Nov. 11.	„	H. T. Stainton (Zoological Record for 1886)	1	0	0
Dec. 31.	„	J. E. Cornish (American Naturalist, 1887)	0	18	0
1887.					
Jan. 18.	„	Gurney & Jackson (Ibis, 1887)	1	1	0
„ 21.	„	J. E. Cornish (Micro. Journal and Naturalist)	0	9	10
Feb. 8.	„	T. Armstrong & Brother (Lens to Condenser)	0	7	6
„ 14.	„	Chas. Simms & Co. (Printing Circulars, etc.)	1	11	0
„ 17.	„	West Newman & Co. (Journal of Botany, 1886-7)	1	4	0
March 4.	„	Parent Society (Sectional Subscription)	2	2	0
„ 29.	„	Parent Society (Half Cost of Gas Bags, etc.)	3	0	0
April 12.	„	W. Roscoe (Postage and Parcels, £1 7s. 4d., Tea and Coffee, £4 2s.)	5	9	4
„ 15.	„	J. E. Cornish (Micro. Journal and Naturalist)	0	9	10
„ 15.	„	John Boyd (Postage, etc.)	0	6	6
„ 15.	„	Cash in the hands of the Treasurer	0	2	4
„ 15.	„	Balance in Manchester and Salford Bank	52	6	2
			£81	11	7

Examined and found correct,
(*Signed*)

JOHN B. PETTIGREW.
HERBERT C. CHADWICK.

April 15th, 1887.

The Hon. Treasurer reported the resignation of Mr. Roscoe, who has been the Society's housekeeper for 23 years, and proposed that in consideration of his long and valued services, and as a mark of the esteem in which the Section holds him, the sum of £5 should be presented to him. This was seconded by Mr. R. C. Cunliffe, and carried unanimously.

The following gentlemen were elected officers and council for the ensuing session:—

President.

Prof. W. C. WILLIAMSON, LL.D., F.R.S.

Vice-Presidents.

CHARLES BAILEY, F.L.S.
R. D. DARBISHIRE, B.A., F.G.S.
J. COSMO MELVILL, M.A., F.L.S.

Hon. Treasurer.

MARK STIRRUP, F.G.S.

Hon. Secretary.

JOHN BOYD.

Council.

WM. BLACKBURN, F.R.M.S.
ALFRED BROTHERS, F.R.A.S.
PETER CAMERON, F.E.S.
R. C. CUNLIFFE.
ALEX HODGKINSON, B.Sc., M.B.
FRANCIS NICHOLSON, F.Z.S.
THOMAS ROGERS.
THEODORE SINGTON.

There were exhibited—By Mr. H. Hyde, skeletons of *Uraster rubens*, beautifully prepared without maceration in water; by Mr. P. Cameron, F.E.S., some Hymenoptera from Mexico; by Mr. Mark Stirrup, F.G.S., the bronze medallion portrait of the eminent French centenarian, M. Chevreul, Member of the Academy of Sciences, Paris; and by Dr. Hodgkinson, a new form of lamp for use with the microscope, made by Smith and Beck.

Mr. H. C. Chadwick gave a short communication on the minute anatomy of *Grantia compressa*, and exhibited under the microscope several preparations in which the ciliated cells lining the chambers which traverse the wall of the sponge could be very distinctly seen. In another preparation the well-known tri-radiate spicules of this species could be seen in situ, supporting the above-mentioned chambers.

Under the microscopes Mr. Theodore Sington exhibited three groups of Rock sections:—(1) From the Slate Quarries at Llanberis: (2) from the Slate Quarries on Honister Crag, Cumberland: (3) from the Mountain Limestone, Castleton, Derbyshire.

(1) On the west and north-east of the village of Llanberis are extensive slate quarries about two miles apart. Running diagonally across both quarries is a dyke of Greenstone: the sections showed the junction of the Slate and the Greenstone. The principal minerals contained in the Greenstone are Hornblende, Felspar, Magnetite, and Apatite: all traces of cleavage has been destroyed in the slate.

(2) The second group of rock sections was from the green slates and porphyries at the Honister Crag Quarries, Cumberland, intermediate in position between the Skiddaw Slates and the Coniston Limestone. The first section was from the slate used for roofing purposes, the second and third were from the beds immediately below the overlying Porphyry in which all trace of cleavage is lost, and the fourth is from the Porphyry. It consists of crystals of Felspar in a greenish felspathic base.

(3) The third group of sections was from the Basalt and the underlying rock exposed above the village of Castleton. The minerals contained in the Basalt are Olivine, Magnetite and Felspar. Traces of fossils can be found in the rock between the unaltered Limestone and the Basalt, but hydrochloric acid does not affect it.